

# Role of immersive media in public understanding of socio scientific issues (SSIs)

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**Published in**

Frontiers in Psychology  
Frontiers in Education



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ISSN 1664-8714  
ISBN 978-2-83251-886-1  
DOI 10.3389/978-2-83251-886-1

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# Role of immersive media in public understanding of socio scientific issues (SSIs)

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## Citation

Asmi, F., Zhou, R., Mundy, D., Zhai, X., Anwar, M. A., eds. (2023). *Role of immersive media in public understanding of socio scientific issues (SSIs)*. Lausanne: Frontiers Media SA. doi: 10.3389/978-2-83251-886-1

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# Scientific Literacy in Communicating Science and Socio-Scientific Issues: Prospects and Challenges

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## OPEN ACCESS

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### Specialty section:

This article was submitted to  
Educational Psychology,  
a section of the journal  
Frontiers in Psychology

**Received:** 13 August 2021

**Accepted:** 21 September 2021

**Published:** 01 November 2021

### Citation:

Li Y and Guo M (2021) Scientific  
Literacy in Communicating Science  
and Socio-Scientific Issues:  
Prospects and Challenges.  
Front. Psychol. 12:758000.  
doi: 10.3389/fpsyg.2021.758000

A holistic view of *scientific literacy*-related literature was generated based on bibliometric analysis. The purpose was to provide insight into and knowledge on evolving knowledge fronts and to highlight the turning points in the existing literature between 1980 and 2019. *Scientific literacy* in society can potentially help to answer unsolved riddles of socio-scientific issues (SSI) to enable people to become smart and responsible global citizens. Specifically, two decades before and after the year 2000 was taken into account as it comprised the most noticeable revolutionary developments in terms of economics, technology, culture, and society. Interestingly, the attention paid to *scientific literacy* significantly increased after the financial crisis of 2008. *International Journal of Science Education* and *the Journal of Research in Science Teaching* were observed to be the top-cited and top publishing journals, respectively. Similarly, Jonathan Osborne, Rosalind Driver, and Norman G. Lederman were recorded as the most cited and most published authors, respectively, during the study period. Alarming, most of the literature evolved in and was dominated by the Western region, indicating the need to understand the regional-cultural complexities of the East and the rest of the world. The recent evolving clusters, with titles of *literacy (as a concept)*, *learning progression*, and *informal reasoning*, were observed to be currently active knowledge areas in the evolution of the intellectual structure of *scientific literacy*-related literature. However, no recent trend or emerging research direction was noticed in the last decade, even though new and digital media (including immersive media) have revolutionized the communication channels and public understanding of science and socio-scientific issues.

**Keywords:** scientific literacy, socio-scientific issues, media, bibliometric, public understanding of science

## INTRODUCTION

The literal meaning of *literate* is a letter (derived from the Latin word *littera*). Moreover, *scientific* reflects knowledge (derived from the Latin word *scientia*; Rusli, 2012). In 1958, the first traces of *scientific literacy* in the academic literature were observed when the need for public understanding of science was raised (Hurd, 1958). However, *scientific literacy* is currently in the limelight in terms of contemporary education (Laugksch, 2000; Levinson, 2010), civic engagement (Greenhow et al., 2015; Rudolph and Horibe, 2016; Brouwer and Hessels, 2019),

and cultural dynamics (Bonney et al., 2009; van Eijck and Roth, 2010). Scientists rarely distinguished *scientific literacy* and *science literacy* in early academic literature (Hurd, 1958; Shen, 1975; Carson, 1997). Conceptually, Victor Showalter (1974) unified the goals of science education through seven dimensions of *scientific literacy*, which comprises the individuals' ability to understand the nature of scientific knowledge, the capability to accurately apply scientific concepts, efficacy to use processes of science, values with the essence of scientific principles, readiness towards science and technology while viewing society, belief in lifelong learning, and with the readiness to develop science and technology-based skills. Moreover, science and *scientific literacy* are closely related terms in science education research (Roberts, 2007), as *scientific literacy* comprises the positivity appreciating the outcome of science (in terms of education and literacy; Miller, 2004). The reading and writing of science text provoke scientific thinking (scientific inquiry), and its proficiency drives the ability to know science in everyday life, which is the demand of participatory science-based civil society (Podgornik et al., 2017). In the authors' view, Vision I and Vision II in science education demand an equal level of attention while examining the evolution of academic literature. Specifically Vision I addresses the processes and product of science, and Vision II pays attention to the significant role of situation and environment where a scientific component exists.

The academic literature on *scientific literacy* has become conceptually diverse and substantial. Over the same period, it has expanded and become voluminous (Laugksch, 2000). Critically, the 4th grade slump (Zheng and Warschauer, 2015), lack of acceptance of evolution (Fowler and Zeidler, 2016), weak ability to engage in SSI reasoning (Çalik and Coll, 2012), less readiness for scientific inquiry (Wu et al., 2015), the urge to increase public understanding of science (Bauer et al., 2007), the need for a life-long learning ability (Falk et al., 2007), missing protocols for scientific communication (Bauer et al., 2007), and insignificant interest in society require immediate attention and revisiting of the *scientific literacy* literature. However, in the authors' view, no comprehensive unified view has been observed which can achieve the goal of *scientific literacy*. The similar standpoint can also be observed in the research contribution by Roberts, 2007, and Roberts and Bybee (2014). The present study intended to predict and understand the development of *scientific literacy*-related literature and to forecast the future trends in the scientific journey to conceptualize a scientific community and responsible citizenship building for the world.

The evolution of the scientific and science literacy literature over the last six decades has left it sufficiently mature as an academic discipline and strategically valuable as a research area to strengthen the workforce, nations, and economies. Thus, the structural evolution of *scientific literacy* in academia can be re-viewed with support of Big Data application for data visualization tools and techniques to underline interesting patterns in the disciplinary growth. The current research was purposefully conducted for the following reasons: (1) to perform a comprehensive review of the intellectual structure of *scientific literacy* with the aid of available data visualization techniques;

and (2) to generate a bibliometric view of *scientific literacy* to achieve a better understanding of the knowledge area by highlighting the dominant research contribution, authors, and countries in the literature evolution. In other words, the purpose of the study is to highlight the evolution of *scientific literacy* in terms of research focus (area of the curriculum) as well as the future directions (research fronts) and academic foundations (intellectual bases) of *scientific literacy*.

Previous notable literature analyses of *scientific literacy* include the notable contribution of Laugksch (2000) who surveyed related English literature, and also highlighted different interest groups and their related terms and definitions. Yore et al. (2003) specifically researched the 25-year contribution of the *International Journal of Science Education* in the growth of academic literature of *scientific literacy*. Miller (2004) emphasized scientific literacy in the United States, Roberts (2007) provided a comprehensive view from the perspective of noticeable academic contributors to define the similarities and differences between science and *scientific literacy*, Allum et al. (2008) examined a cross-cultural view, and Roberts and Bybee (2014) argued about the distinctive characteristics of science and *scientific literacy* and the related need of redefining curriculum. However, no initiative has been taken to examine the intellectual structures through visual citation analysis in the concerned knowledge area. Specifically, *intellectual structure* development comprises a four-step procedure. First, nodes (document or author) which received a citation above the predefined threshold are taken under consideration. Second, an algorithm (pathfinder network scaling) is applied which computes the correlation and factor analysis of co-cited nodes. Third, sub-groups (as the outcome of factor analysis) of the knowledge domain through inter-connectivity are computed. Fourth, the citation of the highly cited node within each subgroup is listed to define the nodes' impact and magnetite in terms of influence within sub-groups (Chen and Paul, 2001). Moreover, the earliest and latest co-citation and its frequency help to gauge potential attractiveness of each node within the intellectual structure (cognitive structure) of the discipline which is labeled as *Burst*. For this purpose, the most user-friendly, standardized, and attested citation analysis software was used, namely, CiteSpace from Drexel University. In particular, this tool is open source and the most renowned in the field of library and information sciences for bibliometric purposes. The distinctive features of the bibliometric approach includes usage of Bradford's dispersion law to examine literature (Budd, 1988), Zipf's law to explore growth-pattern (Piantadosi, 2014), and authors and countries' contribution with the support of Lotka's law (Pao, 1985) to empirically present *scientific literacy* as the knowledge domain and its literary expansion and growth.

Specifically, bibliometric analysis encourages the understanding of particular phenomena (Hérubel, 1999) in the scientific literature in a quantitative manner (Pritchard, 1969). It encourages the exploration of multiple dimensions of evolving academic research to determine trending methods, models, concepts, and terminologies in the pool of literature (White and McCain, 1989; Narin et al., 1994). It helps to identify knowledge bases and research fronts under the examined intellectual structure

of any particular knowledge domain (Li and Zhao, 2015; Mao et al., 2015). Bibliometric analysis of *scientific literacy* enables identification of the dominating nodes (research document, authors, and countries) in the existing literature (Hérubel, 1999; Hood and Wilson, 2001; Wang et al., 2016), and an examination of the evolution of knowledge areas over the timespan of several years (1980 to 2019). Specifically, the noticeable feature of bibliometrics to produce the intellectual structure of discipline makes it distinctive and preferred in contrast to other approaches of literature reviews, i.e., meta-analysis and best-evidence synthesis. The current study aimed to utilize data visualization and network analysis tools to generate an unbiased and comprehensive view of the literature. In further sections, the methodological aspects and detailed results of the study are discussed. This paper also includes a discussion of the findings of the bibliometric results to emphasize future directions and emerging trends.

## METHODOLOGY: BIBLIOMETRIC ANALYSIS

Quantitatively, the bibliometric analysis enables researchers to view scientific knowledge with the ability to determine emerging patterns and their evolution (Pritchard, 1969). The holistic view of disciplinary knowledge evolution through bibliometrics helps to identify knowledge fronts from the intellectual bases of disciplinary knowledge. Interestingly, the rapid pace of multi-disciplinary knowledge evolution has contributed significantly to providing a scientific view of social and environmental problems, although most of the applied research focuses on specialized, narrow research gaps to penetrate intellectual knowledge bases (Swanson, 1993). Thus, the specialization trend allows for vibrant but blurred trends and multi-disciplinary overlaps as gaps in research with the potential to create bursts in knowledge evolution. The bibliographic initiative encourages the examination of disciplinary knowledge to uncover the logical, vital, and untouched structures in the form of dominant participants [i.e., authors, journals, keywords, and research articles (White and McCain, 1989)], which is one of the purposes of the current study. Strategically, this initiative provides an opportunity to magnify micro-level structures and to analyze the corpus of disciplinary knowledge in the form of links and nodes and the nature of associations between them (Narin et al., 1994). Specifically, the co-citation examines the co-occurring trend of two nodes (articles) together in the pool of academic literature. By performing a co-citation analysis of articles in the field of *scientific literacy*, a co-cited article-based cluster view of the intellectual structure was generated to achieve one of the primary purposes of the current study.

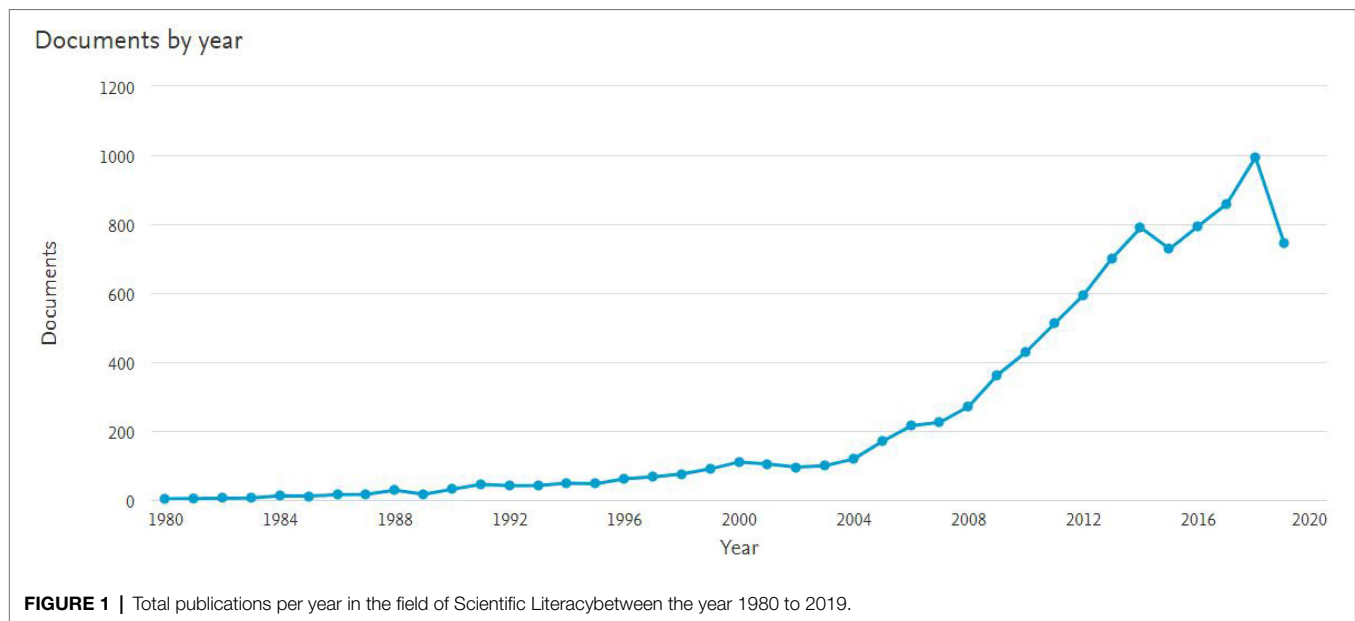
The data visualization and network analysis was performed with the support of CiteSpace. It is a Java-based data visualization tool, which supports Big Data analysis (BDA). With the recent development of the application, it now has more compatibility with the world's leading indexing bodies

(e.g., Thomson Reuters's Web of Science, Scopus). CiteSpace easily encourages network extraction as it uses the 'minimum spanning tree, pathfinder, and expectation-maximization' algorithm with time-slicing features. Previously, CiteSpace was used to examine intellectual fields and how knowledge fronts evolve (Chen et al., 2016; Asmi et al., 2018; Anwar et al., 2019).

During the preliminary phase of data collection and analysis, all of the contributing authors inspected the crawled data against the search query by reviewing the titles, abstracts, and keywords of each of the crawled records. During the manual examination phase, the crawled data records were examined in the relational grid view to generate possible intellectual structures. The process to generate an understandable intellectual crux was achieved by performing the following operations: (1) the co-citation of nodes (articles and authors) using the data visualization tool (CiteSpace); and (2) the co-occurrence of nodes (countries) observed in the crawled data through the data patterns and trend identifiers (CiteSpace). In summary, the bibliometric analysis initiative reveals the intellectual bases, knowledge fronts, and dominant contributing nodes (i.e., scientists, documents, countries, and geographic regions). The current study followed the methodology previously used in studies of a similar nature (Chen et al., 2016; Madani and Weber, 2016; Anwar et al., 2019).

In the current study, metadata from the academic articles published in Scopus were extracted, as these data comprise the most valued and highest quality research on science and *scientific literacy*. After reviewing the pre-analysis settings, a customized search query was used to explore and extract data from the Scopus database. The searching filter was as follows: ALL ("Scientific Literacy"), where 'ALL' was defined as all fields to be searched (including abstract, title, keywords, etc.). To render the search results relevant and reliable, further filters were added to exclude all reviews (588), notes (86), editorials (85), letters (30), short surveys (18), conference reviews (7), and errata (3) as suggested by the previous studies (Gu et al., 2017). Authors' intention to exclude reviews, letters, editorials, and short surveys as a purpose of the current study is to examine the intellectual growth of the related academic literature. However, reviews and brief documents (i.e., letters) are labeled as noise in bibliometric studies (Li et al., 2017). Moreover, authors also excluded the nodes (research document) which hold no bibliographic details, as suggested by previous studies (Seyedghorban et al., 2016). The final count of 9,578 (Open Access: 1487, Others: 8,100) bibliographic records from the years 1980 to 2019 were collected in the third quarter of the year 2020.

CiteSpace was used to help examine the intellectual fields and the knowledge fronts as they evolved (Zhang et al., 2015; Chen et al., 2016), to diversify the literature on *scientific literacy*. The trends in publications and citations were used to evaluate and gauge the importance and popularity of *scientific literacy*. In terms of the publication count for each year, as shown in **Figure 1**, a sudden growth of *scientific literacy* occurred in the decade since the global financial crisis.



## RESULTS

The current section comprises quantitative findings on 148 authors, representing 135 countries, with 159 funding agencies and 158 academic journals observed to have participated in the evolution of the academic literature related to *scientific literacy*. Over the last 40 years, 27 different subject areas were recorded while discussing *scientific literacy*. Specifically, 7,752 records, with a total citation count of 381,159 highlighted the academic worth of the knowledge area of *scientific literacy* to be examined and to be sketched intellectually and structurally. To maximize the understanding of the intellectual structures of *scientific literacy* in the sphere of intellectual growth, institutes, journals, and funding sources were examined. From the primary data analysis, a few interesting trends can be observed. For example, more than 70% of the institutions, which share the top 15 contributors, are from North America. However, very few representatives across the globe succeed to mark their presence, i.e., Universitas Pendidikan Indonesia (Indonesia), the University of Oslo [Norway, Curtin University (Australia), and Nanyang Technological University (Singapore)].

While examining the contribution of journals in the growth of *scientific literacy*-related literature, *International Journal of Science Education* (498), *Journal of Research in Science Teaching* (321), *Science Education* (281), *Research in Science Education* (249), and *Science and Education* (172) were noted as the most active contributors to the literature related to *scientific literacy*. Interestingly, 1,521 research documents by these top 5 contributed journals comprised the subject area of Social Science (84.5%) and Art and Humanities (15.5%).

It is noticed that 50% of the funding institutions belong to North America. The other funding institutions include the Australian Research Council (Australia), Vetenskapsrådet (Sweden), European Commission, Deutsche Forschungsgemeinschaft (Germany), Ministry of Science and

Technology (Taiwan), Economic and Social Research Council (United Kingdom), and Fundação para a Ciência e a Tecnologia (Portugal) as shown in the **Figure 2**.

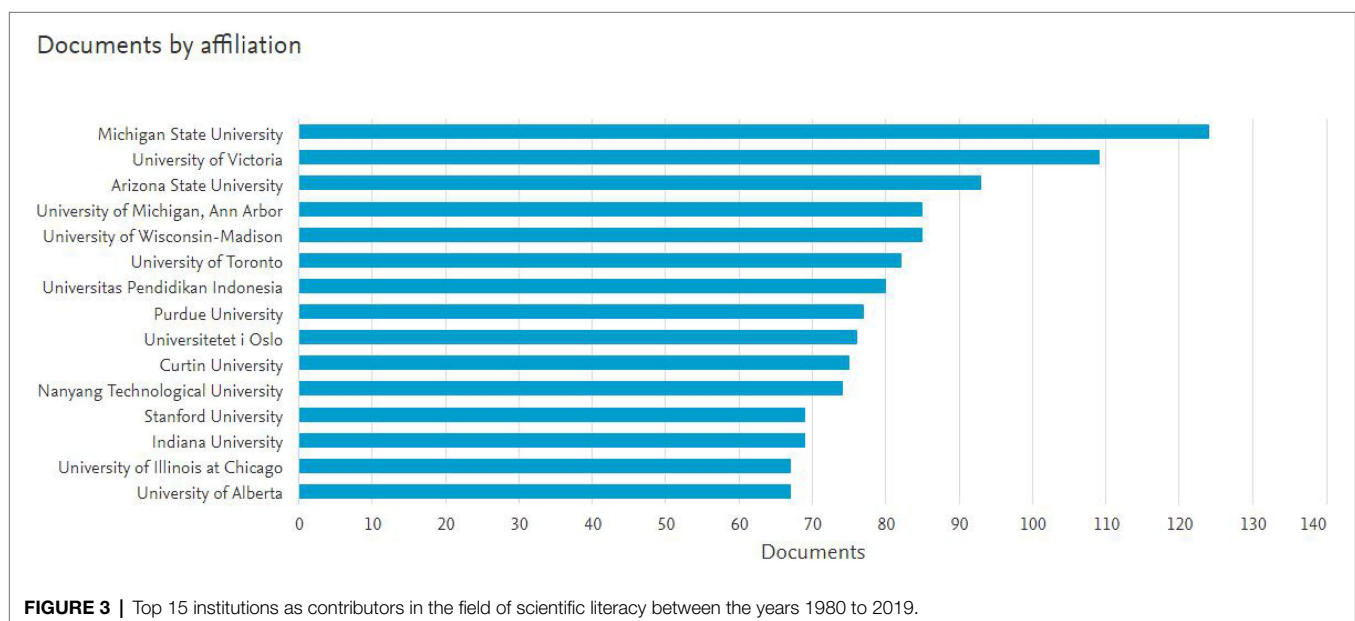
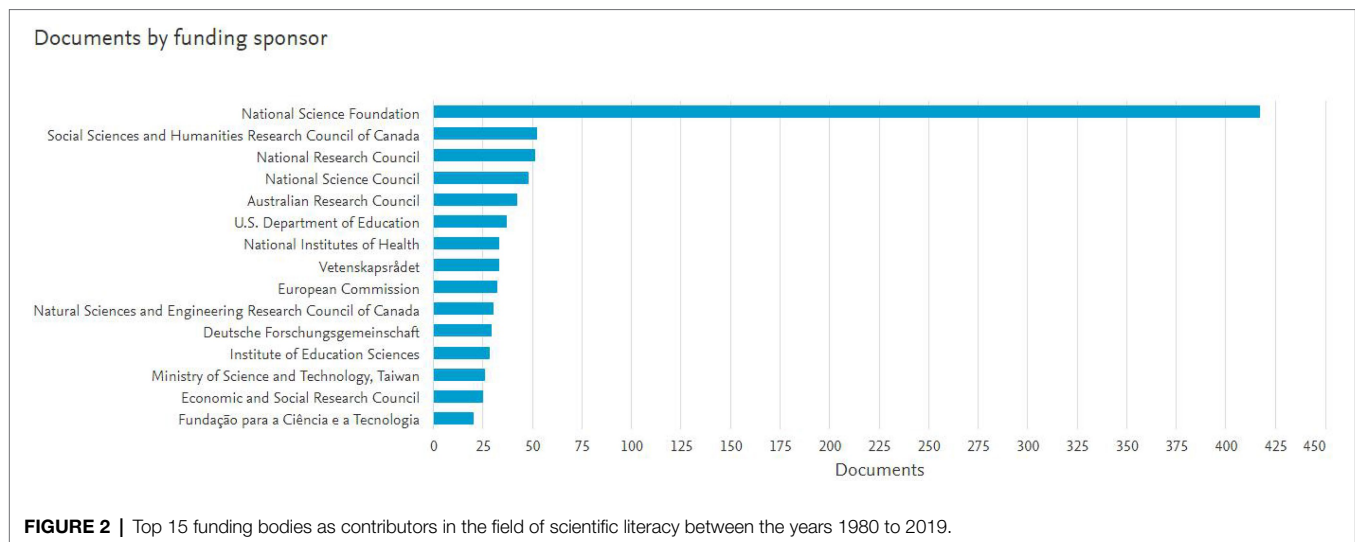
To perform intellectual structural analysis, a co-citation analysis of academic publications and authors was performed. Moreover, the co-occurrence of country was analyzed. The intellectual turning points, most valued articles, and perdition and understanding of the existing and upcoming research fronts were usually driven by the co-citation analysis of the articles. Moreover, the micro- and macro-level structural evolution was examined through the authors' analyses, respectively.

In terms of evolution, the divergence in socio-economic environments always triggers and initiates new interdisciplinary dimensions to better understand social and economic events (Cohen and Lloyd, 2014). The purpose of the following sub-sections is to systemically evaluate the dynamics of this evolution.

## ARTICLE CO-CITATION ANALYSIS

It is important to examine the co-cited references and ensure understanding of their relevancy and the networks among them (Chen and Ibekwe-sanjuan, 2010). Such an examination comprehensively provides the primary structure of the academic research area in an intellectual manner (Chen, 2004). The trends in citations help to identify the associations with the research field (Chen, 2006b). The leading trends in the citation of any specific article indicate the importance of the cited article in the literature (Wang et al., 2014). In the case of *scientific literacy*, 1,648 nodes and 1907 links were identified in the examination of cited references, with the top 50 per slice being initially fixed as the selection criterion. CiteSpace usually considered the rounded shape node as a single cited entity (i.e., author, article, or journal; Chen, 2006a). The size





of each circular node used represents the citation frequency over time (Chen et al., 2012). Similarly, the thinness of the links between two nodes usually indicates the citation frequency (Chen et al., 2012). In other words, a high frequency of co-citation is represented by a thick line between nodes (Chen, 2016).

In **Figure 3** below, the top highly co-cited articles are shown. Specifically, the node by Bonny and his colleagues (2009) entitled as *Citizen Science: A developing tool for expanding science knowledge and Scientific Literacy*, with a co-citation count of 333, where the authors are emphasizing the importance of citizen science to increase scientific knowledge was the highest. It further proposes a model to build and operate citizen science projects. The second highest co-cited document is by the National Research Council's (1996) *National Science Education Standards* as a vision of scientifically literate populace,

with a co-citation count of 162 recorded. It discussed the National Committee on Science Education's efforts to standardize and assess science teaching (in six levels), professional development of science teachers (in four levels), assessment of science education (in five levels), and standardization of science content. The third highest cited document is written by Osborne and Dillon (2008) with the published title of *Science Education in Europe: Critical Reflections* (co-citation = 136), and they questioned science education in Europe (including improving curriculum, pedagogy, assessment, and teaching supply).

Moreover, they proposed seven recommendations to improve science education (about quality of teachers, assessment of science education, improve engagement, engage experimentation, a career in science, innovative curricula, and updating major explanations and the material world). The fourth highly co-cited reference noted was National Research Council's (2013), *Next*

*Generation Science Standards (NGSS): For States, By States'* with a co-citation count of 125. The document examined the NGSS's consistency with the previously defined vision of K-12 science education (framework) and required changes. In the fifth position with a co-citation count of 123, another document by the National Research Council (2011) as NGSS –a 3D view (comprising practice, crosscutting concepts, and disciplinary core ideas) for K-12 science students was presented. The sixth highest co-cited document noted had the title *Scientific Literacy/ Science Literacy* as a book chapter by Roberts (2007) holding a co-citation count of 114. It explored in-depth differences, similarities, and assessments with defining and discussing *scientific literacy* by whom, for whom, and their justification of argumentation.

The seventh highest co-cited document written by Silvertown (2009) with the published title of *A new dawn for Citizen Science* had a co-citation count of 109. The author discussed citizen science as a strategic tool to increase public engagement, accountability, and the sense of free labor. In the eighth slot of the highest co-cited articles, a document by Norris and Phillips (1994) with the title *Interpreting pragmatic meaning when reading popular reports of Science* had a co-citation count of 103. This concluded based on 91 12th grade students' experiments that students are failing to interpret the pragmatic meaning of news reports and failing to accurately understand the scientific status in news in media. In ninth position, Cavagnetto's (2010) contribution with the title of *Argument to foster Scientific Literacy: A review of argument interventions in K-12 Science contexts*, with a co-citation count of 87, emphasized the significance of *scientific literacy* as it provokes argument-based intervention in science education, and explained the wide spectrum of orientations while discussing the nature of argumentation. The tenth most co-cited reference is by Doulas Allchin (2011), with the published title of *Evaluating knowledge of the nature of (whole) science* and a co-citation count of 84. He analyzed the methods to assess the nature of knowledge, with the intentions to transform individuals from declarative to functional, and interpretative into more critical with the ability to profile key information without it being stated.

## EVOLUTIONARY HOTSPOTS IN THE LITERATURE

The following portion of the co-citation investigation through CiteSpace was performed to identify the evolutionary turning points in the literature over the specified period (Zhang et al., 2015). The node (article) can be represented as evolutionary because it connects numerous nodes. During the reference co-citation analysis through CiteSpace, the highlighted nodes with centrality (between-ness) can be seen as shown in the figure (Chen, 2006b; Chen et al., 2012). In other words, centrality behaves like a bridge connecting several time zones in the developmental pace of the intellectual structure of the knowledge area (Chen et al., 2016). Specifically, it includes the linked chain of (1) Bauer (1992), with a centrality of 0.50, who highlighted the importance of science and technology in modern

life. Furthermore, they stated that the misconceptions related to Nature-of-Science and scientific activity are depreciating the use of science in social activities; (2) Shamos (1995), with a centrality of 0.50, who emphasized the less effectiveness of existing educational reforms and urges the increase of science awareness. Specifically, Shamos highlighted (1) the expected value to be produced by science education, and (2) that science is a technique to acquire knowledge, and existing curriculum evaluation methods are less fruitful; (3) Eisenhart et al. (1996), with a centrality of 0.90, discussed how low scientific knowledge, less effective teaching in school, low participation of minorities and women, and less use of science in decision making are obstacles in *scientific literacy* in society; and (4) Driver et al. (2000), with a centrality of 0.90, underlined the lacking of argumentation in scientific controversies among students, as students hold weak oppositional frameworks. Moreover, they concluded the weak pedagogical expertise among teachers as the core reason of low *scientific literacy* among students.

## ARTICLE CO-CITATION BURST ANALYSIS

CiteSpace provides a 'burst detection' algorithm, which simplifies the process of identifying hotspots in the intellectual structure of the literature (Chen et al., 2012). In other words, 'knowledge fronts' are used to retrieve the evolving intellectual bases of the knowledge area through 'burst detection' (Chen and Ibekwe-sanjuan, 2010; Seyedghorban et al., 2016; Zheng et al., 2016). Burst detection assists in emphasizing the articles that are cited intensively during a specific time frame (Chen, 2004, 2006b; Lin et al., 2015). Specifically, Kleinberg's (2003) algorithm was adopted, and it inspects the transient nature of research fronts to identify bursts (Chen, 2006b) in the field of *scientific literacy*. Apart from the contribution made by the highly cited contributors as discussed above, the documents by Dickinson et al. (2012), Roth and Barton (2004), Bell et al. (2009), Sadler (2004), and Duschl et al. (2007) with a high score burst value are shown in the Table 1.

## CLUSTER ANALYSIS

CiteSpace analyses helped to closely group associated cited references and identify weak bonds with less relevant members (Chen, 2006b). The article co-citation network enabled identification of the cluster labels by analyzing the titles, abstracts, and keywords of each of the selected documents. The citation trends through CiteSpace usually follow mathematical algorithms, e.g., Latent Semantic Indexing (LSI), which usually follows a dimension reduction strategy (Wei et al., 2015; Li et al., 2016); Log-Likelihood Ratio (LLR), which is commonly used to measure the goodness of fit by comparing two models derived from the likelihood ratio (Li et al., 2016); and Mutual Information (MI), which, in the context of information theory, explains one term on the basis of the random occurrence of another term to understand the dependencies (Chen and Ibekwe-sanjuan, 2010;

**TABLE 1 |** Top 5 article co-citation bursts in the literature of scientific literacy between the years 1980 to 2019.

Authors and Year	Burst Size	Title	Highlights
Dickinson et al., 2012	38.74	The current state of citizen science as a tool for ecological research and public engagement	Strategic use of citizen science for socio-scientific issues to be addressed, public awareness and education, to appreciate sustainability and to involve non-scientists in scientific research
Roth and Barton, 2004	36.27	Rethinking Scientific Literacy: From Science Education as Propaedeutic to Participation in the Community	Urge to have community participation to build previously uninterested lifelong learning
Bell et al., 2009	28.39	Learning Science in Informal Environments: People, Places, and Pursuits	Importance of learning science from the informal environment, the impact of venue and configuration of the learning environment, and the critical role of media.
Sadler, 2004	27.61	Informal Reasoning Regarding Socio-scientific Issues: A Critical Review of Research	The significance of the relationship between Nature of Science and socio-scientific issues-related decisions, use in curriculum, and argumentation.
Duschl et al., 2007	27.47	Taking Science to School: Learning and Teaching Science in Grades K-8	Examined K-8, and concluded to fundamentally revisit science education to improve foundations with the use of History and Philosophy of Science

Li et al., 2016). However, the labels derived from LLR are preferred because they are used to provide a more comprehensive view of the intellectual network structure (Wei et al., 2015; Li et al., 2016). The term 'silhouette', as the output of the cluster analysis of citation networks, is used to explain the homogeneity within the cluster. Specifically, a higher silhouette value explains a higher degree of consistency among the references shared in the cluster (Kozlov et al., 2015; Yu and Xu, 2016).

The re-visited intellectual base in the cluster view encourages identification of co-citations using different cluster-labeling algorithms, i.e., LLR, MI, and LSI. Moreover, it helps to classify

co-citations and cross-cluster co-citations in a meaningful manner (Chen, 2006a; Chen and Ibekwe-sanjuan, 2010). In the following section, the most influential cited articles in the dominating clusters of the intellectual structure of *scientific literacy* are discussed to obtain a high-level view of the cluster analysis in an explorative manner (Figure 4). Narratively, the top three clusters from the pre and post era of the year 2000 are taken under consideration, as shown in Table 2.

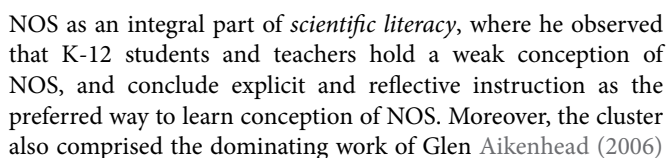
Throughout the evolutionary timeline, a triggering cluster with a silhouette value of 0.997, indicating data from 1981 with the LLR label of (#28) 'economic productivity' was observed, as shown in the lower-left corner of Figure 5. However, in the present era of the intellectual evolution of *scientific literacy*, clusters with the LLR label of Learning Progression and Literacy Component dominate which will be discussed in detail in the following subsection.

From the era of pre-2000, the clusters with the LLR label of (#4) *Cognition and Cognitive apprenticeship* with a silhouette value of 0.822 from the year 1993 were recorded. Specifically, the prominent contributors were noted such as Rosalind Driver et al. (1994) who stressed the importance of social settings, and culture as a tool to socialize learners while developing scientific knowledge. The other prominent names include Joan Solomon and Glen Aikenhead as they emphasized the role of Science, Technology, and Society (STS), student's preconception, and cross-cultural barriers in science education. The second prominent cluster was observed with the LLR label of (#3) *Scientific Reasoning* with a silhouette value of 0.810 from the year 1995. This cluster has the greatest number of cited documents by Millar and Osborne (1998) as it comprehensively discussed the failures and successes from the past, expectations of young students from science education, possible content and structures of science curriculum, and its related challenges and problems. Moreover, David Layton and George E. DeBoer were also noted as significant contributors while discussing the role of *scientific literacy* to enhance public understanding of science and related implications for science education.

Regarding the evolutionary timeline before the year 2000, the third biggest cluster with the mean year of 1996 and LLR (#6) Social Knowledge holding a silhouette value of 0.914 was recorded. During the cluster examination, besides the contribution by the National Research Council (United States) and Margaret Eisenhart, the research document contributed by Fouad Abd-El-Khalick et al. (1998) was one of the most cited articles in this cluster, which mentioned that conceptualization of NOS for classroom practice should be embedded as a cultural element of teacher preparation. Moreover, the social aspect of scientific investigation demands more attention of teachers.

Since the beginning of the 21st century, the academic literature has evolved, addressing the hurdles and barriers to strategically maximize *scientific literacy*. Specifically, noticeable clusters in the post-2000 era include (#1) *Literacy Component*, (#2) *Informal Reasoning*, and (#7) *Learning Progression (argumentation)*. *Scientific literacy* (as a component)-related literature has had prominent contributions by Osborne and Dillon (2008), Roberts (2007), Allchin (2011), and Roth and Barton (2004). It includes Lederman's (2007) work underlining



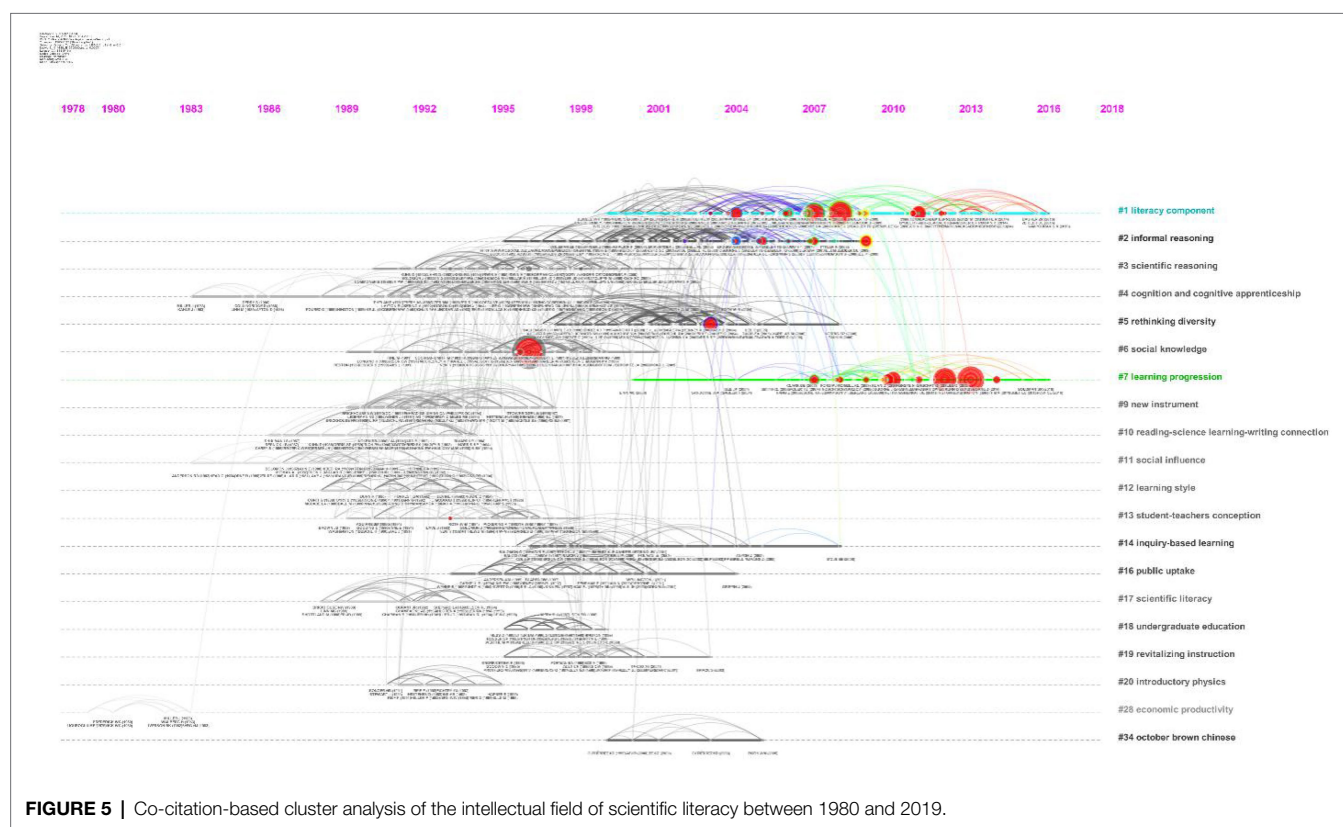


where he emphasized humanistic approaches to science. The *Informal Reasoning* cluster is dominated by the contributions of (1) Zeidler et al. (2005) who discussed cultural, discourse, case-based, and NOS-related issues (as pedagogical importance) to define personal cognitive and moral development through

**TABLE 2** | Six notable clusters in the intellectual structure of scientific literacy pre and post the year 2000 (1980 to 2019).

Mean Year	ID	Size	Silhouette	LSI	LLR	MI
1993	4	53	0.822	Science; science knowledge; cognitive strategy use	Cognition and cognitive apprenticeship; talking their way into science	Cognition and cognitive apprenticeship; marginalized discourses and scientific
1995	3	50	0.810	Science; media; pupils; biomedical communications; reasoning; parents views	Scientific reasoning; misunderstanding science; science and technology	Science and technology; civic scientific literacy
1996	6	33	0.914	Science; nature; instructional practice; competent scientific practice	Social knowledge; cultural basis; information source	Social knowledge; cultural basis; moving toward a portfolio culture
2007	1	96	0.794	Science; nature; evaluating knowledge; curriculum reform; high school	Literacy component; new direction; teaching nature	Equipping student; science model; explicit and reflective versus
2002	2	66	0.885	Science; values; young people; literacy; fundamental sense;	Informal reasoning; society and environment; research on conceptual change	Society and environment; research on conceptual change
2009	7	45	0.871	Science; language; English language learners; argument; online argumentation	Learning progression; scientific argumentation	Argumentation from science studies; epistemic thinking

The order of the clusters is presented according to the cluster size.

**FIGURE 5** | Co-citation-based cluster analysis of the intellectual field of scientific literacy between 1980 and 2019.

SSI education and to promote functional *scientific literacy*. (2) Bell et al.'s (2009) report encouraged an informal learning environment which can be interactive, support participants to interrupt, involve community-educators, and promote the development of educational tools and material. Furthermore, the cluster includes the work of Tytler (2007), Osborne et al. (2004), Sadler (2004), and Driver et al. (2000). The third cluster

from the post-2000 era labeled as *Learning progression (argumentation)* comprises the prominent contribution of the National Research Council's (2011) and National Research Council's (2013) documents addressing the K-12 science education framework and states review, Duschl et al. (2007) who examined science teaching at K-8, and Cavagnetto (2010) who argued for improving communication and critical cognitive

skills. Moreover, it also includes the work by Sampson and Clark (2008) as he reviewed argumentation (in terms of structure, justification, and content), and Britt et al. (2014) who highlighted the significance of *scientific literacy* to understand scientific information. Britt also mentioned the intrinsic complexity of scientific phenomena, interlinkage of different pieces of information, and rhetorical layout of the text as hurdles to learning from science-related text.

## AUTHORS' CO-CITATION ANALYSIS

In terms of publishing academic literature on *scientific literacy* since the year 1980, the most prominent researchers were Wolff-Michael Roth from the University of Victoria, Canada (68), Ingo Eilks from the University of Bremen, Germany (41), and Brian Hand from the University of Iowa, United States (39). However, during the micro-level analysis of the intellectual structure of *scientific literacy*, the most notable authors with the highest numbers of co-citations were Jonathan Osborne from Stanford University, United States (1058), Rosalind Driver from King's College London, United Kingdom (958), and Norman G. Lederman from the Illinois Institute of Technology, United States (725).

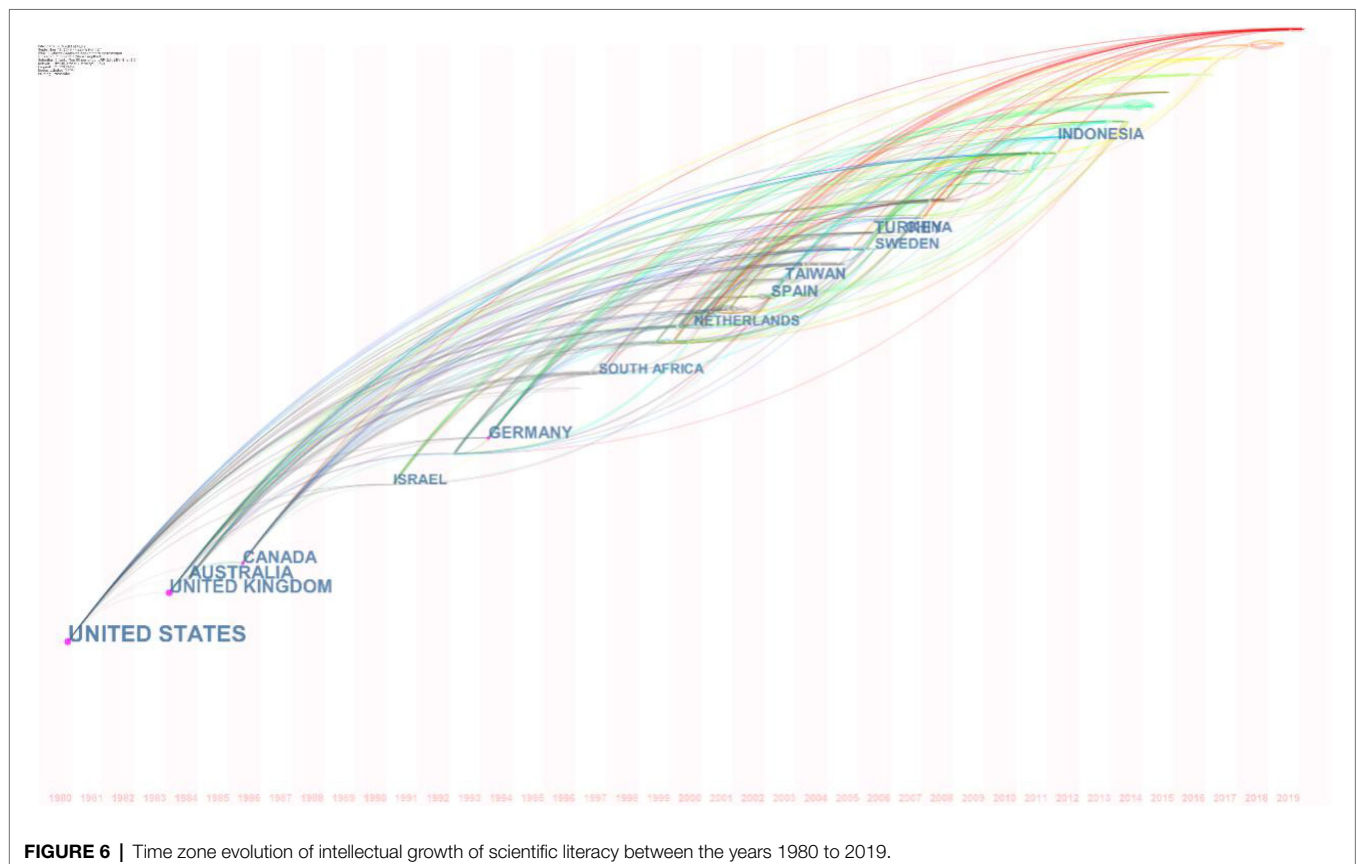
Through the analysis of 931 nodes and 1,611 links during the co-citation analysis using CiteSpace, Rick Bonney had a burst count of 147.42; Janis Dickinson had a burst count of

68.44; Jonathan Silvertown had a burst value of 64.16; David Layton had a burst score of 53.55, and Dominique Brossard had a burst score of 50.66. Interestingly, all the highest bursts scored by individuals emphasized citizen science, technology, and communication as shown in the table below.

## COUNTRY-LEVEL CO-OCCURRENCE ANALYSIS

In the bibliometric approach to analyzing *scientific literacy*-related literature, countries and institutional participation can help to construct macro-level structures of the research field. By the country-level co-occurrence analysis of 135 nodes and 516 links, the United States was ranked first with a frequency of 4,305 and a burst value of 91.76. In other words, the United States accounted for 37.19% of the world's co-citations during the years 1980 to 2019, followed by the United Kingdom (frequency=749, centrality=0.24), Australia (frequency=724, centrality=0.06), and Canada (frequency=597, centrality=0.18). Interestingly, all the dominating countries in terms of co-citation frequency started contributing to the intellectual structure of *scientific literacy* at the beginning of the 1980s as shown in the Figure 6 below.

The findings conclude that in the recent decade, some of the countries which have never dominated in the literature are finally succeeding in marking their presence (in terms of



**TABLE 3 |** Highly co-cited authors in the intellectual structure of scientific literacy between the years 1980 to 2019 with a threshold of 600.

Frequency	Author	Research focus	Affiliation
1,058	Jonathan Osborne	Curriculum, classroom, argumentation, and women's participation in science	Stanford University, United States
958	Rosalind Driver	Conceptual Change, Argumentation	Kings College London, United Kingdom
725	Norman G. Lederman	Nature of Science, Scientific Inquiry	Illinois Institute of Technology, United States
683	Rodger Bybee	Secondary School Science, Curriculum	Carleton College in Northfield, Minnesota, United States
668	Derek Hodson	Curriculum and Pedagogy	Ontario Institute for Studies in Education, Canada
628	Miller Jon D	Citizen science, policy, public attitude, biomedical communication	University of Michigan, United States
614	Robin Millar	Socio-scientific issues, Moral reasoning	University of York, United Kingdom
605	Rick Bonney	Scientific Curriculum, Physicists	New York University, United States

burst) as shown in the table. Moreover, there are many countries from South America, Europe, and Eastern sphere of the globe which are actively contributing to the literature in recent years as shown in **Tables 5** and **6**.

## DISCUSSION

The research work was conducted with the intentions to frame and highlight contributors (articles, country, journal, author, and institutions) through a data visualization technique in the intellectual structure (cognitive structure) of *scientific literacy* in terms of research focus (area of the curriculum) during the last 40 years. The main contribution of the current document is to reveal the existing research areas (research fronts) in the discipline through the objective methodology. It further underlines new directions in academic research (by spotting the bursts) in a structured manner. After a quick overview of the intellectual structure, it can be concluded that apart from highly cited articles, documents emphasizing the importance of science and technology in society, challenging the effectiveness of education reforms, and discussing the lack of argumentation can be seen as turning points (centrality). Moreover, informal learning environments, NOS, socio-scientific issues, and citizen science (as bursts) are the most trending attributes in the literature. In terms of the cluster developmental pattern, the findings conclude that *scientific literacy* triggered *economic*

*productivity* as a prime concern, which further provoked the research related to *cognition and cognitive apprenticeship*. It initiated a parallel stream of research related to *informal learning, social knowledge, instrument development, and learning styles* (as dominating clusters). In the present moment, *literacy and its components (as concept and NOS)*, and *argumentation* are noticed as the most valuable sections of *scientific literacy's* intellectual growth.

A few further interesting findings are as follows: As literature holds a lack of consensus about the definition of *scientific literacy*, the current study highlights that the knowledge background of each of the dominating contributors (authors) hold different educational backgrounds. For example, Joe D. Miller and Rick Bonney are only two researchers in the list of top-cited authors whose research emphasis is public engagement, science communication as policy, and government studies. All other contributors are holding a first degree in physics, biology, chemistry, or other related disciplines. Moreover, authors who have the biggest bursts are emphasizing citizen science, science communication and the role of technology in science education, and *scientific literacy*. In the context of subject areas of literature evolution, the technological aspect is least observed. In other words, literary related to the technology-based environment and its role in *scientific literacy* is less populated. However, it has been researched that motivation to learning about science exerts a mediating effect on technology use, sponsorship of messages (scientist), and trust in the medium (Takahashi and Tandoc, 2016). Hence, the document predicts future subject areas including science communication, and the strategic role of technology could be a potential contributor to the literature of *scientific literacy*.

While exploring the country contributions, Indonesia was observed to be distinctive in terms of burst. However, it is interesting to mention that out of Indonesia's 345 documents, 213 are conference papers and 266 are Open Access documents, and 70% of the publications were only observed in the last 2 years. In contrast, among the top 20 contributing countries, the EU (United Kingdom, Turkey, Germany, Spain, Sweden, Portugal, and Greece) holds 2,209 records (only 123 conference papers, 403 Open Access documents). The purpose of comparing the EU and Indonesia is to predict a sudden growth in the literature, which can bring more challenges in terms of evolving new research fronts in *scientific literacy*.

As shown in **Figure 5**, through the cluster analysis of co-cited references, it can be concluded that the literature is constantly evolving in relation to *informal reasoning, cognitive abilities, social knowledge, argumentation, instruments, learning styles, and inquiry-based learning*. However, none of the new research clusters evolved in the most recent decade, and technology contributed in each of the clusters. Still, *new technology* in terms of media and communication is struggling to mark a distinctive cluster. For instance, only 138 documents were observed while discussing the role of Augmented Reality (AR) in the academic literature of *scientific literacy*. However, only 24% of them originated from North America. The purpose of arguing is to highlight that new trends and new subject areas are evolving globally. However, the origin of publication is



**TABLE 4 |** Authors with highest burst count in the intellectual structure of scientific literacy between the years 1980 to 2019.

Author	Burst	Start year	End year	Timespan	Research Area
Rick Bonney	147.4205	2016	2019		Citizen Sconce
Janis Dickinson	68.4365	2015	2019		Citizen Science
Jonathan Silvertown	64.1567	2016	2019		Citizen Science
David Layton	53.55	1990	2003		Scientific literacy and Technology
Dominique Brossard	50.6621	2015	2019		Science Communication, Media

**TABLE 5 |** Top 5 country-level bursts in the intellectual structure of *scientific literacy* between the years 1980 to 2019.

Country	Frequency	Burst	Starting Year	Ending Year	Timespan
Indonesia	345	114.0624	2017	2019	
United States	4,305	91.7642	1980	1998	
Canada	597	21.3323	1993	2007	
Taiwan	250	18.4882	2011	2015	
Turkey	382	11.9285	2009	2012	

**TABLE 6 |** Ongoing country-level bursts in the intellectual structure of *scientific literacy* between the years 1980 to 2019.

Country	Frequency	Burst	Starting Year	Ending Year	Timespan
Chile	38	5.6422	2015	2019	
Austria	52	6.1447	2016	2019	
Japan	73	7.4828	2016	2019	
Spain	262	4.2639	2016	2019	
Poland	14	4.2647	2016	2019	
Brazil	117	4.372	2016	2019	
Philippines	8	3.8086	2017	2019	

still dominated by North America and it is significantly influencing the appreciation and future evolution of *scientific literacy*-related academic literature. Furthermore, it is important to highlight that 96% of *scientific literacy*-related literature is being produced in English (language). Authors underline that instrumental development, science communication, and *scientific literacy* in an international perspective holds serious challenges for effective and fruitful reforms and development as literature evolution is dominated by a limited pool of origin, language, and funding bodies.

In sum, the evolution of *scientific literacy*'s literature, regardless of research focus, which can be complementary or contradictory to the existing literature, is highly influenced by sponsors' and authors' contextual factors (i.e., education, country, and goals).

## CONCLUSION AND IMPLICATIONS

Although researchers have raised crucial questions for future research, the present study highlights the following trends which can be predicted in the future.

The study highlights that during the last 20 years, *scientific literacy*'s instrument development in the context of formal and informal education has rarely been distinctively examined by academicians, educators, and policymakers (the evolution of literature can be seen in **Figure 5**).

The role of *scientific literacy* is to communicate SSIs that exist in literature. However, the strategic use of *scientific literacy*

while proposing mitigation or coping strategies for SSIs is still lacking. In other words, *scientific literacy*'s relatedness to behavior modeling (persuasive psychological modeling) is needed.

Among the most populous regions of the globe, responsible citizens' behavior and resilient community development are critically important. In other words, diversity of culture demands that the attributes of *scientific literacy* be revisited in emerging economies, as it can be clearly stated that *Social Influence* was one of the initial research fronts of *scientific literacy* in the western region of the globe (the same trend can be predicted in the eastern sphere of the globe).

The technological revolution has transformed the medium of communication (i.e., immersive media), its critical role in learning styles, and individuals' cognitive abilities, while delivering and communicating NOS and concept of science (as a part of literacy components) hold potential to be game-changers in the future. At the same time, technological advancements also have a dark side, i.e., Google-effect, which is affecting humans' cognitive abilities and argumentation abilities.

Moreover, the current initiative holds implications for academicians and policymakers. Noticeably, academicians can use the current research to highlight and understand the evolution of academic literature. The curriculum under the contemporary settings of *scientific literacy* do enhance the public understanding of science. However, there is a dearth of wanting to transform *scientific literacy* into scientific self-efficacy, which can bridge together the construct-level differences of Visions I and II. This transformation both in academic and policy frontiers could

be smooth through the strategic use of immersive media. Furthermore, the concerned policy makers can also propose, design, and re-visit the issues related to science curriculum, public understanding, and science communication in light of an explored intellectual structure. This study concludes that in the recent slice of time, Vision II is getting more attention by academicians and dominating the literature evolution (as compared to the rest of the aspects) within the intellectual structure of *scientific literacy*, as observed nodes related to Vision I in intellectual structure are getting diffused with more inclusion when compared to Vision II, which directs the need and emphasis of academicians towards a scientifically literate populace. The study observed convergence of *citizen science* and *technology*-based research fronts within the literature of *scientific literacy* focusing on SSI (particularly comprised of ecological and environmental concerns). This converging trend of citizen science and technology should include other phenomena related to sustainable behaviors (i.e., GMO, energy consumption, and green modes of mobility), which can help citizens to become smarter and responsible stakeholders of sustainable society.

In terms of Victor Showalter's (1974) view about society as a dimension of *scientific literacy*, authors argue that domination of North American nodes (i.e., authors, institutions, and countries) are depicting skewness in the intellectual structure of *scientific literacy*, which is also underlining the domination of specific cultures and regions. In other words, existing literature related to instruments of development, argumentation, components of literacy, social knowledge, and influence from the rest of the world is less observable (i.e., BRICS which comprise almost 40% of the world's population is rarely observed in contributions in the intellectual structure of *scientific literacy*). Moreover, in a global view, the contribution by the eastern sphere (i.e., China, Taiwan and Japan) is getting distinction in terms of scientific research studies and nation's IQ, regardless their less significant contribution in *scientific literacy*'s intellectual structure. The above argument emphasizes the need to conduct cross-cultural research which can help to (re) align the construct level conceptualization

of *scientific literacy*, and also encourage contributors from the rest of the world to participate in the literature.

Strategic stakeholder management in the case of developing *scientific literacy* is rarely observed in literature. In the authors' view, a comprehensive framework for the active mode of communication and synchronization among educators, policy makers, and concerned public offices is needed to efficiently design, test, and deliver research-proven and standards-based science curricula. Indeed, for the prosperity and sustainable growth of our planet, *scientific literacy* is a threshold regarding competencies for every human. However, the 'soft challenges' (i.e., 'cultural openness', 'digital divide', 'religious beliefs', and 'skilled and knowledgeable human resource'), tangible resources (teaching instruments, curricula, and resources), and institutional forces (governing bodies to design and implement policies and structures for educational infrastructure) have encountered a new spectrum of 'literacy' (i.e., information literacy, media literacy, research literacy, and critical literacy), opening up a large range of interdisciplinary challenges and research directions for all stakeholders in *scientific literacy* (i.e., educators, teachers, and researchers).

## DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

## AUTHOR CONTRIBUTIONS

YL: conceptualization, funding, acquisition, supervision, and writing. MG: formal analysis, investigation, methodology, software, validation, and visualization. YL and MG: writing - review and editing. All authors contributed to the article and approved the submitted version.

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# Impacts of Cues on Learning and Attention in Immersive 360-Degree Video: An Eye-Tracking Study

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## OPEN ACCESS

### Edited by:

Xuesong Zhai,  
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Changcheng Wu,  
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Jihong Ding,  
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### Specialty section:

This article was submitted to  
Educational Psychology,  
a section of the journal  
Frontiers in Psychology

**Received:** 09 October 2021

**Accepted:** 29 December 2021

**Published:** 27 January 2022

### Citation:

Liu R, Xu X, Yang H, Li Z and  
Huang G (2022) Impacts of Cues on  
Learning and Attention in Immersive  
360-Degree Video: An Eye-Tracking  
Study. *Front. Psychol.* 12:792069.  
doi: 10.3389/fpsyg.2021.792069

Immersive 360-degree video has become a new learning resource because of its immersive sensory experience. This study examined the effects of textual and visual cues on learning and attention in immersive 360-degree video by using eye-tracking equipment integrated in a virtual reality head-mounted display. Participants ( $n = 110$ ) were randomly assigned to one of four conditions: (1) no cues, (2) textual cues in the initial field of view (FOV), (3) textual cues outside the initial FOV, and (4) textual cues outside the initial FOV + visual cues. The results showed that the cues (annotations or annotations + arrows) helped learners achieve better learning outcomes and spend more time focusing on the areas with cues. In addition, the study found a serious imbalance in the distribution of learners' attention in each region of the video. The attention directed to textual cues in the initial FOV is much higher than the attention directed to textual cues outside the initial FOV. Adding visual cues can effectively direct attention to textual cues outside the initial FOV and alleviate the imbalance of attention distribution. Consequently, adding cues to immersive 360-degree video can be an appropriate approach to promote learning and guide attention in immersive 360-degree video learning environments. This study provided new insights into the design and development of immersive 360-degree video instructional resources.

**Keywords:** immersive 360-degree video, signaling, cues, learning outcome, attention allocation, eye-tracking technologies

## INTRODUCTION

Virtual reality (VR) can create an immersive three-dimensional interactive virtual environment. As a new learning tool, VR is increasingly used in education (Radianti et al., 2020). Immersive 360-degree video, which is a new type of video based on VR technology, possesses great application potential in education. Immersive 360-degree video differs very much from traditional video with regard to experience. Currently, there are few relevant studies on the impact of these differences on cognition. The Cognitive Theory of Multimedia Learning (CTML) divides multimedia learning materials into words and pictures. People process information *via* visual/pictorial and auditory/verbal channels (Mayer, 2005). As in other VR environments, the presentation of information in immersive 360-degree video is (as in traditional multimedia) mainly through spoken words and animation (Parong and Mayer, 2018). Therefore, the CTML may provide a theoretical basis for us to study cognition in an immersive 360-degree video learning environment. In a VR learning environment, due to the increase in visual range and interactivity, information capacity

is greatly improved, thus possibly causing distraction, increasing unnecessary cognitive load, and reducing the learning effect (Parong and Mayer, 2020). Additionally, in immersive 360-degree video, learners' field of view (FOV) has limitations. Learners can observe only partial pictures of the video at a certain point in time; consequently, learners may miss important learning content. According to the signal principle of CTML, adding cues to multimedia learning materials is a means to effectively guide learners' attention, improve learning efficiency and reduce cognitive load in learning (Karich et al., 2014). Then, can adding cues to immersive 360-degree video reduce the interference of irrelevant processing on learning, effectively guide attention, and promote learning? Therefore, the aim of this study was to investigate the effect of cues on learning and attention in an immersive 360-degree video learning environment.

## Virtual Reality and Immersive 360-Degree Video

Virtual reality uses computer technology to simulate real-time interactions between 3D entities in the virtual world so that participants can immerse themselves in a pseudonatural way by perceiving the motion channel. There are many advantages to using VR in a teaching or training environment. For example, VR can simulate the use of rare and expensive tools, reduce learning risks and costs, simulate complex or dangerous situations, control the learning environment or situation, and reproduce elements of real life (Arnaldi et al., 2018). Some studies have shown that VR technology can improve students' learning motivation and learning achievements (Gunn et al., 2017; Kavanagh et al., 2017; Makransky et al., 2019).

Although VR has been proven to be helpful for learning, the technical and financial cost of interactive 3D VR resource development is high, thus greatly hindering the popularization of virtual reality in teaching (Yang et al., 2010). The emergence of immersive 360-degree video provides a good solution. Panoramic or 360-degree video is a new type of video in which users can adjust the viewing direction at will. According to different viewing methods, 360-degree video can be divided into non-immersive 360-degree video and immersive 360-degree video (also known as 360-degree VR video). Immersive 360-degree video needs to be played on special VR head-mounted displays (HMDs), such as the HTC Vive or Oculus Rift. With the help of simple tools, such as cardboard, smartphones can also be converted into simple VR headsets (Rupp et al., 2019). Compared with the development cost of 3D interactive VR resources, the development cost of immersive 360-degree video is lower. After simple training, teachers can develop their own learning content (Chien et al., 2020).

The CTML holds that when learners take the initiative in cognitive processing, the best learning effect is produced (Mayer, 2005). An immersive virtual learning environment can help learners establish the connection between new knowledge and existing knowledge; encourage learners to actively select, organize and integrate information; and achieve meaningful learning (Araiza-Alba et al., 2021). A previous study confirmed that compared with 360-degree video that is watched directly on

the screen, immersive 360-degree video can provide greater immersion, a more positive learning experience and a better learning effect (Rupp et al., 2019). Other studies have shown that the highly immersive user experience of immersive 360-degree video can activate the sense of presence and enhance learning interest and engagement (Rupp et al., 2016; Harrington et al., 2018).

Compared with traditional video, 360-degree video provides users with a larger visual range. In the VR environment, although users can adjust the viewing angle by turning their head to focus on content outside the current FOV, the content observed at a certain time is limited (Zhu et al., 2018). A limited view means that it is easy to overlook important content when watching immersive 360-degree video (Ardisara and Fung, 2018). The Cognitive Load Theory (CLT) holds that human working memory capacity is limited. Any learning task consumes cognitive resources and produces cognitive load (Sweller, 1988). A free visual angle and redundant visual information may produce a higher cognitive load, thereby resulting in cognitive overload. Therefore, when watching immersive 360-degree videos, the attention allocation of learners may differ from their attention when they watch traditional videos, and excessive cognitive load may affect learning.

## Signal Principle in Multimedia Learning

The CTML assumes that humans process information *via* two channels: auditory/verbal and visual/pictorial. The information processing capacity of each channel is limited. Humans are active agents who process cognitive resources and carry out meaningful learning through selection, organization and integration (Mayer, 2014). Based on the above assumptions and a series of empirical studies, Mayer (2014) proposed multimedia design principles that provided a basis for designing an effective multimedia learning environment. Among these principles, the signaling principle (or cueing principle) suggests that the use of cues in learning materials to guide learners' attention to relevant information or highlight key content will produce a better learning effect (Gog, 2014). Since not all learning situations involve teachers who monitor learning progress, it is necessary to use attention-guiding features in learning materials to coordinate the selection of relevant information (Schneider et al., 2018). In addition to performing a guiding function, cues can emphasize the topics and organization of instruction and make the relationship between elements more salient to promote their integration (De Koning et al., 2009). In a VR learning environment, because the presentation of visual stimuli is converted from the 2D plane to 360-degree all-around visibility, the search and orientation processes of learning materials may become more complicated (Albus et al., 2021). Thus, in immersive 360-degree videos, cues can be used to help learners understand the relationships between information, reduce unnecessary visual searches, and enhance auditory narration.

Cues in multimedia learning can be divided into textual cues and visual cues (Mayer, 2021). Textual cues include headings, annotations, summaries, font colors, text picture references, and intonation (Schneider et al., 2018). Annotations are common

textual cues that can highlight the internal relationships between information, support mapping and integration processes, and repeat the crucial terms of the auditory text as needed to help deepen learners' understanding of information (Vogt et al., 2021). A study found that in VR, annotations could improve learners' recall performance and germane cognitive load (Albus et al., 2021). In immersive 360-degree videos, visual information is rich and intense, while narrative information acquired through the auditory channel is transient and easily overlooked. Based on the spatial and temporal contiguity principles (Mayer, 2005), annotations can be placed next to key pictures as a supplement and emphasis, and appear simultaneously with the narration, thus helping learners establish a mapping relationship between the pictures and the narration and promoting the further organization and integration of information.

Visual cues include arrows, colors, gestures, flashes, labels, and graphic organizers, all of which can guide learners to pay attention to key information (Schneider et al., 2018). Mayer (2017) found that in multimedia learning, if important content is indicated by highlights, colors or arrows, learners' performance can be improved. The FOV is the size of the visual field in the degrees of the visual angle that can be viewed instantaneously (Bowman and McMahan, 2007). A previous study suggested that in a VR environment, the FOV affects enjoyment, memory, and simulator sickness (Lin et al., 2002). Although the field of regard (FOR) of immersive 360-degree video is large (close to the real environment), the observer's FOV is limited and even smaller than in the real environment (Jang et al., 2016; Miola et al., 2021). Therefore, it is necessary to constantly move the head or body while watching to perceive information beyond the current FOV. A study suggested that in a VR environment, in terms of attention to the target stimuli, although the detection time in the FOV is faster than that outside the FOV, the time difference between the two is significantly shortened if cues are added (Jang et al., 2016). Therefore, visual cues may play a positive role in directing and locating attention in immersive 360-degree videos.

The eye-mind hypothesis states that learners' fixation on certain information and psychological processing of the information are carried out at the same time; that is, the information currently being viewed by human eyes is the information currently being processed by the human brain (Just and Carpenter, 1976). Therefore, eye movement data can provide effective information about learners' cognitive processing (Ballard et al., 1997). The influence of cues may stem from guiding attention to relevant information (Lorch, 1989). Since eye movement measurements are often used to reveal visual attention on the items in the scene and changes in the focus of visual attention (Just and Carpenter, 1980), eye-tracking technology can be used to reveal the influence of cues on learners' attention. Some eye-tracking studies found that visual cues can guide learners' attention, enhance visual search, effectively improve learning speed and reduce the interference of extraneous cognitive load (Tabbers et al., 2008; De Koning et al., 2010; Ozcelik et al., 2010; Kuhl et al., 2012). The study of eye movement behavior in VR environments is a new research field. A study used eye movement technology to predict the movement path of the eyes and head in 360-degree videos and explored the relationship between

social anxiety and attention (Rubin et al., 2020). However, there are few eye-tracking studies on the impact of cues on attention in virtual reality environments. Therefore, this study used eye-tracking equipment integrated into a VR HMD to evaluate learning behaviors in an immersive 360-degree video learning environment.

## The Present Study

The main aim of this study was to examine the effects of cues in immersive 360-degree video on learners' learning outcomes and attention allocation. It was assumed that learning materials applying the signal principle could contribute to attention allocation and lead to higher learning outcomes. Based on existing studies, we proposed the following research questions and hypotheses:

**Q1:** In an immersive 360-degree video learning environment, does the addition of textual cues affect learning outcomes and attention allocation?

**H1:** Compared to learners studying without textual cues, learners studying immersive 360-degree video with textual cues were expected to have better learning outcomes (H1a) and a longer fixation duration (H1b). The rationale for this prediction is that textual cues help guide attention to relevant information and timely repetition of the narrative content (the Signaling Principle: Mayer, 2021). Moreover, learners in the cues condition may attend to signaled elements more frequently (Scheiter and Eitel, 2015; Wang et al., 2020).

**Q2:** Do textual cues have different effects on learning outcomes and attention allocation when they are inside or outside the learner's initial FOV?

**H2:** Learners were expected to perform better (H2a) and to fixate more on the annotated areas (H2b) when textual cues were inside rather than outside the initial FOV. The rationale for this prediction is that students learn better when textual cues and relevant information are presented close to each other rather than separately (the spatial contiguity principle: Mayer, 2021).

**Q3:** When the textual cues are outside the initial FOV, does the presence or absence of visual cues have different effects on learning outcomes and attention allocation?

**H3:** Compared to learners studying without textual cues, learners studying immersive 360-degree video with directional visual cues were expected to have better learning outcomes (H3a). Moreover, learners were expected to fixate more on the annotated areas that were guided by visual cues (H3b). When learners' cognitive resources are consumed by excessive visual searching, learning will be hindered if learners are not guided by appropriate cues (Ozcelik et al., 2010).

## MATERIALS AND METHODS

### Participants and Design

We recruited 112 undergraduates from a university in China. Two participants had to be excluded from data analyses due to technical issues with eye-tracking device. Of the remaining 110 participants, 74 were females ( $M_{\text{age}} = 20.52$ ,  $SD_{\text{age}} = 1.30$ , age range: 18–24). More than 95% of participants had no experience with virtual reality, and all of the participants had no VR or 360-degree video learning experience. All participants had normal hearing and normal or corrected-to-normal vision. At the end of the study, the participants received a small gift (consisting of a notebook, pen and candy).

This study adopted the mixed research method of experimental research and semi-structured interviews. We used a single factor intergroup design with 4 groups. The participants were randomly assigned to one of four conditions by simple random sampling: the no cues (NC) group ( $n = 27$ ), the textual cues in the initial FOV (TCIIF) group ( $n = 27$ ), the textual cues outside the initial FOV (TCOIF) group ( $n = 28$ ), and the textual cues outside the initial FOV + visual cues (TCOIF + VC) group ( $n = 28$ ). Concerning dependent variables, we measured the learning outcomes of the participants and main eye movement indicators (total fixation duration, fixation duration on annotation areas of interest (AOIs), fixation duration on initial FOV AOIs and fixation heatmaps). Concerning control variables, we considered prior knowledge and spatial ability. In addition, semi-structured interviews were conducted with the participants after the experiment. The experimental conditions and procedure are shown in **Figure 1**.

### Devices and Materials

#### Virtual Reality and Eye-Tracking Devices

An HTC Vive Pro HMD was used as a display device with a resolution of  $2160 \times 1200$  ( $1080 \times 1200$  for each eye) and a refresh rate of 90 Hz. The HMD binocular FOV was  $110^\circ$ . The Tobii Pro VR eye tracker was used as eye-tracking equipment. The device was integrated into the HTC Vive Pro HMD with an accuracy of  $0.5^\circ$  and a sampling frequency of 120 Hz. Tobii Pro lab 1.1 software was used to perform calibration, play videos, and analyze the eye-tracking data after the experiment.

#### Learning Materials

The 360-degree video “*Intercellular*,” developed by Random42 Scientific Communication, was used as the learning material. The video presented and explained the forms and functions of various cells in the human body by using realistic 3D animation. The total video duration is 3 min and 24 s, and the resolution is  $2,304 \times 1,080$ . The original video was provided with English narration, with English annotations at key positions and no subtitles. To reduce the interference of irrelevant factors, we converted the video into Chinese narrations and annotations and invited domain-related experts to improve the translation to ensure accuracy and fluency.

According to the four conditions of the experimental design, the video was processed into four corresponding versions. **Figure 2** provides snapshots of the four conditions: (1) No

cues (NC), i.e., there were no textual or visual cues in the learning materials. (2) Textual cues in the initial FOV (TCIIF), in which key information was presented in the learner’s initial FOV in the form of annotations. We added 17 annotations. Some annotations were explanations of the pictures; for example, the annotation “red blood cells” was added next to red blood cells when they were presented. Other annotations were repetitions of the narration; the annotation “the human body produces approximately 200 billion red blood cells every day” was used. (3) Textual cues outside the initial FOV (TCOIF). As with the TCIIF condition, key information was presented in the form of annotations. The difference was that in the TCOIF condition, most of the annotations appeared outside the learners’ initial FOV. That is, learners needed to turn their heads to see these annotations. (4) Textual cues outside the initial FOV + visual cues (TCOIF + VC). As with the TCOIF condition, the key information was presented outside the learners’ initial FOV in the form of annotations. The difference was that in the TCOIF + VC condition, arrows pointing to these annotations were added in the initial FOV.

### Measures

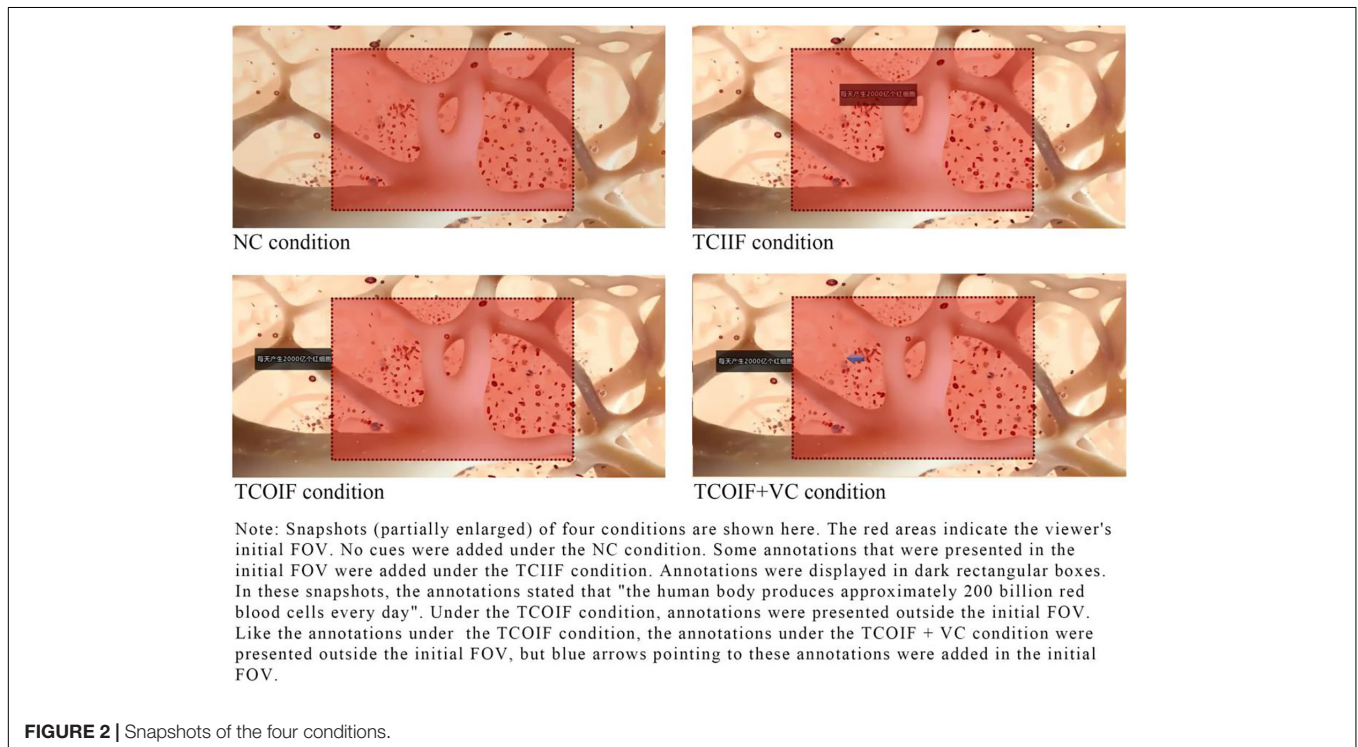
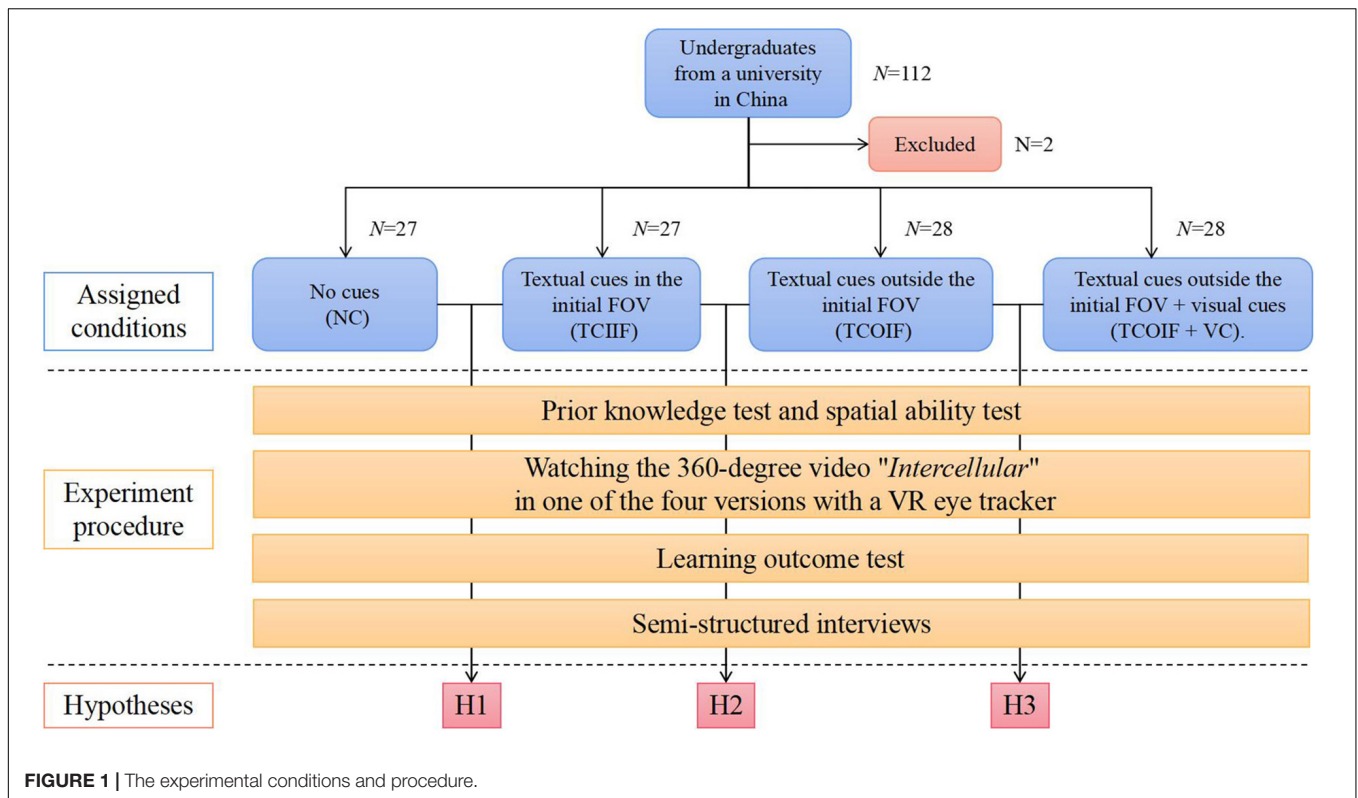
A prior knowledge test was used to assess the level of biological knowledge related to the learning task. The questionnaire consisted of five short self-evaluation questions, such as “I can describe the main structure of cells” and “I can explain the cause of leukemia.” From the five options, participants were asked to choose the option that fit their actual situation. The options ranged from “completely inconsistent” to “completely consistent” and corresponded consecutively to 1–5 points. The prior knowledge test showed high internal consistency ( $\alpha = 0.81$ ).

The paper-folding test and the card rotation test were used to measure the participants’ spatial ability (Ekstrom et al., 1976). The two tests assessed two types of spatial abilities—spatial visualization and mental rotation. The participants were given one point for each question they answered correctly, with the final total indicating each participant’s spatial ability.

The learning outcome test consisted of 11 questions, all closely related to the learning material and developed by two domain-related experts. The test was divided into multiple-choice and single-choice questions. Each question was worth 1 point for a total score of 11 points. The answers to all the questions were presented in the video narration. Considering that the differences among the four conditions were reflected mainly in the cues, the answers to most of the questions were emphasized in the annotations of the video (except for the NC group). An example of a single-choice question is “What organizational structure is shown in the figure? A. synapses; B. leukocytes; C. immune cells; D. axons.” An example of a multiple-choice question is “Which structures in the gut can assist in food digestion and nutrient absorption? A. villi; B. bacterial colony; C. capillaries; D. microvilli.” The spatial ability test showed moderate internal consistency ( $\alpha = 0.71$ ).

Eye movement indexes, such as the total fixation duration of the learning materials, the total fixation duration of the AOIs, and fixation heatmaps, were used. The total fixation duration was the total amount of time of all the fixation durations in





specified AOIs; this index can be used to reflect the processing depth or degree of attention of learners to the content (Ponce and Mayer, 2014). The heatmaps used different colors to illustrate

the participants' fixation duration in the stimulation area; the heatmaps reflected the participants' overall allocation of cognitive resources (Wang et al., 2020). Red usually indicates the longest

fixation duration, and green indicates the shortest fixation duration. There are different levels between the two colors.

A previous study suggested that the combination of a concurrent verbal protocol and eye movement data analysis can enhance insight into cognition (Gog et al., 2010). To better analyze the cognition reflected by eye movement data and to understand learners' subjective feelings, semi-structured interviews were conducted after the experiment. During the interviews, the participants answered several open-ended questions, such as, "Do you think immersive 360-degree video is helpful for learning? What do you think are the advantages and disadvantages of immersive 360-degree video? Do the annotations and arrows in the video help clarify the learning content?"

## Procedure

First, the participants entered the preparation room, provided basic information, and took a test of prior knowledge and spatial ability. Next, the participants were brought into the testing room and seated. The participants read the instructions of the experiment to understand the experiment content, and the experiment assistant taught the participants how to use the VR HMD. Then, the participants wore the HTC Vive Pro HMD, performed five-point calibration of the eye movement system, and watched video materials randomly assigned under one of the four conditions. After watching the video, the participants were tested for learning outcomes and interviewed. The entire process took approximately 15 min.

## RESULTS

### Descriptive Statistics (Means and Standard Deviations)

**Table 1** shows the descriptive data statistics of prior knowledge, spatial ability, learning outcomes, and main eye movement indicators. We conducted an ANOVA with regard to prior knowledge and spatial ability. The results showed no significant differences among the groups in their prior knowledge [ $F(3, 106) = 0.44, p = 0.724$ ] and spatial ability [ $F(3, 106) = 1.51, p = 0.216$ ].

## Learning Outcomes

The descriptive results showed that the TCIF group had the best learning performance, followed by the learning performance of the TCOIF + VC group. The NC group had the worst learning performance (see **Table 1**). We used one-factor ANOVA to analyze the differences in learning outcomes between the four conditions. The results showed that there were significant differences in the learning outcomes of participants between the different conditions, i.e.,  $F(3, 106) = 9.87, p < 0.001$ . The follow-up *post hoc* analysis using a least significant difference (LSD) test showed that the TCIF group ( $p < 0.001$ ) (H1a), the TCOIF group ( $p < 0.05$ ) and the TCOIF + VC group ( $p < 0.001$ ) outperformed the NC group, and the TCIF group outperformed the TCOIF group ( $p < 0.05$ ) (H2a). There was no significant difference between the TCIF group and the TCOIF + VC group ( $p > 0.05$ ). These results were consistent with each hypothesis; that is, adding cues (annotations, arrows, or annotations + arrows) helped to improve learners' learning effect, and the position of the annotations affected learning outcomes.

## Eye-Tracking Outcomes

### Fixation Duration

To explore the effect of textual cues on learners' attention allocation, one-factor ANOVA was used to analyze the total fixation duration under the four conditions. The results showed that there were significant differences in total fixation duration under the different conditions, i.e.,  $F(3, 106) = 2.74, p = 0.047$ . The follow-up *post hoc* analysis using an LSD test showed that the total fixation duration in the TCIF group was significantly longer than that in the NC group ( $p = 0.038$ ) (H1b) and the TCOIF group ( $p = 0.007$ ). There was no significant difference in the total fixation duration between the NC group, the TCOIF group and the TCOIF + VC group. The results showed that learners paid more attention to the learning material when there were textual cues in the initial FOV.

To explore whether the location of textual cues and the guidance of visual cues affected learners' attention to textual cues, we set the annotation areas of the TCIF group, the TCOIF group and the TCOIF + VC group as AOIs and conducted an ANOVA for the total fixation duration of the AOIs between the groups. The results showed that the total fixation duration of the annotation areas was significantly different under

**TABLE 1** | Descriptive data for all variables under the four conditions.

Dependent variables	NC group (N = 27)		TCIF group (N = 27)		TCOIF group (N = 28)		TCOIF + VC group (N = 28)	
	M	SD	M	SD	M	SD	M	SD
Prior knowledge	16.44	3.80	15.41	3.58	16.36	4.25	16.07	2.99
Spatial ability	9.63	2.29	10.70	2.16	10.04	2.30	9.61	1.93
Learning outcome	5.19	1.86	7.44	1.22	6.21	1.79	7.14	1.80
Total fixation duration (in seconds)	126.78	28.40	139.33	17.25	130.45	20.64	123.19	19.79
Fixation duration on annotation AOIs (in seconds)	N/A	N/A	14.03	5.60	6.98	3.86	13.64	6.06
Fixation duration on initial FOV AOIs (in seconds)	123.99	29.07	138.08	18.61	127.99	21.65	116.05	20.53

The maximum score on the prior knowledge test was 25; the maximum score on the spatial ability test was 15; and the maximum score on the learning outcome test was 11.

different conditions,  $F(2, 80) = 15.79$ ,  $p < 0.001$ . The follow-up *post hoc* analysis using an LSD test showed that the total fixation duration of the annotation areas of the TCOIF group was significantly lower than that of the TCIF group ( $p < 0.001$ ) (H2b) and the TCOIF + VC group ( $p < 0.001$ ) (H3b), but there was no significant difference between the TCIF and TCOIF + VC groups ( $p > 0.05$ ). The results were consistent with the hypotheses. Attention to annotations outside the initial FOV was much lower than that inside the initial FOV, and the arrows effectively guided learners' attention to annotations outside the FOV.

To explore the effect of cueing on the allocation of attention in the initial FOV, we set areas of the initial FOV to AOIs and performed an ANOVA. The results showed that there was a significant difference in the total fixation duration of the initial FOV between groups, i.e.,  $F(3, 106) = 4.44$ ,  $p = 0.006$ . The follow-up *post hoc* analysis using an LSD test showed that the total fixation duration of the initial FOV in the NC group ( $p = 0.025$ ) and the TCOIF + VC group ( $p = 0.001$ ) was significantly shorter than that in the TCIF group. There was no significant difference between the NC group and the TCOIF + VC group, and there was no significant difference between the TCOIF group and the other groups.

### Heatmaps

The fixation heatmaps reflected the differences in learners' fixation duration in different areas during the video playback time. As shown in **Figure 3**, under the four conditions, participants allocated most of their attention to the initial FOV (the rectangular areas in the figure are the learners' initial FOV). The annotation areas outside the initial FOV were significantly hotter in the TCOIF + VC group than in the TCOIF group, thus indicating that these areas received more attention and suggesting that visual cues (arrows) had an obvious guiding effect on attention.

## DISCUSSION

The main purpose of this study was to explore the effects of cues on learning outcomes and attention allocation when using immersive 360-degree video for learning. We assumed that the signal principle based on the CTML was also applicable to the immersive 360-degree video learning environment and assumed that whether the cues were in the initial FOV would have different effects on learning and attention. The experimental results supported our hypothesis that in immersive 360-degree videos, cues guide attention and help improve learners' learning performance. Additionally, there was a serious imbalance in learners' attention allocation in each area of the video pictures, and the addition of visual cues affected attention allocation in each area. According to the interview results, the participants believed that an overly strong immersion would distract their attention, while a limited FOV might cause them to miss important information, and a lack of VR experience would also hinder learning. Some participants mentioned that the arrows helped them locate key information more quickly.

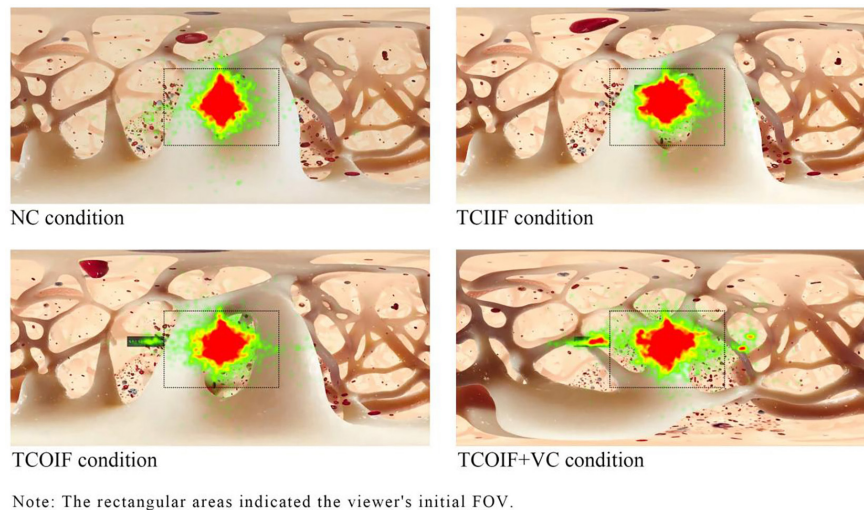
## Effects of Annotations on Learning Outcomes and Attention Allocation

To answer the first question, we analyzed whether learning outcomes (H1a) and attention (H1b) within the initial FOV were affected by annotations. We found that participants who watched annotated learning materials outperformed the control group without annotations. Consistent with our expectations, in the immersive 360-degree video, adding annotations positively affected cognition, thereby supporting a previous study (Albus et al., 2021). This finding has two possible explanations. First, when annotations and narration appear at the same time, learners more easily associate auditory and visual information; thus, using annotations and narration simultaneously can reduce unnecessary visual searches (Jeung et al., 1997). According to the CLT, reducing unnecessary visual search processes can reduce extraneous cognitive load. Learners will have more cognitive resources for learning and can understand learning materials more easily (Sweller et al., 1998). Second, due to the simultaneous presentation of annotations and animations, the interconnection between verbal and non-verbal systems was enhanced to achieve more efficient dual coding (the Multimedia Principle: Mayer, 2021). The eye-movement data also matched expectations: the presence of annotations led to a longer fixation duration; this finding is consistent with that of a previous study (De Koning et al., 2007; Wang et al., 2020). Some participants mentioned that the learning materials were extremely immersive and stimulating, and the large visual range and fast-paced animation made the participants lose focus on the learning objectives. However, when annotations were present, learners' attention was attracted by them, thus reducing unnecessary visual searches and allowing learners to focus more on key content.

## Effects of Annotation Position on Learning Outcomes and Attention Allocation

To answer the second question, we analyzed the learning outcomes and attention allocation of the annotations inside and outside the initial FOV. We found that compared with learners in the TCOIF group, learners in the TCIF group achieved better learning scores (H2a). This finding has two possible explanations. First, for immersive 360-degree video, although an immersive scene with an almost 360-degree field of view is created, there is still a main FOV that is the initial default FOV when watching, and most of the key content is displayed in this FOV. According to the spatial contiguity principle (Mayer, 2021), when annotations are within the initial FOV, learners can better associate annotations with pictures without consuming cognitive resources in the visual search. In this way, it is more likely that learners will retain the information in their short-term memory (Mayer, 2021). Second, when the annotations were outside the initial FOV, if the learner did not turn his or her head to change the FOV, they would be ignored entirely. This was completely different from the situation of classical multimedia learning. Many participants said that the blind area due to the large range of vision caused them to miss important details. The results of eye movement records also supported this. Compared





**FIGURE 3 |** Fixation heatmaps of the four conditions.

with learners in the TCOIF group, learners in the TCIIF group spent a greater fixation duration on the annotation areas (H2b). More interestingly, up to 57% of participants in the TCOIF group had zero fixation duration for the annotations outside the initial FOV. Therefore, for these participants, the annotations outside the initial FOV did not affect the participants' cognition. The heatmaps also showed that most of the participants' attention was focused on the initial FOV. We suspect that this phenomenon may be related to the participants' VR experience. Some studies have supported that prior experience using the applied VR technologies is effective for reducing simulator sickness and improving behaviors in VR (Shafer et al., 2017; Mittelstaedt et al., 2018). Most of the participants in this study had no experience watching immersive 360-degree video. Although all participants were informed in advance that they could see more content by turning their heads, during the formal experience, due to the high immersion and fast-paced sensory stimulation, some participants had no time or forgot to turn their heads but subconsciously viewed the 360-degree video as a traditional video. In the interviews, the participants also mentioned that the lack of VR experience negatively affected the perception of visual blind areas. However, considering the poor boundary vision of the human visual system (Johnson, 2021), if the position of the annotations is not in the center of the FOV, even if participants turn their heads, participants are likely to miss the annotations due to the interference of the fast-moving picture. Therefore, if annotations (or other key content items) appear outside the initial FOV, it is necessary to use some means to guide learners' attention and the FOV.

## Effects of Visual Cues on Learning Outcomes and Attention Allocation

Our third question explored the effects of visual cues on learning outcomes and attention allocation. When adding annotations outside the initial FOV, the additional visual cues (arrows) more

positively affected the learning outcomes (H3a). Additionally, the eye movement results showed that visual cues had an obvious guiding effect on learners' attention: the TCOIF + VC group spent more fixation time in the annotation area (H3b). Previous eye-tracking studies have found that learners pay more attention to relevant areas when guided by visual cues (Jamet, 2014; Wang et al., 2020); this finding is consistent with our results. In contrast to previous studies, we examined the guiding effect of visual cues on the FOV in immersive 360-degree video. We found that compared with the TCOIF group, the TCOIF + VC group showed a significant increase (from 43 to 96%) in the proportion of attention to annotations outside the initial FOV. The CTML holds that meaningful learning includes three basic cognitive processes, namely, selection, organization and integration, and the selection of key information precedes other processes of learning (Alpizar et al., 2020). In the immersive 360-degree video learning environment, because learners' FOV accounts for only a small part of the visual range, the difficulty of information selection is significantly higher than when using traditional video. Therefore, it is particularly important to use visual cues to guide learners' attention, especially to the information outside the initial FOV. Some participants mentioned that arrows could help them consciously notice annotations outside their FOV. According to the limited capacity assumption, the information that people can process at one time is very limited (Mayer, 2005). When visual cues lead learners' attention to annotations (or other AOIs), learners will inevitably reduce their visual attention to other pictures. Eye movement data analysis also confirmed that compared with learners in the TCIIF group, learners in the TCOIF + VC group had significantly less fixation duration in the initial FOV. The positioning assistance function of visual cues can reduce the difficulty of spatial positioning in an immersive 360-degree video learning environment. However, visual cues also consume limited cognitive resources and frequently intervene in the allocation of attention through exogenous positioning, which may increase irrelevant processing and lead to cognitive



overload. Therefore, the reasonable and appropriate use of visual cues may be the key to the success of immersive 360-degree video instructional design.

## Limitations and Suggestions

This study has several limitations. First, this study involved short-term learning provided in a lab setting. Although this study provided preliminary empirical results on the effectiveness of adding cues to immersive 360-degree video learning materials, the external validity of the results needs to be tested in authentic learning contexts. Second, we did not measure the effect of the learner's VR experience. Almost all participants in this study had no experience in immersive VR learning. Although, in the interviews, some participants mentioned that immersive VR devices were not friendly to novices and required some time to learn and adapt, the impact caused by lack of experience needs further research. Third, there were certain restrictions on learning materials. The learning materials used in this study were mainly declarative knowledge, and the length was only 3 min. Therefore, measuring learning outcomes involved primarily assessing the retention of knowledge and not the transfer of knowledge. Furthermore, the type of learning materials might also affect the experimental results. For example, compared with the form of 3D animation adopted in this study, 360-degree videos shot based on real scenes may be more prone to place illusions because these scenes are closer to the real world. Place illusion can improve performance within VR by providing accurate perceptual cues to users (Slater and Sanchez-Vives, 2016). Fourth, we evaluated the impact of only annotations and arrows and did not involve other features of textual and visual cues. Finally, this study controlled prior knowledge and spatial ability as interference variables and did not discuss the interaction between learners' individual characteristics and cues, such as prior knowledge and spatial ability.

Based on the current research findings, we propose the following for relevant studies in the future:

- (1) Future work should involve investigating more authentic learning contexts.
- (2) We suggest examining the effect of learners' VR experience on attentional tendency.
- (3) We suggest using more complex learning materials to evaluate learning outcomes at the level of other cognitive learning objectives.
- (4) We recommend evaluating the effects of different types of learning materials, such as 360-degree video of real scenes.
- (5) We suggest that future studies investigate the effects of other cue features, such as vocal emphasis, colors, flashing, direction of cues, number of cues, and existence time of cues.
- (6) The interaction between learners' individual characteristics (prior knowledge, spatial ability, cognitive style, age and motivation, etc.) and cues is also an interesting research direction, which is suggested to be investigated in future work.

## CONCLUSION

In this study, we explored the effects of cues on learning outcomes and attention allocation in an immersive 360-degree video learning environment. In comparison to previous studies, we focused on finding patterns of attention distribution by using eye-tracking studies (Rupp et al., 2016; Albus et al., 2021; Vogt et al., 2021). The results showed that textual and visual cues positively affected cognition, thereby proving that the signal principle of CTML is also applicable in the immersive 360-degree video learning environment. Additionally, we found that learners paid much more attention to the initial FOV than other regions, thus leading learners to miss most of the information outside the initial FOV. This result might be related to the large range of vision and the lack of VR experience. In view of this phenomenon, we found that using visual cues to guide attention to blind areas of sight was an effective solution. Therefore, we suggest supporting learners with cues when designing immersive 360-degree video learning environments. In short, the results of this study not only expand the applicable scenarios of multimedia learning theory but also make a practical contribution to the rational design of immersive 360-degree video learning environments. In this study, we adopted eye-tracking technology, which provides a new idea and method for studying VR learning environments.

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Ethics Committee of China West Normal University. The patients/participants provided their written informed consent to participate in this study.

## AUTHOR CONTRIBUTIONS

RL: writing—review and editing, methodology, manuscript revision, and funding acquisition. XX: acquisition of the original data, software, and formal analysis. HY: conceptualization and methodology. ZL and GH: reference management and critical manuscript revision. All authors contributed to the article and approved the submitted version.

## FUNDING

This study was supported by the Projects of Industry-University Collaborative Education of the Ministry of Education (202102464026 and 201902227029), the Project

of Nanchong Social Science Planning, the General Project of Educational Research Grant of Sichuan Education Department (SCJG21A111), the Project of Sichuan

Teacher Education Research Center (TER2019-011), and the Youth Fund Project of China West Normal University (20B021).

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# Research on the Resilience Evaluation and Spatial Correlation of China's Sports Regional Development Under the New Concept

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## OPEN ACCESS

### Edited by:

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### Specialty section:

This article was submitted to  
Personality and Social Psychology,  
a section of the journal  
Frontiers in Psychology

**Received:** 24 August 2021

**Accepted:** 26 November 2021

**Published:** 04 February 2022

### Citation:

Zhang J, Gan J-R, Wu Y, Liu J-B,  
Zhang S and Shao B (2022) Research  
on the Resilience Evaluation  
and Spatial Correlation of China's  
Sports Regional Development Under  
the New Concept.  
Front. Psychol. 12:763501.  
doi: 10.3389/fpsyg.2021.763501

In order to fully implement the new development concept, bring into full play the potential of sports development, and maintain the resilience of China's sports development. This paper studies the resilience evaluation and spatial correlation of Chinese sports development under the new development concept. First, we constructed Resilience Evaluation Indexes System for Sports Development in China based on the analysis of the resilience features of sports development and the DPSIR model, which is from the five aspects of "driving force – pressure – state – influence – response." Second, used Coefficient of Variation and Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) Method to measure the resilience level of sports development in 31 provinces in China from 2013 to 2017. Then, we introduced the obstacle degree model to identify the obstacle factors that hinder the resilience of Chinese sports development in different periods. Finally, we used the global and local Moran indexes to analyze the spatial correlation of China sports regional development. The results showed that: (1) overall, the development level of sports resilience in 31 provinces in China showed an upward trend from 2013 to 2017, while some provinces showed obvious fluctuations. (2) The obstacles to the development of sports resilience in China mainly include sports scientific research equipment, the number of national fitness monitoring stations, the number of national fitness centers, the full-time equivalent of (R&D) personnel, and the number of sports scientific research projects. The response subsystem is the main obstacle factor that affects the improvement of the resilience level of sports development in China. (3) There is a positive spatial autocorrelation between the resilience level of sports development and regional spatial distribution, and the correlation shows a weakening trend, and the internal difference is significant. Finally, we concluded that we must take the new development philosophy as the guiding principle. First, we should stick to innovation-driven development to fully upgrade the resilience of China's sports development. Second, we should adhere to the principle of coordinated development to promote the overall and balanced development of sports. Lastly, we should promote shared development so as to deliver benefits for all in an equal way.

**Keywords:** new concept, resilience of sports development, DPSIR model, TOPSIS method, obstacle degree, spatial correlation



## INTRODUCTION

With the development of economic globalization, sports have become an important criterion for measuring the development level of a country or a region. China has made remarkable achievements in the transformation, in which China became a sports great power not only in quantity but also in quality (Liu, 2021).

In recent years, the emergence of new situations such as the global financial crisis, political crisis, and climate change, especially the COVID-19 pandemic, has accelerated the occurrence of risks, and the world is facing greater risks and uncertainties (Adger, 2006). Some major risks and emergencies seriously threaten people's physical and mental health and may have a major impact on global economic development and social stability. Therefore, resilience theory has been widely applied in multidisciplinary fields such as social ecology, economics, management, and urban planning, and abundant research results have been achieved in social resilience, regional resilience, and urban resilience (Xu et al., 2017).

At the time of the "14th Five-Year Plan," the new phase of China's development was not hindered by the epidemic, instead, it burst out with stronger development momentum, demonstrating resilience and strength of development, showing China's strong restorability and vitality. This "resilience" is reflected in a variety of fields, including sports.

As China enters a new stage of development, with the approach of the Winter Olympics, new development concepts must be carried out completely, accurately, and comprehensively throughout the development and in the field of sports. While emphasizing sports development planning, we should also pay more attention to the transformation of sports development, gather reform momentum, promote practical development, promote the full potential of sports development, continue to maintain the resilience of China's sports development, and take greater action in the future. Therefore, the study of human social development from the perspective of sports adaptation is a promising research field to find more effective coping strategies.

## REVIEW OF THE THEORY ABOUT RESILIENCE OR RELATED RESEARCH

The concept of resilience firstly appeared in the field of physics and was raised by Alexander, referring to the capability of a strained body to restore its size and shape after deformation caused especially by compressive stress (Holling, 1973). In 1973, Canadian ecologist Holling firstly introduced the concept of resilience to the field of ecology and applied it to the research of systemic questions. The concept of resilience has evolved from "engineering resilience" to "ecosystem resilience," then to "socio-ecological system resilience" (Ni and Li, 2019). "Engineering resilience" emphasizes equilibrium of system and equilibrium state and believes that the system has only one equilibrium state; "ecological resilience" goes beyond the limit of single equilibrium of engineering resilience, based on ecological theory, emphasizes the connection between resilience and system, and

believes that resilience can further promote new equilibrium based on restoring the equilibrium of the system. The concept of "socio-ecological resilience" extends the concept of resilience from natural ecosystem to social ecosystem, emphasizing not only the restoration of resilience balance and new equilibrium state but also the ability of the system to resist perturbations in the complex social ecosystem and to adapt to new circumstances. In other words, the system can repair, adapt, and change itself (Gunderson et al., 1995; Walker et al., 2004; Folke, 2006). In the evolution from engineering resilience, ecological resilience to socio-ecological resilience, the concept of resilience, system characteristics, and essential goals have changed. The connotation and extension of the concept of resilience have become more enriched, and the study of resilience theory has also become more fleshed out. Research on resilience, vulnerability, adaptability, and resilience has become the focus of attention in the fields of global change, disaster prevention and mitigation, and sustainable development. In particular, the topic of "resilience" has received increasing attention from society (Leichenko, 2011). Sport is a huge and complex system with external "driver" and internal "dynamism." Once a sport system is impacted by external shocks, external drive decreases, or internal adaptability decreases, the sport system may stagnate or collapse (Zhu, 2014).

The research on resilience extends from psychology (psychological resilience) to management (organizational resilience), sociology (social resilience), and planning (urban and regional resilience). With the development of resilience theory, the concept of resilience has become richer in connotation and extension, and the research of resilience theory has also become more abundant. The research of resilience theory in sports systems is a new topic in recent years. Fletcher and Wagstaff (2009) and Paul et al. (2013) believe that sports organizations are characterized by highly complex social and organizational environments, and organizational resilience is likely to have a positive impact not only on the operation of sports organizations themselves but also on the resilience of individuals and teams. Kirsten et al. (2021) proposed a definition of organizational resilience applicable to elite sports organizations and determined the characteristics of elite sports organizations' resilience, which provided an important basis for future research and practice in this field. Wang and Sun (2020) believe that the construction of stadium facilities should be adjusted in time with different stages of urban development to enhance the resilience of stadium facilities and improve their long-term adaptability (Hu et al., 2020). Ling et al. (2020) believe that enhanced stadium operation resilience can deal with the sudden risk crisis of large stadiums, effectively resist and absorb disturbance, and achieve adaptive development (Ling et al., 2020).

## THE INFLUENCE OF SPORTS ON SOCIAL DEVELOPMENT

The development includes individual development, organization development, and social development. Sustainable development should be achieved for individuals, organizations, entire regions,

or societies. The sustainable development of the three is both systematic and interactive. Individuals are nested in organizations, which in turn are nested in a certain region or society. There must be mutual influence and interaction among regions, organizations, and individuals.

With the increase of capital strength and the need for cultural communication in the process of urbanization, sports have become one of the important ways to promote regional modernization, social development, and economic growth. On the one hand, it can set up a national or regional image and improve government capacity (Yu, 2002). On the other hand, it can optimize the economic structure and promote the improvement of regional infrastructure (Gratton and Henry, 2001; Kaplanidou and Karadakis, 2010). At the same time, the development of sports can improve population literacy, for example, a successful sports event can also make people generate good “psychological income,” such as increasing citizens’ sense of pride and honor (Cao and Lei, 2010; Shi et al., 2014).

Although individuals, organizations, and regions are separate systems, they are all complex and organized wholes. When facing the adversity caused by unexpected events, the region, organization, and individual need emergency linkage to minimize the loss caused by unexpected events. The development of sports can effectively enhance regional or social capital, which is conducive to the linkage and cooperation between the government, enterprises, social organizations, and residents. Therefore, a social network of common governance can be formed to effectively cope with social crises and improve the resilience of urban society, which is consistent with the resilience construction of urban society (Yan and Li, 2021). This study will explore effective coping strategies for the development of human society from the perspective of regional sports resilience by combining qualitative and quantitative methods.

## CONSTRUCTION OF A RESILIENCE EVALUATION INDEXES SYSTEM FOR SPORTS REGIONAL DEVELOPMENT IN CHINA BASED ON THE DRIVING FORCE – PRESSURE – STATE – INFLUENCE – RESPONSE MODEL

### The Driving Force – Pressure – State – Influence – Response Model

The “driving force – pressure – state – influence – response” (DPSIR) framework model was developed by the European Environment Agency in 1993 based on the PSR and DSR models. This model has inherited the advantages of PSR and DSR in constructing index systems using the “cause-effect-response” method and includes four major elements: economy, society, environment, and policy, which can greatly show the relationship between the external environment and human activities (Niemeijer and Groot, 2008; Svarstad et al., 2008).

Although DPSIR conceptual model is an important theory widely used in environmental and ecological governance, it is

also suitable for the study of sports resilience development. Firstly, sport is a complex giant system with an open structure in nature, which is affected by both external environment and internal factors (Shao and Man, 2010; Chen, 2013; Shao, 2015). Secondly, the DPSIR model can show the interaction between humans and the environment from the perspective of the system life cycle, reflect the stage characteristics of resilience, and better reflect the timeliness and compatibility of resilience applied to the current regional sports development research. Finally, although those specific indexes of this model characterize human beings’ different feedbacks to environmental systems in dynamic activities, its cyclical approach fits with the evolutionary mechanism of resilience when the sport is disturbed in the development.

Therefore, it is reasonable to apply the DPSIR model to the evaluation of regional sports resilience development in this research, to show the relationship between human and environment interaction from the perspective of the system life cycle, and to construct an evaluation index system based on the process sequence of regional sports resilience stage.

In the DPSIR model, the driver (D) refers to the economic, social, and natural drivers of change and development in sports resilience, and is the initial index of change in sports resilience; the pressure (P) refers to indexes, under the effect of drivers, that directly exert pressure within the sport system so that changes are caused in urban competitive sports resilience; the state (S) refers to the real performance of sports resilience under the effect of drivers and pressures; the impact (I) refers to the economic, social, and natural effects of change in sports resilience; and the response (R) refers to the action taken in the face of change in sports resilience. State (S) refers to the actual performance of sports resilience under the driver and pressure; Impact (I) refers to the effect on economic, social, and natural aspects when sports resilience changes; Response (R) refers to the effective measures and countermeasures to be taken when sports resilience changes. Based on the DPSIR model, following the principles of comparability, operability, and incompatibility, considering the availability of data, referring to the research results of related literature (Li et al., 2020; Wang and Man, 2020), and at the same time, considering the actual situation of sports resilience development, 27 indexes were selected from five aspects: driver, pressure, state, impact, and response, to build an evaluation index system, as shown in Table 1.

### The Selection of Evaluation Index of Regional Development Resilience of Sports in China Driver Indexes

The development of the sports system is subject to the combined effects of the external and internal environment. The external environment is the necessary conditions that sports development must rely on, including economic, social, natural, and elements of other aspects (Chen, 2013). At the same time, the internal driver is also the driver of the self-organized development of the sports system, which is the key point to the development of the sports system’s

**TABLE 1 |** Resilience evaluation indexes system for sports regional development in China.

Target layer	Guideline layer	Index layer	unit	Indicator symbols
Driver	External drivers	GDP(+)	Billion yuan	D <sub>1</sub>
		Year-end population(+)	10,000	D <sub>2</sub>
		per capita disposable income(+)	Yuan	D <sub>3</sub>
		(R&D) personnel full-time equivalent(+)	FTE	D <sub>4</sub>
	Internal drivers	Culture, Sports and Media Financial Expenditure(+)	Billion	D <sub>5</sub>
		sports industry practitioners(+)	people	D <sub>6</sub>
		Numbers of public sports facilities(+)	PCS	D <sub>7</sub>
Pressure(P)	Economical pressure	GDP growth rate(+)	%	P <sub>1</sub>
	Population pressure	Natural population growth rate(+)	%	P <sub>2</sub>
	Social pressure	Unemployment rate	%	P <sub>3</sub>
	Natural resource pressure	Green coverage of built-up(+)	%	P <sub>4</sub>
State(S)	Competitive sports	Numbers of athletes of excellent sports teams(+)	people	S <sub>1</sub>
	Mass sports	rate of national reaching standard for physical quality measuring(+)	%	S <sub>2</sub>
		number of sports social organizations(+)	PCS	S <sub>3</sub>
		Sports lottery sales(+)	10,000yuan	S <sub>4</sub>
Impact(I)	Economic impact	value added of tertiary industry(+)	Hundred million yuan	I <sub>1</sub>
	Social impact	Employment in culture, sports and entertainment (+)	10,000 people	I <sub>2</sub>
	Demographic impact	Death rate	%	I <sub>3</sub>
	Natural resource impact	Forrest coverage(+)	%	I <sub>4</sub>
Response(R)	Early warning ability	Number of mobile internet users(+)	10,000 people	R <sub>1</sub>
		Number of graded athletes in development(+)	people	R <sub>2</sub>
		Number of reserve sports talents(+)	people	R <sub>3</sub>
		Number of youth sports clubs(+)	PCS	R <sub>4</sub>
	Restorability	number of national physical quality monitoring stations(+)	PCS	R <sub>5</sub>
		number of public fit-trail projects(+)	PCS	R <sub>6</sub>
		number of sports research instruments and equipment(+)	PCS	R <sub>7</sub>
		number of sports research projects(+)	PCS	R <sub>8</sub>

"+" in parentheses indicates a positive index and "-" indicates an inverse index (Zhao et al., 2021).

resilience (Shao, 2015). It mainly refers to elements like human resources, material resources, financial resources, and scientific technology in the development of sports resilience. Before the sport system experiences perturbations, strong drivers, which is regarded as the prevention ability of the sport system, can effectively prevent the impact and perturbations on the sport system caused by internal and external environmental changes. Therefore, this study evaluated the driver in two dimensions: external driver and internal driver, and selects 7 indexes: gross national product, year-end population, disposable income per capita (R&D) personnel full-time equivalent, financial expenditure on culture, sports and media, number of practitioners in the sports industry and number of public sports facilities.

### Pressure Indexes

The sports system, stimulated by internal and external environment drivers, would exert pressure directly or indirectly within the system, arousing the system's internal structural element changes and buffering external impacts. This is regarded as an ability to buffer against impacts. This study will select four indexes in terms of economy, population society, and natural environmental pressure, which specify as GDP growth rate, natural population growth rate,

unemployment rate, and green coverage rate of built-up areas (Ji et al., 2020).

### State Indexes

Under the effect of "pressure," the sports system deforms in various ways and presents different "states." This state is the realistic performance of the resilience of sports development under drivers and pressures. It is also a kind of goal to be achieved by sports. This state is reflected in aspects of competitive sports, mass sports, and the sports industry. Therefore, this study selects four indexes: the number of athletes in excellent sports teams, the rate of national reaching standard for physical quality measuring, the number of sports social organizations, and sports lottery sales.

### Impact Indexes

In the development of sports resilience, the internal and external environment will have impacts on the sport system, and in turn, changes in the sports system's resilience state will also have various "impacts" on the surrounding ecological, economic, and social environment. In this study, four indexes are selected in terms of economy, society, and natural environments: the value-added of tertiary industry, the number of people employed in culture, sports,

and entertainment industries, the death rate, and the forest coverage rate.

### Response Indexes

Response refers to the effective measures and countermeasures taken by urban competitive sports subjects in the face of changes in the state of the urban competitive sports system. The process of sports system response is the process of system subjects deploying resources, responding to risk perturbations, and improving their own adaptivity and learning capabilities, which can generally be divided into three phases: early warning, restoration, and learning and innovation. The early warning ability of the sports system is mainly expressed as the ability to collect and transmit data, which is reflected in the level of network informationization of the sports system. Restorability refers to the ability of the system to recover from a crisis after a disturbance to the level before the system was disturbed (Bruneau et al., 2003). In other words, it is the subject's ability to invest, integrate and mobilize the corresponding financial, material, and human resources. Learning and innovation ability refers to the system's ability to not only restore to its original level after being disturbed but even to adapt to the new environment after the crisis, which is mainly reflected in the sports system's level of scientific technology. Therefore, 8 indexes are selected in this study: the number of mobile Internet users, the number of graded athletes in development, the number of reserve sports talents, the number of youth sports clubs, the number of national physical quality monitoring stations, the number of public fit-trail projects, the number of sports research instruments and equipment, and the number of sports research projects.

## ANALYSIS OF THE RESILIENCE OF CHINA'S SPORTS REGIONAL DEVELOPMENT

### Research Design

In accordance with the new development philosophy and requirements of resilience development, this study attempted to build an evaluative index system for the resilience of China's sports development with China's 31 provinces, municipalities directly under the central government and autonomous regions as main research objects under the guidance of The CPC Central Committee's proposals for formulating the 14th Five-Year Plan (2021–2025) for National Economic and Social Development and the Long-Range Objectives Through the Year 2035. All data, which range from 2013 to 2017, are collected from the China City Statistical Yearbook, China Sports Statistical Yearbook, and statistical commune of provinces and municipalities on national economic and social development over the years. Some index values are re-adjusted and calculated based on the statistics of the yearbook. The resilience of China's sports development in different regions will be evaluated from the perspective of stages of sports development with the help of the DPSIR model, namely driver, pressure, state, impact, and response model.

## Research Methodology and Model Determination of Evaluation Index Weights

### (1) Normalize the matrix.

In collecting statistics for the evaluation index regarding the resilience of China's sports development, different dimensions are found in 27 indexes. Therefore, we normalize each index via min-max normalization to avoid biases. Out of 27 indexes, only two of them have negative impacts, i.e., unemployment rate and death rate. Indexes with positive impact mean that when the value of one indicator increases, so does the resilience of sports development, whereas the smaller value of an index with negative impact means weaker resilience. The mathematical formulation for indexes with positive impact is

$$x'_{ij} = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}} \quad (1)$$

The mathematical formulation for indexes with negative impact is

$$x'_{ij} = \frac{\max x_{ij} - x_{ij}}{\max x_{ij} - \min x_{ij}} \quad (2)$$

$x'_{ij}$  stands for the normalized value of indicator  $j$  for a region in the  $i$  year,  $x_{ij}$  is the default value of indicator  $j$  for a region in the  $i$  year,  $\min x_{ij}$  means the minimum value of index  $j$  while  $\max x_{ij}$  the maximum value.  $i = 1, 2, \dots, 31$ .  $j = 1, 2, \dots, 27$ .

### (2) Consider the weights based on the coefficient of variation.

To avoid subjectivity, the method of coefficient of variation is adopted to calculate weights for 27 indexes. The following are formulations for calculating the weight of each index:

$$V_j = \frac{S_j}{\bar{x}_j} \quad (3)$$

$$W_j = \frac{V_j}{\sum_{j=1}^{27} V_j} \quad (4)$$

$\bar{x}_j$  is the mean value of indicator  $j$ ,  $S_j$  is the sample standard deviation of indicator  $j$ ,  $V_j$  is the coefficient of variation of indicator  $j$ , and is the weight of indicator  $j$ .

We add up the values of 27 indicators according to the weight of each indicator, meaning that a normalized weighted matrix is created via  $W = (0.047, 0.030, 0.020, 0.062, \dots, 0.067, 0.040, 0.096, 0.064)$  with  $m = 31$ ,  $n = 27$ .

$$R = (z_{ij})_{m \times n} = (W_j x'_{ij})_{m \times n} \quad (5)$$

## Evaluative Method Based on Technique for Order Preference by Similarity to an Ideal Solution Model

Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) model refers to a multi-criteria decision-making technique that makes the choice of the best alternative from among a finite set of decision alternatives in terms of multiple criteria (Zhao et al., 2017). TOPSIS provides an objective



**TABLE 2 |** Scores and rankings of the resilience of sports development in each region in China.

Region /Year	2013	2014	2015	2016	2017
Jiangsu	0.4004 1	0.4295 1	0.3933 2	0.4235 3	0.4427 2
Guangdong	0.3563 2	0.3995 2	0.3937 1	0.4200 4	0.4795 1
Zhejiang	0.3562 3	0.3296 4	0.3775 3	0.3855 5	0.4012 3
Shandong	0.3234 4	0.3455 3	0.3468 4	0.3795 6	0.3796 4
Hubei	0.2003 10	0.3212 6	0.2369 7	0.4423 2	0.3013 5
Henan	0.2250 8	0.3294 5	0.2429 6	0.2621 8	0.2803 6
Beijing	0.2488 6	0.2242 9	0.3059 5	0.2291 10	0.2645 9
Hebei	0.2710 5	0.2306 7	0.2218 9	0.2675 7	0.2769 7
Shanxi	0.1798 14	0.1601 17	0.1612 18	0.4458 1	0.2763 8
Sichuan	0.2113 9	0.2139 11	0.2237 8	0.2284 11	0.2292 12
Hunan	0.1799 13	0.1899 14	0.2097 10	0.2392 9	0.2637 10
Fujian	0.1845 12	0.2022 12	0.2083 11	0.2178 12	0.2337 11
Liaoning	0.1932 11	0.2249 8	0.1955 12	0.1924 16	0.1311 20
Anhui	0.1609 16	0.1941 13	0.1955 13	0.2133 13	0.2082 14
Jiangxi	0.2305 7	0.1723 15	0.1773 15	0.1688 18	0.2009 16
Shanghai	0.1786 15	0.1701 16	0.1729 17	0.2005 15	0.2142 13
Guangxi	0.1597 17	0.2217 10	0.1775 14	0.1698 17	0.1741 17
Yunnan	0.1490 18	0.1511 18	0.1546 19	0.2031 14	0.1740 18
Heilongjiang	0.1321 23	0.1491 19	0.1771 16	0.1638 19	0.1656 19
Neimeng	0.1075 29	0.1354 20	0.1331 20	0.1661 20	0.2060 15

Source: Author's calculations. Limited by space, only the top 20 provinces and autonomous regions are listed here. The bottom 11 provinces and autonomous regions, including Tianjin, Shanxi, Jilin, Hainan, Chongqing, Guizhou, Tibet, Gansu, Qinghai, Ningxia, and Xinjiang, are not included in the list.

evaluation through the geometric distance (or similarity) between the chosen alternative and the ideal solution (both positive and negative) (Hwang and Yoon, 1981; Li et al., 2014).

Identify the positive and negative ideal solutions.

We identified the positive ideal solutions  $Z^+$  and negative ideal solutions  $Z^-$ , where positive ideal solutions are the maximum of each column in  $R$ , whereas negative ideal solutions are the minimum.

$$Z^+ = (\max Z_{i1}, \max Z_{i2}, \dots, \max Z_{in}) \quad (6)$$

$$Z^- = (\min Z_{i1}, \min Z_{i2}, \dots, \min Z_{in}) \quad (7)$$

Identify the distance from an alternative to the positive and negative ideal solutions, respectively.

We calculated the Euclidean distances ( $D_i^+$  and  $D_i^-$ ) from the positive ideal solution ( $Z^+$ ) and the negative ideal solution ( $Z^-$ ) of each alternative (every year of a region) respectively. The formulations are as follows:

$$D_i^+ = \sqrt{\sum_{j=1}^m (\max Z_{ij} - Z_{ij})^2} \quad (8)$$

$$D_i^- = \sqrt{\sum_{j=1}^m (\min Z_{ij} - Z_{ij})^2} \quad (9)$$

$$C_i = \frac{D_i^-}{D_i^- + D_i^+} \quad (10)$$

Calculate the comprehensive evaluation index

We calculated the relative closeness  $C_i$  (i.e., resilience) for each alternative with respect to positive ideal solutions according to formulation (10). The best alternative is one that is closer to a positive ideal solution and has a higher value  $C_i$ , meaning greater resilience of sports development for that specific region. Later, we measure and rank the resilience of sports development in each province in China according to the statistics obtained.

## Result Analysis and Discussion

### Analysis of the Integral Evaluation Results of the Resilience of Sports Regional Development in China

We calculated the resilience of sports development in five consecutive years (2013–2017) in 31 provinces, municipalities, and autonomous regions, as can be seen in **Table 2**. Overall, the result signified an upward trajectory in terms of resilience of sports development while certain provinces witnessed pronounced fluctuations. Jiangsu, Guangdong, and Zhejiang provinces have topped the lists from 2013 to 2017, ranking among the top three every year. Shandong provinces, despite slight fluctuations in ranking, boasted a steady increase. Moreover, major fluctuations happened in Hubei province in 2015 and 2017 with the index down by 26.25 and 31.88%, respectively. The result can be attributed to the decline in fixed-asset investment in culture, sports, and entertainment industries, in the natural growth rate of population, in the number of national fitness centers, youth sports clubs, fitness surveillance centers, and research on sports. Shanxi province experienced declining resilience of sports development because of less robust economic growth. Even though Shaanxi province, a landlocked province located in northwest China, is the gateway connecting the northwest, southwest, north, and central China and borders on eight neighboring provinces, municipalities, and autonomous regions, it receives less support from the reform and opening-up policy which has been led by the economic development of eastern, coastal areas. However, the ranking of Shaanxi province grew rapidly because growing western and central regions and regional development strategies have led to thriving economic

**TABLE 3 |** Clustering of average scores based on the integral development resilience assessment.

Scores	The first level (Average Score $\geq 0.3$ )	The second level ( $0.15 \leq \text{Average Score} < 0.3$ )	The third level ( $0 \leq \text{Average Score} < 0.15$ )
Region	Jiaangsu, Gaaangdong, Zhejiang, Shansong, Hubei	Henan, Beijing, Hebei, Shanxi, Sichuan, Hunan, Fujian, Liaoning, Anhui, Jiangxi, Shanghai, Guangxi, Yunnan, Heilongjiang	Neimeng, Shanxi, Chongqing, Xinjiang, Guizhou, Hainan, Jilin, Tianjin, Gansu, Tibet, Ningxia, Qinghai
Location	Almost all in the eastern region	Most are in the eastern and central regions	Most of them are in the western region

development in Shaanxi province, thus increasing the fixed-asset investment in culture, sports and entertainment industries, the investment in sports personnel and materials, and the support for sports technology.

**Table 3** presents the result of cluster analysis after the average of comprehensive evaluation indices of each region between 2013 and 2017 is calculated. As can be seen in **Figure 1**, compared with those in the west, regions in east China enjoyed higher resilience of sports development, serving as a driver in China's sports development.

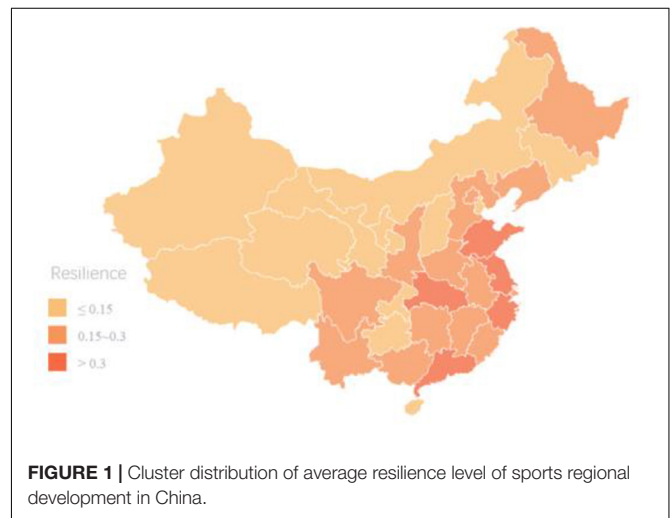
## Evaluation and Analysis of Each Subsystem of the Level of Resilient Development of Sports in Each Region in China

### (1) Driving force subsystem

Firstly, we selected the top provinces in the driving force score for comparison and analysis, as shown in **Figure 2**. On the whole, Jiangsu and Guangdong's driving force scores were higher than those of Shandong, Zhejiang, and Beijing, and they were showing a clear upward trend. Although Shandong's driving force scores in 2015 and 2017 declined compared with the previous year, it is still relatively high compared to other provinces. Zhejiang's driving force score has risen steadily and is relatively stable. However, Beijing's driving force score shows a "W" trend, with large fluctuations. In 2014 and 2016, the driving force score of Beijing dropped to 0.2268 and 0.1993, a decrease of 29.95 and 56.46%, respectively, from the previous year. The development trend of sports is unstable.

Secondly, we used the years 2013, 2015, and 2017 to compare and analyze the changing trends of the driving force levels of various provinces in China, as shown in **Figure 3** (Zhu et al., 2020). It was found that Guangdong, Jiangsu, and Inner Mongolia have changed a lot in driving force. Guangdong and Jiangsu had steadily increased their driving force scores. Due to their own geographical location and environmental advantages, as well as the support of national policies, they had shown huge development space and potential. In recent years, under the influence of policies such as the Great Western Development, Inner Mongolia has gradually strengthened its driving force and has certain development potential.

In summary, the overall driving force scores of most provinces in China are on the rise, indicating that the pressure on the sports system caused by China's social and economic development is gradually decreasing, and a good driving effect has been achieved.

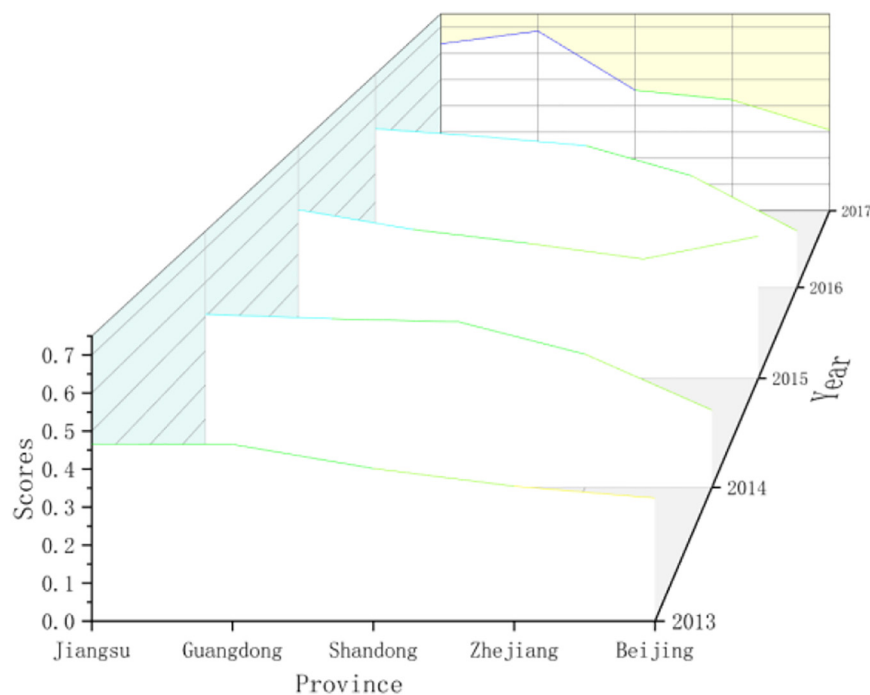
**FIGURE 1 |** Cluster distribution of average resilience level of sports regional development in China.

### (2) Pressure subsystem:

As shown in **Figure 4**, during the period of 2013–2017, the scores of the pressure subsystem of sports resilience development in China's provinces did not change much. Among them, Zhejiang, Anhui, Fujian, Hubei, Guangdong, and Sichuan's pressure scores increased slightly. Their pressure subsystems are at a relatively good level by stimulating GDP growth, increasing the natural population growth rate, improving social stability, and improving the natural environment. Liaoning, Jilin, and Heilongjiang are faced with slow GDP growth, population decline, over-exploitation of natural resources, and environmental damage, so their pressure subsystem scores are low and have a slight downward trend. Other provinces like Beijing, Hebei, Hainan, Shanxi, Henan, Guangxi, Gansu, Qinghai, Ningxia, and Xinjiang are affected by the western development policy, which has driven their GDP to grow rapidly. At the same time, they have the advantage of population growth, which puts them under pressure. The system is at a good level, but the development is unstable, showing small fluctuations.

### (3) Status subsystem

Under the dual effects of driving force and pressure, as shown in **Figure 5**, Jiangsu, Shandong, Guangdong, and other eastern regions are actively cultivating emerging sports industries, formulating sports development strategies and systems, and implementing regional sports plans under the rapid economic



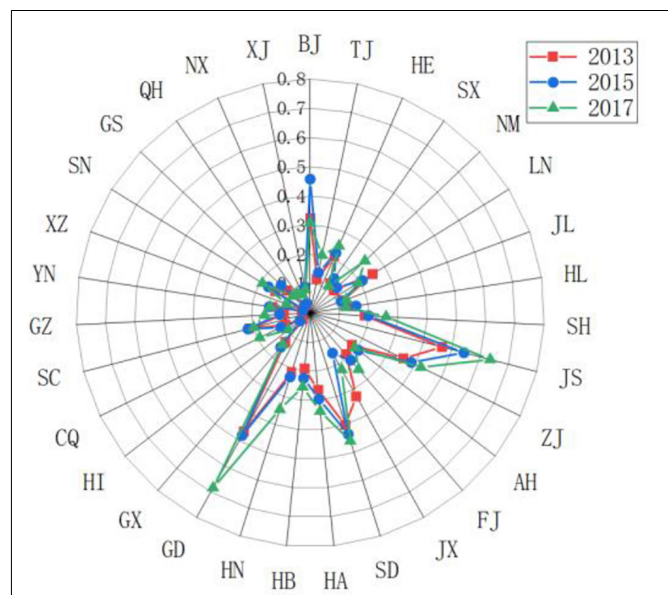
**FIGURE 2 |** Comparing the scores of the sports development resilience driving force subsystem in some regional in China.

development. Which effectively eliminates part of the negative impact and maintains a better state of sports development. When Beijing, Tianjin, Inner Mongolia, Jilin, Shanghai, Hainan, Guizhou, Tibet, Guizhou, Qinghai, Ningxia, and Xinjiang face the problems caused by the development of sports, the effectiveness of governance measures taken is not obvious, resulting in insufficient effective supply of sports resources. Insufficient talents and other problems appear, the existing governance measures cannot effectively improve the state of sports development, so the state subsystem scores are at a low level.

Generally speaking, the current state of sports development in the eastern and central provinces of China is relatively good. Although the state of sports development in the western region is on the rise, sports resources and environmental issues have not been effectively resolved. In order to improve the state of sports development, sports resources, and sports environment, it needs to be further rationally utilized, managed and protected, and further improved.

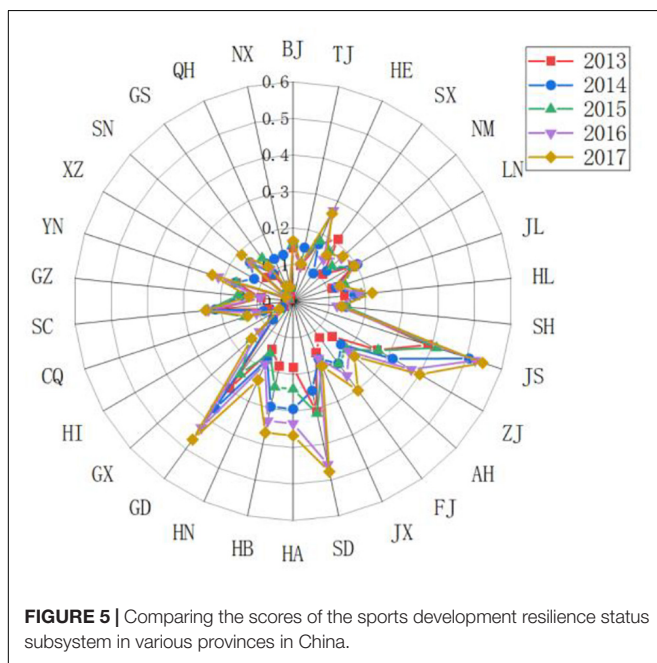
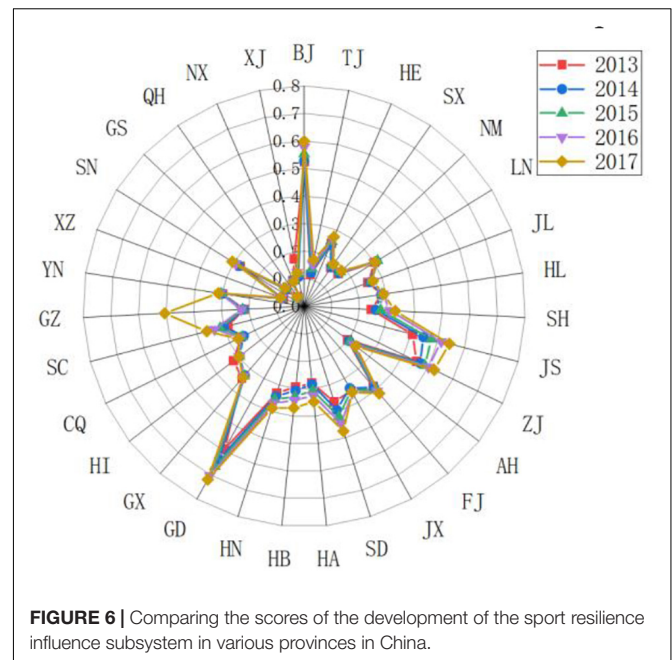
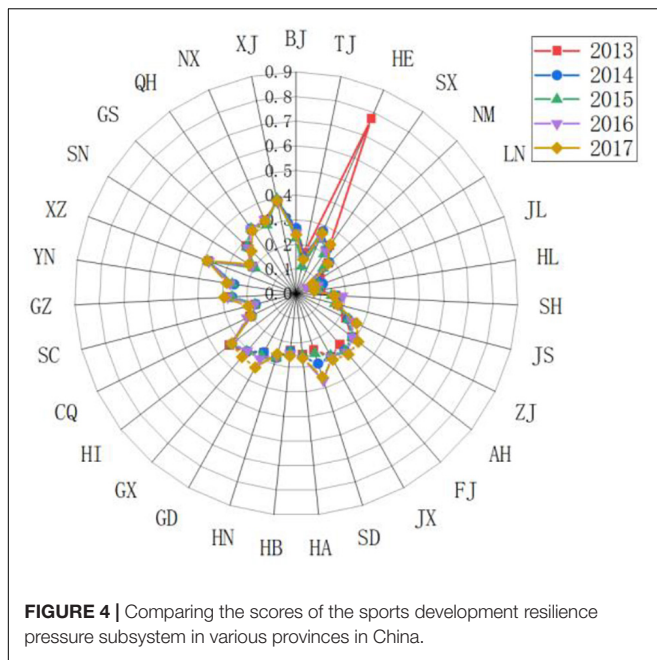
#### (4) Influence subsystem

Judging from the impact of the economy, society, population, and natural resources of each province, the impact subsystem of Guangdong, as shown in **Figure 6**, Beijing, and Jiangsu is at a relatively high level. Sports promote the value of the tertiary industry and increase the employment population. Health promotion and improvement of environmental resource utilization have significant effects. Tianjin, Shanxi, Inner Mongolia, Anhui, Tibet, Gansu, Qinghai, Ningxia, and Xinjiang have been greatly negatively affected, making the impact



**FIGURE 3 |** Comparing the scores of the sports development resilience driving force subsystem in various regional in China.

subsystem at a low level. Under the background of globalization, the sports industry has not been fully promoted. Development has failed to give full play to the role of sports social organizations in national fitness and cultivating competitive sports talents, resulting in a low level of influencing subsystems. Therefore, it is



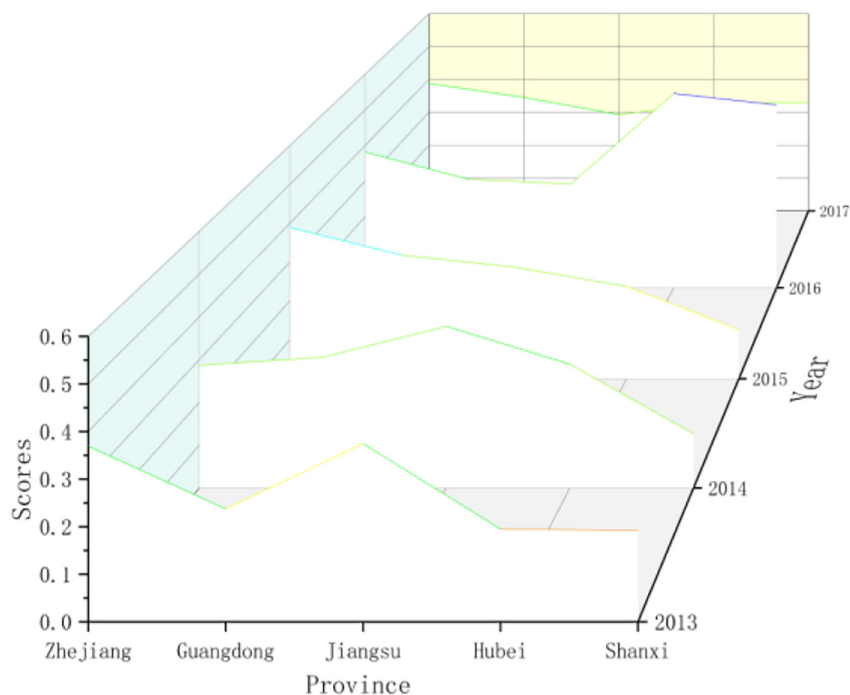
necessary to fully improve the sports industry policy, optimize the development environment, release development potential, and then stimulate economic growth and promote employment. At the same time, implement national fitness activities, strengthen the construction of green sports projects such as sports parks, improve the local natural resource environment, and further promote society's various developments.

#### (5) Response subsystem

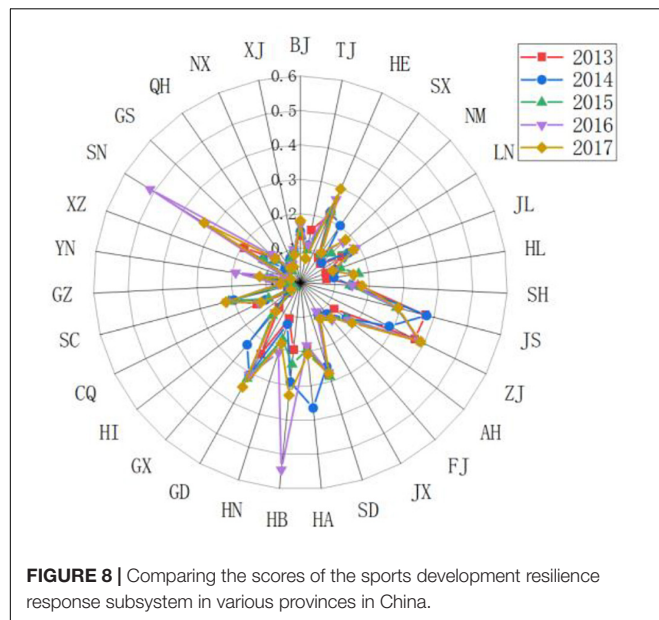
Different provinces have different response levels to the driving force and pressure of sports development.

As shown in **Figures 7, 8**, Zhejiang, Guangdong, Jiangsu, Hubei, and Shaanxi have achieved better governance results. In terms of sports talent training, vigorously develop the number of level athletes, strengthen the training of sports reserve talents, and vigorously establish youth sports clubs. In terms of national fitness, strengthen the construction of national fitness monitoring stations and national fitness path projects. In terms of technological innovation, we invested in sports technology equipment and strengthened sports project research to improve the level of sports technology innovation and promoted higher scores in response subsystems. The scores of response subsystems in Zhejiang, Guangdong, and Jiangsu remained within the range of 0.3–0.6. Various sports management Policies and measures have achieved good results. The sports management policies and measures implemented in Beijing, Tianjin, and Shanghai have achieved low response effects. Sports governance capabilities and sports technology innovation levels are difficult to adapt to the rapid growth of the sports industry and the demand for national fitness in Beijing, Tianjin, and Shanghai in recent years. Investment in governance and sports technology innovation needs to be increased. Guizhou, Yunnan, Tibet, Gansu, Qinghai, Ningxia, and western Xinjiang have relatively low scores in response subsystems, and there are still relatively large areas of informatization, investment in sports resources, training of sports talents, construction of national fitness projects, and innovation in sports science and technology. The problem is that although some provinces have adopted some measures and achieved some results, the overall situation is still not ideal and still faces severe tests.





**FIGURE 7 |** Comparing the scores of the sports development resilience response subsystem in some provinces in China.



**FIGURE 8 |** Comparing the scores of the sports development resilience response subsystem in various provinces in China.

degree model to diagnose and identify the main obstacle factors that affect the resilience of sports development in China during 2013–2015. Then the first five major factors will be analyzed.

## Research Method

The obstacle model can provide some suggestions for the formulation and adjustment of sports development policy by analyzing and diagnosing the obstacle factors that affect the resilience level of sports development in each province (Pan et al., 2019). The factor contribution degree is represented by the weight  $w_j$  of a single index. Index deviation degree  $I_j$  refers to the difference between a single index and the target expressed as the difference between the standardized value of each indicator and 1, and  $x'_j$  is standardized data. Obstacle degree  $O_j$  means the degree to which each indicator or criterion layer factors affect the development of regional sports resilience in China (Huang et al., 2020). The obstacle degree is calculated as follows:

$$I_j = 1 - x'_j \quad (11)$$

$$O_j = \frac{I_j \times w_j}{\sum_{j=1}^n I_j \times w_j} \times 100\% \quad (12)$$

According to the calculation formula of the obstacle degree, the influence degree of each index on the development toughness of China's sports regions is obtained.

## OBSTACLE FACTORS AFFECTING THE RESILIENCE OF SPORTS REGIONAL DEVELOPMENT IN CHINA

### Research Design

Based on the evaluation of the development level of sports resilience in China from 2013 to 2015. We introduce the obstacle

**TABLE 4 |** The main obstacle factors and obstacle degree in the evaluation index layer of sports regional development resilience in China from 2013 to 2015.

Year	Type	Order of indexes				
		1	2	3	4	5
2013	obstacle factors	<b>R<sub>7</sub></b>	<b>R<sub>5</sub></b>	<b>P<sub>1</sub></b>	<b>D<sub>7</sub></b>	<b>D<sub>4</sub></b>
	obstacle degree	10.03%	8.34%	7.01%	6.84%	6.63%
2014	obstacle factors	<b>S<sub>1</sub></b>	<b>R<sub>7</sub></b>	<b>R<sub>8</sub></b>	<b>D<sub>4</sub></b>	<b>R<sub>5</sub></b>
	obstacle degree	10.00%	8.92%	8.81%	6.71%	6.08%
2015	obstacle factors	<b>R<sub>7</sub></b>	<b>R<sub>5</sub></b>	<b>D<sub>1</sub></b>	<b>D<sub>7</sub></b>	<b>D<sub>4</sub></b>
	obstacle degree	9.29%	8.36%	7.99%	7.73%	7.22%
2016	obstacle factors	<b>R<sub>7</sub></b>	<b>R<sub>5</sub></b>	<b>D<sub>7</sub></b>	<b>R<sub>8</sub></b>	<b>D<sub>4</sub></b>
	obstacle degree	12.24%	8.54%	7.59%	7.27%	6.95%
2017	obstacle factors	<b>R<sub>7</sub></b>	<b>R<sub>5</sub></b>	<b>D<sub>7</sub></b>	<b>R<sub>8</sub></b>	<b>D<sub>4</sub></b>
	obstacle degree	10.10%	9.61%	8.80%	7.47%	7.22%

## Result Analysis and Discussion

### The Main Obstacle Factors Affecting the Resilience of Sports Regional Development in China

It can be seen from **Table 4** that the obstacles (frequency greater than 5) affecting the development of sports resilience in China from 2013 to 2015 are in order as follows: sports scientific research equipment (R7), the number of national fitness monitoring stations (R5), the number of national fitness activity centers (D7), the full-time equivalent of (R&D) personnel (D4), and the number of sports scientific research projects (R8).

In terms of time periods, in 2013 the top five factors affecting the resilience of China's sports development were sports scientific research equipment (R7) the number of national fitness monitoring stations (R5), GDP growth (P1), the number of national fitness activity centers (D7), and the full-time equivalent of (R&D) personnel (D4). It shows that the development level of sports science and technology in China is weaker at this stage, and the national investment in sports science and technology is lower, the national construction project is not well carried out, and the investment in national fitness testing center and fitness activity center is not enough. In addition, the decline in GDP growth rate has also increased the pressure on the sports system and has also hindered the development of sports to some extent.

In 2014, the top five factors affecting the resilience of China's sports development were the number of athletes in elite sports teams (S1), sports scientific research equipment (R7), the number of sports science research projects R8, full-time equivalent (R&D) personnel (D4), and the number of national fitness monitoring stations (R5). Elite sport is a demonstration of the strength of a country and a nation. After experiencing the glory of the 2018 Beijing Olympic Games, elite sports in China were declining to some extent. Elite athletes are the most critical human resources for the development of national elite sports. At this stage, there were problems in the cultivation of elite athletes, which became the most important obstacle to the resilience of China's sports development. In addition, the national investment in sports

science and technology is still low, showing a bold form of development. National physique monitoring, meanwhile, has not received enough attention. All these have influenced the development of sports.

In 2015, sports scientific research equipment (R7) and the number of national physical fitness monitoring stations (R5) are still the first and second obstacles affecting the resilience of sports development in China. It shows that the level of sports science and technology still needs to be improved. In addition, GDP (D1) became the third obstacles factor. It shows that national economic development is still the main factor that restricts the development of sports. Thirdly, the number of national fitness centers (D7) and the full-time equivalent (R&D) personnel (D4) are still the main obstacles affecting the development of sports in China. This also shows that the country's investment in national fitness and science and technology still needs to be improved.

In 2016 and 2017, the main obstacles affecting the resilience of sports development in China were sports scientific research equipment (R7), the number of national fitness monitoring stations (R5), the number of national fitness activity centers (D7), the number of sports science research projects, the full-time equivalent of R8 (R&D) personnel, and (D4). This also shows that technology is still the primary productive force in the development of sports, especially in the new era. Under the new development concept, science and technology, especially digital sports, will inject new impetus into the development of national health and sports. At present, although China has made great progress in sports science and technology, the basic research ability of sports science and technology is insufficient, the number of high-level sports science and technology laboratories is short, and the quality of research results and the ability of transformation need to be improved. Although, sports has achieved rapid development through the promulgations of national strategies such as "Sports power," and "Healthy China," it still cannot meet the growing material and cultural needs of the people. It was still a lack of Sports infrastructure. Therefore, China should continue to promote the national fitness project construction, especially increase the investment in national fitness infrastructure, to promote the vigorous development of sports in China.

### The Main Obstacle Factors Affecting Each Subsystem of the Resilience of Sports Regional Development in China

By calculating the obstacle degree of the five subsystems, the results are shown in **Table 5**. The response subsystem is the main classification index obstacle factor that affects the resilience improvement of sports development in China, followed by the driving force subsystem and the state subsystem. The order is: response > driving force > state > impact > pressure. Therefore, in order to further improve the resilience of sports development in China, in the context of the changing complex environment and the increasing pressure of sports development environment. We should focus on the response

**TABLE 5 |** The Subsystem obstacle degree of sports regional development resilience in China from 2013 to 2015.

Year	Obstacle degree				
	Driving force subsystem	Pressure subsystem	State subsystem	Impact subsystem	Response subsystem
2013	27.52%	9.73%	11.10%	9.93%	41.71%
2014	27.19%	3.71%	17.37%	10.26%	41.47%
2015	33.66%	4.54%	9.60%	10.60%	41.60%
2016	29.34%	4.54%	10.82%	10.23%	45.07%
2017	31.07%	4.21%	10.52%	10.73%	43.48%

subsystem, balancing the driving force subsystem and the state subsystem. Establishing the development concept with national fitness as the core, making full use of science and technology innovation, coordinating the development of national fitness and elite sports, and developing the sports industry. In this way, we can alleviate the negative effects of sports development.

## ANALYSIS OF SPATIAL CORRELATION OF SPORTS DEVELOPMENT IN CHINA'S DIFFERENT REGIONS

### Research Design

According to the First Law of Geography, everything is related to everything else, but near things are more related than distant things (Pan et al., 2020). This study will analyze the spatial correlation of the resilience of sports development in 31 provinces, municipalities, and autonomous regions in China from 2013 to 2017 to figure out whether a spatial correlation exists. Spatial autocorrelation can be classified into global spatial autocorrelation and local spatial autocorrelation. Measures of global spatial autocorrelation include Moran's I, General G; whereas methods of local spatial autocorrelation mainly contain LISA, local G and the Moran scatter plot. Global Moran's I and the Moran scatter plot will be adopted to study the spatial correlation of the resilience of sports development among different regions in China.

### Research Method

In this paper, the Global Moran's I and local Moran's I are used to study the spatial correlation of the development resilience levels of sports regions in China. Global Moran's I, the most common indicator of spatial autocorrelation, is used to analyze the spatial homogeneity of an overall region and measure how one feature of different variables is similar or correlated to others surrounding it (Wang and Ge, 2012). Moran's I is defined as

$$I = \frac{\sum_{i=1}^n \sum_{j=1}^n w_{ij} (X_i - \bar{X})(X_j - \bar{X})}{s^2 \sum_{i=1}^n \sum_{j=1}^n w_{ij}} \quad (13)$$

**TABLE 6 |** Global Moran's I about the Resilience of China's Sport Region Development from 2013 to 2017.

Year	Moran's I	z-score	p-value
2013	0.251	2.429	0.008
2014	0.185	1.854	0.032
2015	0.147	1.535	0.062
2016	0.052	0.718	0.236
2017	0.137	1.453	0.073

In particular,  $x_{ij}$  stands for the value of resilience of sports development in each region;  $w_{ij}$  is the normalized spatial weights matrix.

Since global Moran's I cannot visualize the similarity or difference in terms of spatial gathering in a certain locality, we calculated the local Moran's I for 31 provinces, municipalities, and autonomous regions between 2013 and 2017 and then analyzed the local spatial correlation with Moran scatter plot (Yu et al., 2016). The formulation of local Moran's I is presented as follows:

$$I_i = \frac{(x_i - \bar{x})}{s^2} \sum_{j=1}^n w_{ij} (x_j - \bar{x})^2 \quad (14)$$

## Result Analysis and Discussion

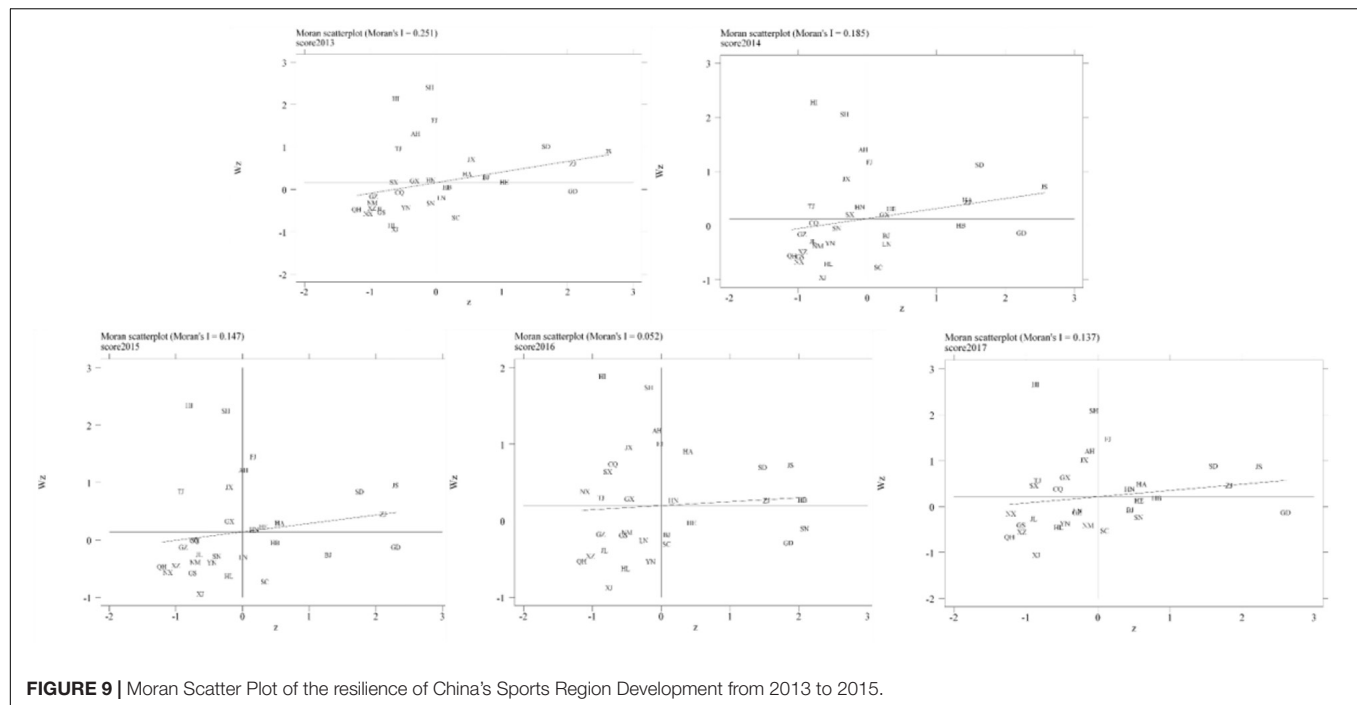
### Analysis of Global Spatial Correlation

Table 6 presents the result of global Moran's I about the resilience of China's sports development. The value of Moran's I was all above 0 from 2013 to 2017. Except for 2016, the global Moran's I value of each year passed the test of significance (10% threshold). As for the z-score, 2013 witnessed a significant positive correlation between location and the resilience of sports development with the z-score exceeding 1.95. The same result can be seen in the year 2014 with a z-score over 1.65. The z-score from 2015 to 2017 indicated that the spatial autocorrelation is insignificant with no obvious clustering. In addition, the value of Moran's I from 2013 to 2017 was 0.251, 0.185, 0.147, 0.052, and 0.137, respectively. The unstable and downward trend indicated that the spatial autocorrelation was declining.

### Analysis of Local Spatial Correlation

The Moran scatter plot is decomposed into four quadrants, corresponding with high-high (H-H, the upper-right quadrant), low-high (L-H, the upper-left quadrant), high-low (H-L, the lower-right quadrant), and low-low (L-L, the lower-left quadrant) spatial correlation. Figure 9 visualizes the local spatial correlation.

- (1) H-H quadrant: A province in the H-H quadrant means it enjoys higher resilience of sports development, so do its surroundings and neighboring provinces, showing a small spatial difference. Jiangsu, Zhejiang, Shandong, Jiangxi, and Henan provinces, as well as Beijing Municipality, belonged to the H-H quadrant in 2013, among which Jiangsu, Zhejiang, Shandong, and Henan provinces have always



**FIGURE 9 |** Moran Scatter Plot of the resilience of China's Sports Region Development from 2013 to 2015.

been in this quadrant. The result indicated that cluster development on a large scale has been established among the abovementioned provinces and their neighborhood, mainly in the eastern region with strong economic growth, advanced IT application, abundant sports resources, large public investment in sports, and full-fledged sports infrastructure. In terms of time span, Hebei, Guangxi, Fujian, and Hunan provinces have been uplifted from H-L to H-H quadrant with each passing day, reflecting a stronger spatial correlation with neighboring provinces. For example, Hebei province's development was made possible by the impact from the neighboring provinces of Shandong and Henan which enjoy rapid development in sports, while Fujian benefited from the neighboring provinces of Zhejiang. All these led to a coordinative development with the neighboring provinces and at the same time sustained self-development (Xu et al., 2021).

- (2) L-H quadrant: A province in the L-H quadrant means it has lower resilience of sports development whereas its surroundings and neighboring provinces boast higher resilience. Tianjin, Shanghai municipalities, and Hainan, and Anhui provinces belonged to the L-H quadrant in 2013, but Jiangxi province was downgraded from H-H to L-H quadrant from 2014 to 2017, showing the influence of surroundings was weak despite strong development in Jiangxi. On the contrary, Fujian province was upgraded from L-H to H-H quadrant gradually, showing that Fujian province has strengthened its ties with neighboring provinces while improving its own resilience of sports development, thus forming a robust cluster development with its neighbors.

- (3) H-L quadrant: A province in the H-L quadrant means it boasts higher resilience of sports development whereas its surroundings and neighboring provinces have lower resilience. Guangdong, Sichuan, Liaoning, and Hubei provinces belonged to the H-L quadrant in 2013, meaning that focus on self-development in sports brought greater resilience of development. However, due to the slow growth of neighbors, little cluster development can be found in the provinces mentioned above. Starting from 2014, Beijing municipality has downgraded from H-H to H-L quadrant, demonstrating a declining correlation with its surroundings due to weakening radiation impact. In contrast, the upgrading of Shaanxi province from L-H to H-L quadrant showed that with sustained economic development, this province has paid high attention to sports development, improving the resilience while the development of the slow sport caused restricted resilience.
- (4) L-L quadrant: A province in the H-H quadrant means it enjoys higher resilience of sports development, as do its surroundings and neighboring provinces. In 2013, the L-L quadrant was home to 12 provinces and autonomous regions including Qinghai, Ningxia, Gansu, Guizhou, and Xinjiang. The same result can be seen even in 2017. Most of them, located in the western region, grew slowly in terms of the economy because of the location, natural environment, and other conditions. In addition, the long-distance between provinces in the west and those in the east resulted in weak radiation and made it difficult to obtain greater resilience and form cluster development on a large scale, leading to slow sports development.



## RESEARCH RESULTS AND SUGGESTIONS

### Research Results

- (1) Obtain the weight of the evaluation index. The study, in the spirit of new development philosophy, analyzed features of China's sports development, created an evaluative index system measuring the resilience of China's sports development in different regions from five dimensions of "driver, pressure, state, impact and response" (DPSIR model) according to the dynamism of China's sports development and determined the evaluation index weights based on the coefficient of variation.
- (2) Measured the resilience level of sports development in each region. With the help of the TOPSIS model (Zhu et al., 2016), we calculated the resilience of sports development from 2013 to 2017 in 31 provinces, municipalities, and autonomous regions, finding out an upward trajectory in terms of resilience of sports development overall while certain provinces witnessed pronounced fluctuations. Compared with localities in the west, regions in the east enjoy higher resilience of sports development. Among different sub-systems, the score of driver and impact showed an upward trend while that of pressure remained basically unchanged with slight fluctuations. Also, the score of impact bounced back rapidly after a temporary slowdown while that of response declined after a gradual increase.
- (3) Rank the obstacles degree. Obstacles affecting the resilience of China's sports development identified by the Obstacle Degree Model (ODM) include (in the order of scores): equipment for sports science, fitness surveillance center, national fitness center, the full-time equivalent (FTE) of R&D personnel, and amounts of research on sports. The order of obstacle degree is response > driver > state > impact > pressure.
- (4) Analyzed the spatial correlation of the resilience of sports development. Analysis of spatial correlation of the resilience of sports development in 31 provinces, municipalities, and autonomous regions in China from 2013 to 2017 proved a strong cluster in terms of resilience in 2013 and 2014 while no obvious cluster was found from 2015 to 2017. Moreover, spatial autocorrelation of the resilience of China's sports development continues to weaken. With regard to the local Moran scatter plot, great differences remain in different regions with the H-H quadrant home to economically developed provinces in the east and the L-L quadrant containing underdeveloped provinces, municipalities, and autonomous regions in the west with low resilience.

### Suggestions

The Fifth Plenary Session of the 19<sup>th</sup> CPC Central Committee adopted *The CPC Central Committee's proposals for formulating the 14th Five-Year Plan (2021–2025)* for

*National Economic and Social Development and the Long-Range Objectives Through the Year 2035*, stating that "We must ensure the new development philosophy is applied in every stage and aspect of development." To improve the resilience of China's sports development in an all-around way, we must take the new development philosophy as the guiding principle. First, we should stick to innovation-driven development to fully upgrade the resilience of China's sports development. Since innovation is a powerful engine propelling sports development in the new era, it is necessary to boost innovation in different dimensions of sports development, in particular the innovation of sports technology. Moreover, effort should be made to increase input in human capital and funding for innovative development while following through the strategy of innovation-driven development so as to improve the efficiency of innovative sports development in an all-around way.

Second, we should adhere to the principle of coordinated development to promote the overall and balanced development of sports. Efforts should be made to expand national fitness facilities in a bid to greatly promote national fitness and health while enhancing coordinated development of competitive sports and fitness, thus improving people's health while looking for and cultivating talents for competitive sports. At the same time, we should strengthen information exchanges and cooperation among different localities by establishing a highly efficient coordinative mechanism and a sound and stable cooperation platform to promote the free flow of sports resources in various regions. Furthermore, all regions should share resources, draw on each other's strengths, and deepen coordination and cooperation so as to achieve win-win results. It is imperative to strengthen measures to reach a new stage in the large-scale development of the western region; help the central region rise by tapping into local strengths; support the eastern region in taking the lead in pursuing optimal development through innovation. To this end, we need to put in place new, effective mechanisms to ensure coordinated development of different regions.

Lastly, we should promote shared development so as to deliver benefits for all in an equal way. All provinces, municipalities, and autonomous regions should carry out institutional reforms of sports development, explore new policy measures and cooperation methods, and focus on closing the gap among different regions in terms of sports development. Regions with higher resilience of sports development should not only ensure sustained growth but also exert a greater positive impact on surrounding areas, fully improving the resilience of sports development in other regions. In addition, regions with inadequate resilience of sports development should seize new opportunities brought by the policies such as China Western Development and integrated development of sports among regions, learn from the experience of developed regions so as to achieve greater development.

## DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author/s.

## AUTHOR CONTRIBUTIONS

JZ designed the research and wrote the manuscript. J-RG and J-BL undertook the statistical analysis and graphical representation of the data. YW and SZ aided in reference collection and summary as well as participated in the manuscript preparation. BS directed the research process and revised the draft. All authors who designed

this study contributed to the article and approved the final manuscript.

## FUNDING

This research was supported by Anhui Philosophy Social Sciences Planning Project (AHSKY2017D11).

## SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpsyg.2021.763501/full#supplementary-material>

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# An Empirical Study of Geography Learning on Students' Emotions and Motivation in Immersive Virtual Reality

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## OPEN ACCESS

### Edited by:

Xuesong Zhai,  
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United Kingdom

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### Specialty section:

This article was submitted to  
Educational Psychology,  
a section of the journal  
Frontiers in Education

**Received:** 08 December 2021

**Accepted:** 31 January 2022

**Published:** 23 February 2022

### Citation:

Shen Y, Wang Z, Li M, Yuan J and  
Gu Y (2022) An Empirical Study  
of Geography Learning on Students'  
Emotions and Motivation in Immersive  
Virtual Reality. *Front. Educ.* 7:831619.  
doi: 10.3389/feduc.2022.831619

This paper assesses the impact of emotional arousal on learning through a virtual reality video of geography immersion learning. Validity was measured with traditional questionnaire data and using electroencephalography (EEG). Twenty-four human subjects were recruited and presented with eight geography immersive learning videos with different affective tendencies. EEG data of the subjects were collected while they were watching the videos. After the video watching, subjects were requested to fill in an emotion scale, a learning motivation scale, and a mind flow experience. The results of the study show that VR video learning materials can well induce the positive and negative emotions of the subjects. Compared with negative emotions, the alpha band power in the frontal lobe of the brain, beta and gamma bands in the temporal lobe region is significantly higher under positive emotions. In addition, the results of the subjective scales indicate that subjects have stronger intrinsic motivations and better flow experiences under positive emotions. However, there was no significant difference for the immersion under positive and negative emotions. Our findings demonstrate the usability of teaching virtual reality situational geography stories and the broad value of using this teaching method for future instruction.

**Keywords:** virtual reality, immersive learning, EEG, emotion, motivation

## INTRODUCTION

Virtual reality technology has revolutionized traditional education, which involves medicine, architecture, and other disciplines (Shen et al., 2021). With the superior advantages of immersion and interaction, virtual reality can be seamlessly integrated into geography teaching to build an immersive virtual geography learning environment for learners. In traditional geography teaching, due to various factors, students cannot easily go out of campus for geography study activities. Thus, students can't access the field scenes and lack on-site practice, not to mention the in-depth understanding and re-creation of knowledge (Thomas et al., 2018). Virtual Reality (VR) immersion learning, on the other hand, is a concept that combines groundbreaking virtual reality technology and traditional narrative lecturing. The virtual reality-based 3D animation technology simulates and demonstrates the process of movement and change of geographical phenomena by the laws of geography. Students are immersed in the colorful and dynamic surrounding scenes and feel the thousands of changes in the laws of geography. It enhances students' emotional experience,



which initiates learners' learning motivation and thus enhances learners' learning effect. Emotion elicitation, as an essential instructional design tool in multimedia teaching, can effectively induce learners' emotions and may have an impact on their learning outcomes and subjective feelings (Park et al., 2015; Kumar et al., 2016; Münchow et al., 2017). However, there is controversy among the available research findings on how evoked emotions affect learners' learning performance and subjective feelings. And some studies have shown that immersive learning is very effective in developing students' learning skills and motivation (Moreau et al., 2018). Therefore, based on an immersive geography immersive learning teaching activity to elicit learners' emotions, this study aims to use more realistic and objective physiological data of brain waves to characterize emotions and investigate the emotion-evoking effects of this learning style on learners. It also investigates the relationship between emotion-evoking and factors, such as learning motivation and mind-flow experience, to conduct virtual reality emotion-evoking in future virtual reality immersive learning teaching design.

In the present study, three research questions were presented and addressed.

Hypothesis 1: VR immersive learning in a virtual reality environment can have an evocative effect on learners' emotions.

Hypothesis 2: VR immersive learning in a virtual reality environment can have an impact on learners' motivation levels.

Hypothesis 3: There is a correlation between emotion and motivation, flow experience, and immersion levels, respectively, for immersive learning in a virtual reality environment.

## LITERATURE REVIEW

### Immersive Virtual Reality Learning What Is Immersive Virtual Reality Learning

Immersive virtual reality learning involves user-centered engagement with narratives that unfold as witnesses or participants (Dooley, 2017). Immersive virtual reality learning offers a rare opportunity to present abstract experiences that challenge boundaries, heighten emotions, and convey previously intangible concepts (Hardie et al., 2020). This new approach to immersive virtual reality geography learning differs from traditional narrative media, such as film and television, in which the audience is mostly a passive participant. Immersive virtual reality learning is not about teaching the audience something as it is about allowing the audience to discover the knowledge (Bucher, 2017).

### Educational Applications of Geography Learning in Immersive Virtual Reality

In recent years, immersive learning in virtual reality has also received much attention as a potential new tool for science

education (Zhai et al., 2021b). VR immersive environment provides a unique opportunity to present abstract experiences that push boundaries, stimulate learners' emotions, and explain previously incomprehensible concepts (Bucher, 2017). However, most of the current educational applications for immersive learning under virtual exist in healthcare and education, and less for geoscience.

However, immersive geography learning is also particularly important in earth science. On the one hand, real-life experience is an important part of geography teaching. Geography course is a very comprehensive and life course, the course itself covers the geographical knowledge content and the geographical environment of students' actual life is closely related, from a drop of water, a piece of soil, to the famous mountains and rivers of the motherland, are all students need to pay attention to when learning geography courses. In traditional classrooms, it seems impossible for teachers to take students to all geographic environments due to other factors such as funding, time, and safety. Instead, with VR devices, students can experience some geographic processes and geographic environments that they cannot experience in real life (Bucher, 2017). For example, Virvou and Katsionis (2008) use virtual geography games for classroom teaching, teaching students geography, and then making evaluation experiments. This way of teaching virtual reality games allows students to gain knowledge through experience and promotes the development of students. Professor Yukiko Inoue conducted an experimental survey using virtual reality technology and video teaching to evaluate the effectiveness of the classroom when high school students learned about world geography (Inoue, 1999).

On the other hand, interactive experience is an important way in geography teaching, based on virtual reality interactive technology and by the content of geographic experiments, the creation of human-landscape interactive virtual geographic experiments (such as virtual globes, virtual solar system, etc.), so that students through hands-on experiments, enhance the contextual experience and interactive experience of geography learning—this to a certain extent make up for the current geography teaching through multimedia courseware and teaching aids model experiments exist in the situational interaction limitations. In immersive virtual reality learning, learners follow narrative stories presented by the teacher, which integrates storytelling and interactivity into an engaging learning scenario. Combining geographic narratives with virtual reality can create memorable experiences that evoke emotions and make it easier for learners to remember due to the power of its sensory associations. Scientific research in immersive VR learning is still in its infancy, especially in the area of geography and natural science narratives (Li et al., 2007).

### Emotional Arousal

Emotion is a coping response used to help individuals better adapt to the environment they are in Roseman (1996), and research has proven that the emotions of disgust, fear, happiness, surprise, sadness, and anger are common in life (Ekman, 1992). Mayer (2010) points out that there are still certain moderating variables or boundary conditions in the practical application

of multimedia teaching principles, namely multimedia learning principles may only be more effective if they are targeted to specific learners and if certain specific design approaches or learning materials are used (Zhai et al., 2021a).

The external emotion elicitation methods used in previous empirical studies usually contain video and non-video (e.g., music, declarative sentences, etc.) As the two types of elicitation (Knörzer et al., 2016; Liew and Tan, 2016), but compared to this, immersive virtual reality can make full use of the psychological and physiological components of the subject, thus inducing learners' emotions more completely (Pallavicini and Pepe, 2020). Thus, with its three-dimensional and realistic environment, virtual reality allows users to enjoy an immersive and intuitive sensation and is the superior emotion-evoking meta.

### The Relationship Between Emotional Triggers and Motivation

In the study of emotion-inducing effects, researchers not only paid attention to the effect of induced emotions on learning effects but also paid attention to the changes in the subjective feelings of learners in multimedia learning. Based on previous studies, studies on emotion induction have focused on intrinsic motivation as an indicator (Shen et al., 2021).

Eisenberg et al. (1992) and Vansteenkiste et al. (2012) argue that motivation is a continuum of intrinsic motivation to extrinsic motivation. Based on this view, Weiner (1986) and Chandler and Connell (1987) divide motivation into intrinsic motivation, internalized motivation, and extrinsic motivation. Among them, internalized motivation refers to the intrinsic identification and pursuit of the meaning of learning activities by external factors, and becomes the leading driving force for learning. Motivation is a significant cognitive factor that influences learning; therefore, better-motivated students can learn more effectively (Cobb and Fraser, 2005). Researchers have studied the relationship between emotion and motivation during learning, but the results vary. Mayer (2014) states that performing emotional design is an attempt to combine motivation with cognition. That is, emotional design motivates learners to put more mental effort, which will result in higher motivation for positive processing and ultimately lead to better learning outcomes. In terms of intrinsic motivation, Mayer (2013) used a combination of external emotion elicitation and internal emotion elicitation and found that the positive emotion elicitation group was more intrinsically motivated than the neutral group. Plass et al. (2014) also used external emotion elicitation and internal emotion elicitation but only found that the internal positive emotion elicitation group was more intrinsically motivated than the internal neutral emotion elicitation group. In contrast, Kumar et al. (2016), who also used only internal emotion elicitation methods, found that emotion elicitation did not affect learners' internal motivation. Pavelescu (2019) explored the relationship between motivation and affective factors through two contrasting cases, demonstrating that strong positive emotions can enhance and sustain motivation. Although emotion elicitation and motivation in learning experiences have been extensively studied, the relationship between motivation and emotion in virtual reality has not been thoroughly researched.

Limniou et al. (2008) showed that 3D fully immersive VRLE would increase learners' interest and motivation compared to learning in a 2D animated environment. Burdea and Coiffet (2003) suggested that through interaction and potentially high repetition, virtual reality helps to increase knowledge retention and positive student emotions and motivation.

## Measurement

### Measurement of Motivation

Objective or quantitative assessment of learners' motivations represents one of the most critical tasks in this research, to better understand and gauge the effects of the proposed VR-based learning approach. There have been various prior research efforts aiming to provide solutions for this complex task. Different methodologies were proposed (Ghergulescu and Muntean, 2014) to measure and assess a learner's motivation:

- (i) Questionnaire-based methodology;
- (ii) Interaction-based methodology;
- (iii) Psychophysiology-based methodology.

Motivation measurement and assessment based on physiology and psychology rely on additional devices such as behavioral data (facial expressions, eye movements) and data on physiological responses (heart rate, brain signals, and skin electricity). Kleih et al. (2010) investigated the relationship between motivation and P300 (an event-related potential). Pi et al. (2021) proposed electroencephalography (EEG)-based measure of motivation for learning in a video learning environment g. The participants had to perform a spelling words task. Furthermore, the results have shown that motivation can be significantly predicted by P300. Therefore, psychophysiological-based methodologies that make use of sensor-based recognition are preferred as they usually do not require an interruption of the learning process (Ghergulescu and Muntean, 2014).

### Measurement of Emotions

Facial expressions, voice intonation, gestures, and physiological signals can all be used as data sources for emotion evaluation. However, sometimes the emotional state can be disguised. For example, one person is angry inside, but he expresses a happy expression for social reasons. Therefore, in these situations, facial expressions and voice intonations cannot accurately recognize emotions. In addition, physiological signals are difficult to disguise and contain more information.

In this paper, we use physiological signals and subjective scale data to measure emotions. These two types of data are important indicators for evaluating emotions, some studies have shown differences between physiological signals and subjective scales under different emotions (Zheng and Lu, 2015). It is well known that neural oscillations in the theta frequency band (4–8 Hz) are associated with memory (Herweg et al., 2020).

## MATERIALS AND METHODS

### Participants

24 healthy participants (14 males and 10 females), aged between 21 and 33 were recruited for this study, and all participants

had a normal or corrected-to-normal vision. None of them had a history of heart disease, neurological disorders, or other mood-related disorders. The local ethics committee has approved the investigation.

## Instruments

### Measuring Tool

#### *The Self-Assessment Manikins Questionnaire*

In this experiment, we use the Self-Assessment Manikins (SAM). The scale contains information such as Arousal, Valence, Dominance, and Liking. Here we mainly collect the subjects' arousal scores and valence scores, which correspond to the two-dimensional model of emotions.

The horizontal and vertical axes of this model represent the degree of valence and arousal, respectively. The valence represents the degree of pleasure of the emotion, arousal represents the intensity of the emotion. The four poles of the model represent four different discrete emotion categories: happiness (high valence/High arousal), ease (high valence/low arousal), boredom (low valence/low arousal), panic (low valence/high arousal). In the literature, this two-dimensional representation model is often called VA (Valence-Arousal) Model

#### *The Learning Motivation Scale*

The learning motivation measure was developed by Wang and Chen (2010) based on the measure proposed by Pintrich (1991). Six items were included to measure learners' internal and external motivations in virtual reality immersion learning.

#### *Virtual Reality Immersive Immersion Scale*

Huang et al. (2010) developed this instrument to investigate learners' attitudes toward virtual reality learning environments (VRLE), which is based on a constructivist theoretical approach that examines students' interaction, immersion, imagination, motivation, and problem-solving with virtual reality learning environments.

#### *Flow Experience Scale*

Flow is defined as a psychological experience reflecting cognitive regulation in behaviors (Chen, 2007; Csikszentmihalyi, 2014). Flow theory focuses on the emotional experiences of individuals, focusing on the generation of internal motivations that drive individuals to engage in an activity. Once students have a flow experience in the geography classroom, they will devote themselves to geography learning with great enthusiasm, transforming external motivations into internal motivations, and ultimately forming a virtuous circle. This study, based on Cheng's scale of the virtual reality game, adopted a five-point scale of the virtual reality environment, including four dimensions: namely challenge, skill, telepresence, flow. They represent the challenges faced in the learning process, the skills learned in this teaching method, and the selfless realm in learning and a state of mind sometimes experienced by people who are deeply involved in this activity. After modifying the scale according to the immersive learning environment of virtual reality, we used the modified version for pre-testing, reliability testing, and validity testing. We conducted project analysis, reliability, and validity analysis of

the data. The scale has good reliability and can be used in VR geography Learning.

## Emotional Evocation Video Selection

This research uses immersive virtual reality videos as the primary teaching media learning environment and immersive geography videos as the main content. The video comes from the Stanford immersive VR video public database (Li et al., 2017). The dataset contains 73 immersive VR videos, and each video has a corresponding valence and arousal score, which are distributed in the four quadrants of the arousal valence plane (V plane). We selected virtual reality videos consistent with the content of compulsory high school textbooks and described the virtual scenes. Sample screenshots of VR videos are shown in **Figure 1**. We then merged the described voice description with the virtual video to form a supporting virtual reality immersive geography video. The average duration of each video is 300 s. The emotional categories and topics of VR videos are shown in **Table 1**.

## The Measurements of Brain Waves

Our experimental equipment consists of the following parts: a computer (Intel Core i7 processor, GTX 2060 graphics card, and 16GB RAM), an HTC Vive Pro HMD for displaying VR videos. We measured and set the interpupillary distance for each participant. EEG signals were collected by the ANT Neuro equipment, whose electrode placement follows the 10/20 system. Besides, to prevent the head-mounted device (HMD) from applying pressure on the frontocentral electrodes, a lateral elastic band is used to fix the HMD while the upper elastic band is loose. The experiment recorded a total of thirty-two (32) EEG channels, which is the same as the DEAP and MAHNOB-HCI datasets. As shown in **Figure 2**, similar to the DEAP and MAHNOB-HCI datasets, all electrodes were grounded to the forehead, referenced to CPz, and then re-referenced to the linked papillae offline. The HMD and EEG caps used in this experiment are shown in **Figure 3**.

## Statistical Analysis Method

In this experiment, we used the non-parametric Wilcoxon signed-rank test to analyze the differences in learning motivation and flow experience under different emotional states. This analysis method does not require the data to follow a normal distribution. The significance level in all experiments is 0.05.

## Procedure

The experimental, temperature-controlled laboratory was set at a constant temperature of 20°C. The windowless lab also allowed the complete darkness in the room to minimize distractions and avoid light affecting the quality of the projected image. As shown in **Figure 4**, the study consisted of the following three steps. In the first step, all participants washed their hair to lower the impedance. Then, they filled out the demographic information form (e.g., age, gender). In Step Two, the experimental subjects wore HMD and watched eight virtual reality geographic videos in a random order. At the end of the video viewing, participants completed psychometric questionnaires on motivation to learn,





**FIGURE 1** | Sample screenshots of VR videos with different emotions they watched.

**TABLE 1** | Video topics.

Emotional		Video topics	Video content
Positive emotions	Delighted	Human geography	Foreign urban structure Appreciation of our human tourism resources
	Excitement	Environmental protection	Whale Encounters Coral reef migrations
	Negative emotion	Phobia	Natural disasters and their impact
	Sorrowful	Earth in the Universe	Turmoil Volcanic eruption Flooding outbreak

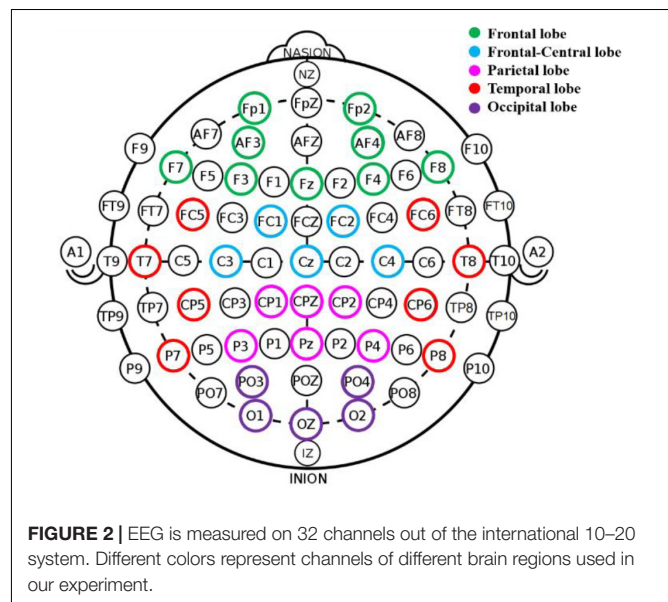
mind-flow experience, and emotions. The entire experiment lasted approximately 2 h.

## Data Analysis

In this section, we analyze the results from five aspects, including the effect of positive and negative emotions on students' motivation, flow experience, and immersion was investigated through subjective scale scores and objective physiological data.

## Analysis of Self-Assessment Manikins Questionnaire Ratings

We calculate the average SAM ratings of eight VR videos watched by 24 subjects. The results are shown in **Table 2**. For four negative VR videos, the valence scores are generally lower: 3.1, 3.2, 2.3, and 2.1, respectively. For the four VR videos with positive emotions, the corresponding valence scores are generally higher: 6.7, 6.8, 6.6, and 7.9, respectively.



Then, we compare the arousal and valence scores of 24 subjects under positive and negative emotions. The non-parametric Wilcoxon signed-rank test analyzes statistical differences between these two emotional states. As shown from **Figure 5**, we can see a significant difference ( $p < 0.001$ ) for valence scores between positive (6.99) and negative (2.68) emotions. But there has no significant difference for arousal scores under positive (5.68) and negative (5.38) emotions. The reason for these results may be the subjects were able to immerse themselves in the VR scene and complete the learning task well regardless of whether they were in negative or positive emotions. So there is no significant difference in arousal scores. In short, the results suggest that the eight VR videos, as learning materials in the





**FIGURE 3** | EEG equipment was used in our study.

experiments, successfully induced the positive and negative emotions of the subjects, which **supports our Hypothesis 1**.

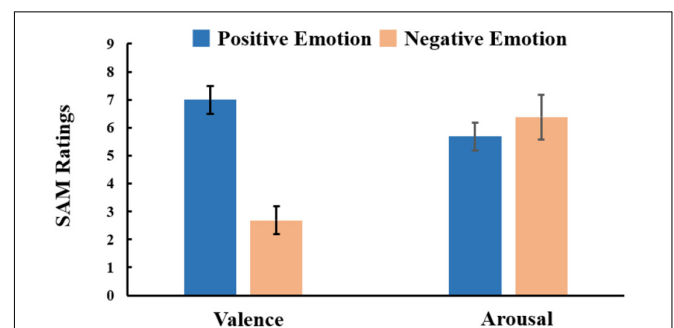
## Electroencephalography Frequency Feature Analysis

To compare the difference of EEG frequency features between positive and negative emotional states. We first resampled the EEG data to 256 Hz. Python's MNE package was used to filter the signal and keep the data only between 0.1 and 47 Hz frequency band. Then we used the independent component analysis (ICA) to remove electrooculogram (EOG) artifacts. Finally, the Welch method was used to extract the power spectral density (PSD) features over the five bands of the EEG signal delta, theta, alpha, beta, and gamma. These power features were averaged on the corresponding waveband and then were also averaged over all electrode channels.

The statistical analysis results through the non-parametric Wilcoxon signed-rank test are shown in **Figure 6**. There has a significant difference for the PSD features of alpha-band over the forehead region. The alpha-band feature values under

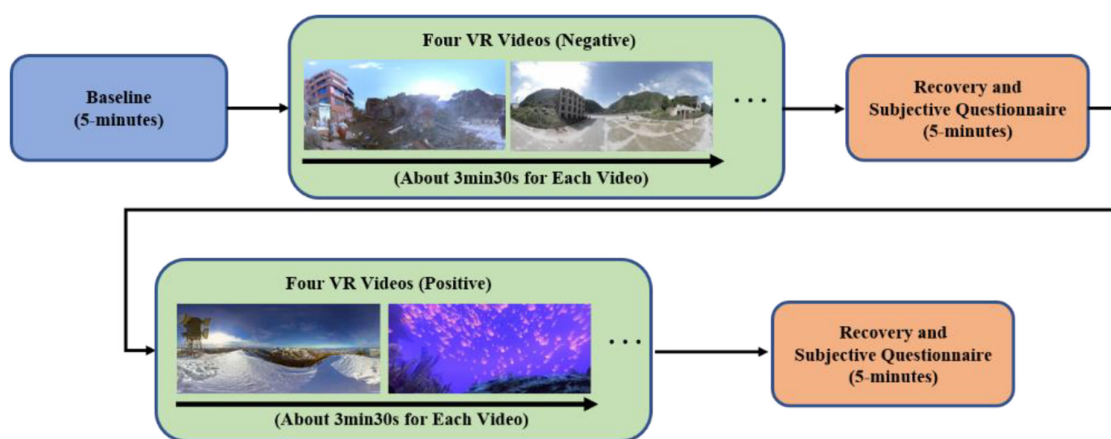
**TABLE 2** | Eight VR videos' mean valence and arousal ratings (standard deviations).

Videos	Valence	Arousal
Nepal earthquake	3.1 (0.5)	4.5 (0.4)
Turmoil	3.2 (0.8)	4.8 (0.3)
Volcanic eruption	2.3 (0.4)	8.1 (1.2)
Flooding outbreak	2.1 (0.2)	8.2 (1.3)
Foreign urban structure	6.7 (0.9)	4.1 (0.5)
Appreciation of our human tourism resources	6.8 (1.0)	4.0 (0.3)
Whale encounters	6.6 (0.8)	7.4 (0.9)
Coral reef migrations	7.9 (1.0)	7.2 (0.7)

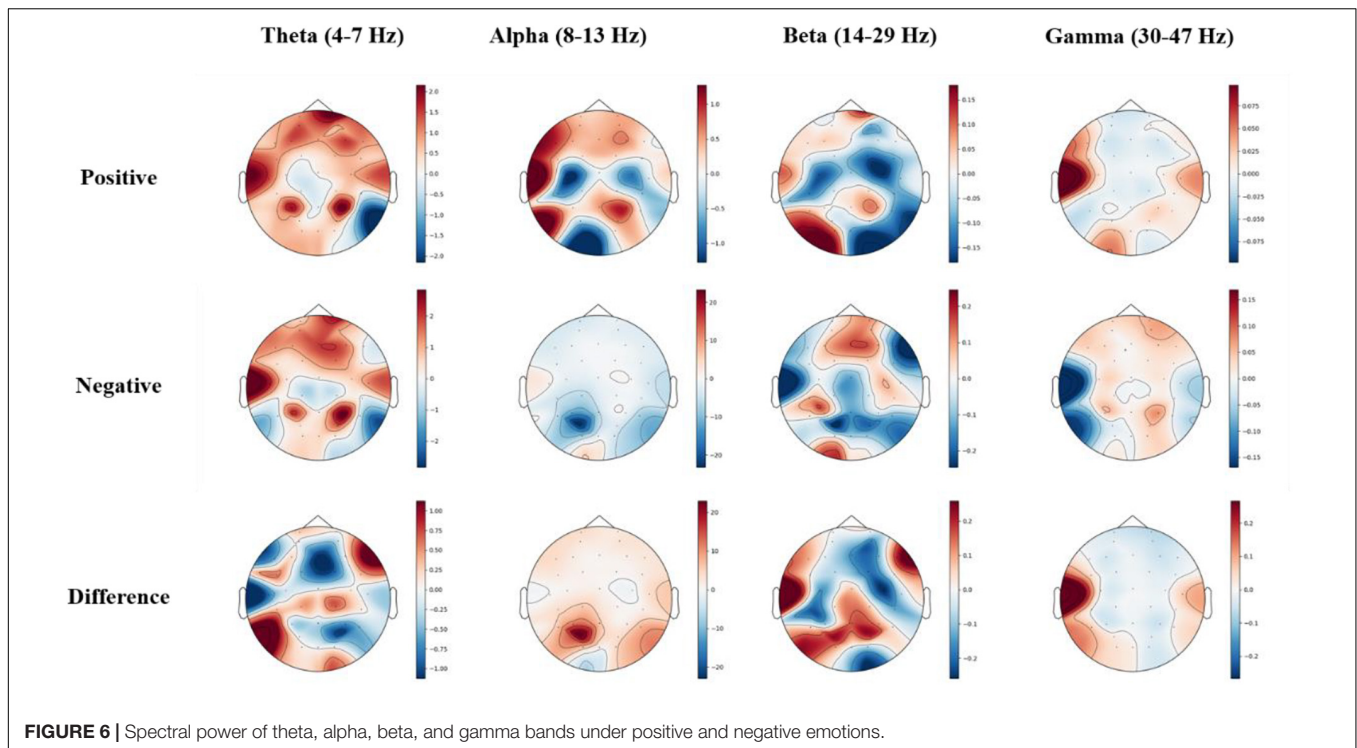


**FIGURE 5** | The mean valence and arousal scores are under positive and negative emotions.

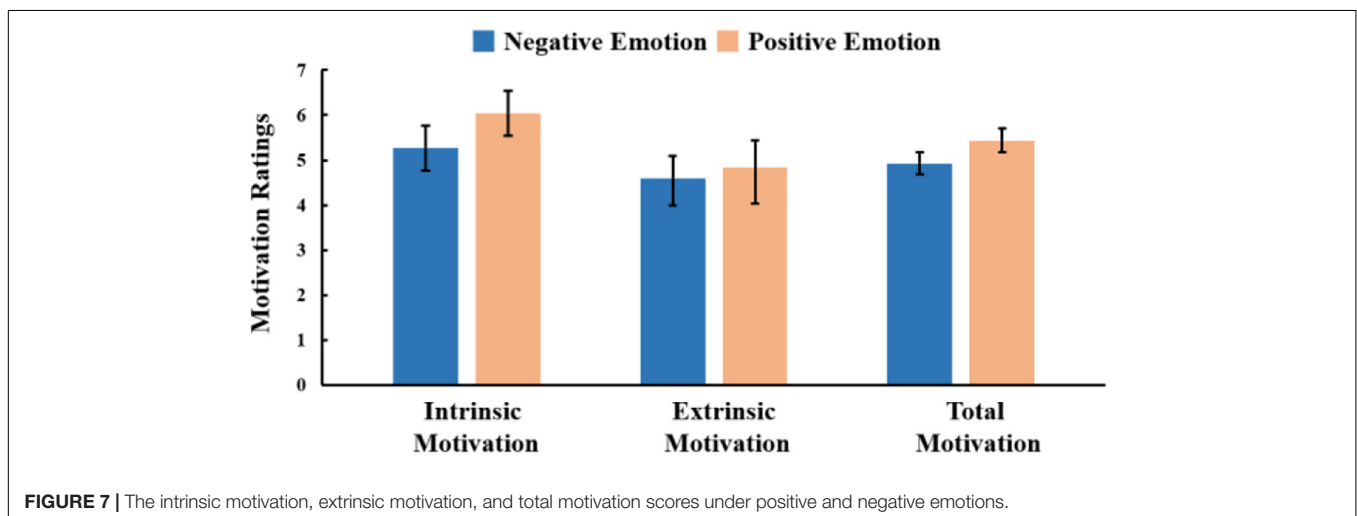
positive emotions are significantly higher than the values under negative emotions ( $p < 0.01$ ). In addition, the PSD features are significantly different for the beta-band of the temporal lobe. The feature values under positive emotions are significantly higher than those under negative emotions ( $p < 0.001$ ). Similarly, as shown in **Figure 6**, for the gamma-band of the temporal lobe, the values of the features under positive emotions are also significantly higher than the values of negative emotions.



**FIGURE 4** | The experimental design of our study.



**FIGURE 6 |** Spectral power of theta, alpha, beta, and gamma bands under positive and negative emotions.



**FIGURE 7 |** The intrinsic motivation, extrinsic motivation, and total motivation scores under positive and negative emotions.

## Analysis of Learning Motivation Under Positive and Negative Emotions

To study the level of extrinsic motivation, intrinsic motivation, and total motivation under different emotions, we use the non-parametric Wilcoxon signed-rank test that was conducted on each of the six items on the learning motivation scale.

The descriptive results are shown in **Figure 7**. Only intrinsic motivation has a significant difference between positive and negative emotions ( $p < 0.01$ ). Subjects have greater determination and motivation to complete learning tasks under positive emotions. Regarding extrinsic motivation and total motivation, positive emotions and negative emotions have no

significant difference. We believe the reason for this phenomenon is that most of the subjects use VR as learning material for the first time, and they are generally excited. Therefore, in future work, we will let the subjects familiarize themselves with VR before the experiment begins. This kind of “warm-up” session may help eliminate the “first excitement.” Even if they have negative emotions, they can still maintain sufficient motivation to participate in the learning task. This result supports Hypothesis 2. It is also evident from the study that the novelty of virtual reality technology as a multi-sensor user interface promotes learners’ motivations by representing personality traits, engaging media, and stimulating dialogue (Huang et al., 2010).

**TABLE 3 |** The mean flow experience, immersion ratings, and standard deviations under negative and positive emotions.

Score	Condition	<i>n</i>	Mean	<i>SD</i>
Flow experience	Negative emotion	24	3.750	0.386
	Positive emotion	24	4.196	0.793
Immersion	Negative emotion	24	3.928	0.788
	Positive emotion	24	4.250	0.537

## Analysis of Flow Experience Under Positive and Negative Emotion

We also examined the influence of 24 subjects' flow experience under positive and negative emotions. The results are shown in Table 3, the average total flow experience score is 4.196 ( $SD = 0.386$ ) for positive emotions, and 3.750 ( $SD = 0.793$ ) for negative emotions. The results of the non-parametric Wilcoxon signed-rank test show a significant difference in the flow experience under these two emotional states ( $p < 0.05$ ).

## Analysis of Immersion Under Positive and Negative Emotions

The influence of 24 subjects' immersion under positive and negative emotions is also shown in Table 3. It can be seen that the average total immersion score is 4.250 ( $SD = 0.537$ ) for positive emotions and 3.928 ( $SD = 0.788$ ) for negative emotions. Also using the non-parametric Wilcoxon signed-rank test, the results suggest that there is no significant difference in the immersion under these two emotional states. The reason for this result is that the subjects watched the video learning materials from the first perspective, and the immersion in VR is generally high. Therefore, positive emotions and negative emotions have little effect on the subjects' immersion experience.

## Relation Analysis of Emotion and Motivation, Flow Experience, and Immersion

To study whether positive and negative emotions are related to motivation, flow experience, and immersion. We analyzed the Spearman correlation coefficients between the valence scores and total motivation, flow experience, and immersion scores of 8 videos. Valence scores are used as the independent variables,

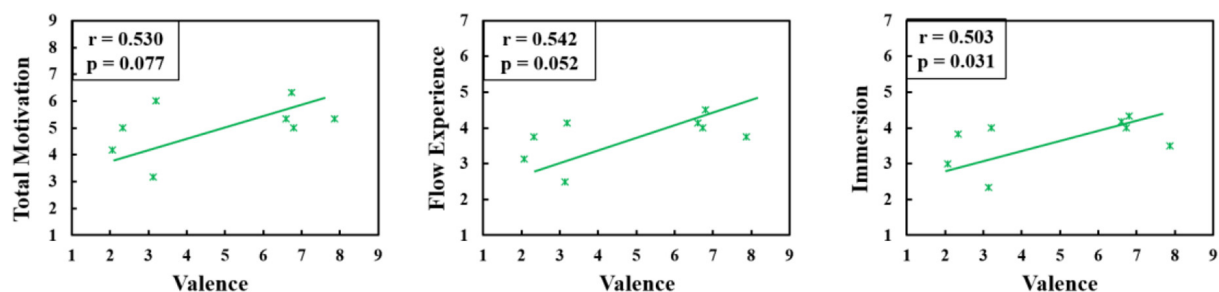
and three experience scores are used as the dependent variables. As shown in Figure 8, there is a certain correlation between the valence and the three experience scores. With the increase in video valence scores, the three experience scores also show an increasing trend. Among them, the Spearman correlation coefficients between the valence and a specific experience score are  $r = 0.530$  for the total motivation,  $r = 0.542$  for the flow experience, and  $r = 0.503$  for the immersion, respectively. This result supports Hypothesis 3.

## Analysis of Interviews

The researcher used both unstructured and semi-structured interviews with college students majoring in geography. In general, learners had good feedback on the VR immersion learning approach.

In terms of learning content, learners generally found that they could learn and understand the knowledge in a more specialized lesson using the VR immersion learning method of teaching. Students had a strong visual experience of learning this component through VR immersion learning. When they recalled the course content, they said that they could make a connection between the text content of the lecture and the virtual reality video, so it created a deep memory, which was helpful for them to review the knowledge of the lesson and learn new knowledge. This has similar findings to a previous study by Rauch (2007) who concluded that "realistic, interactive digital characters, as instructors and role-players, have been shown to significantly increase learner motivation and retention." This study supports these findings, as students expressed that VR immersion learning experience improved their comprehension, sequencing, and recall of abstract concepts (Alfalah et al., 2019). Essentially, both personal and emotional stories engage the brain and are therefore easier to remember than just stating facts. They expressed strong interest in using this approach to learn again if given the opportunity.

In terms of learning methods, in the previous geography learning, students acquired indirect experience based on textbooks and teachers' words, and they found it difficult to understand the acquisition of direct experience which was often difficult to achieve due to the teaching conditions and class time constraints. Students indicated that the VR immersion learning approach allows direct and indirect experiences to be blended, with much less restrictive factors than the traditional learning

**FIGURE 8 |** The Immersion scores under positive and negative emotions.

methods to which they are normally subjected. Learners can access diverse information from multiple sources in such an environment, thus maintaining a sense of enjoyment, focus, control, and immersion in learning.

Furthermore, a small proportion of students also presented a negative review of the VR immersion learning experience. Specifically, as Suh and Prophet (2018), a few students reported similar findings citing immersive technology did not always create a positive learning experience and this study caused motion sickness to them. It is thus necessary to determine what features of the VR immersion learning experience influenced the participants' viewing behavior and the degree of emotional arousal and specific triggers for motion sickness.

## DISCUSSION

### Presents an Immersive Virtual Reality Geography Landscape That Mobilizes a Positive Experience in the Geography Classroom

Firstly, virtual reality immersive geography teaching could eliminate the distance between students and the geography environment. The distant geographic landscape becomes accessible to meet the curiosity and fascination of students with different geographic scenery. Secondly, through virtual reality technology, students immerse themselves in the visual, auditory, and other senses into the realities of different landscapes and fully experience the gorgeous, dreamy, and strange geographical landscapes. At the same time, these sensory triggers can help the listeners/viewers of the stories understand the nature of complex concepts and ideas in a more accessible and effective manner (Storr, 2020). Through data analysis, it is found that immersive geography learning is a teaching tool that elicits an emotional response and captures students' attention, thus stimulating their interest in learning. In addition, we found that positive emotions elicited more interest, motivation, and immersion in learning than negative emotions during the learning process.

### The New Method Measures Emotional Perception During Learning

Although the emotional feelings of learners can be measured to some extent by questionnaires, they are considered less objective and trustable (Muir et al., 2016). The study attempts to measure the learner's process emotions through EEG expression analysis to expand the understanding of the learner's emotions in multimedia learning. The relationships between negative emotions, positive emotions, and brain waves were found by recording the brain waves of the learners throughout the entire learning process. This study has shown that brain wave characteristics in positive emotions are significantly higher than those in negative emotions. This is consistent with previous research studies in psychology. Klimesch has demonstrated that the alpha band can reflect the brain's attention processing

when performing tasks (Huang et al., 2010). People tend to be more relaxed under positive emotions, so their alpha band will have a greater response. The research done by Cole and Ray (1985) has also shown that the beta and gamma bands have higher energy responses when the brain processes positive emotions.

### New Teaching Methods Are Created to Broaden the Scope of Teaching Virtual Reality Immersive Geography Learning

Several recommendations concerning the implementation of VR immersive geography learning as an active pedagogy can be made using the findings of this pilot study. The exploratory pilot study addresses the gap in the literature examining the application of immersive VR geography learning as an active pedagogy in geography education. One of the biggest challenges facing instructional designers of virtual reality learning environments is how to integrate virtual reality features into lessons to motivate students' learning (Cole and Ray, 1985). With the increasing abundance of personalized instructional resources, more knowledge and skills can be placed in immersive virtual reality learning to enhance learners' mind-flow experiences by including more elements in instructional scripts that induce positive emotions, instructional designs that enhance positive emotions and motivation, and focus on multichannel and multimodal cognitive loads.

## CONCLUSION

In this research, we conducted an empirical study about the influence and effect of the novel immersive VR learning, by comparing EEG waveforms and emotion evoked among different learners. The study found that the positive emotional clues produced during VR immersive learning did trigger the change in the learner's mood. The comparison concludes that this instructional approach can significantly enhance learners' motivation, mind-flow experience.

However, this study did not measure the learning effect, and it is impossible to show through quantitative data that this type of teaching method can improve the learning effect of learners. We also need to design an assessment paper or scale specifically to evaluate the teaching effectiveness of this type of teaching method in future research, to conduct a more scientific learning assessment. Virtual reality technology can be applied to the broad scope of earth science research, such as architecture, geographic information, town planning, digitalization, and natural science. VR's application in earth sciences helps people better understand nature and improve their quality of life. Building realistic virtual models can give people feedback and allow them to make timely improvements and fixes to nature, achieving a win-win situation for both people and earth sciences. However, most of the existing apps are not designed and optimized for learning and teaching purposes. They are limited to passive viewing experiences, or



lack well-developed story structures (Shih and Yang, 2008). The design of emotional cues based on VR immersive learning is still an open research topic. Specifically, some research questions still need to be properly investigated and addressed in the future, such as choosing the frequency and timing of emotional clues transmission, improving learners' learning motivation and flow experience through emotional design, etc.

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

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## ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Beijing Normal University. The patients/participants provided their written informed consent to participate in this study.

## AUTHOR CONTRIBUTIONS

YS: write the thesis, organize, and coordinate. ZW: write the thesis and literature research. ML and JY: data analysis. YG: data analysis and literature research. All authors contributed to the article and approved the submitted version.

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# An Empirical Study on the Improvement of College Students' Employability Based on University Factors

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### Specialty section:

This article was submitted to  
Educational Psychology,  
a section of the journal  
Frontiers in Psychology

**Received:** 12 October 2021

**Accepted:** 02 February 2022

**Published:** 07 March 2022

### Citation:

Zhang Y-C, Zhang Y, Xiong X-L,  
Liu J-B and Zhai R-B (2022) An  
Empirical Study on the Improvement  
of College Students' Employability  
Based on University Factors.  
Front. Psychol. 13:793492.  
doi: 10.3389/fpsyg.2022.793492

With the popularization of higher education and the promotion of college enrollment expansion, the number of college graduates increases sharply. At the same time, the continuous transformation and upgrading of the industrial structure put forward higher requirements on the employability of college students, which leads to the imbalance between supply and demand in the labor market. The key to dealing with employment difficulties lie in the improvement of college students' employability. Therefore, we make a regression analysis of 263 valid samples from universities in Anhui Province and extract the factors that influence the improvement of college students' employability in the process of talent cultivation in university. The result shows that there is a positive correlation between course setting, course teaching, club activities, and college students' employability, among which the course teaching and club activities are the most critical factors which may influence college students' employability. In addition, from the viewpoint of individual college students, the overall grades of college students and the time of participating in the internship are also closely related to their employability, i.e., college students with good overall grades and long internship time should also have stronger employability.

**Keywords:** course setting, course teaching, club activities, employment guidance, college students' employability

## INTRODUCTION

Along with the popularization of higher education and the promotion of college expansion, the number of college graduates in China has shown explosive growth. According to statistics, the number of college graduates in China will be as high as 8.74 million in 2020 (Source: China Statistical Yearbook 2020). At the same time, the transformation and upgrading of China's industrial structure and the improvement of production methods have put forward newer and

higher requirements for the quality and ability of college graduates. Therefore, an “employment gap” has been left in the labor market, i.e., college graduates cannot find suitable jobs and enterprises cannot recruit suitable talents. To solve the employment difficulties of college graduates, it is crucial to improve the employability of college students. Employability is an important element of talent training in universities and a key indicator of the quality of higher education training, and a core competency that the supply side of the labor market should have (Abd Majid et al., 2020; Misni et al., 2020). Qian Weichang, an academican of the Chinese Academy of Sciences, held the opinion that higher education institutions should focus on cultivating college students’ self-learning ability, practical ability, and the ability to acquire knowledge and that efficient teachers are crucial in the teaching process (Chen, 2020). Therefore, based on the perspective of the university, we explore the factors influencing the employability of college students. It is of great practical significance to enhance the employability of college students and improve the difficult employment situation.

## LITERATURE REVIEW

### Employability Study

Up to now, scholars have not reached an academic consensus on the definition of employability, and the representative view is that employability is a person’s ability to obtain a job and become employed, maintain employment, and re-enter employment for various reasons, including factors affecting employability such as knowledge, skills, and attitudes (Hillage and Pollard, 1998; Harvey, 2001). College students can improve their employability through independent study and social practice (Meyer and Benguerna, 2019; Pitan and Muller, 2019). With the rapid development of the global economy, talent is becoming an increasingly scarce resource, which has contributed to the general focus on employability in twenty-first century society (Nicholas, 2018; Pitan and Muller, 2019).

### Employability Structure

The denotation and connotation of “employability structure” have not been clearly defined by scholars. The more recognized USEM model, proposed by the British scholar’s Knight and Yorke, includes comprehension of professional and subject knowledge, acquisition of professional and general skills required for the job, and self-efficacy including personal qualities, self-confidence, enjoyment of learning, and metacognition that reflects strategic responses and thinking (Small et al., 2018). Zheng (2002), a professor at Tsinghua University, classified college students’ employability into five dimensions: learning ability, thinking ability, practical ability, job application ability, and adaptability. Based on the USEM model, Shi and Wang (2018) proposed that employability includes four aspects: subject comprehension, basic skills, self-efficacy, and metacognition. This study proposes the composition structure of college students’ employability, including professional knowledge and skills, learning ability, adaptability, practical ability, communication

ability, teamwork ability, information acquisition ability, and career planning ability.

### Factors Influencing Employability

There are also many studies on the factors influencing the employability of college students. Some scholars believed that employability has a strong correlation with individual factors. For example, Zhu (2014) investigated 327 high-tech enterprises in Zhejiang Province as a sample and used the *t*-test to conclude that college students’ employability is closely related to individual learning ability and innovation ability. Peng (2014) investigated the graduates of five colleges and universities in Nanchang, empirically analyzed the influencing factors of college students’ employability by using econometric modeling, and found that social practice activities and work practice had a significant positive influence on college students’ employability. Lu et al. (2017) investigated college students in six universities in Tianjin and used the structural equation modeling method to reveal the factors influencing college students’ employability, and confirmed that personal traits, professional quality, and social adaptability had a strong positive relationship with college students’ employability, while basic skills had a positive relationship with college students’ professional quality. Other scholars argued that employability is closely related to the factors of colleges. For example, Tan (2014) combed through the relevant literature and pointed out that the key point to enhance the employability of college students is the higher education model. Based on the CareerEDGE model, Tang et al. (2015) surveyed 236 fresh university graduates in economics and management, 101 staff members of employers, and 89 university faculty members, and found that there are five core factors influencing graduates’ employability, such as “strong ability to adapt to the environment” and two short-term factors influencing job search, such as “self-presentation ability.” The survey shows that there are differences in the perceptions of students’ employability among university teachers, students, and employers. Zhang et al. (2018) empirically analyzed the influence of the cultivation mechanism of colleges and universities on the employability of college students by establishing a mathematical model.

In summary, scholars have studied the concept of employability of college students and the influencing mechanism from different perspectives and achieved certain research outcomes. However, by combing through the literature, we find some limitations. First, employability dimensions generally lack a theoretical foundation, and the logical relationship between employability dimensions and definitions of employability is not strong. Second, the conceptualization of college students’ employability is inconsistent, and studies on information acquisition and career planning skills in the employability dimension are rarely seen. Third, the antecedent variables of college students’ employability are inconsistent, and few studies consider the factors of club activities and employment guidance. Fourth, although some scholars pointed out that higher education influences college students’ employability, most of them focused on theoretical elaboration, few of them used empirical analysis to verify whether there is a positive correlation between higher education and college students’



employability and what college factors have a more significant effect on improving college students' employability. Therefore, based on the perspective of colleges and universities, this article proposes four factors that affect college students' employability: course setting, course teaching, club activities, and employment guidance. By obtaining data through questionnaires, we empirically analyze the correlation between the aforesaid factors and college students' employability and investigate which factor has the most critical influence on improving college students' employability.

## THEORETICAL BACKGROUND AND RESEARCH HYPOTHESIS

In this study, we divide the college factors into four aspects: course setting, course teaching, club activities, and employment guidance, and analyze their effects on the improvement of college students' employability.

### Prediction of Course Setting on College Students' Employability

Human capital theory suggests that the increase in human capital, such as human knowledge and skills, far exceeds the contribution of labor resources to social and economic development. Education is the most effective investment for individual capital appreciation, and by continuously acquiring knowledge in learning and practice, one can effectively improve his employability (Leonardi and Chertkovskaya, 2017). Therefore, the reasonable setting, of course, is an effective way to improve the input-output ratio of college students' human capital, which has an important impact on the employability of college students. Considering the above background, we put forward the following hypotheses.

Hypothesis 1: The rationality of college course setting has a positive contribution to the improvement of college students' employability.

### Prediction of Course Teaching on College Students' Employability

The course setting is the teaching plan of universities, while course teaching is the implementation of the teaching plan. The key to course teaching lies in the enhancement of teaching quality and the investment of teachers' time and energy. For one thing, the quality of teaching in college courses is fundamental to the improvement of students' employability, and some studies have shown that the stricter the quality control of teaching, the more knowledge students acquire (Wu et al., 2019). For another, the more time and energy teachers invest in teaching (e.g., helping students answer questions and solve problems, and handling student assignments on time), the better they can promote the teacher-student interaction, which can stimulate students' interest in learning and improve their independent learning. Garnett (2014) have shown that the more enthusiasm teachers invest in teaching and the more time they spend helping students answer questions and solve problems, the more knowledge and

skills students will acquire. Based on the previous discussion, we put forward the following hypotheses.

Hypothesis 2: The teaching of college courses has a positive contribution to the improvement of college students' employability.

### Prediction of Club Activities on College Students' Employability

Club activities are an important form of practical education for college students and a complement to theoretical education in universities. Social capital theory suggests that people acquire tangible and intangible resources at the individual, group, and organizational levels through social interactions and connections with others. One of the key ideas of the theory is that social capital resources are embedded in the social networks of interconnected individuals, groups, or organizations and can be accessed through social networks of relationships. As a social organization on campus, the college club assumes the role of building bridges for communication and exchange. Therefore, college clubs can be seen as a kind of social capital. Club activities can provide more opportunities for students to communicate and exchange ideas, and bring them a stable social relationship. When college students participate in social activities, they can deepen their understanding of theoretical knowledge and transform it into practical skills for work. Furthermore, they can strengthen their communication with others and enhance their sense of cooperation. Some studies have shown that college students who regularly participate in club activities have better communication skills (Buckley and Lee, 2021). In addition, participation in club activities, especially college-enterprise cooperation, gives college students more opportunities to get in touch with the outside society and know more about job-hunting, corporate recruitment needs, and the workplace environment. By having extensive contact and communication with society and making full use of the information gained in the job-hunting process, college students can increase their success rate in employment. From the above discussion, we put forward the following hypothesis.

Hypothesis 3: College club activities have a positive contribution to the improvement of college students' employability.

### Prediction of Employment Guidance on College Students' Employability

Employment guidance includes a series of employment services, such as career training courses, career seminars, CV guidance, and so on, provided by colleges to enhance the success rate of employment. Nowadays, colleges have set up career planning offices and employment guidance centers. The influence of the establishment of employment guidance institutions on the employability of college students also belongs to the research scope of social capital theory. Social capital theory suggests that individuals exist in social networks and have distinctly strong and weak relationships with members of the organizations in the network. Strong relationships in networks refer to a strong homogeneity of network members, i.e., a convergence of

opinions held by groups of people in social interactions, a close relationship between people, and a strong emotional element that sustains them. Therefore, strong relationships are a very favorable channel for job hunting. The counterpart to strong relationships is weak relationships, and although they are less stable than strong relationships, they are broader in scope and still have a more important impact on the job-hunting channel.

Currently, most college students obtain job-hunting information through the Internet or the job market. Although this formal channel can bring more job opportunities for college students, there are some specific problems such as low employment quality, rate, and efficiency. Conducting employment guidance activities is an important way of making recommendations for college students, aiming at providing high-quality employment information and broadening their employment channels. This informal job search channel can provide college students with high-quality employment opportunities (Pitan and Atiku, 2017; Lu, 2019; Okolie et al., 2020). We put forward the following hypotheses.

Hypothesis 4: College employment guidance has a positive impact on the improvement of college students' employability

## RESEARCH DESIGN AND RESULTS ANALYSIS

### Questionnaire Design and Data Collection

To ensure the credibility of the questionnaire, the questionnaire design was analyzed in detail before the survey, and scholars were invited to revise the presentation and wording of the questionnaire. To ensure the reliability of the questionnaire, a small-scale preliminary test (exploratory factor analysis) was conducted, the questionnaire was analyzed and revised to address the issues revealed during the test.

After the pilot test, the authors started the formal questionnaire survey. To ensure the validity and timeliness of the questionnaire distribution, we used the resources of the college and distributed paper questionnaires in different colleges. Meanwhile, we also handed out the questionnaire online by using the "Wenjuanxing" platform. The time span of the questionnaire distribution was from August to November 2020, which lasted for 3 months in total. In this article, undergraduates from Anhui provincial universities, namely, Anhui University, Hefei University of Technology, and Hefei College, were the main research subjects (sample data). A total of 1,000 college students were selected as the sample of this study. A total of 293 questionnaires were collected, and 266 valid responses were obtained by eliminating those with missing values or irregularities, resulting in a valid response rate of 26.6%. To ensure that this study was not affected by non-response bias, we divided the responses into two parts, including early responses and late responses, and compared the differences in age, gender, and family background between the two parts of the

questionnaire respondents. The results showed that there was no non-response bias.

### Variable Measurement and Reliability and Validity

Reliability refers to the degree of consistency in the results obtained when the same method is used to measure the same object repeatedly. Validity refers to the degree to which a measurement instrument can accurately measure something, and the higher the validity, the better the item reflects the content being examined. Therefore, to accurately analyze the influence of the four factors of course setting, course teaching, club activities, and employment guidance on students' employability, we need to conduct reliability and validity analyses on the data obtained from the questionnaire. All variables in the questionnaire were measured by 5-point Likert scales ranging from 1 (strongly disagree) to 5 (strongly agree). The factor load of each variable was obtained by Anderson-Rubin's factor analysis method, and the reliability threshold was used to represent the scale reliability ( $\alpha > 0.6$ ).

### Employability

As there is no standardized scale for measuring employability, this article draws on the mainstream literature (McQuaid, 2005) and summarizes previous research to propose a scale for measuring employability. The scale consists of eight secondary dimensions: professional knowledge and skills, learning ability, strain ability, practical ability, communication ability, teamwork ability, information acquisition ability, and career planning ability, which can truly reflect both the employability and overall quality of college students. To further ensure that the employability scale can reflect the employability of college students accurately, 10 college students were invited to be interviewed, after the first batch of questionnaire revision, and analyzed and verified the validity of the employability scale.

The abovementioned 10 respondents assessed each of the employability questions on a scale of 1–4 (1 = not relevant, 2 = somewhat relevant, 3 = very relevant, and 4 = highly relevant). Subsequently, in this article, the content validity index (CVI) is used to assess the validity of the employability scale by judging the results given by the college students interviewed (Sirén et al., 2012).

In terms of validity, the CVI values for each of the eight secondary-level dimensions of the employability scale were above the set threshold of 0.8. In terms of reliability, the Cronbach's alphas for all eight secondary-level dimensions of the employability scale were greater than 0.7, and the overall Cronbach's alphas for the scale was 0.823. The factor loadings were in the range of 0.606–0.806 which exceeds the minimum threshold of 0.6 (Sirén et al., 2012). The previous data indicate that the reliability of the employability scale is satisfactory. The employability scale is shown in **Table 1**.

### Course Setting

Based on the planning of the college course setting, referencing the literature (McLean et al., 2016), this article adopts ten question items to measure the overall situation of the course

**TABLE 1 |** Employability scale.

Variable name	Number	Item	Cronbach's alphas
Professional knowledge and skills	1	Communicate with others in English fluently	0.731
	2	Knowledge of laws and regulations	
	3	My professional knowledge and skills are firmly mastered	
	4	I have obtained professional certificates of computer	
Learning ability	1	In the conflict between study and entertainment, I will give priority to study.	0.828
	2	Ability to apply professional knowledge and skills.	
	3	I can learn without supervision.	
	4	I can study hard even if I do not like the course.	
Strain ability	1	No matter how the external environment changes, I can adapt quickly.	0.799
	2	I can handle emergencies with ease.	
	3	I am able to adjust my mindset in time.	
Communication ability	1	I can always communicate well with others.	0.808
	2	I can organize my words and express my ideas accurately.	
	3	I can understand other people's feelings and communicate emotionally.	
Practical ability	1	I can effectively use my knowledge, skills and experience to solve problems.	0.882
	2	I can flexibly use what I have learned to deal with problems.	
	3	I can learn from experience and lessons in practice.	
	4	When encountering difficulties, I can combine my professional knowledge to deal with them.	
Teamwork ability	1	I can solve tough problems as a team.	0.836
	2	In order to ensure the smooth solution of the problems, I will seek the opinions and suggestions of team members.	
	3	I will effectively cooperate with the team to complete the task.	
Information acquisition ability	1	Access to information through multiple channels.	0.897
	2	Be able to accurately grasp the key to information.	
	3	Ability to listen attentively and capture important information of a conversation.	
Career planning ability	4	Can filter out false information in the mass of information.	0.802
	5	Ability to quickly and comprehensively analyze information.	
	1	It is believed that good career planning ability can improve the success rate of job-hunting.	
	2	Have a clear plan for your future career development.	
	3	Have a career plan that promotes self-development.	

setting. The questions evaluate the rationality of the course setting in terms of its specialization, knowledge coverage, course system, and course frontiers. The Cronbach's alpha of the scale was 0.946 and the range of factor loadings was 0.691–0.831. The data showed that the reliability of the course setting scale was satisfactory. The course setting scale is shown in **Table 2**.

### Course Teaching

Based on the current situation of college course teaching and the relevant literature (McLean et al., 2016), this article adopts six questions to measure the basic situation of course teaching. The relatively comprehensive question items evaluate the rationality of course teaching in terms of the instructor's commitment to the course, efficiency in dealing with problems, and the instructor's length of service. The Cronbach's alphas of the scale were 0.908 and the factor loadings ranged from 0.676 to 0.856. The data results showed that the reliability of the course teaching scale was qualified, and the course teaching scale is shown in **Table 3**.

### Club Activities

Based on the performance of college students' club activities and the reference literature (Graupensperger et al., 2020), this article

**TABLE 2 |** Course setting scale.

Variable name	Number	Item
Course setting	1	The scope of knowledge covered by specialized courses.
	2	The degree of implementation of practical lessons.
	3	The degree of crossover and integration between specialized disciplines.
	4	The reflection of English instruction to the demand of current social employability.
	5	The degree of emphasis on the combination of theory and practice in practice courses.
	6	The amount of network equipment and the openness of the computer lab.
	7	The degree of enrichment of professional courses and basic theories.
	8	The effectiveness of practical courses in improving comprehensive ability.
	9	The utilization of laboratories and training grounds.
	10	The content of specialized courses is related to the development of the discipline and the cutting-edge trend.

**TABLE 3 |** Course teaching scale.

Variable name	Number	Item
Course teaching	1	Teachers' stimulation of students' interest in learning during the teaching process.
	2	The attitude and efficiency of college teachers in dealing with teaching accidents.
	3	Effective use of teaching cases in the course of teaching.
	4	The timeliness of teachers' correcting of and feedback on students' homework.
	5	The number of years of English and computer teaching.
	6	Teachers' commitment to teaching.

adopts four questions to measure the basic situation of college club activities. The question items assess club activities in terms of the diversity and importance of clubs. The Cronbach's alphas of the scale were 0.884 and the range of factor loadings was 0.812–0.898. The data results showed that the reliability of the club activity scale was satisfactory and the club activity scale is shown in **Table 4**.

### Employment Guidance

Based on the performance of college employment guidance and concerning relevant literature (Andrews and Higson, 2008), this article adopts four question items to measure the basic situation of employment guidance. The question items assess employment guidance in terms of the assessment methods of employment guidance, the soundness of career service providers, and career services. The Cronbach's alphas for the scale were 0.889 and the factor loadings ranged from 0.788 to 0.859. The results of the data indicated that the reliability of the employment guidance scale was satisfactory. The employment guidance scale is shown in **Table 5**.

### Control Variables

To control the possible endogeneity problems in the study and to enhance the robustness of the findings, individual college students are introduced as control variables in this article. Previous research has shown that college students as individuals have some specificities, such as whether they are class leaders or not, and their grade ranking, which can affect their performance in future employment. Therefore, in this article, the student's family background, overall grade ranking, internship duration, and class cadre status are used as control variables. The control variables of class cadre status are coded through dummy variables, where 1 means being a class cadre and 0 means not being a class cadre (class cadre status is used as the baseline variable for not being a class cadre). Overall grade

ranking, family status, and internship status are measured using continuous variables.

## Data Analysis

### Descriptive Statistics

**Table 6** shows the descriptive statistics of the survey sample information. From **Table 6**, it can be seen that 92.1% of the sample members are under 25 years old. A total of 41.4% of the respondents were male and 58.6% of the respondents were female. Of the 266 graduates surveyed, 47% had an overall ranking in the top 25% of their class, 36% had an overall ranking between 25 and 50% of their class, 16.5% had an overall ranking between 50 and 75% of their class, and only 4.9% had an overall ranking below 75%. In addition, 56.8% of the students were class cadre at colleges.

### Validity and Correlation

In this article, we further analyzed the validity of each variable based on the reliability of the questionnaire. Validity is divided into convergent validity and discriminative validity, the former referring to the degree of similarity of the same feature measured by different measurement methods, and the latter indicating that when different methods are used to measure different constructs, the observed values should be able to be distinguished. First, to test the convergent validity of all the independent and dependent variables, this article used the statistical software PLS to test the average variance extracted (AVE) values of each variable. The results of the test showed that the AVE values of all variables were above 0.6, which was higher than the minimum threshold of AVE, indicating that the aggregated validity of each variable was good. Second, the discriminant validity of the variables was tested in two ways: the competitive model and the pairing combination method. The competitive model combines four independent variables and one dependent variable randomly into single-factor, two-factor, three-factor, four-factor, and five-factor models, and compares the goodness of fit of different factor models. The results in **Table 7** show that the goodness of fit indicators of the five-factor model are better than those of other factor models, which indicates that the goodness of fit

**TABLE 4 |** Club activities scale.

Variable name	Number	Item
Club activity	1	The effectiveness of the college's club activities.
	2	The diversity of club organizations.
	3	The college's support of and emphasis on club activities
	4	Effectiveness of club activities in improving the corresponding competencies.

**TABLE 5 |** Employment guidance scale.

Variable name	Number	Item
Employment guidance	1	Assessment methods for employment guidance courses.
	2	Soundness and completeness of the employment service institutions.
	3	Publicity and interpretation of the college's employment situation and employment policies.
	4	Guidance on interview techniques and CV preparation.

**TABLE 6 |** Sample description.

	Characteristic	Frequency	%
Score ranking	The top 25%	125	47
	25–50%	84	31.6
	50–75%	44	16.5
	Less than 75%	13	4.9
Gender	Male	110	41.4
	Female	156	58.6
Family background	Poor	44	16.5
	General	207	77.8
	Good	15	5.6
Class cadre	Yes	151	56.8
	No	115	43.2
Major	Arts	159	59.8
	Science	107	40.2



of the model separated from each variable is the best. From the perspective of the pairing combination method, this study conducted arbitrary pairing for five major variables and used the chi-squared test to distinguish the goodness of fit between different pairing models. Two models are established for each pair of variables by the structural equation model: the restrictive model with fixed covariance of 1 and the non-restrictive model without fixed covariance. The results showed that the fitting index of the unconstrained model was significantly better than that of the constrained model ( $P < 0.001$ ). At the same time, PLS fitting test results of the structural equation model showed that the fitting degree of the model was good ( $\chi^2/df = 1.821$ ,  $CFI = 0.943$ ,  $TLI = 0.924$ ,  $SRMR = 0.042$ ,  $RMSEA = 0.045$ ). To sum up, the variables involved in this article have good validity.

Based on the above research, this article analyzed the correlation between variables. **Table 8** shows that there is a significant correlation between course setting, course teaching, club activities, employment guidance, and employability. This result tentatively verifies that course setting, course teaching, club activities, and employment guidance have a positive impact on employability. In addition, the results show that there is a significant correlation between variables, and the correlation coefficients are all lower than 0.6, which indicates that there is no multicollinearity problem in the analysis process of hypothesis testing in this study.

### Hypothesis Testing

To objectively and accurately analyze the influence of college factors on the employability of college students, we added four control variables: family situation, overall grades, internship duration, and class cadre. The impact of different college factors on the employability of college students was analyzed. The specific results of the regression analysis are given in **Table 9**.

First, the control variables were added to Model 1, and the results showed that internship duration ( $\beta = 0.281$ ,  $P < 0.01$ )

and overall grades ( $\beta = 0.113$ ,  $P < 0.01$ ) had a positive effect on the employability of college students, and the effective coefficient of internship duration was greater than that of overall grades. In Model 2, course setting was added as an independent variable, and the results showed that course setting had a significant positive effect on employability ( $\beta = 0.272$ ,  $P < 0.01$ ), i.e., the more reasonable course setting was, the stronger the employability of college students was. Hypothesis 1 was supported. In Model 3, course teaching was added as an independent variable, and the results showed that course teaching also had a significant positive effect on employability ( $\beta = 0.311$ ,  $P < 0.01$ ), i.e., the higher the level of college course teaching, the stronger the employability of college students. Hypothesis 2 was supported. In Model 4, club activities were added as an independent variable, and the results showed that club activities also had a significant positive impact on the employability of college students ( $\beta = 0.304$ ,  $P < 0.01$ ). When club activities were more plentiful, there was a more significant increase in the employability of college students. Hypothesis 3 was confirmed. Model 5 added employment guidance and the results showed that college employment guidance activities also had a significant positive impact on college students' employability ( $\beta = 0.289$ ,  $P < 0.01$ ). College students' employability was strengthened with the improvement of employment guidance activities, and Hypothesis 4 was supported.

To further analyze the relationship between the main variables and the effect on the dependent variable, we conducted a regression analysis with the four main variables simultaneously as independent variables. The result shows that the influence coefficient of course teaching and employment guidance is still the highest, and the explanatory power of  $R^2$  reaches 20.6%. This shows that the overall influence of the principal variable on the dependent variable is unchanged.

### Common Method Bias

This article adopted two ways to avoid the common method bias: precontrol and postcontrol. In precontrol, the order of variables in the questionnaire was arranged randomly to ensure that respondents fill in the questionnaire anonymously. In postcontrol, all variables were analyzed by exploratory factor analysis mainly through the single-factor test, and the results showed that all factors accounted for 60% of the total variables. Therefore, there is no common method bias in this article.

## DISCUSSION

Based on human capital theory and social capital theory, this study investigated the influence of college factors on college students' employability, and the results show that among the university factors, course setting, course teaching, club activities, and employment guidance have a positive correlation with college students' employability, among which course teaching and club activities have the most critical influence on college students' employability. In addition, from the viewpoint of individual college students, the overall grades of college students, and the time of participating in the internship are also closely

**TABLE 7 |** Discriminant validity of constructs.

Model	$\chi^2/df$	RMSEA	CFI	TLI	SRMR
Five-factor	1.821	0.045	0.943	0.924	0.042
Four-factors	2.321	0.077	0.816	0.842	0.061
Three-factors	2.509	0.083	0.775	0.767	0.064
Two-factors	2.769	0.085	0.731	0.718	0.067
Single-factors	2.456	0.089	0.711	0.702	0.070

**TABLE 8 |** Correlation between variables ( $N = 266$ ).

	Average	Variance	1	2	3	4
1 Course setting	3.847	0.6902				
2 Course teaching	3.868	0.7235	0.325**			
3 Club activity	3.769	0.7453	0.439**	0.451**		
4 Employment guidance	3.844	0.7770	0.476**	0.378**	0.366**	
5 Employability	3.737	0.5779	0.446**	0.434**	0.342*	0.396***

\* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

**TABLE 9 |** Regression analysis.

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Internship duration	0.281**	0.101*	0.092*	0.101*	0.089*	0.081
Class cadre	0.124	0.098	0.088	0.079	0.081	0.077
Overall grades	0.113*	0.084*	0.099*	0.102*	0.096*	0.101*
Family background	0.063	0.059	0.047	0.058	0.066	0.045
Master variable						
Course setting		0.272**				0.252**
Course teaching			0.311**			0.301**
Club activity				0.304**		0.289**
Employment guidance					0.289**	0.264**
$R^2$	0.142	0.199	0.221	0.211	0.204	0.206
Adjustment of $R^2$	0.092	0.176	0.193	0.181	0.174	0.188
$F$	4.8732**	24.5672**	28.6793*	26.8432**	19.3827**	27.567**

The dependent variable for all the models in the table is the employability of college students. \* $p < 0.05$ , \*\* $p < 0.01$ .

related to their employability, i.e., college students with good overall grades and long internship time should also have stronger employability.

## Theoretical Implications

The main results of this study have several important theoretical implications.

First, the employability constructs of college students were inconsistent, and few pieces of literature included information acquisition ability and career planning ability into the employability dimension, which were included in this study. The results indicated that the employability constructs had good reliability and validity. Therefore, this study further argued for the logical relationship between the employability concept and the employability construct.

Second, the antecedent variables of college students' employability were inconsistent and using social capital theory, two antecedent variables were added to this study: club activities and employment guidance. The results showed that the coefficient of influence of club activities ( $\beta = 0.304$ ,  $P < 0.01$ ) ranked second after course instruction ( $\beta = 0.311$ ,  $P < 0.01$ ) on college students' employability, which indicates that club activities have a very important influence on college student's employability. College students' participation in club activities cannot only enhance their practical ability but also enhance their communication and teamwork ability, thus improving their employability. The coefficient of the influence of employment guidance on college students' employability ( $\beta = 0.289$ ,  $P < 0.01$ ) ranks third, which indicates that employment guidance is also important for college students' employability improvement. College students' participation in employment guidance activities can improve their ability of information acquisition and career planning, thus, enhancing their employability. Therefore, this study provides a new perspective for the study of employability and offers new research findings in this field.

Third, based on human capital theory, this study considered individual college students' factors, and the results showed that there was a positive correlation between individual college students' overall grades ( $\beta = 0.113$ ,  $P < 0.01$ ) and participation in internships ( $\beta = 0.281$ ,  $P < 0.01$ ) and college students'

employability. The more outstanding the overall performance of individual college students, the stronger their own employability. The longer the duration of participation in an internship, the stronger their own employability. The improvement of college students' overall performance was more closely related to the input of course teaching and the reasonableness of the course setting. Therefore, the research results also indirectly confirm the key role of course setting and course teaching in improving the employability of college students.

## Practical Implications

Based on the college perspective, this study explores the factors influencing the enhancement of college students' employability, and the findings have important practical implications for higher education.

First, the conclusion of the study points out that the rationality of the course setting helps to enhance the employability of college students. Therefore, the college should actively promote course reform and improve the course setting. For one thing, the course setting should be oriented to market demand, innovate talent training mode, and develop a forward-looking and practical course system. For another, scientific allocation of teaching time for basic college courses, professional courses, and practical courses is required. Among them, the professional course setting focuses on improving the professional skills of college students, and the social practice course setting focuses on improving the social practice ability of college students.

Second, this study concludes that the quality of course teaching helps to improve the employability of college students. Therefore, teaching quality control should be strengthened in the process of implementing the teaching plan. It is required to improve the course teaching process management and full management by the course teaching supervision office, from teaching faculty construction to course teaching implementation to teach quality assessment. Besides, it is necessary to improve the teachers' assessment system and increase the weight coefficient, of course, teaching quality assessment, so that teachers will devote more time and energy to course teaching work. In addition, the college should encourage teachers to adopt a variety of teaching methods for course teaching, avoid

indoctrination, and authoritative teaching mode, should focus on students' enthusiasm and initiative, and actively promote heuristic teaching mode, such as through case teaching, to shorten the emotional distance between teachers and students as much as possible.

Third, this study concludes that college students' active participation in club activities helps to improve their employability. Therefore, colleges should actively build platforms for club activities, college-enterprise cooperation, and social practice. For one thing, colleges should create a variety of club activities organizations to provide diversified choices for college students. At the same time, the college should actively carry out employment market research and build a college-enterprise cooperation platform according to the employment market demand, to provide more social practice opportunities for college students. For another, the college should improve the supporting facilities to ensure the benign operation of the practice platform. For example, it should improve the management system of clubs, provide funds for club activities, encourage students to participate in internships in the college-enterprise cooperation platform, and provide basic life support.

Fourth, this study concludes that college employment guidance activities help to enhance the employability of college students. Therefore, it is essential to improve the employment guidance system. For one thing, colleges should actively offer employability training courses, focusing on employment cognitive education, so that college students have a clearer understanding of the current employment situation and employment policies, plan their careers scientifically, and improve the comprehensive quality of college students' employment. For another, the college should introduce social power to carry out employment guidance activities, including senior human resource experts from large foreign-funded enterprises, state-owned enterprises, and scientific and innovative growing enterprises, who can give lectures and provide one-to-one employment guidance services.

## Limitations and Future Directions

This study has some limitations. First, the sample data of this study are only limited to Anhui provincial universities, which slightly limits the generalizability of our findings. Future research can further verify our findings by expanding the sample source and sample size and analyzing the generalizability and applicability of the findings in different situations.

Second, the construct measurement scales in this study are mainly generalized based on previous studies by referring to some mainstream journal literature. Although these scales passed a series of reliability and validity tests, some scales measure design indicators that are only qualitative but not quantitative, such as the employability secondary interview (1 = not relevant, 2 = somewhat relevant, 3 = very relevant, and 4 = highly relevant), and suffer from a lack of discrimination. Future research needs to further develop and validate the scales, especially in terms of content validity.

Third, the sample of this study has variability, especially the quality of the college students' group itself, and it is difficult to control effectively in the experiment. Therefore, the

regression model derived from this study is not very effective, such as  $R^2$  and univariate analysis are relatively low in terms of statistical significance. In fact, there are many factors influencing college students' employability, and this study only conducted a preliminary exploratory study on four factors: course setting, course teaching, club activities, and employment guidance.

Fourth, this study considers the initial employability of college students, and takes getting a job as the performance of employability but does not consider the quality of college students' employment. Future research focuses on the relevance of university factors to college students' employability and college students' employment quality.

## CONCLUSION

Based on human capital theory and social capital theory, this study explored the influence of university factors on college students' employability enhancement. The results show that among the university factors, course setting, course teaching, club activities, and employment guidance are positively correlated with college students' employability, among which course teaching and club activities have the most critical influence on college students' employability. In addition, from the perspective of individual college students, the overall grades of college students and the length of their internship are also closely related to their employability. In other words, if students have good overall grades and longer internship time, their employability will be stronger.

## DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

## AUTHOR CONTRIBUTIONS

Y-CZ proposed the research hypothesis and research design and analyzed the experimental data. YZ contributed to questionnaires and collected data. X-LX combed the literature. J-BL analyzed the experimental results. R-BZ designed the framework of the manuscript and discussed the experimental results. All authors contributed to the article and approved the submitted version.

## FUNDING

This study was funded by Research on the Construction and Path Exploration of Cooperative Governance Model for Multi-subject Emergency Response to Major Public Health Emergencies (2021zr001) and the Research on Cultivating College Students' Innovation Ability Under the Background of Digital Economy (IFQE202003), and Research on the Cultivation of Innovative Ability of Local Application-oriented College Students Based on the "Second Class Transcript" (SK2019A0750).

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# How Does Inequality Affect the Residents' Subjective Well-Being: Inequality of Opportunity and Inequality of Effort

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## OPEN ACCESS

### Edited by:

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### Specialty section:

This article was submitted to  
Personality and Social Psychology,  
a section of the journal  
Frontiers in Psychology

**Received:** 27 December 2021

**Accepted:** 21 February 2022

**Published:** 06 April 2022

### Citation:

He Q, Tong H and Liu J-B (2022)  
How Does Inequality Affect  
the Residents' Subjective Well-Being:  
Inequality of Opportunity  
and Inequality of Effort.  
Front. Psychol. 13:843854.  
doi: 10.3389/fpsyg.2022.843854

Based on the Chinese General Social Survey database (2010–2015), this article explores the relationship between income inequality and residents' subjective well-being from the perspective of inequality of opportunity and inequality of effort. We find that inequality of opportunity has a negative impact on subjective well-being in China, where inequality of effort has a positive impact. Our empirical results are robust for changing the inequality indicators. In the sub-sample studies, consistent conclusions are obtained in rural areas, whereas in urban areas only inequality of effort has a significant impact. The results of mechanism study show that inequality of opportunity decreases residents' sense of fairness, and inequality of effort increases residents' sense of fairness, thus affecting their subjective well-being. The results of this study provide a good response to the inconclusive research findings on the impact of income inequality on subjective well-being.

**Keywords:** subjective well-being, inequality, opportunity, effort, China

## INTRODUCTION

The ultimate goal of economic development in all countries is to improve residents' living standards and well-being. Earlier studies found that a country's higher gross domestic product does not necessarily mean its residents are happier (Easterlin, 1974). This particular economic phenomenon is known as the "Easterlin paradox" in academic circles. Since Richard Easterlin's prominent work, many researchers have examined the "Easterlin Paradox" in some high income countries (Clark et al., 2008; Starkauskienė and Galinskaitė, 2015; Antolini and Simonetti, 2019). These studies confirm an apparent contradiction in the data about whether happiness is a function of income. As showed by the Easterlin paradox, based on inter-individual and inter-nation (cross-sectional) income data, there is evidence that happiness is a function of income. But based on intra-individual (time series) comparisons over time spans of more than a decade, income is found to be ultimately unrelated to happiness (Khalil, 2019).

In addition to focusing on the relationship between income and happiness, many researchers try to explain the happiness-income paradox from the perspective of income inequality. But the research results are still inconclusive. A number of studies found that the income inequality has the negative impact on subjective well-being. Using aggregate data from all rounds of the European

and the World Values Surveys carried out between 1981 and 2004, Verme (2011) found that income inequality is negatively correlated with life satisfaction. Employing data from the European Quality of Life Survey (EQLS), Delhey and Dragolov (2014) believed that inequality can lead to distrust and status anxiety, which lowers the European's subjective well-being (SWB). Utilizing European Social Survey data from 29 countries, Hajdu and Hajdu (2014) similarly discovered that Europeans' subjective well-being increased as income inequality declined. Using two longitudinal data sets from 34 countries, Oishi et al. (2011) documented that income inequality is one of the reasons why subjective well-being does not increase with economic growth.

In contrast, some studies indicated that the income inequality has the positive impact on happiness. Clark (2003) found a significant positive correlation between subjective well-being and income inequality in the reference group. It seems to the respondents that income inequality implies opportunity in some way. Haller and Hadler (2006) found in the study that the inequality of Latin American countries was at high level among all countries in their samples, the residents' happiness in these countries was also at high level. Other studies showed a non-linear relationship between income inequality and happiness. Employing data from the China General Social Survey (CGSS), Wang et al. (2015) documented that there is an inverted-U shaped relationship between the income inequality and residents' happiness. Their empirical results are also supported by urban and rural sub-samples. Tavor et al. (2018) divided the Gini values into different ranges and found that at the extreme value of inequality measured by the Gini index, the effect of happiness is negative, while in the middle, the effect of index changes on happiness is ambiguous. Using data from CGSS, Ding et al. (2021) also found that there is an inverted-U shaped relationship between income inequality and subjective well-being for the urban residents.

The differences in research method, or in the selected samples may explain the differences in the relationship between the income inequality and subjective well-being described above. Actually, income gaps just reflect the inequality outcomes, which are associated with the residents' happiness. It does not mean the existence of income gaps between individuals is unreasonable. Inequality of opportunity may be the most important factor affecting the subjective well-being (He and Pan, 2011). With respect to the egalitarian philosophers, the distribution of justice does not mean the equality of individual outcomes, but requires that individuals own the equal opportunities to achieve valuable results. Equality of opportunity is the best explanation for equality as a distributive ideal (Arneson, 1989).

According to Roemer's research framework (1993, 1998), the sources of income inequality are mainly composed of two aspects: one is the circumstance factors that individuals can not control, such as, race, gender, family background and so on. Another is the effort factors that individuals can control, such as education and work. The former is called inequality of opportunity and the latter is inequality of effort. Although the issue of inequality of opportunity has drawn wide concern. The related researches mainly focus on the measurement of inequality of opportunity

(Bourguignon et al., 2003, 2007; Ferreira and Gignoux, 2011; Bosmans and Öztürk, 2021). There are few papers of which we are aware that study the impact of inequality of opportunity on subjective well-being. He and Pan (2011) constructed the "inequality of opportunity perception index" through three questions related to income equality, educational opportunity and socioeconomic status in the questionnaire, and studied its impact on subjective well-being. As a supplement to the study on this relationship, this article measures the indicators of inequality of opportunity based on the individuals' annual income, and explores the impact of inequality of opportunity and inequality of effort on residents' subjective well-being.

The main contributions of this work can be denoted as follows: firstly, we measure the inequality of opportunity index and the inequality of effort index in prefecture-level cities (usually in term of years or countries), which enrich the study of inequality in China. Secondly, we use the measured inequality of opportunity index and inequality of effort index to explore their influence on residents' subjective well-being, respectively, providing beneficial help for us to understand how inequality affects subjective well-being. Thirdly, we further examine the impact results at provincial level and in urban and rural areas, which support the robustness and heterogeneity analysis of this article. The remainder of this article is organized as follows: Section 2 explains the influence mechanism of inequality of opportunity and inequality of effort on subjective well-being, respectively. Section 3 is the empirical framework. Section 4 describes the data sources and processing. Results are given in Section 5. The influence mechanism test and the robustness test are reported in sections 6 and 7, respectively. The last section is conclusion.

## THE INFLUENCING MECHANISM OF INEQUALITY ON SUBJECTIVE WELL-BEING

The rise in income inequality does not always have negative effects on society. A degree of inequality can contribute to an economy's early economic growth by promoting the accumulation of physical capital (Galor and Moav, 2004). The existing studies have shown that inequality has different effects on residents' subjective well-being in a specific economic system or in different periods. However, previous studies on how income inequality affects residents' subjective well-being only focus on the inequality outcome, ignoring the "structure" of inequality. According to the introduction part, we believe that these two types of inequality may have significantly different effects on residents' subjective well-being.

No society can dictate a perfectly equal distribution model in which every individual receives the same absolute amount of income, even in a planned economy. This "unequal" distribution should be considered fair if it is determined by the factors under individuals' control (Cappelen et al., 2014). That is to say, income gaps caused by the differences in individual efforts are acceptable. But income gaps caused by the external circumstance factors that beyond the individual control are not acceptable. In the latter case, when residents' income is closely related to factors of

individual identity rather than their efforts, equal opportunities may be undermined. Inequality of opportunity reduces the correlation between individuals' efforts and returns. So it brings in less income mobility, causing a "lock-in effect" on residents' income expectations (He and Pan, 2011). In addition, whether a person has a local urban hukou (China's household registration system) is closely related to whether he or she is subject to identity discrimination and discriminated against in a range of policies such as social security and public services (Lu, 2011). Family resources and regional factors are related to educational level, and affect the equality of education opportunity (Wu, 2007). Inequality of opportunities in adult health is influenced by the household socioeconomic status during childhood and the parental education attainment (Fajardo-Gonzalez, 2016). Individuals have an innate aversion to the sense of unfairness. Such identity-related inequalities are inherently unfair and reduce individuals' happiness (Lu et al., 2014).

Social identities are not just a list of sociodemographic groups that are used to classify individuals (e.g., gender, age, ethnicity, religion). Social identities are relative, and different individuals perceive them as psychological descriptions of themselves (Haslam et al., 2009). They satisfy basic psychological needs such as belonging, self-esteem, control, and meaningful existence (Greenaway et al., 2016). When people lack access to social resources related to education, health, food, housing and mobility, they realize that there is a strong connection between different socioeconomic backgrounds and access to social resources to achieve their goals. Perceived economic inequality makes them highly sensitive to the relevance of cultural capital in sharpening differences between individuals of different status (García-Sánchez et al., 2018). Socioeconomic status comparison becomes a dimension people care about as economic inequality increases. Economic inequality makes people compete with each other and strive for favorable position on the bases of material resources they possess (Melita et al., 2021). Because relative economic status is closely related to residents' life satisfaction (Cheung and Lucas, 2016). According to status anxiety theory, if a person lives in a society with a large income gap, he may feel great pressure to obtain equality or more social resources than others. As a result, residents' subjective well-being is negatively affected.

Why a certain degree of income disparity is reasonable and likely to increase residents' subjective well-being. At the beginning of Chinese reform and opening up, some people were encouraged to get rich first through hard work and legitimate business, and then some people who got rich first would in turn help poor areas and people to become rich. In the process of the economy being allowed to grow in this way, the income gap of residents is gradually widening in China. Individuals show a certain "tolerance" to such income inequality. Residents of poor areas are beginning to imitate some of those who got rich first and move to the cities to find jobs, hoping to increase their family incomes. It's like driving through a two-lane tunnel, with both lanes heading in the same direction, and getting stuck in a terrible traffic jam, which can be very frustrating. After a while, the cars in the side lane begin to move. Naturally his frustration would be relieved when he knows the blockage has been broken.

Although he is still not moving, he will feel better than before, because he has anticipation of his upcoming movement. This visual analogy of wealth can be called "tunnel effect" (Hirschman and Rothschild, 1973). Poor people can also expect their incomes to increase if they think they can do so by increasing their efforts. Such income inequality among residents produces a good demonstration effect, which can make low-income people have expectations for future progress (Knight et al., 2009). In other words, the income gap caused by inequality of effort is tolerable, which makes them have good expectations for the future income increase and believes that efforts can be made to reduce the income gap, thus increasing their subjective well-being.

## EMPIRICAL FRAMEWORK

### The Construction of Inequality Indexes

The inequality of opportunity index and inequality of effort index are the key independent variables of this article. Existing studies on inequality of opportunity provide an important reference for this article. Roemer (1993, 1998) summarizes and develops the theory of inequality of opportunity in a series of studies, establishing a research framework that clearly distinguishes between circumstance and effort variables. The inequality caused by the former is called inequality of opportunity, and the inequality caused by the latter is inequality of effort. On this basis, many scholars have measured the inequality of opportunity. The measuring methods include parametric estimates (Bourguignon et al., 2003, 2007; Carpentier and Sapata, 2013; Gong et al., 2017) and non-parametric estimates (Checchi and Peragine, 2010; Ferreira and Gignoux, 2011; Jiang et al., 2014). Using parametric method to measure inequality of opportunity needs to set up the model in advance, and the measurement results depend on the determined model form. To avoid the influence of model setting error on the measurement results, this article follows Ferreira and Gignoux (2011) and employs the non-parametric method to measure the inequality of opportunity. The framework of measurement of inequality of opportunity and inequality of effort can be defined as:

$$y_i = f(C_i, E_i, \mu_i) \quad (1)$$

$$E_i = (C_i, v_i) \quad (2)$$

Where  $C_i$  and  $E_i$  denote a vector of circumstance (opportunities set) and effort variables, respectively,  $y_i$  denotes the individuals' income (advantage). The income variable  $y_i$  is influenced by circumstance variables  $C_i$ , effort variables  $E_i$  and random error  $\mu_i$ . Also effort variables  $E_i$  are influenced by circumstance variables  $C_i$  and random error  $v_i$ . Supposing that individuals with a total population of  $N$ , and can be divided into  $M$  groups according to circumstances variables  $C$ . Individuals in each group have the same circumstance, that is  $C_i = C^m$ ,  $i = 1, \dots, N$ ,  $m = 1, \dots, M$ . For individual residents  $i$  in Group  $m$ , the individuals' income can be defined as  $\{y_i^m | C_i = C^m\}$ , and the distribution function is  $F(y, C^m)$ . Equality of opportunity implies that circumstance variables have no effect on individuals' income, and we can denote it as

$F(y, C^m) = F(y, C^k)$ . Therefore, we can measure inequality of opportunity by comparing the difference of distribution function among different types.

Although the method of stochastic dominance (Lefranc et al., 2009) can help us to determine which type of income distribution function is better, it is difficult to directly apply it in the actual measurement process. Because this method needs a large sample size. In order to better decompose and measure the inequality of opportunity, Ferreira and Gignoux (2011) construct a smoothed distribution  $\{u_i^m\}$ , replacing individuals' income  $y_i$  by calculating the group-specific mean  $\mu^m$ , to eliminate all within-group inequality. Inequality of opportunity can be denoted as  $I(\{\mu_i^m\})$ . Further, specific inequality indexes  $I(\bullet)$  are expressed in the following Generalized Entropy Index:

$$\theta_i = \frac{1}{N} \sum_{i=1}^N \ln \left( \frac{\bar{y}}{\mu^m} \right) \quad (3)$$

$$\theta_e = \frac{1}{N} \sum_{i=1}^N \ln \left( \frac{\mu^m}{y_i} \right) \quad (4)$$

Where  $\theta_i$  denotes the inequality of opportunity index, and  $\theta_e$  denotes the inequality of effort index.

## Methodology

The dependent variable in this article, subjective well-being, is an ordered variable of five categories. We use the Ordered Probit model to empirically test the effect of inequality on residents' subjective well-being. The model is defined as follows:

$$Happy_{iz}^* = \alpha_1 OI_{iz} + \alpha_2 EI_{iz} + X'_{iz} B + e_{iz} \quad (5)$$

$$Happy_{iz} = \begin{cases} 1, & Happy^* \leq a_0 \\ 2, & a_0 < Happy^* \leq a_1 \\ 3, & a_1 < Happy^* \leq a_2 \\ 4, & a_2 < Happy^* \leq a_3 \\ 5, & a_3 < Happy^* \end{cases} \quad (6)$$

Where  $Happy_{iz}$  denotes the dependent variable subjective well-being, the subscript  $i$  and  $z$  represent the individual residents and the regions (prefecture-level city), respectively.  $Happy_{iz}^*$  denotes an non-observable latent variable.  $OI_{iz}$ ,  $EI_{iz}$  and  $B$  denote opportunity inequality variables, effort inequality variables and other control variables, respectively.  $a_j$ , ( $j = 0, 1, 2, 3, 4$ ) is called the "cutoff point" and is the parameter to be estimated.  $\alpha_1$ ,  $\alpha_2$  and  $X$  denote the coefficients of the relevant variables to be estimated.

Supposing that the residuals  $e_{iz}$  follow a standard normal distribution:  $e_{iz} \sim N(0, 1)$ , and the likelihood function of the sample is as follows:

$$\begin{aligned} P(Happy_{iz} = k | OI, EI, B) &= P(a_{k-1} < Happy_{iz}^* \leq a_k | OI, EI, B) \\ &= P(Happy_{iz}^* \leq a_k | OI, EI, B) - P(Happy_{iz}^* \leq a_{k-1} | OI, EI, B) \\ &= \phi[a_k - (\alpha_1 OI_{iz} + \alpha_2 EI_{iz} + X'_{iz} B)] \\ &\quad - \phi[a_{k-1} - (\alpha_1 OI_{iz} + \alpha_2 EI_{iz} + X'_{iz} B)] \end{aligned}$$

Where  $\phi(\bullet)$  denotes the distribution function of the residuals, we use the maximum likelihood method (MLE) to estimate the parameters.

## VARIABLES DEFINITION AND STATISTICAL DESCRIPTION

### Data Processing

This article utilizes Chinese General Social Survey (CGSS) data. The CGSS is a comprehensive and continuous academic survey project on China, conducted by the China Survey and Data Center of Renmin University of China. The empirical study needs to decompose income inequality into inequality of opportunity and inequality of effort at the regional level (prefecture-level city), the sample size has to be large. So in order to solve this problem, we use the survey data from 2010 to 2015 (excluding the data of 2014<sup>1</sup>). We take the CGSS2015 data as a base period and then aggregate data from other years into this year. In the process of aggregating, we have made adjustments in two aspects: Firstly, the annual household income in other years is adjusted according to the CPI of that year and the CPI of 2015. Secondly, the age of individuals from other years is also adjusted to 2015. The total number of aggregated cross-section data is 51574.

To meet the research needs of this article, we processed the data further: (1) Delete the sample with negative annual household income; (2) The answers (including do not know, do not apply, refuse to answer, and do not know clearly) to the relevant questions in the sample are deleted; (3) Delete missing data and other incorrect data from the sample. And the total number of processed data is 42308, of which the sample size in 2015 is 8761, the sample size in 2013 is 9567, the sample size in 2012 is 9947, the sample size in 2011 is 4619, and the sample size in 2010 is 9414.

### Dependent Variable: Subjective Well-Being

The subjective well-being data come from the CGSS database. The question about dependent variable, subjective well-being, in the CGSS questionnaire is "In general, do you think you are happy with your life?" And the answers are: Very Unhappy = 1, Unhappy = 2, Normal = 3, Happy = 4, and Very Happy = 5. **Table 1** shows the individual happiness level, mean value and standard deviation from 2010 to 2015.

The average happiness level of residents does not change much and is close to the Happy – level (Happy = 4), other levels of happiness show similar characteristics, which do not change much from 2010 to 2015. For instance in 2015, individuals who report their own happiness accounted for over 60 percent of all respondents, in contrast, fewer individuals reported being unhappy and very unhappy, accounting for 6.23% and 1.22% of all respondents, respectively. Individuals who report being very happy and those who report feeling normal accounted for about 15% of all respondents, respectively.

<sup>1</sup>CGSS2014 is a special survey: Chinese Elderly Society Tracking Survey. At present, the data of 2014 is not released to the public.



**TABLE 1** | Statistical description of happiness in China.

Year	Very happy (%)	Happy (%)	Normal (%)	Unhappy (%)	Very unhappy (%)	Mean	Std. Dev.
2010	16.28	56.84	17.28	7.52	2.07	3.7775	0.8795
2011	20.26	60.01	11.17	6.69	1.86	3.9013	0.8602
2012	16.31	60.05	15.11	7.08	1.46	3.8267	0.8358
2013	13.81	59.49	18.16	7.15	1.40	3.7715	0.8243
2015	17.66	60.47	14.42	6.23	1.22	3.8711	0.8145

## Independent Variable: Inequality of Opportunity and Inequality of Effort

In this article, the key explanatory variables are the inequality indexes, including inequality of opportunity and inequality of effort index. There is no precise measure of individual inequality of opportunity and inequality of effort in the questionnaire, and the existing research methods cannot directly measure the opportunity inequality and effort inequality at the individual level. We use the generalized entropy index of the region (prefecture-level city) where the individual residents live as the individual inequality index (He and Pan, 2011), and further decompose it into the inequality of opportunity index and the inequality of effort index.

Firstly, the residents of the same area are grouped into a group according to region where they live (89 groups in total). Then the samples in each group are classified into different types with respect to circumstance variables. The key to measure inequality of opportunity and inequality of effort is how to distinguish circumstance variables from effort variables. There is no consistent division in specific studies. According to inequality of opportunity theory, circumstance variables are defined as all factors that are innate and beyond one's control. The inequality created by these factors is unacceptable. In the existing representative literature on measuring inequality of opportunity (Bourguignon et al., 2007; Ferreira and Gignoux, 2011), the selection of circumstance variables includes: Race, Father's and mother's education, Father's and mother's occupation, and region of birth. Efforts is something that individuals can

control and take responsibility for, such as working hours, so the resulting income inequality is acceptable. Considering the availability of data and the feasibility of the study, we choose Father's and mother's education, Father's and Mother's Occupation, Hukou, and Father and Mother's Party Membership as the circumstance variables. Combined with China's special urban-rural dual economic structure, no matter what specific variable is chosen, the hukou circumstance variable is the most characteristic and indispensable. In this way, income inequality can be divided into inequality caused by circumstance factors (inequality of opportunity) and the remainder is called inequality of effort.

As the selected circumstance variables increase, different types of residents can be more accurately divided into different groups (Types). While this article measures inequality at a regional level, a potential problem is that some groups may not have sample sizes. So we integrate the Father's and Mother's Education, Father's and Mother's Occupation, and Father and Mother's Party Membership into Parental Education (three Groups: below junior high school education, between junior high school education and Senior high school education, over Senior high school education), Parental Occupation (two Groups: full-time job and part-time job), and Parental Party Membership (two Groups: Party Membership and Non-party Membership), respectively. Although we try to include as more circumstance variables as possible to make the measurement of the inequality index more accurate, some variables are missed inevitably. The above method provided a narrow range of lower-boundary for inequality of opportunity (Ferreira and Gignoux, 2011). According to the determined circumstance variables, residents in the same region are divided into different types, and then we measure the inequality index of residents by using the method provided in section "The Construction of Inequality Indexes."

In addition, there are many other factors affecting the residents' subjective well-being. According to the existing research literature on subjective well-being (Senik, 2004; Brockmann et al., 2009; Zagorski et al., 2014), we also introduce a series of the same related control variables: Gender (male = 1, female = 0), Age (calculated by the date of birth), Education (number of years of education), Party Membership (party membership = 1, non-party membership = 0), Hukou (urban = 1, rural = 0), Married (married = 1, others = 0), Healthy (healthy = 1, others = 0), Rank (family social hierarchy). Considering that the subjective well-being may be affected by economic growth and may change with time, this article also introduces the degree of economic growth as a control

**TABLE 2** | Descriptive statistics for the variables.

Variables	Obs	Mean	Std. Dev.	Min	Max
Happy	42308	3.8206	0.8428	1	5
OI	42308	0.0453	0.0385	-0.0108	0.2390
EI	42308	0.2535	0.1318	-0.0399	0.5689
Gender	42308	0.5029	0.5000	0	1
Age	42308	51.3381	15.9362	18	101
Educ	42308	8.8651	4.7022	0	19
Party	42308	0.1185	0.3232	0	1
Hukou	42308	0.4092	0.4917	0	1
Married	42308	0.9122	0.2830	0	1
Healthy	42308	3.5852	1.1044	1	5
Rank_high	42308	0.0231	0.1505	0	1
Rank_moderate	42308	0.3237	0.4679	0	1
Ln_GDP	42308	10.5716	0.4562	9.4636	11.6497

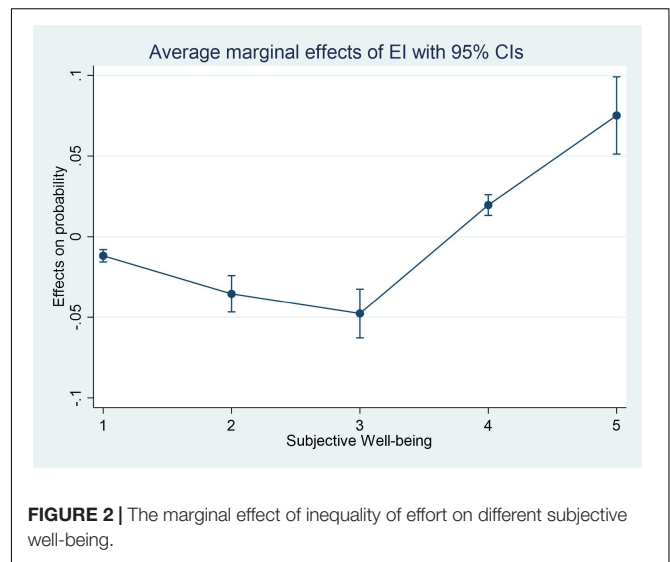
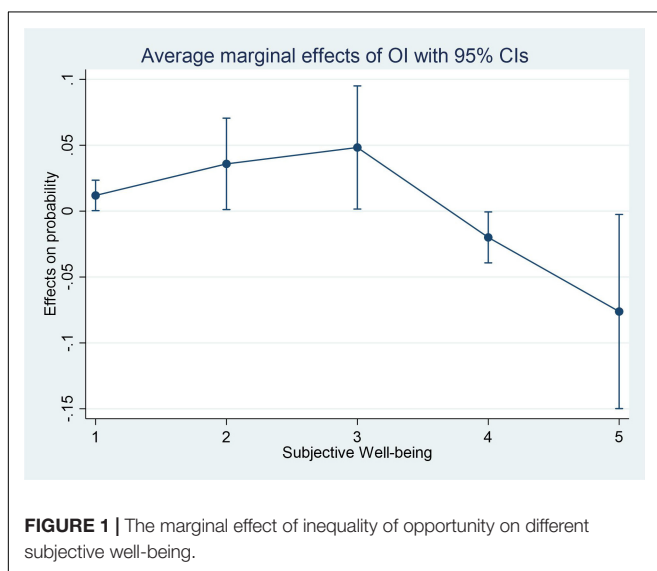
(per capital GDP) and controls the time effect. The statistical description of all independent variables is shown in **Table 2**.

## RESULTS

### Full Sample Analysis

As the theoretical analysis points out that the expansion of income gaps may reduce the residents' subjective well-being, but not all income inequality will reduce residents' subjective well-being. A certain degree of income gaps may increase residents' subjective well-being (Knight et al., 2009). We further decompose income inequality into inequality of opportunity and inequality of effort, and explore their effects on residents' subjective well-being, respectively. **Table 3** reports the regression results of the ordered probit model. The regression results are denoted in the column (1): inequality of opportunity has a significant negative influence on residents' subjective well-being, while inequality of effort has a positive influence on residents' subjective well-being.

The regression results of ordered probit model can only judge the significance and direction of influence of variables. To give a more intuitive explanation of the regression results, **Table 3** further provides the marginal effect of independent variables on different levels of happiness, as shown in columns (2–6). The inequality of opportunity index increases by one unit, the probability of residents feeling “very happy” and “happy” decreases by 7.62% and 1.99%, respectively, and the probability of being “normal,” “unhappy,” and “very unhappy” increases by 4.83%, 3.59%, and 1.19%, respectively. The inequality of effort index increases by one unit, the probability of residents feeling “very happy” and “happy” increases by 7.51% and 1.97%, respectively, and the probability of being “normal,” “unhappy,” and “very unhappy” decreases by 4.77%, 3.54%, and 1.18%, respectively.



**Figures 1, 2** clearly show the average impact of inequality of opportunity and inequality of effort on residents' subjective well-being at different levels, respectively. The directions of influence of the two indexes show opposite results. We can draw the preliminary conclusion that the inequality of opportunity is the main factor that reduces the residents' subjective well-being, which makes residents feel deprived of equal opportunities or produce a certain degree of anxiety. On the contrary, the inequality of effort will increase the residents' subjective well-being, which shows the positive “Tunnel Effect” of income gaps.

We also get some important results for other control variables. Considering the limitation of the length of the article, we take column (6) as an example: male reported lower levels of happiness than female, 2.40% percent less on average. It is a common life pattern in Chinese families that men work outside and women take care of the family, men face more social pressure and women are tied down to daily housework that also means a loss of freedom and autonomy, which reduces happiness. On average, social pressure causes more unhappiness than pressure generated within the family. In addition, women are more able to withstand stress and are more likely to be happy than men, which may have something to do with female personality. Residents' subjective well-being increased by an average of 0.13% with each year of age. The older people are, the more likely they are to achieve career success and enjoy family happiness. Residents' subjective well-being increased by 0.37% on average for each year of increase in their education level. The more years that residents have received education, the more likely they will get in return and improve their social status, which is beneficial to improve their subjective well-being. Residents with party membership reported an average increase of 5.40% in subjective well-being compared with those without party membership. People with rural hukou are on average 0.80% happier than those with urban hukou. Residents who are married reported an average increase of 2.53% in subjective well-being compared with those who are not married. Residents who are in good health reported an average increase of 4.50% in subjective well-being compared

**TABLE 3 |** Empirical results of inequality affecting residents' subjective well-being.

	(1)	(2)	(3)	(4)	(5)	(6)
Variable	Oprobit	Happy = 1	Happy = 2	Happy = 3	Happy = 4	Happy = 5
OI	−0.3169** (−2.03)	0.0119** (2.02)	0.0359** (2.03)	0.0483** (2.03)	−0.0199** (−2.02)	−0.0762** (−2.03)
EI	0.3126*** (6.16)	−0.0118*** (−6.02)	−0.0354*** (−6.14)	−0.0477*** (−6.16)	0.0197*** (6.00)	0.0751*** (6.16)
Gender	−0.0997*** (−8.94)	0.0038*** (8.55)	0.0113*** (8.88)	0.0152*** (8.93)	−0.0063*** (−8.48)	−0.0240*** (−8.94)
Age	0.0055*** (12.16)	−0.0002*** (−11.23)	−0.0006*** (−11.99)	−0.0008*** (−12.13)	0.0003*** (11.07)	0.0013*** (12.15)
Educ	0.0156*** (9.57)	−0.0006*** (−9.13)	−0.0018*** (−9.48)	−0.0024*** (−9.54)	0.0010*** (9.02)	0.0037*** (9.56)
Party	0.2246*** (12.32)	−0.0085*** (−11.39)	−0.0254*** (−12.13)	−0.0342*** (−12.28)	0.0141*** (11.11)	0.0540*** (12.33)
Hukou	−0.0331** (−2.50)	0.0012** (2.49)	0.0037** (2.49)	0.0050** (2.50)	−0.0021** (−2.49)	−0.0080** (−2.50)
Married	0.1053*** (5.02)	−0.0040*** (−4.96)	−0.0119*** (−5.01)	−0.0161*** (−5.02)	0.0066*** (4.94)	0.0253*** (5.02)
Healthy	0.1871*** (35.65)	−0.0070*** (−22.86)	−0.0212*** (−31.93)	−0.0285*** (−34.99)	0.0118*** (21.64)	0.0450*** (35.19)
Rank_high	0.2579*** (7.07)	−0.0097*** (−6.86)	−0.0292*** (−7.04)	−0.0393*** (−7.07)	0.0162*** (6.82)	0.0620*** (7.07)
Rank_moderate	0.1213*** (9.89)	−0.0046*** (−9.37)	−0.0137*** (−9.81)	−0.0185*** (−9.88)	0.0076*** (9.28)	0.0292*** (9.89)
Ln_GDP	0.0334** (0.037)	−0.0013** (2.08)	−0.0038** (−2.09)	−0.0051*** (−2.09)	0.0021** (2.08)	0.0080** (2.09)
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Obs	42307	42307	42307	42307	42307	42307
Pseudo R <sup>2</sup>	0.0226	0.0226	0.0226	0.0226	0.0226	0.0226

The z-value is reported in parentheses to the right of the regression coefficient. The superscripts \*\*\*, and \*\* represent  $p < 1\%$ , and  $p < 5\%$ , respectively.

**TABLE 4 |** The difference of regional regression results.

Variable	Urban			Rural		
	(1)	(2)	(3)	(4)	(5)	(6)
OI	0.1529 (0.52)	0.0064 (0.52)	0.0380 (0.52)	−0.5039*** (−2.71)	−0.0387*** (−2.69)	−0.1182*** (−2.71)
EI	0.4374*** (4.59)	0.0184*** (4.25)	0.1088*** (4.59)	0.2517*** (4.15)	0.0193*** (4.10)	0.0590*** (4.15)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Obs	17312	17312	17312	24995	24995	24995
Pseudo R <sup>2</sup>	0.0225	0.0225	0.0225	0.0224	0.0224	0.0224

The z-value is reported in parentheses to the right of the regression coefficient. The superscripts \*\*\* represent  $p < 1\%$ , respectively.

with those with poor health. Residents with higher family rank reported an average increase of 6.20% in subjective well-being compared to those with lower family rank. Additionally, with the increase of economic growth, residents' subjective well-being will increase.

## Heterogeneity Analysis: Analysis of Urban and Rural Regional Differences

Table 4 demonstrates the empirical regression results of urban and rural areas. Columns (1) and (4) are the regression results of the ordered probit model. Columns (2) and (3) are the marginal effects of inequality of opportunity and inequality of effort on “happy” and “very happy” for urban residents. Columns (4) and (5) are the marginal effects of inequality of opportunity and inequality of effort on “happy” and “very happy” for rural residents. The regression results show that inequality of opportunity and inequality of effort have different effects on subjective well-being among urban and rural residents.

The inequality of opportunity has no significant effect on the subjective well-being of urban residents, while the inequality of effort can improve their happiness (0.4374,  $z = 4.59$ ). Perhaps because urban residents generally have a better “circumstance,”

where their parents tend to be highly educated, have formal full-time jobs, and come from higher social classes. And the overall difference is not particularly huge for most of the urban residents surveyed. So, urban residents are more likely to perceive the income gaps between them, prompting them to work hard and generate expectations of future income growth, which in turn significantly increases their own happiness.

For rural residents, inequality of opportunity significantly reduces their happiness (−0.5039,  $z = -2.71$ ), and inequality of effort can increase their happiness (0.2517,  $z = 4.15$ ). One possible explanation is that rural residents generally have a worse “circumstance,” and small “circumstance” differences may cause huge income gaps between residents, so the inequality of opportunities caused by the “circumstance” will reduce the subjective well-being of rural residents. Although the direction of influence of core explanatory variables on residents' subjective well-being is consistent with the regression results of the full sample, the effect intensity is greater in the rural sample, which to some extent reflects the more serious circumstance inequality in rural areas. Similarly, for rural residents, inequality of effort can also increase their subjective well-being through the “tunneling effect.”

**TABLE 5** | The regression results with instrument variables.

	(1)	(2)	(3)	(4)	(5)	(6)
Variable	IV oprobbit	Happy = 1	Happy = 2	Happy = 3	Happy = 4	Happy = 5
OI	−23.7128*** (−31.96)	4.3482*** (9.08)	1.4884*** (12.12)	1.100*** (8.93)	0.3665*** (6.64)	−7.3031*** (−25.57)
EI	3.7077*** (22.97)	−0.6799*** (−8.38)	−0.2327*** (−12.73)	−0.1720*** (−9.40)	−0.0573** (−6.59)	1.1419*** (19.99)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Obs	42308	42308	42308	42308	42308	42308

The z-value is reported in parentheses to the right of the regression coefficient. The superscripts \*\*\*, and \*\* represent  $p < 1\%$ , and  $p < 5\%$ , respectively.

## Endogeneity Issue

Although we construct inequality indicators at the regional level (prefecture-city level), endogeneity issue caused by reverse causality is effectively avoided. However, endogeneity caused by missing variables still inevitably exist in the model, which may lead to bias in regression results. We perform CMP estimation methods to address endogeneity between inequality and residents' subjective well-being. The key to this method is to choose instrument variables (IV) that are highly correlated with inequality variables but not with the random error term.

To be specific, in regard to the geographical location of China, we divide the provinces studied in this article into three regions: the eastern, central and western regions. We use the average value of inequality of opportunity and the average value of inequality of effort of other provinces in the same region as instrumental variables. On the one hand, the instrumental variables selected by us in this way have no direct causal relationship with the residents' subjective well-being in the province. On the other hand, because the provinces in the same region have similar developmental levels and are closely related to each other, these instrumental variables are highly correlated with the inequality variables (Ge et al., 2021).

**Table 5** illustrates the results of endogeneity analysis. Column (1) reports the IV ordered probit regression results. Columns (2–6) report the marginal effect of inequality of opportunity and inequality of effort. After controlling for possible endogeneity issues, the inequality of opportunity significantly reduces residents' subjective well-being (−23.7128,  $z = -31.96$ ), and the inequality of effort significantly increases residents' subjective

well-being (3.7077,  $z = 22.97$ ), which is consistent with the regression results in **Table 3**, indicating that the regression results of model are robust.

## MECHANISM AND CHANNELS TESTS

The above empirical study results show that the relationship between inequality of opportunity and residents' subjective well-being is negative, while the relationship between inequality of effort and residents' subjective well-being is positive. What are the possible influencing mechanism of inequality variables? Residents' sense of happiness is a comprehensive category, which is the embodiment of various kinds of pleasure and other emotions produced by individuals in certain social relations. On the one hand, inequality of opportunity creates a sense of unfairness. Such an unfairness circumstance may produce great disparity of individuals' social status, and the comparison between the individuals will further cause negative feelings such as estrangement and jealousy, leading to the decrease of residents' subjective well-being. On the other hand, inequality of effort increases the sense of individual fairness, leading residents to believe that the harder they work, the happier they are. Therefore, we use causal steps approach (Baron and Kenny, 1986) to examine whether inequality can affect residents' subjective well-being through "fairness" channels.

**Table 6** reports the results of the impact of inequality on residents' sense of fairness and subjective well-being. Column (1) shows the effects of inequality of opportunity and inequality of effort on residents' sense of fairness. The coefficient of inequality of opportunity is significantly negative (−0.4287,  $z = -2.82$ ). The coefficient of inequality of effort is significantly positive (0.7026,  $z = 14.29$ ), indicating that inequality of opportunity can decrease residents' sense of fairness and inequality of effort can increase the residents' sense of fairness. Column (2) shows fairness mediating variable has a significant effect on subjective well-being (0.3070,  $z = 57.72$ ). Column (3) shows the results of adding fairness variable to the original regression model. After adding fairness variable, the variable of inequality of opportunity becomes no longer significant, while the variable coefficient magnitude of inequality of effort decreases significantly, indicating that inequality of opportunity has the effect on subjective well-being entirely through the residents' sense of fairness. And the inequality of effort partly influences the subjective well-being through residents' sense of fairness.

**TABLE 6** | The results of influencing mechanism.

	(1)	(2)	(3)
Variable	Fair	Happy	Happy
Fair		0.3070*** (57.72)	0.3062*** (57.45)
OI	−0.4287*** (−2.82)		−0.2277 (−1.44)
EI	0.7026*** (14.29)		0.1260** (2.46)
Control variables	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes
Obs	42307	42307	42307
Pseudo $R^2$	0.0167	0.0570	0.0571

The z-value is reported in parentheses to the right of the regression coefficient. The superscripts \*\*\*, and \*\* represent  $p < 1\%$ , and  $p < 5\%$ , respectively.



**TABLE 7 |** Robustness tests: Change the circumstance variable.

	(1)	(2)	(3)	(4)	(5)	(6)
Variable	Oprobit	Happy = 1	Happy = 2	Happy = 3	Happy = 4	Happy = 5
OI	−0.3924** (−2.34)	0.0148** (2.33)	0.0444** (2.34)	0.0598** (2.34)	−0.0247** (−2.33)	−0.0943** (−2.34)
EI	0.3210*** (6.27)	−0.0121*** (−6.12)	−0.0363*** (−6.25)	−0.0489*** (−6.27)	0.0202*** (6.10)	0.0772*** (6.27)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Obs	42307	42307	42307	42307	42307	42307
Pseudo R <sup>2</sup>	0.0226	0.0226	0.0226	0.0226	0.0226	0.0226

The z-value is reported in parentheses to the right of the regression coefficient. The superscripts \*\*\*, \*\*, and \* represent  $p < 1\%$ ,  $p < 5\%$ , and  $p < 10\%$ , respectively.

**TABLE 8 |** Robustness tests: Use provincial inequality indexes.

	(1)	(2)	(3)	(4)	(5)	(6)
Variable	Oprobit	Happy = 1	Happy = 2	Happy = 3	Happy = 4	Happy = 5
OI	−0.4398* (−1.77)	0.0165* (1.77)	0.0498* (1.77)	0.0670* (1.77)	−0.0276* (1.77)	−0.1057* (1.77)
EI	0.5377*** (7.83)	−0.0202*** (−7.56)	−0.0608*** (−7.79)	−0.0819*** (−7.83)	0.0338*** (7.52)	0.1292*** (7.83)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Obs	42307	42307	42307	42307	42307	42307
Pseudo R <sup>2</sup>	0.0229	0.0229	0.0229	0.0229	0.0229	0.0229

The z-value is reported in parentheses to the right of the regression coefficient. The superscripts \*\*\*, and \* represent  $p < 1\%$ , and  $p < 10\%$ , respectively.

## ROBUSTNESS TESTS

### Change the Circumstance Variables

In order to verify the reliability of the regression results, we replace the circumstance variable of hukou with the circumstance variable of family social rank, and further determine the type of circumstance to which residents belong. We use the method in section “The Construction of Inequality Indexes” again to remeasure the inequality of opportunity index and inequality of effort index of residents, and further test their impact on residents’ subjective well-being. **Table 7** shows the empirical regression results of robustness tests. Column (1) is the regression results of the ordered probit model. Columns (2–6) are the marginal effects of inequality of opportunity and inequality of effort on residents’ subjective well-being. No matter the regression results of ordered probit model or marginal effect analysis, the regression results in **Table 7** are consistent with those in **Table 3**. The conclusions of this article are robust when we change the circumstance variable.

### Regression Based on Provincial Inequality Indexes

Employing the provincial inequality indexes and the method in section “The Construction of Inequality Indexes,” we empirically test the impact of inequality of opportunity and inequality of effort on residents’ subjective well-being. **Table 8** reports the regression results. Column (1) is the regression results of the ordered probit model. Columns (2–6) are the marginal effects of inequality of opportunity and inequality of effort on residents’ subjective well-being. The results we can get from the first

column (1) is that inequality of opportunity has a significant negative impact on residents’ subjective well-being (−0.4398,  $z = -1.77$ ), while the inequality of effort has a significant positive impact on residents’ subjective well-being (0.5377,  $z = 7.83$ ). The marginal effects in columns (2–6) are consistent with those in **Table 3**, except that the significance of inequality of opportunity coefficient decreases, indicating that the empirical regression results are robust.

## CONCLUSION

Existing papers have conducted a large number of constructive studies on residents’ subjective well-being from the perspective of income inequality by using different methods and data, but have not reached a unified conclusion. Distinguishing between “fair” income inequality and “unfair” income inequality, this article uses China’s data from 2010 to 2015 to decompose income inequality into inequality of opportunity and inequality of effort. We empirically test their impact on residents’ subjective well-being, and attempt to explain the differences in these results from the perspectives of unfairness effect and positive tunneling effect.

It is found that the inequality of opportunity has a significant negative impact on residents’ subjective well-being. The inequality of opportunity caused by circumstance factors will lead residents to have a sense of unfairness or anxiety, which is the reason for the weakening of residents’ subjective well-being. The inequality of effort has a significant positive impact on residents’ subjective well-being, which may make people maintain good expectations for the future income increase and

the narrowing of income gaps, thus enhancing their subjective well-being through the “tunneling effect.” Based on a regional heterogeneity study, we find that only the inequality of effort has a significant positive impact on residents’ subjective well-being in urban areas. In rural areas, inequality of opportunities and inequality of efforts both have significant effects on residents’ subjective well-being. In the process of investigating the possible influencing mechanism, we confirm that fairness plays an critical mediating role in the impact of inequality of opportunity and inequality of effort on subjective well-being. This reminds us of the importance of paying attention to and distinguishing between unfair income gaps caused by gender, race, etc., and income gaps caused by differences in individual efforts.

Therefore, while paying close attention to the income gaps of residents, more importantly, we need to create a fair environment for residents and reduce the factors that make residents dislike. As for inequality of effort, it may give a sense that everyone can improve their subjective well-being through hard work. Ideological beliefs related to meritocracy, upward social mobility, attributes about the rich enable hardworking people to have rosy expectations of the future and accept such inequality. In fact, in modern society, resources are increasingly concentrated in the rich and the income gaps between the rich and the poor is increasing, which is one of the severe problems China faces at the present stage. Therefore, accepted such beliefs may create a trap that perpetuates the inequality outcomes and there is intergenerational transmission, further creating inequality of opportunity. In general, while actively maintaining the sound operation of the society, the government should pay more attention to reducing or eliminating inequality of opportunity, forming a reasonable social system and a fair social environment through legislation and other means.

In sum, our discussion shows that it is indeed important to distinguish between inequality of opportunity and inequality of effort while studying the relationship between inequality and subjective well-being. It should be pointed out that since we did the inequality index decomposition at regional level, there may be many interfering factors in the use of regional variables to explain individual behavior in causal inference. And there is a complex interaction between circumstance and effort factors in the process of determining personal income (Gong et al., 2017). Therefore,

in the case of quantitative analysis, the impact of inequality of effort on inequality of opportunity needs to be focused. Also the regression results are valid under the implicit assumption that individuals’ self-reported happiness can be compared (Yang et al., 2019), but happiness is a subjective feeling, and thus the value measured by the surveyed data may be influenced by the respondent’s feeling at the time. With the rapid development of the information science and computer technology, internet data are crawled and applied in the financial field (He et al., 2021), and crawling the text data having micro characteristics and then constructing the object index of happiness should be carried out in the future.

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## AUTHOR CONTRIBUTIONS

HT performed the material preparation, data collection and analysis, and wrote the first draft of the manuscript. All authors contributed to the study conception and design, commented on previous versions of the manuscript, and read and approved the final manuscript.

## FUNDING

This work was supported by the National Social Science Foundation of China under Grant No. 21BTJ002, Humanities and Social Science Fund of Ministry of Education of China under Grant No. 20YJA790021, Major Project of Philosophy and Social Science Planning of Zhejiang Province under Grant No. 22YJRC07ZD, General Project of Anhui Natural Science Foundation under Grant No. 1908085MG232, Anhui Universities Major Project of Humanities and Social Science Research under Grant No. SK2020ZD006, and Anhui Universities General Project of Humanities and Social Science Research under Grant No. SK202107.

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# The Development and Prospects of Socioscientific Issues Teaching in the Context of Immersive Media Technology

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## OPEN ACCESS

### Edited by:

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### Specialty section:

This article was submitted to  
Educational Psychology,  
a section of the journal  
Frontiers in Psychology

**Received:** 16 February 2022

**Accepted:** 04 April 2022

**Published:** 28 April 2022

### Citation:

Kong Z, Zhang S, Zhu F and  
Zhang J (2022) The Development  
and Prospects of Socioscientific  
Issues Teaching in the Context  
of Immersive Media Technology.  
Front. Psychol. 13:877311.  
doi: 10.3389/fpsyg.2022.877311

Marshall McLuhan once proposed the concept of “global village,” believing that with the help of electronic media, Earth has become indistinguishable from a community, and there is only one Earth for human beings and one world for all countries. Today, with the continuous development of media technology, the concept of a human destiny community has also gained the general consensus of people around the world. The global value of the human destiny community encompasses the interdependent concept of international power, the concept of common interests, the concept of sustainable development, and the concept of global governance. In particular, the concepts of sustainable development and global governance have been advocated by the public, which in turn has led to extensive public discussions on Socioscientific Issues (SSI), in which the teaching of SSI is gradually considered by the international science education community as one of the important goals of science education. The current issues and challenges facing SSI teaching and how immersive media technologies can facilitate SSI teaching have become important issues of keen public interest.

**Keywords:** media technology, immersive media, SSI, convergence development, teaching method

## INTRODUCTION

Socioscientific issues (SSI) stems from a reflection on the role of science and technology as a double-edged sword that brings positive utility on the one hand and adverse effects on the other in its application. Therefore, the application of science and technology is always associated with moral and ethical issues, and science and technology also bring about ecological and environmental problems, global governance, etc. These problems are increasingly affecting the survival of human beings, and people will think ethically and morally about the application of science and technology. In the process of thinking, controversial issues are generated, which is the source of SSI (Sadler et al., 2007). SSI is an emerging pedagogical model that goes beyond STS education, which emphasizes the requirements for science education goals but never pursues the ethical issues arising from science and technology. Unlike STS education that simply links science in the form of end results



to social applications, SSI education is based on STS education that emphasizes the cultivation of scientific literacy (Bingle and Gaskell, 1994). Furthermore, along with science education, SSI education places more emphasis on introducing social scientific issues into the educational process, allowing students to reflect on the ethical and moral issues that arise in the application of science and technology based on a deep understanding of the nature of science and technology, and allowing students to participate in decision-making on issues with this reflection. By doing so, the educational value of SSI is not only limited to cultivating students' basic scientific literacy, but also helps improve students' awareness of ethical and moral issues, while invariably enhancing their reasoning and judgment skills in the process of participating in decision-making. In the context of globalization, the issues brought about by science and technologies extend to all aspects of the world, which poses many new challenges to SSI teaching. At the same time, with continuous development of electronic media technology, the concept of international power, common interests, sustainable development and global governance embedded in the concept of human destiny community provides a new vision for the world to carry out SSI teaching. In response to the global issues brought about by science and technology, it is of great practical significance to study the challenges faced by SSI education in the new environment and new technological conditions, and how to apply immersive media technology to SSI teaching, given the rapid development and widespread application of immersive media technologies.

A large number of existing studies have examined SSI-based learning can enhance students' disciplinary knowledge and scientific literacy. These articles emphasized interdisciplinarity approach in socio-scientific issues in terms of specific issues. Zowada et al. (2020) states the potential relevance of pesticides for chemistry education in connection with education for sustainable development. Bioscientific advances also put forward numerous new ethical dilemmas. Lombard et al. (2020) advocated cognitive empathy, which is rarely developed in schools, is a crucial skill to address the complex socioscientific issues (SSIs) that recent neuroscience raises. Apart from socio-scientific issues in general, extensive recent studies focus on how SSI-based learning can contribute to science education in the era of the COVID-19. Fooladi (2020) constructed three models as a new composite model that assist communicators and educators understand and analyse complex socio-scientific issues in pandemic. The model is applied on the contradictory issue of Norwegian and Swedish governments' very different responses to the pandemic (Fooladi, 2020). Reiss (2020) showed how COVID-19 has broadened and deepen the moral philosophy that students typically meet in biology lessons.

Despite the focus on school lessons, some researchers notes the comprehensive abilities for being an outstanding citizen when dealing with socio-scientific issues. These abilities involved many aspects, such as Critical Thinking (CT), Rumor discrimination ability, and other higher-order cognitive thinking skill for making decisions. For instance, Barzilai and Chinn (2020) proposed diverse perspectives on how post-truth problems related to scientific and socio-scientific issues might be educationally

addressed. Evagorou et al. (2020) conduct a qualitative study of a classroom of 10–12-year-old students working collaboratively in argumentation and modeling and further explore how primary school students use their models whilst arguing about a socio-scientific issue. Likewise, Ke et al. (2021) proposed the significance of learning and using multiple models for students in the context of SSI.

Some researches revealed relevant individual attitudes toward SSIs. Ke et al. (2020) focus on students' perceptions of SSI-based learning and uses semi-structured interviews from 33 students in a midwestern U.S. high school to investigate students' perceptions of SSI-based learning and how to support students in considering the epistemic aspects of SSI learning. While Nida et al. (2020) collected questionnaires from 99 Indonesian science teachers and explored their experience and perceptions toward SSI-based education. The authors found that almost all of the participants saw potential in SSI-based education for the character formation of students, but most of the respondents did not implement SSI-based teaching very often in their lessons because of a range of limitations (Nida et al., 2020).

Numerous scholars have conducted extensive research in diverse teaching methods used in SSI-based Education. Suryani et al. (2020) conducted a Classroom Action Research in order to find out how implementing Group Investigation (GI) learning model combined with SSI improve students' Problem-solving skills. Some authors have driven the further development of online SSI-based education. Rodrigues Martins et al. (2020) introduced a curricular approach where a research group consisted of schoolteachers, undergraduate and graduate students analyzed controversies and fake news in the production of a web page. Similarly, Puig Mauriz et al. (2021) carried out an empirical study with a group of secondary students engaged in diverse online activities that required them to practice critical thinking and argumentation for dealing with coronavirus information and disinformation, and aimed to examine students' critical assessment about SSIs.

There are also a small number of studies have involved immersive media technology in SSI education. Filter et al. (2020) found that immersive technology could stimulate interest about nature related to the socio-scientific issue, even among people who did not already hold positive attitudes toward that issue. The authors pointed out that immersive technology provide nature experiences with positive affective learning outcomes (Filter et al., 2020). However, the study focused on nature experiences in VR and was not an educational experience.

Overall, there has been very little discussion about SSIs in an Immersive Media Technology Context. On the one hand, the existing studies are predominantly focused on a single topic of SSIs, and lacked a systematic classification of these topics. On the other hand, the role of Immersive Media technologies and its effects in SSIs teaching were not discussed in-depth. This manuscript establishes an evaluation system for SSIs education, systematically and quantitatively examines the factors that influence SSIs education, and discusses the role of Immersive Media in public understanding of SSI in a bid to address the gap.

## CONSTRUCTION OF SOCIOSCIENTIFIC ISSUES TEACHING MEASUREMENT INDICATORS

Back in the 1920s, when radio technology was first invented, McLuhan used the term “global village” to describe the great impact of radio technology on human society. McLuhan used the term “global village” as such, “But one thing is for sure: the discovery of electromagnetic waves has reshaped the synchronous ‘field’ of all human things, so that the human family exists in the ‘global village’ state” (McLuhan, 2014), or something like “it is a new world of global village” (McLuhan, 2011). Nowadays, with the rapid development and high prosperity of information technology and electronic media, the term “global village” is widely known and has become a buzzword used on many occasions. Now people usually use “global village” to describe Earth has been no different from the community. People in any country or region can rely on electronic media technology to be linked together as one. Human beings live in a common Earth and a world, electronic media technology has brought everyone closer. The concept of “global village” and the human destiny community both describe the state of Earth becoming increasingly integrated today; moreover, the concept of human destiny community has a rich connotation. At present, among the results of domestic academic research on SSI, there are fewer literatures that analyze the impact of the concept of human destiny community on SSI from the perspective of globalization and human destiny community, which also makes the research from this particular perspective novel and innovative. We can see that each of the four aspects embedded in the global value of the human destiny community provides a multidimensional and new perspective for SSI research.

### International Power Concept and Socioscientific Issues

For many centuries, the struggle for international power among different countries and groups has been dominated by wars, which have brought untold disasters to mankind and caused many tragedies in human history. Today, with the increasingly frequent transnational movement of science and technology, capital, population and other elements, the world is tightly linked into a whole. A bond of interest is formed between countries in order to realize their respective interests. Therefore, a country that wants to assert its international power and thus achieve its interests does not necessarily have to go to war, as it did before. The economic interdependence between countries has contributed to the slowing down of the international situation. During the formation of the international system, the contrast between the level of science and technology between countries can be used as a measure of the international position occupied by a country. Therefore, all countries hope to enhance their economic strength and international status through innovative research in basic science and the application of new technologies, so as to take their place in the international system. It is for this reason that the moral and ethical issues of countries in

applying science and technology to gain international status have been raised, and these issues have become a hot topic of public concern, which has given rise to SSI on the international concept of power. The common topics of SSI on the international view of power and its manifestations include the following: (1) Discussion of “hegemonism” in science and technology. Scientific and technological “hegemonism” manifests itself in the form of international suppression, bullying, and isolation of countries with a later start, a weaker foundation, and a lower level of science and technology by some countries that have started the scientific and technological revolution earlier and are therefore stronger in science and technology. It also manifests itself in unilateral protectionism in science and technology, imposing sanctions on technology companies of other countries. (2) Discussion of nuclear war. The emergence of nuclear weapons is a great progress in the history of human science and technology, but at the same time, it will also cause a crisis of human's own survival. Once a nuclear war breaks out, mankind will face an unprecedented disaster. The famous scientist Albert Einstein once said candidly that mankind should destroy nuclear weapons to avoid possible nuclear war. Currently, however, mankind obviously has no intention of destroying nuclear weapons, which has to arouse people's concern and discussion on this issue. (3) The discussion of artificial intelligence technology. AI technology is the frontier and focus of world science and technology competition at present and in the near future, so it is also a hot area of science and technology innovation in various countries. However, will AI benefit mankind? Stephen Hawking has questioned it, and he warned that people should be wary of AI. The discussion of AI technology also appears in people's daily lives.

### View of Common Interests and Socioscientific Issues

The view of national interest has different connotations in different times. During the monarchy period, the interests of the state represented only the interests of the monarch and the royal aristocracy in the country. In the 20th century, the interests of the international community were described as a zero-sum relationship with an exclusive nature. Under the conditions of economic globalization, the concept of national interests has been defined in a new way. First of all, there is a deeper reflection on the traditional view of national interests. Today, as the world is increasingly integrated into a “global village,” one country may serve its own interests and realize its own interests to the detriment of others, because the interests of all countries have become highly intertwined and formed a chain of interests that binds all countries together. Globalization has broken the limitation of time and space, which makes the people of the world more and more closely connected to each other and their interests more and more intertwined. However, conflicts of interests and disputes among countries still exist, and the phenomenon of unreasonable and unjust distribution of international interests still exists (Xinxin, 2019). In this context, the issues that arise include the following:

(1) the discussion of international “unilateralism.” At present, there are still big countries uphold the zero-sum game thinking, in order to maintain their own interests at the expense of other countries’ interests. Without regard for the wishes of the majority of countries and people, they individually or take the lead in withdrawing from or challenging the rules and systems that have been established or agreed upon to maintain international, regional, and collective peace, development, and progress. They also manifest behaviors and tendencies that have destructive effects and consequences on global or local peace, development, and progress. (2) For the discussion of world food safety issues. When food safety problems occur in one country, this country may export food with safety problems to other countries in the world, thus jeopardizing the food safety interests of other countries. (3) A discussion of refugee movement. Nowadays the increasing development of transportation has made it possible to move waves of refugees. This puts a country in a dilemma, where it may be in its interest to keep refugees out of the country, but it will be subject to humanitarian condemnation.

## Sustainable Development Concept and Socioscientific Issues

Among the concepts of the human destiny community, the concept of sustainable development is the most discussed topic in daily life. The concept of sustainable development that conforms to the development interests of all countries in the world has gradually become the broadest consensus around the world. This is because in the context of economic globalization, environmental issues have evolved into a human issue, which are related to the survival of human beings. As we all know, the natural environment is the natural basis for the existence and development of human society, and it is impossible for human beings to survive alone without a certain natural environment. If the momentum of further deterioration of the earth’s environment is not reversed, the civilization created by human society may suffer from extinction and go down the drain. Therefore, how to achieve harmony between man and nature and how to achieve sustainable development in this harmonious relationship is a major issue facing humanity. The contradictory state between man and nature originated from the technological revolution, and the transitional development of industry caused unprecedented damage to the natural ecological environment. Starting from the first technological revolution, which took place at the end of the 18th century, mankind applied science and technology to the production process on a large scale. From the use of the steam engine, which symbolized the beginning of the first technological revolution, to the arrival of the internal combustion engine on the industrial stage in the second technological revolution, to the application of more modern and advanced science and technology in the production process today, the conflict between man and nature has become more and more acute. Against this backdrop, “*The Rio Declaration on Environment and Development*,” “*The Johannesburg Plan of Implementation*,” and “*The Future We Want*” and other achievement documents

with the core concept of sustainable development have emerged. The concept of sustainable development is increasingly becoming a consensus issue for countries around the world to consider when formulating their development plans. Led by the value of sustainable development, SSI focuses on reflecting on the environmental problems brought by science and technology to human beings. At present, the environmental problems plaguing human beings include global warming, the sharp decline of biodiversity, the deterioration of air quality, and the shortage and deterioration of water resources, etc. The SSI on sustainable development is also centered on these issues. (1) Discussion of global warming. Although the international community has made a collective effort, and the “*Paris Agreement*” established in 2015 set the goal of keeping global warming within 2°C of pre-industrial levels for nearly a century and striving to achieve the target of 1.5°C (United Nations, 2017). However, the trend of global warming has not been reversed, and the environmental problems brought about by global warming have prompted people to reflect on the nature of science and technology. (2) Discussion on the deterioration of water resources. Improper discharge of industrial wastewater and domestic wastewater can directly cause water quality deterioration and affect the safety of aquatic organisms. If a country discharges too much wastewater into the sea then the wastewater may affect other countries with the flow of ocean currents. People gradually have a new understanding of science and technology and its application in the discussion of these issues. Some foreign scholars believe that we still need to use science and technology to change nature, making it meet people’s needs. In addition, technology is once again considered as a means that can promote the development and health of ecosystems, both individual organisms and human communities. Therefore members of these communities enhance the health and life of these ecosystems in their actions (Gunderson et al., 2010, pp. 167–195). Guided by the concept of sustainable development, SSI provides a guide for human beings to use advanced science and technology to solve environmental problems and achieve harmonious relationship between human and nature by reflecting on the environmental problems brought about by science and technology. This is the reason why SSI on the concept of sustainable development can be so extensively discussed.

## Global Governance and Socioscientific Issues

The scientific concept of global governance was introduced in the report “*The World is Our Neighborhood*” of the Commission on Global Governance (CGG) published on the 50th anniversary of the United Nations. The core concept of global governance is that, in the context of the era of global integration, the international action subjects are diversified. The subjects to deal with global issues also consist of different governments, intergovernmental organizations, non-governmental organizations, multinational corporations, etc. It is only through the interaction of these pluralistic subjects in joint participation and mutual consultation that the current global issues can be solved in a good and

practical way. The global governance issues facing human society are diverse, ranging from development issues, security issues, to environmental and other multifaceted issues. How to formulate a reasonable global governance norm in the global context and make it universally mechanism and morally binding to the global governance subjects has become the key to properly deal with these global issues. Throughout the context of global integration, various global problems caused by science and technology are not well solved because of the absence of such a well-regulated global governance system. Therefore, the SSI on the concept of global governance revolves around these issues. (1) Discussion of the ethical norms of biotechnology. Biotechnology is also a globally developed technology field, and biotechnology without appropriate ethical norms to restrict its use may lead to global biosafety issues and moral and ethical problems. The development of cloning technology, for example, has led people to think about the ethical issues involved. In particular, nowadays the emergence of cloning technologies such as gene cloning has forced people to be wary of such biotechnology. Another example is the question of whether genetically modified foods are harmful to human health, which makes people fearful when they talk about genetic modification. Furthermore, the problem of microbial leakage caused by experiments on viruses and other microorganisms has a direct impact on the survival of human beings. (2) Discussions by regional organizations. An international organization formed by some countries to promote the unity and solidarity of the region to which they belong and to strengthen mutual cooperation in politics, economics, diplomacy, defense and security. For example, the European Union, BRICs, G8 Group, etc. The issue of how to achieve benefit sharing has been widely discussed.

## MODEL CONSTRUCTION

In order to establish an assessment system for SSI education and to systematically and quantitatively examine the influence of various factors on SSI education, this study uses a hierarchical structure model for specific model construction. The model consists of two primary criteria, four secondary criteria and 15 tertiary criteria, which are expressed as shown in **Figure 1**.

In the multi-level structure model, the importance of each indicator is bound to vary, and it is necessary to quantitatively describe the same level elements by comparing them two by two through the 9-level scale method, construct a judgment matrix, and calculate the weights occupied by each criterion to assist in decision analysis.

## Delphi Method of Collecting Expert Opinions

To enhance the rationality and refinement of the model, this study was based on the Delphi method, and the importance of the above factors was judged by distributing questionnaires to 20 experts. The expert group selected for this study was composed of teachers from several universities and Ph.D.

students with education-related backgrounds with remarkable representativeness, all with higher education and certain teaching experience, to ensure the authenticity, scientific validity, and accuracy of the feedback data. In order to eliminate interference, the experts evaluated the questionnaires based solely on their personal perceptions during the process of distribution, without meeting, communicating or interfering with each other.

## Hierarchical Analysis to Determine the Weight of Subjective Indicators

Hierarchical analysis was first proposed in the 1970s by American operations researcher T. L. Saaty, a professor at the University of Pittsburgh, as a method of analysis for multiple indicator problems (Saaty and Kearns, 1985). It operates by combining expert opinion and relevant literature to divide the influencing factors of a problem into an ordered hierarchy of interrelated factors and to determine the weights of the criteria at each level.

Based on Thomas Satie's literature, this study used a 5-level scale approach, in which experts were asked to subjectively assign weights to the indicators in the model. The hierarchical analysis method is divided into five scales: equally important, slightly important, quite important, extremely important, and absolutely important, with the values 1, 3, 5, 7, and 9, in addition to four scales between these five scales, namely 2, 4, 6, and 8. The assessment scales and their interpretations are shown in **Table 1**.

The judgment matrix  $Q$  is obtained after pairwise comparison of each indicator at the same level of hierarchy as follows. In  $Q$ ,  $\alpha_i, \alpha_j$  ( $i, j = 1, 2, \dots, n$ ) denote factors.  $\alpha_{ij}$  denotes the relative importance value of  $\alpha_i$  to  $\alpha_j$ , satisfying  $\alpha_{ij} > 0$  and  $\alpha_{ij} = 1/\alpha_{ji}$ , and the judgment matrix is expressed as follows:

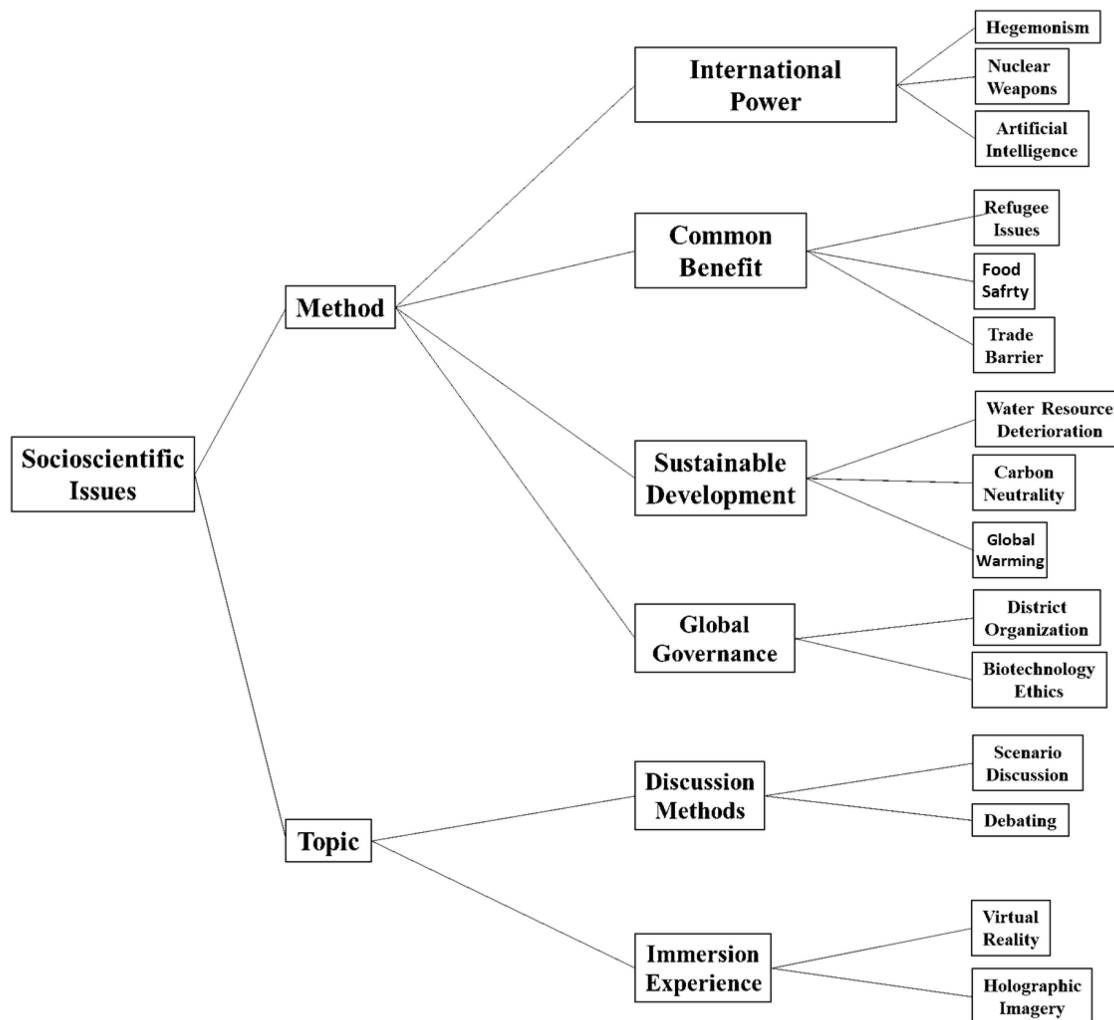
$$Q = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{bmatrix}$$

In order to avoid contradictions in the logic brought about by subjective decisions during pairwise comparison of the criteria of each level of SSI education by the relevant experts, a consistency test is needed to detect the reasonableness of the judgments made by the expert questionnaire. The test method is as follows:  $CR = CI/RI$ , where  $CI = (\lambda_{\max} - n)/(n - 1)$ .

In the above equation,  $CR$  is the consistency ratio,  $CI$  is the consistency index,  $\lambda_{\max}$  denotes the maximum eigenvalue of the matrix, and  $RI$  is the random consistency index, whose values are shown in **Table 2**.

According to Satie's suggestion, when  $CR < 0.1$ , the degree of consistency of the judgment matrix is more desirable; otherwise, the values of indicators in each layer need to be readjusted. In the judgment matrix of this study, all the  $CR$  values are less than 0.1, so the expert decision data pass the consistency test. After calculation, the weight data in **Table 3** can reflect the influence of each factor on SSI education in a more comprehensive way. Among the primary criteria, the quality of information is the most important. Among the secondary criteria, timeliness





**FIGURE 1 |** Hierarchy of socioscientific issues (SSI) educational assessment.

of feedback service, update rate of the system and ease of information comprehension are the most important.

## TECHNOLOGY IMMERSION: THE INTEGRATION OF IMMERSIVE MEDIA TECHNOLOGY AND SOCIOSCIENTIFIC ISSUES TEACHING

Immersive media refers to the use of computer generated technologies such as VR, AR that isolate the users from the real world while presenting reality as a three-dimensional virtual environment (Herrera et al., 2018). The fundamental idea of immersive media is to allow the participant to see the world from the first-person perspective, which could lead to greater audience involvement (De la Peña et al., 2010). Immersive Media is an emerging technology that is being increasingly used in teaching and learning as it continues to develop and mature. In our model of the SSI teaching assessment system, instructional methods

and content are included in the same level of criteria, and the results of the expert opinion collection and calculation show that instructional methods are given more weight than content. This indicates that the choice of a teaching method is very critical to the effectiveness of SSI teaching. Virtual worlds, serious games, simulations, and augmented reality are enabling students and instructors to connect with content and each other in novel ways. Many have noted the new support these media provide and their impact on important pedagogical constructs such as presence, immediacy, and immersion (Bronack, 2011). Because of the many characteristics of immersive media technologies themselves, such as the ability to break the limits of time and space and to construct virtual realities and thus immerse people, their application to science teaching can have unexpected effects. In the process of science teaching, the biggest advantage of immersive media technology is to provide students with a three-dimensional experience, thus it has the effect of greatly enhancing the enthusiasm of students to learn actively. For example, in high school physics classes, immersive media technology can

**TABLE 1 |** Assessment scales and their interpretations.

Assessment scales	Interpretations
1	Both guidelines are equally important
3	The former is slightly more important than the latter
5	The former is quite more important than the latter
7	The former is extremely more important than the latter
9	The former is absolutely more important than the latter
2, 4, 6, 8	Intermediate value of adjacent scales
Inverse of the above scale	The inverse comparison of two criteria, such as criterion i to criterion j with a scale of xij and vice versa with 1/xij

**TABLE 2 |** Randomized indicators.

n	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45

**TABLE 3 |** Weights table of education evaluation indicators with socioscientific issues (SSI).

Criteria name	Global weights	Peer weights
Topic selection	0.4916	0.4916
Teaching style	0.5084	0.5084
International power	0.1121	0.2281
Common interests	0.1236	0.2514
Sustainability	0.1354	0.2754
Global governance	0.1205	0.2451
Discussion style	0.2463	0.4845
Immersion	0.2621	0.5155
Hegemonism	0.0357	0.3181
Nuclear weapons	0.0372	0.3317
Artificial intelligence	0.0393	0.3502
Unilateralism	0.0376	0.304
Food safety	0.0432	0.3495
Refugee issues	0.0428	0.3466
Carbon neutrality	0.044	0.3252
Global warming	0.0467	0.3452
Water resources deterioration	0.0446	0.3296
Regional organizations	0.062	0.5143
Biotechnology ethics code	0.0585	0.4857
Scenario discussion style	0.1218	0.4945
Debate style	0.1245	0.5055
Virtual reality (online)	0.1349	0.5149
Holographic imagery (offline)	0.1271	0.4851

bring students to the vast universe of stars, so that they can personally experience the magic and wonders of the universe. In SSI teaching, immersive media technology can likewise gain a wide scope of application. However, the integration of SSI teaching with immersive media technologies still faces many difficulties, and the results of the model show that the traditional SSI instructional approach of debate style still has a higher weighting than that of immersive instruction. Today, with rapid development and increasing popularity of immersive media technologies, combining SSI teaching with immersive media technologies has become a new expectation for SSI education.

## Teaching Socioscientific Issues Online

In today's rapid development of information technology, the Internet has entered thousands of households. Especially, the popularity of cell phones has increased people's access to the Internet and reduced the cost. According to the data, the Internet penetration rate in China has reached 94.6% by 2019. Thus, it becomes possible to implement SSI teaching online. When we compare the offline viewing SSI teaching with the online immersion SSI teaching, we know that the online immersion SSI teaching has more weight. This is because online immersive SSI teaching is not only convenient, but also maximizes the characteristics and advantages of immersive media technologies that are not limited by time and space. Although there are many weaknesses in the current online teaching resource platforms, such as the lack of sharing among different teaching resource platforms, slow updating of teaching resources, and teachers' inability to understand students' online learning, etc. (Kone et al., 2000). However, it is undeniable that online immersive SSI teaching has a wide application prospect. Teachers can build SSI scenarios online for students to conduct online SSI learning and discussion, which can fully engage students in SSI discussions compared with traditional classroom teaching of only 50 mins. Moreover, with the addition of immersive media technology, the SSI scenarios built online are more impactful for students, allowing them to face the conflict situations online through the virtual and three-dimensional experiences brought by immersive media technology. By exposing students to the intricacies of issue conflict, they can experience how conflict arises in the process of value formation, conflict, and decision making, and guide them to actively consider how to apply due process to resolve conflict so that conflict can become a driving force for democratic development has become an important experience in teaching SSI abroad (Yucheng, 2013). Inspired by this experience, building a shared, comprehensive and open online teaching platform for SSI and making full use of the advantages of immersive media technology in SSI teaching have become the main trend for conducting SSI teaching at present and in the future.

## Establishing a Multi-Functional Immersive Teaching Experience to Promote Socioscientific Issues Teaching in a Comprehensive Manner

The development of immersive media technology has broken the limitations of traditional SSI teaching methods. Traditional SSI teaching methods are limited to book teaching, oral teaching, electronic audio-visual teaching, etc. These traditional SSI teaching methods are increasingly inadequate to meet the demands of SSI teaching in the context of globalization and the increasing global issues today. People are no longer satisfied with the traditional means of accessing SSI resources through reading books, especially for children who are full of the unknown and eager to learn about the world. Traditional SSI teaching methods are not only limited in satisfying children's curiosity, but also not motivating children to think actively. Immersive media technology certainly provides a new opportunity to revolutionize

SSI teaching and learning. Immersive media technologies can provide high quality, intuitive and multi-sensory stimulating SSI situations to the educated population. Multi-functional immersive SSI teaching and learning experience centers with low entry barriers can be established in various places, and science teachers can regularly lead children to visit, experience and learn in the experience centers, so that they can realistically and genuinely feel the multifaceted problems brought by technology to human beings and drive them to think actively. In the comparison of the secondary guidelines, the view of sustainable development has the greatest weight, because environmental protection and sustainable development are becoming major issues of concern. The global warming issue, the deterioration of water resources, and the carbon neutrality issue, which are related to the view of sustainable development, are all given considerable weight in the three-level guidelines we developed. The peer weights they occupied are 0.3452, 0.3296, and 0.3252, respectively. Therefore, we can conduct immersive SSI teaching for these issues of sustainable development. For example, we can use immersive media technology to build an experience hall that can virtually simulate the ecological and environmental crises of the Earth, and in the process of teaching biology courses, we can lead students to visit this experience hall to make them feel the ecological and environmental crises that Earth is suffering from. This will lead them to think about the science nature and establish a correct view of the science nature. In addition, although the weight of nuclear weapons in the tertiary guidelines is not significant, we are always facing the threat of nuclear war and nuclear leakage. With the development of immersive media technology, we can even establish experience museums to simulate nuclear war and nuclear leakage and other situations, which also become the future of immersive SSI instruction.

### **Simultaneous Immersive Media Technology Training and Socioscientific Issues Instructional Training for Science Teachers**

Compared to traditional SSI teaching, there is a certain threshold of technical proficiency in using immersive media technologies for SSI teaching. For most science teachers, the ability to use and manipulate immersive media technology to build highly feasible SSI instructional contexts is limited by the science teachers' proficiency with this technology. Therefore, training science teachers on immersive media technology becomes critical to the success and effectiveness of immersive media technology in facilitating SSI teaching. In addition, training science teachers in immersive media technology should be accompanied by training them in SSI teaching, and this is an even more important aspect. First, training should be conducted to strengthen science teachers' understanding of SSI content knowledge. Research studies by Liu Enshan's team as well as by Tidemand and Nielsen (2016) from abroad have shown that the current understanding of science teachers about SSI content knowledge is not ideal and there are misconceptions about SSI content knowledge (Bing and Enshan, 2021). This predisposes teachers to neglect the

cognitive and ethical development of students in SSI teaching. Therefore, enhancing the training of science teachers' SSI content knowledge in practice becomes a prerequisite for SSI teaching using immersive media technologies. Second, science teachers should be trained to teach SSI on an individual basis. The different subject matter knowledge taught by science teachers in different disciplines has resulted in variability in SSI teaching in different disciplines, and the training of science teachers in SSI teaching should also be conscious of this variability. For instance, teachers of biological sciences should be made aware of the current problems in the world due to the use of biological sciences, so that they can properly teach SSI in biological sciences classrooms in conjunction with immersive media technologies that are appropriate for the biological disciplines. Along with training science teachers in immersive media technologies, training them in SSI teaching can create a highly qualified science teacher force that will continue to develop a feasible space for the integration of immersive media technologies in SSI teaching.

### **Application of Immersive Media Technology for Socioscientific Issues Teaching Should Target Global Issues**

Under the leadership of the value of human destiny community, SSI teaching must focus on global issues, including development issues, governance issues, political and economic conflicts, sustainable development issues, and other issues faced by human beings. This has become an irreversible trend in SSI teaching. In the secondary guidelines, the peer weights of international power perspective, common interest perspective, sustainable development perspective and global governance perspective are 0.2281, 0.2514, 0.2754, and 0.2451, respectively. To carry out immersive SSI teaching accordingly, scientific and reasonable teaching plans and contents should be formulated according to the different weights. In the process of continuously promoting the integration of immersive media technology and SSI teaching, more attention should be paid to the characteristics and advantages of immersive media technology, i.e., the ability to build SSI teaching contexts by constructing virtual scenarios. For example, in SSI teaching about sustainable development, the use of immersive media technology to build virtual scenarios of environmental deterioration not only allows students to intuitively experience the environmental problems in their own countries, but also allows them to see the impact of the environmental deterioration problems brought by technology to Earth on the oceans, glaciers, climate, and various other aspects. This is beneficial for students to expand their perspective and understand the nature of science. The question of how immersive media technologies can be integrated into SSI teaching, and how to focus on global issues in this integration, is a critical topic for research.

## **CONCLUSION**

This manuscript has explored the multidimensional perspectives provided by the international power perspective, common

interest perspective, sustainable development perspective, and global governance perspective on SSI under the value of human destiny community. At the same time, an assessment system of SSI teaching is constructed in order to quantitatively examine the impact of each factor on SSI teaching. By collecting experts' opinions through Delphi method to measure the indicators of the model, we found that it is more critical to choose a type of SSI teaching method to enhance the effectiveness of SSI teaching than the choice of SSI teaching content. In the context of accelerated globalization, there are a variety of issues raised by science and technology, and there are also a variety of SSIs generated. SSI teaching methods must keep pace with them, which requires us to continuously improve teaching methods and adopt different teaching methods for different SSIs. Immersive SSI teaching is better than traditional debate-based SSI teaching both in terms of weighting and teaching effectiveness. Therefore, this manuscript proposes four feasible suggestions on how to achieve the integration of immersive media technology and SSI teaching. Combined with the results of the model, this manuscript suggests that we should actively explore the application of immersive media technology in SSI on international power, common interests, and global governance, and build practical SSI teaching contexts. The corresponding SSI teaching methods can be based on offline discussion-based teaching and online immersion-based teaching. For SSI teaching on sustainability, the use of immersive media technology will be more widespread. We can establish a multi-functional immersive media technology experience hall and build a variety of virtual situations for SSI teaching, so that students can personally feel the changes that are taking place in the global environment. Thus students can actively reflect on the global warming problem and find ways to solve it, and they can therefore care for and protect nature more. In addition, it is worth mentioning that regional organizations in the global governance perspective are

also attracting more attention. This is because in the context of the accelerated evolution of globalization, a variety of regional organizations are increasingly influencing people's lives and have become an indispensable part of global governance. Therefore, teaching in this area should be appropriately increased in the content of immersive SSI. The application of immersive media technology in SSI teaching is still very promising, and how to apply it to SSI teaching and its effect is still a new problem for us. This manuscript tries to provide theoretical guidance on how to achieve the integration of immersive media technology and SSI teaching in the context of globalization.

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

## AUTHOR CONTRIBUTIONS

JZ: conceptualization, methodology, and software. ZK: data curation, writing – original draft preparation. SZ: visualization and investigation. FZ: software and validation. All authors contributed to the article and approved the submitted version.

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# The Improvement of Teaching Ideological and Political Theory Courses in Universities Based on Immersive Media Technology

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This paper focuses on the characteristics of immersive media technology and the advantages, problems and solutions in applying this technology to improve the teaching effectiveness of ideological and political theory courses in colleges and universities. Firstly, it introduces the current development and characteristics of immersive media technology. Secondly, it analyzed the outstanding advantages of immersive media technology in teaching from the following perspectives: virtual reality and augmented reality; sensory stimulation and emotional experience; and human-computer interaction and self-harmony. Thirdly, it puts forward the ways to improve the teaching effectiveness based on immersive media technology from the aspects of theoretical study, history study, and practical study of ideological and political theory courses in colleges and universities. Finally, it discusses the problems in applying immersive media technology to teaching the above courses and puts forward some solutions.

**Keywords:** effectiveness, ideological and political theory courses, colleges and universities, immersive media technology, teaching

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### Specialty section:

This article was submitted to  
Educational Psychology,  
a section of the journal  
Frontiers in Psychology

**Received:** 16 February 2022

**Accepted:** 11 April 2022

**Published:** 29 April 2022

### Citation:

Su L and Li M (2022) The  
Improvement of Teaching Ideological  
and Political Theory Courses in  
Universities Based on Immersive  
Media Technology.  
Front. Psychol. 13:877288.  
doi: 10.3389/fpsyg.2022.877288

## THE CONCEPT AND CHARACTERISTICS OF IMMERSIVE MEDIA TECHNOLOGY

### Immersive Media Technology

The concept of immersion originates from the immersion theory put forward by American psychologist Mihaly Csikszentmihalyi. According to this theory, immersion refers to the pleasure people may experience when they complete devotion to and concentration on ongoing activities and situations (Mihaly, 2017). When people are engaged in an activity that can attract their full attention and if the challenge coming with it matches their ability, they will be in a mental state of heightened focus and get along with the activity smoothly and efficiently, with all irrelevant perceptions filtered out and time standing still for them. This psychological experience is the state of immersion. We have immersive media when the above theory is applied to human-computer interactive media.

In *Universal Principles of Design*, the word “immersion” is interpreted as a kind of extreme concentration, an utter forgetfulness of the natural world around (William, 2010). This enables people to focus on the target situation created by the designer and thus feel pleasure and contentment. To experience the state of immersion requires two prerequisites. One is the

experience atmosphere. Being immersed in something means one is literally immersed in all the relevant information (as one is immersed in water while diving) with all the irrelevant things staved off. Physically and psychologically, we perceive the external world through sensory stimulation, including a series of sensory stimuli such as sight, hearing, touch, smell, and taste. The outside world stimulates people's senses through the joint action of these sensory channels, thus enabling people to form a perception of their environment and have a three-dimensional and all-around cognition of the outside world. Therefore, the other prerequisite is: in order to realize the state of immersion, it is necessary to create an immersive situation in which people's senses can be integrated into the content provided by the immersive media (Chen, 2020).

All audio and video technology that enables people to immerse themselves can be called immersive media. For example, a video call can make the caller have the same experience as talking face to face with a person who is far away. Another example is watching a movie on a high definition TV set. Though the viewer may have the feeling of coming to the scene presented in the movie, the immersion experience that these scenes can provide is not complete and thorough (Fu Y. 2020; Fu Y. Y. 2020).

One of the essential ways to achieve deeper immersion hinges on the isolation degree of the immersion atmosphere and to what extent one can stay undisturbed by external stimuli. Special immersive terminal equipment, such as a VR helmet, will produce a powerful sense of visual immersion. The immersive experience provided by VR technology makes use of the input oneness of human visual senses to create an experienced atmosphere that shields other irrelevant external visual stimuli, so that users can be completely immersed in the virtual world and forget about the real world. Another factor that affects the depth of immersion experience is content design. The balance between ability and challenge is one of the first conditions for an individual to realize the immersion experience (Mihaly, 2009). When completing a specific task, one can fully realize whether there is a match between his existing skills and the challenges. Immersive experiences are most easily achieved when the individual has a clear goal and can perceive the skill level to complete the challenge. For example, the most popular video games tend to be ones with a specific challenge that the players themselves are capable of handling. If a game is too difficult, players will often feel anxious and frustrated after failed attempts rather than have fun and satisfaction that the game itself should give, and as a result, they will inevitably give up in the end. If it is too easy, players are also likely to give up the game because of boredom and get immersed in it. Therefore, in the immersive experience, designing challenges for the experiencers, reasonably setting the balance between challenges and skills, and giving immediate feedback on the completion of the challenges will help the experiencers to build up the immersive experience.

Technically, when the immersion theory is extended to human-computer interaction, AR (augmented reality) technology and VR (virtual reality) technology are developed to provide a deep immersion experience. The emergence of AR and VR has enabled people to find ways to use technology to describe

the world in immersive media better. Relying on the industrialization process of computer 3D modeling, near-eye display, surround sound, force feedback vibration, micro-sensors and other technologies, immersive media will achieve the vividness of vision, hearing, touch, and smell and smoothness of interaction in the real world. Under such conditions, the users will enter a mode of shared experience in which their consciousness is concentrated in a small range, other irrelevant perceptions and thoughts being filtered, and only specific goals and explicit feedback being responded to. This produces a sense of control and affirmation of their own ability. The application of the above-mentioned technologies and devices to media effects immersive media technology.

## Application Prospect of Immersive Media to Improving Teaching Effectiveness in Education Field

Immersive media, as a brand-new media that combines psychology, acoustics, optics, and computer virtual technology, has been applied in various fields at present. The most typical one is the cultural tourism industry. Using immersive media technology and AR, VR and somatosensory interactive devices, a virtual environment is created according to historical facts, ideas or plots, so that participants can immerse themselves in the virtual environment to see, feel and interact, and their experience is significantly improved. Another broader stage for immersive media technology to exert its application value is the field of education. When the application of immersive media technology can be consistent with the teaching theory, the correct design and appropriate arrangement will provide strong support for the expansion and deepening of the course contents and the improvement and optimization of learning effectiveness. This is almost beyond traditional teaching methods.

The wave of educational informatization has unprecedentedly highlighted the power of education. By integrating educational informatization, innovating teaching modes, enriching teaching means and improving teaching effectiveness, immersive media technology is currently one of the most popular innovative means in the field of education reform in the world. Whether it is in the case of school education or social education, the contribution of immersive media technology is prominent. At present, quite a few universities in China have introduced immersive media technology to classroom teaching to improve the teaching effectiveness of some courses previously taught poorly in the traditional teaching model. In particular, the application of immersive media technology will effectively diversify and reify the teaching of ideological and political theory courses, which are the essential courses to implement the fundamental task of building up moral integrity and cultivating talents of virtues in the whole process of higher education. It can effectively help students to reduce cognitive load, stay motivated, improve practical ability, and cultivate positive emotions, thus achieving the desired teaching effectiveness.

Chinese President Xi Jinping once emphasized that "we should use new media and new technologies to conduct our

work vigorously, promote the high integration of traditional advantages of ideological and political education with information technology, and enhance the sense of the times and attraction” (Cao, 2017). In order to dynamize the teaching of ideological and political theory courses in colleges and universities, it is essential to innovate the teaching contents and have more effective educational carriers and forms. Immersive media technology is currently representative of cutting-edge media technology. It can be applied to improve the teaching effectiveness of ideological and political theory courses in colleges and universities by enhancing the sense of the times and attraction. With further development and maturity of computer virtual technology, sensor technology and network technology, the immersive media technology integrated into educational informatization is bound to flourish. Further integration between education and this technology is well on the way. It is bound to provide more convenient and efficient learning conditions for teaching ideological and political theory courses in colleges and universities and then cultivate more high-quality talents for our society.

## THE PROMINENT ADVANTAGES OF IMMERSIVE MEDIA IN IMPROVING THE TEACHING EFFECTIVENESS OF IDEOLOGICAL AND POLITICAL THEORY COURSES IN COLLEGES AND UNIVERSITIES

Immersive media has outstanding advantages in solving the problems of monotony and abstraction in the traditional teaching of ideological and political theory courses, helping students to reduce cognitive load, stay focused and motivated, and enhancing practical ability and team spirit. The tapping advantages of immersive media technology will make teaching ideological and political theory courses in colleges and universities yield twice the result with half the effort.

In order to verify and evaluate the advantages of immersive media in improving the teaching effectiveness of ideological and political theory courses in colleges and universities, experiments have been carried out among undergraduates in Liaoning University. Subjects participated in the experiment through voluntary registration. After excluding those who already knew about the experiment content, 60 undergraduates from Liaoning University were recruited as subjects. During the experiment, 240 valid questionnaires were collected. See **Table 1** for the specific information of experimental subjects.

The materials used in the experiment included traditional teaching media and immersion teaching media. Traditional teaching media included PPT slides (including text and static pictures) based on Section 2 of Chapter 5 in *Outline of Modern Chinese History*, a textbook for university ideological and political courses, and the documentary *Long March* filmed by China Central Television. Immersive teaching media included the immersive virtual simulation course system “Stay Confident on the Long March in the New Era—Decoding the Long March

**TABLE 1** | Information form of experiment subjects.

		Total number of people	Proportion
Academic degree	Undergraduate	60	100%
Age bracket	18–20 years old	60	100%
Gender	Male	24	40%
	Female	36	60%
Specialized subject	There are seven majors involved.		

Spirit” produced by Liaoning University, which could give subjects an overview of the Long March through time and space in the virtual Long March Memorial Hall. In addition, there was the VR interactive simulation experience system “Crossing Jinsha River” developed by Peijing Technology. The experiencer would become a boatman and help the Red Army main force to cross the torrential Jinsha River through human-computer interaction.

The 7-day experiment was conducted in the conference room and the multi-functional classroom of Marxism College of Liaoning University. The conference room had a big screen for PPT and video. The multi-functional classroom was equipped with 10 computers for VR equipment experience. During the experiment, 60 students were evenly divided into Group 1 and Group 2. Group 1 only used traditional teaching media to study, while Group 2 adopted immersion teaching media. The 30 students in Group 1 were taught the content of the Long March in the second section of Chapter 5 of *Outline of Modern Chinese History* by teachers in the conference room in one class, and in the other class, they watched the teaching video *Long March* (excerpt) and then filled out the questionnaire. The 30 students in Group 2 listened to the teachers in the conference room together with Group 1 in the first class. Then, in the second class, they went to the multi-functional classroom where they were subdivided into three groups of 10 students and continued to study using immersive teaching media. They watched videos, wore VR equipment, and filled out relevant questionnaires. After data collection, we used EXCEL for data statistics and analysis.

## The Blending of Virtual Reality and Augmented Reality Stimulates Excellent Attention Restoration Ability

The application of immersive media in promoting education and teaching practice is mainly based on VR, AR, and other technical equipment. VR technology is a comprehensive technology integrating computer technology, sensor technology, psychology, and physiology. The main simulation objects include environment, skills, and perceptions. It aims to simulate the external environment through the simulation software and hardware systems such as computers, audio-visual terminals, and tactile terminals and provide users with highly restorable, informative, and interactive virtual physiological and psychological experiences. AR technology is a combination of the virtual and the real. It simulates through computers and



terminals such information as vision, sound, taste, and touch that are difficult to experience in a certain time and space. It then superimposes the information on the real world for human senses to recognize to achieve cognitive experience beyond reality.

Attention is the concentration and focus of people's mental efforts—selective, transferable and distractible. Attention restoration is the process in which attention is distracted, briefly shifted and focused again (John, 2000). The attention restoration theory holds that in order to carry out daily life efficiently, people must keep their cognition clear, and clear cognition requires focused attention. The decline of focused attention ability will lead to many negative effects, such as reduced irritability, reduced planning ability, reduced sensitivity to interpersonal information, and increased cognitive error rate. However, focused attention requires individuals to ignore all potential distractions, which leads to huge energy consumption and fatigue (Stephen, 1995). Attention is a limited resource (Mihaly, 2009). The decline of attention will directly affect the teaching effect of ideological and political theory courses in colleges and universities. To achieve good effect in traditional teaching mode, teachers find it is a must to keep students fully aware of what is going on and frequently call their attention. At the same time, students are required to ignore all potential interference in class. This places a heavy burden on both teachers and students.

Ideological and political theory courses in colleges and universities, such as Basic Principles of Marxism, emphasize theoretical study. The teaching contents of these courses are often abstract, monotonous and theoretically challenging. Naturally, students may often find them too boring and difficult and burdensome since these courses usually require students to be good at abstract reasoning. So, the confusion, repetition and the complex learning content make it all the more difficult for students to restore attention. VR and AR technology is applied to teaching ideological and political theory courses in colleges and universities to solve this problem. This technology can improve the attraction of teaching contents, help to hold students' attention, and promptly restore attention if diverted. The cutting-edge MR technology can combine the advantages of both VR and AR, help students to visualize what they study, and reduce their cognitive burden. In the VR and AR learning environment under the framework of immersive media technology, teachers will show the course contents to students through mental and perceptual simulation, create a virtual space conducive to students' understanding and learning, or present the virtual contents in the real situation, to engage students in teaching through real-time interaction. When the learning situation ultimately attracts students' senses, their consciousness will narrowly focus on learning activities. At the same time, the differences between themselves and the environment, between stimuli and reactions, between the past, present and the future will almost disappear. They will only respond to clear goals and specific feedback, and irrelevant perceptions and ideas will be filtered out. Another important factor that affects students' attention restoration is the freedom learners enjoy thanks to the application of immersive technology.

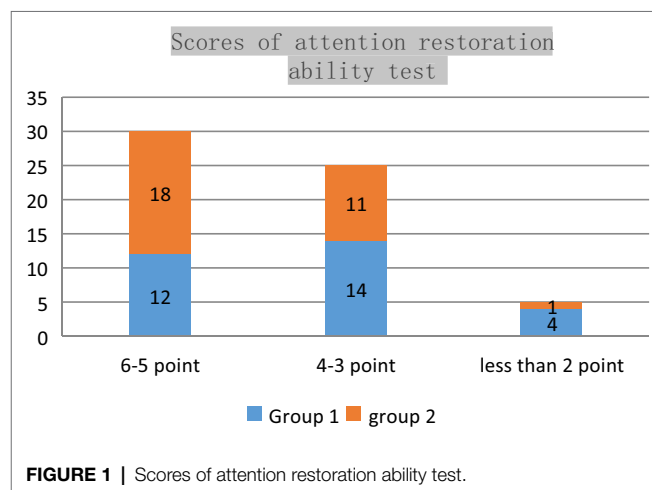
The greater the freedom is the easier it is for the students to ignore irrelevant information and focus on what they should learn.

In the questionnaire, the students of Group 1, who only learned through watching the video, were compared with the subjects who learned through VR teaching media made with immersive media technology. Whenever a major battle named after a river appears in the course for the first time (the teaching contents for the two groups are basically the same. Six major battles were mentioned. Only the first time counted), the subject needs to raise his hand within 3 s. A correct move scores one point; a wrong or failed one scores none. The number of students in the second group with a score of 6-5 is significantly higher than that in the first group. It can be seen that the use of immersive media technology in ideological and political theory teaching can effectively improve students' attention restoration ability (Figure 1).

## The Combination of Cognitive Experience and Emotional Experience Opens Up a Wider Learning Space

A learner's learning experience mainly consists of cognitive experience and emotional experience. The change of cognitive experience causes emotional response, so the promotion of emotional experience is based on the promotion of cognitive experience (Elliott, 2018). Cognition is knowing, learning, and understanding based on perceptions and judgment. Emotional experience, on the other hand, is sympathetic response to familiar experiences and the culture and spirit conveyed by the media contents. The learning situation displayed by immersive media technology often features a clear visual and realistic cognitive experience environment, and an immediate feedback and emotional incentive mechanism, which facilitates students' proper cognition, and arouse in them "a more sympathetic response, so that students may identify with happiness and sorrows in the situation, thus unconsciously informed and edified" (Suzhou Junior High School Chinese Teaching Panel, 2010).

One of the biggest limitations of traditional classroom teaching methods lies in the limitations of time and space on teaching situations. It is not easy to simulate and reproduce some specific



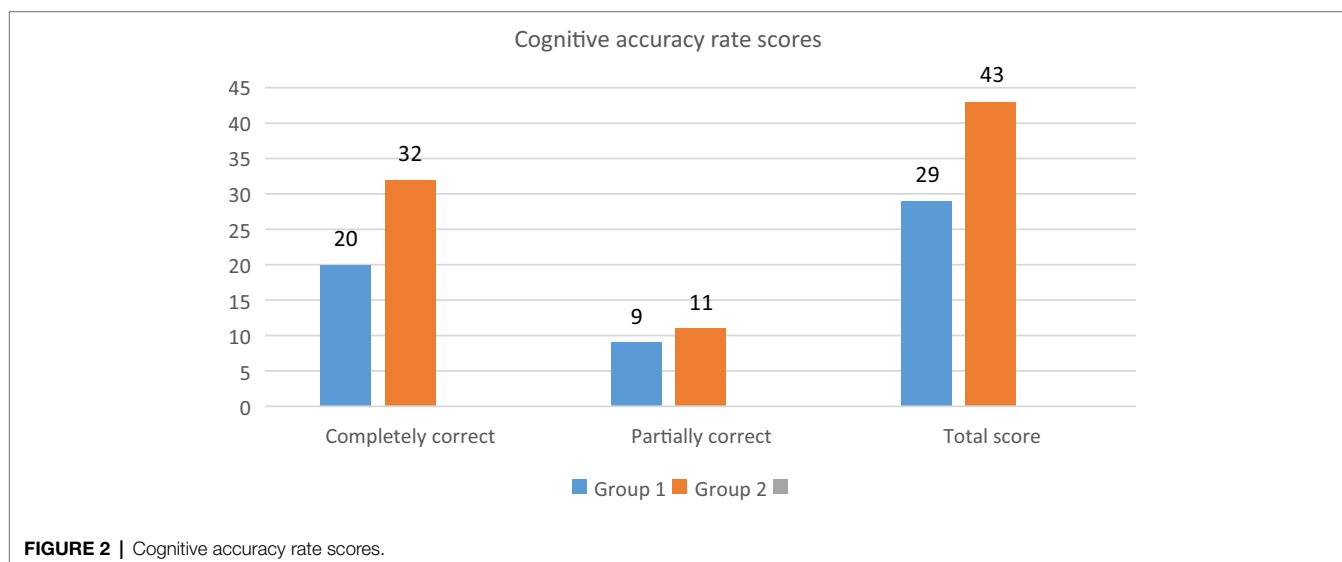
historical scenes in an all-around way to teach ideological and political theory courses in colleges and universities in a traditional way. Due to various objective factors, some historical scenes and historical figures are displayed only by one-dimensional text descriptions or two-dimensional photos and videos in the teaching process, which are usually not easily understood and accepted by students (Chen, 2018; Elliott, 2018). With the help of AR and VR terminals under the framework of immersive media technology, we can create a specific learning situation that conforms to the teaching contents through the virtual stimulation of senses such as vision, hearing, and touch. The historical scenes and characters can be simulated sufficiently realistic. So, teachers can decide to give instructions any time they want, but students can also “experience” the moments of history through simulated scenes and human-computer interaction. This breaks the limitation of time and space of classroom teaching and narrows the gap between theory and historical facts. Its effects on students’ accurate understanding is shown in **Figure 2**.

The questionnaire had a task: match the following statements with the battles they describe—Crossing Dadu River/Crossing Xiangjiang River/Crossing Jinsha River. Statement A was “This is the most tragic and fierce war on Red Army’s Long March. The river is dyed red with blood.” Statement B was “For 7 days and nights, the main force of the Red Army only relied on seven boats to cross the river.” Statement C was “The Red Army soldiers carried muskets and few grenades, holding on to the rickety iron rope and braving the fierce fire on the other side.” Students would score 2 points if they gave all correct answers, 1 point for some correct answers and 0 point for all wrong answers. The second group using immersion media had obvious cognitive accuracy advantages compared to the first group using only text materials and static PPT slides. It can be seen that the use of immersive media in teaching can effectively improve the accuracy of understanding and enhance the level of cognitive experience.

Fostering patriotism and cultivating national confidence is one of the important teaching tasks of ideological and political theory courses in colleges and universities. Immersive media

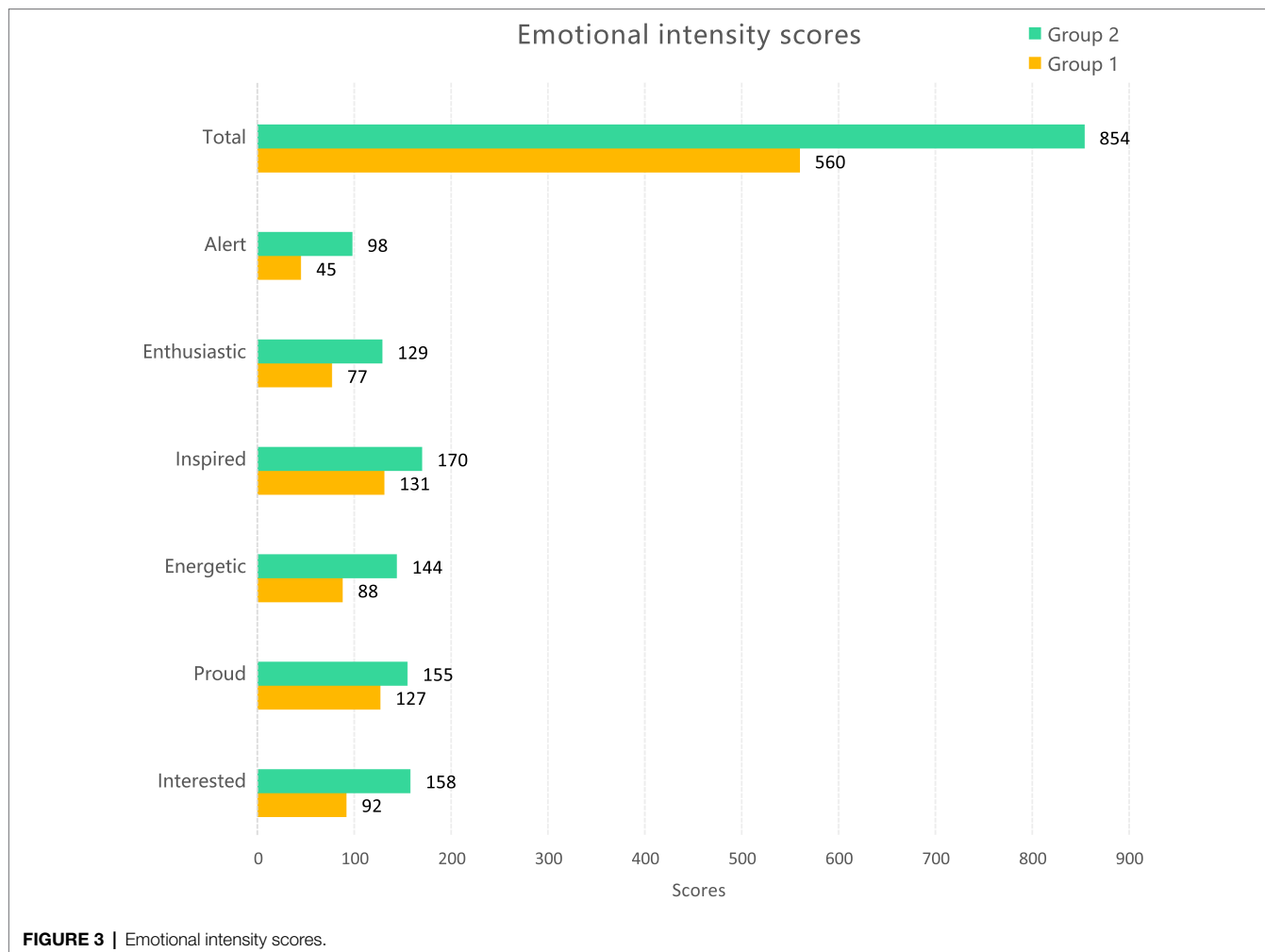
technology plays a positive role in creating emotional experiences and arousing emotional resonance. The most significant advantage of immersive media is to render the audience immersed. Real pictures, sounds, colors, shapes, etc., make the audience completely immersed in the “real world” of the virtual world and impact the emotional experience of the audience. Wise use of immersive media technology can enhance students’ emotional experience and effectively improve the teaching effect (Clifford and Montgomery, 2015). One of the important factors affecting students’ emotional experience is the vividness of learners’ experience in immersive media. Because students perceive things in the virtual learning environment the same as they do in the real world, they can feel the existence of “me” in the virtual world. This psychological identity makes learners feel keener about the experience. This emotional experience is positive and active, enabling learners to have a great sense of pleasure and fulfillment in the participation process, thus effectively improving the teaching effectiveness.

The positive and negative affect scale (PA-NAS) compiled by Watson and others was used to test the degree of participation in the emotional experience of the two groups. In the questionnaire (as shown in **Table 2**), five ideological and political theory courses, teachers preset six indicators of emotional response expected of students in teaching practice: interested, enthusiastic, proud, inspired, energetic, and alert. In the experiment, the numbers 1–5 represent the emotional intensity, and the larger the number, the higher the emotional intensity. The data gathered from the questionnaire completed by the two groups reveal that the first group scored 854 points, and the second earned 560. See **Figure 3** for statistics of specific emotional indicators. It can be seen that the application of immersion media enables the second group to have a significantly stronger intensity of all emotions listed than the first group, who were taught otherwise. It can be seen from the data in the table that there are significant differences between the two groups, both individually and collectively. Therefore, compared with traditional teaching media, immersion teaching media tend to arouse stronger feelings.



**TABLE 2 |** Students' self-assessment of ability improvement.

	Cooperation	Ability to handle different situations	Thinking ability	Esthetic understanding	Other abilities
Group 1	0	0	5	0	1
Group 2	7	1	14	12	7



Compared with traditional media, immersive media technology applied to teaching ideological and political theory courses in colleges and universities can give full play to the advantages of this technology in enhancing cognitive experience and emotional experience, providing students with a superior learning experience significantly improve teaching effectiveness.

### The Integration of Human-Computer Interaction and Interpersonal Interaction Enriches the Growth Environment of Subjects

The communication process of immersive media is “people-centered information communication, the blend of human nature and personality” and “a process of subjective creation based on the objective” (Li, 2017). The subjects who used

immersive media to learn ideological and political theory courses are college students. To give full play to the advantages of immersive media in improving teaching effectiveness, they have to be learner-centered, which means they should accommodate students' personality and help with the growth of students' abilities. The process of teaching is itself a process of communication between teachers and students and development on both parts. Without communication and interaction, teaching will not exist or it will be difficult to teach” (Guo, 2006). Immersive media technology can provide an environment of human-computer interaction and interpersonal interaction, including “social integration, creating new experiences” and “providing special incentive mechanism” to support the cooperative learning model, promote students' self-affirmation and self-harmony, and at the same time, help them to realize the growth of cooperation and communication skills,

which is an essential advantage that the traditional teaching model does not have (Wang, 2016).

Immersive media can provide a human-computer interaction beyond the traditional sense. Relying on the interactive sensing function, the immersive media software and hardware can create a virtual environment or a physical sensory experience combining the real and the virtual. In this interactive environment, learners emotionally communicate with the virtual world and become doers in the experience. They perceive and behave. Instead of simply receiving information and various sensory stimuli in immersive media, they actively participate in the construction and presentation of the virtual world. In the brand-new “human-computer interaction” mode, they can feel the three-dimensional and all-round environmental stimuli like they do in the real world and enjoy the self-harmony attributable to the scientific mechanism of progressive learning and the challenge of teaching games that match their skills. This self-harmony is a kind of “advanced human experience, which leads to development, self-realization and personality perfection” (Vasilyuk, 1989). In this active learning state, which is caused by the deep interaction between people and devices, students may complete some learning tasks that cannot be fulfilled under normal conditions, and achieve learning effects beyond expectations. However, learners often do not realize that the challenges brought by learning activities have already exceeded the level that they can handle in the past. In this case, students will fully affirm their own learning ability and be more willing to study hard for new knowledge to achieve a positive state of pleasure, satisfaction, excitement, and fulfillment. They will be inspired to pursue growth on a higher and more complex level.

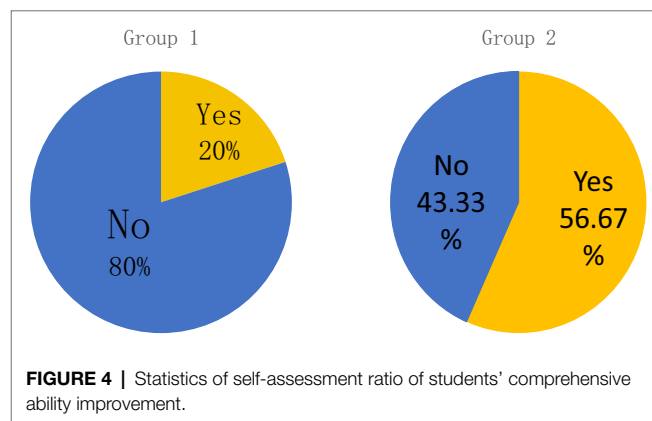
The cultivation of team spirit and communicative skills is generally considered to be an essential part of building up moral integrity and cultivating people in colleges and universities. In this regard, the most effective way of education is to complete practical tasks through communication and collaboration with others in real situations, following the learning method of social construction. The virtual environment created by immersive media technology enables “people to communicate with each other through virtual reality devices to the effect that they have a face-to-face communication” (Wang, 2016). Students can practice and test their learning achievements through human-computer interaction and peer interaction in virtual situations, and even get the experience of solving practical problems with learning partners in scenes they are unlikely to witness in real life (because of cost, danger, contingency, and other factors), so as to improve their comprehensive ability (Zhang, 2020).

Group 1, which only learned about the Battle of the Long March on the Jinsha River through traditional classroom teaching media, was compared with the subjects who studied through the VR interactive simulation experience system “Crossing Jinsha River” made with immersive media technology. The questionnaire asked this question: Through this round of learning, do you feel that you have gained and improved in other abilities besides classroom knowledge? If yes, please describe it.” The responses given by the two groups are shown

in Figure 4 and Table 3. A significantly higher number of students in Group 2 believed they improved their ability in other respects. These students think their improvement lie in thinking ability, collaboration, ability to handle different situations, esthetic understanding and other aspects, while those who have the same opinion in Group 1 tend to believe their improvement only lies in thinking ability. It can be seen that, in teaching ideological and political theory courses in colleges and universities, giving full play to the interactive advantages of immersive media technology will effectively stimulate students’ learning motivation, promote the growth of students’ comprehensive ability, and attain some of the goals of building up moral integrity and cultivating talents.

## WAYS TO IMPROVE THE TEACHING EFFECTIVENESS OF IDEOLOGICAL AND POLITICAL THEORY COURSES IN COLLEGES AND UNIVERSITIES BASED ON IMMERSIVE MEDIA TECHNOLOGY

The increased use of immersive media technology in the field of education means an ever-growing impact on the improvement of teaching effectiveness. However, in order to rapidly improve the teaching effectiveness of ideological and political theory courses in colleges and universities, we should explore the relationship between the teaching of these courses and immersive media technology from the perspective of theory and practice,



**FIGURE 4 |** Statistics of self-assessment ratio of students' comprehensive ability improvement.

**TABLE 3 |** Questionnaire for emotional responses.

Please tick <input checked="" type="checkbox"/> your emotional intensity after the learning process is completed (please tick one for each and every emotional response).					
Types of emotions	Strength 1 point	Strength 2 points	Strength 3 points	Strength 4 points	Strength 5 points
Alert	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Enthusiastic	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Inspired	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Energetic	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Proud	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Interested	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>



and seek for a new way to improve the teaching effect of ideological and political theory courses in colleges and universities through the application of this technology.

## **The Well-Designed Narration Makes the Theoretical Learning Model Leap From “Rational Cognition” to “Affective Identification”**

Affection is a person's attitude toward the relationship between objective things and himself. Affective identification refers to a psychological process when people have positive feelings for others, groups or things, and then emulate or assimilate them as the driving force to achieve their own goals. It is different from perceptual cognition. The realization of affective identification has to be based on reason. If a person cannot identify with another person or thing in terms of ideas, s/he is unlikely to develop a positive attitude of closeness, admiration, or trust emotionally. It can be said that the degree of affective identification indicates the degree of internalization of people or things that people pay attention to.

For students, in learning ideological and political theory courses in colleges and universities, affective identification has the functions of selection, motivation and correction. First of all, it can induce positive emotions to influence the judgment standard of students when they recognize things. Whether college students can resonate with the ideological and political theory courses will inevitably depend on the individual's emotional choice. Successful stimulation of students' inner positive emotions will make them actively participate in the learning process, thus resulting in an improved teaching effect. Secondly, effective identification is also the driving force for people to realize their value. With it, they will be motivated consciously or unconsciously into action. If students are expected to internalize the teaching content of the ideological and political theory course and externalize it into practice, they must have positive emotional experience first. Thirdly, effective identification has a curative effect. It can eliminate destructive emotions and improve people's willpower and self-control. Students will inevitably encounter fatigue, difficulties and problems in the learning process. Cultivating their affective identification with the courses and the curriculum contents can ensure that they learn with a healthy, stable and positive attitude.

At present, the actual situation is that college students' understanding of ideological and political theory courses basically stays at the level of “rational cognition.” To improve the teaching effectiveness, they have to leap from “rational cognition” to “affective identification.” The starting point to achieve this goal lies in the narrative way of teaching. The narrative is an essential means of emotional motivation and knowledge transmission, whatever teaching methods are concerned. The ideological and political theory courses are highly theoretical, abstract, and challenging. Still, they have a close connection with social life, so we should pay more attention to the innovative narrative methods in the teaching process. Immersive media has the unique advantages of breaking the limitation of time and space, vividly representing historical situations, turning abstract into

concrete and arousing emotional resonance. Suppose we can creatively use immersive media technology in the narration while teaching these courses. In that case, we can create a teaching situation that enables students to appreciate the historical situation of the times fully, clearly understand the theoretical logic of the teaching content, deeply experience the relationship between the course content and their life practice, and cultivate their emotional identification with the Communist Party of China, our country and the socialist system with Chinese characteristics. The integration of immersive media technology and educational informatization undoubtedly provides an all-around upgrade for the narrative ability of ideological and political theory teaching in colleges and universities. Driven by the fascinating narrative carefully designed with the support of VR and AR technology, students can fully understand and internalize what they have learned into effective identification, and most willingly immerse themselves in the whole learning environment.

## **Building a Virtual Teaching Platform That Can Enable Students to Have a “Time Travel Through History” Rather Than Just “a Glimpse of History” in History Classes**

Historical knowledge is an essential part of the teaching content of ideological and political theory courses in colleges and universities. Teaching historical knowledge is one of the major tasks of teachers. For example, the course “Outline of Modern and Contemporary Chinese History” informs students of the basic theory, ideals and beliefs of Marxism by teaching modern Chinese history and guiding students to establish a correct world outlook, outlook on life, and values and scientific outlook on history. Another example is “Introduction to Mao Zedong Thought and the Theoretical System of Socialism with Chinese Characteristics.” This course is about the historical process of the CPC's combination of the basic principles of Marxism with China's reality. Even a course that focuses on a theoretical study such as “Basic Principles of Marxism” also includes historical materialism and other knowledge related to history.

The traditional way of teaching historical knowledge can only give students a glimpse of history. Teachers usually prioritize lecturing, supplemented by conventional teaching media such as historical documents, photos, audio, videos, and charts. They try to help students to understand and appreciate historical knowledge by showing them some representative sketches, clips and moments in the historical process. Under this teaching model, the historical images presented in students' minds are not directly formed through visual and auditory perception as in the real world. They are just some mental pictures which are spliced by the refraction of their own experience and imagination. These pictures are not three-dimensional or clear, so they are unlikely to arouse students' emotional identification.

The application of immersive media technology in practice has remarkably influenced the teaching of ideological and political theory courses in colleges and universities. Although it will not completely replace the traditional teaching mode, it is sure to play a significant and positive role in constructing

knowledge structure and improving efficiency and depth of knowledge transmission, especially when it comes to historical knowledge. By means of virtual reality and augmented reality, students are encouraged to apply what they have learned to lifelike or simulated historical or social contexts. This becomes the main contents and way of teaching. The combination of learning with practice enables students to immerse themselves in specific situations and take initiatives to learn. Undoubtedly, the advantage of immersive media in the teaching of history knowledge is obvious. By creating a virtual world, restoring a specific historical situation, and promoting the understanding of historical knowledge in the ideological and political theory course through the integrated experience of multiple senses, such as vision, hearing, touch and smell, immersive media can effectively help teachers and students to overcome learning difficulties and appreciate the times, and improve the teaching effectiveness by controlling the sense of presence in the teaching process. The application of this technology to these courses can provide students with an excellent learning experience similar to “time travel through history.” However, colleges and universities must build a special virtual simulation teaching platform to support the teaching of ideological and political theory courses if they want to scale up and sustain the excellent teaching effectiveness brought by this teaching method based on advanced technology.

The virtual simulation teaching platform based on immersive media technology can enable students to be immersed in historical scenes from the first person's perspective and devote themselves fully to learning. The design of learning content, based on the teaching materials of ideological and political theory courses, covers representative historical knowledge points in key chapters, and fully combines the advantages of red cultural resources in the region where the university is located to create an immersive media learning situation with strong sense of participation, immersion, ceremony, experience and interaction. In terms of curriculum arrangement, the class hours completed in the virtual simulation teaching platform can account for a part of the whole class hours, and the performance in the learning process is included in the class grades. When learning on the virtual simulation platform, students can have the right to freely combine relevant learning modules based on their own interests and command of knowledge and decide what to learn first to enjoy maximum autonomy in learning. This will be followed by improved teaching effectiveness of history knowledge.

For teachers, the strengths of immersive media technology lie in its duplicability and safety. In teaching, learners can be placed in various situations that they are unlikely to encounter in reality to carry out targeted training on their own for as many times as they want, so as to give full play to students' subjectivity, maintain their interest in learning and quickly improve their command of knowledge and skills. In addition, safety is the most critical consideration in practical teaching. The potential danger faced by the virtual environment is far less than that in reality. Learners can boldly try various learning options in a virtual environment. Even if serious mistakes occur, they will not cause the same adverse consequences and

damages as in the real world. At the same time, learners' error rate, learning time and other data will also be recorded and evaluated by the platform as the reference for the final assessment.

## Human-Computer Interaction Transforms the Way of Teaching From “Copying Ideas” to “Exploring Meaning”

At present, teachers usually try to imbue students with different ideas by teaching ideological and political theory courses in colleges and universities. The conventional indoctrination way is questioned with the connotative development of education and teaching reform of ideological and political theory courses. In essence, indoctrination is an effective way to turn ideas into power. Indoctrination in teaching ideological and political theory courses is the only way for political parties to occupy ideological vantage. It is also inevitable for Chinese universities to adhere to the socialist direction of running schools. No matter how innovative the teaching methods are, the ideological and political theory courses must stick to the correct political status and value orientation in the new historical era. The basic principles of indoctrination remain unchanged, but the methods of indoctrination can be changed. Indoctrination in teaching ideological and political theory courses in colleges and universities does not mean that students are required to “copy and paste” the teaching materials and immediately accept and follow what is taught. In fact, in order to truly realize the teaching task of building up moral integrity and cultivating talents of virtues, colleges and universities must adhere to the heuristic methods in teaching ideological and political theory courses, consciously follow the law of cognition and the law of physical and mental growth, and teach these courses scientifically and effectively.

Heuristic teaching conforms to teaching objectives and objective laws of learning. It also takes into consideration students' natural conditions. Basically, it refers to “using such teaching methods as elicitation and heuristic teaching to impart knowledge and cultivate abilities, so as to urge students to study on their initiative, and thus to promote their physical and mental development” (Guo, 2006). In order to solve the problems existing in the teaching of ideological and political theory courses in colleges and universities, the application of immersive media technology into the teaching process can give full play to the advantages of the technology in human-computer interaction, combine indoctrination with elicitation and heuristic teaching, and improve the teaching effectiveness. Setting proper problem-solving situations is crucial to the success of heuristic teaching. Immersive media technology can provide interactive and controllable learning situations for students. In these situations, students will take the initiative to think and explore rather than passively receiving or mechanically copying the ideas fed to them. The basis of heuristic teaching is to stimulate students' inner learning motivation. In the virtual environment based on immersive media technology, VR and AR technology can mobilize students' sensory perception, guide their psychological feelings, and create an overall atmosphere to stimulate their interest and initiative and maximize their participation in learning activities. Heuristic teaching emphasizes the connection

between theory and practice and the combination between knowledge and direct experience (Skedsmo and Huber, 2018). Immersive media technology can provide vivid and visual thinking materials for students' learning and understanding activities. The human-computer interaction breaks through the limitation of time and space on teaching activities so that students can participate in teaching activities in realistic VR environments. It helps to strengthen their cognition of abstract concepts and supernatural phenomena, and guide them to further explore and think about the intrinsic meaning of what they have learned.

When students are reasoned into the conviction of the political views, they will learn to internalize the views into their ideals and beliefs. They will be more likely to be edified by noble sentiments and guide their behavior with sound values, thereby enhancing the teaching effectiveness of ideological and political theory courses.

## CONCLUSION

Immersive media technology integrates state-of-the-art technologies in such fields as psychology, acoustics, optics, and computer science. It can improve teaching effectiveness and promote innovative teaching ideas and methods when applied to the teaching of ideological and political theory courses in colleges and universities. In immersive-media-technology-aided education, teachers of these courses should accommodate the psychological features and needs of college students as well as the teaching contents and plans. Based on these considerations, they should also adopt new teaching tools such as human-computer interaction, virtual environment reproduction, and augmented reality experience. This research has proved that the courses' purpose of building up moral integrity and cultivating talents of virtues will be better achieved if the advantages of immersive media technology in improving attention restoration, practical ability and emotional and cognitive experience can be brought into full play. Moreover, the application

of immersive media technology will also produce a positive spillover effect. It is conducive to the improvement of college students' communicative skills, cooperation ability, esthetic ability and physical and mental wellbeing.

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the patients/participants was not required to participate in this study in accordance with the national legislation and the institutional requirements.

## AUTHOR CONTRIBUTIONS

LS is the major contributors of this work, contributed to the conception of the study and performed the data analyses and wrote the manuscript; ML contributed significantly to analysis and manuscript preparation, helped perform the analysis with constructive discussions.

## FUNDING

This work was supported by the Youth Research Project National Social Science Fund of China "A Study of General Secretary Xi Jinping's Thought on 'Mind' Study of Communists" (18CKS034).

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# Why Do Women Pretend to Be Men? Female Gender Swapping in Online Games

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## OPEN ACCESS

### Edited by:

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James D. Ivory,  
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### Specialty section:

This article was submitted to  
Personality and Social Psychology,  
a section of the journal  
Frontiers in Psychology

**Received:** 13 November 2021

**Accepted:** 25 April 2022

**Published:** 12 May 2022

### Citation:

Zhou L, Han N, Xu Z, Brian C and  
Hussain S (2022) Why Do Women  
Pretend to Be Men? Female Gender  
Swapping in Online Games.  
Front. Psychol. 13:810954.  
doi: 10.3389/fpsyg.2022.810954

This research explored the influencing factors of gender swapping among female players in online games and their impact on online gaming behavior. Based on an online survey of 3,658 female players in China, we found that perceived benefits and the *Tanbi* tendency, a psychological indulgence in enjoying novels, comics, or series on love and sex between attractive males, were the most important factors for female players to employ male avatars. Sexual orientation, perceived anonymity, and perceived tolerance also had a significant influence on gender swapping. Different from the practical benefits perceived by men who use female avatars in online games, the perceived benefit for female players who use male avatars was to avoid gender discrimination. In order to obtain more freedom and fairer treatment, they chose male avatars for a better experience. Female players with a higher degree of gender swapping showed a stronger aggressiveness and dominant “hyper-masculinity” behavior tendency in the game. Though online virtual worlds may be a convenient place for females to experience gender equality through gender swapping, the findings of this study suggest that gender swapping in games may, to some extent, perpetuate or even reinforce gender stereotypes in the real world.

**Keywords:** gender, online games, gender swapping, gender role, avatar, *Tanbi*

## INTRODUCTION

The development of the Internet has made it easier for people, regardless of their gender, to freely interact with others through online games. This has led to a growing number of online gamers worldwide. The COVID-19 pandemic has further increased the importance of virtual worlds. The demand for video games has increased, and many people have turned to online games to cope with stress and forget about the pandemic (Şener et al., 2021). Currently, there are an estimated 1 billion internet gamers worldwide (Clement, 2021). Female players are becoming increasingly prevalent in online gaming environments around the world, and many females are spending more time on gaming (Google and Niko Partners, 2020). In China, the market revenue of online games

has exceeded 41 billion dollars. And there has also been an upsurge in the number of female gamers online. Around 390 million female gamers were reported in China as of February 2020 which accounts for 45.6% of the overall gamers in China (Thomala, 2021). However, players who reveal themselves as females in online games are known to be vulnerable as they are often mistreated by other players (male players) (Cote, 2017; McLean and Griffiths, 2019; Tang et al., 2019; Hao et al., 2020). These experiences may lead to female gamers' choosing male avatars in online games, a practice known as gender swapping.

Gender swapping in online games refers to the behavior of game players using avatars of different genders (Tseng et al., 2018). This phenomenon is commonly seen in massively multiplayer online role-playing games (MMORPGs or MMOGs for short). Due to the nature of MMOGs, gamers can play various virtual roles through virtual gender swapping. However, gamers were mainly male in early stages of gaming history (McClure and Mears, 1984; Krotoski, 2004). This led to the fact that most studies on virtual gender swapping focus on male players (Hussain and Griffiths, 2008; Huh and Williams, 2010; Lehdonvirta et al., 2012; Lou et al., 2013; Song and Jung, 2015). Therefore, there is still a research gap regarding the reasons why female players, particularly female players in China, disguise themselves with male avatars in online games, as well as the consequences of this behavior in real life.

The question is, why do females use male avatars in online games? What does this gender-swapping behavior mean? What impacts does gender swapping in online games have on gamers in real life? Based on these questions, this research conducted an empirical study on female players, focusing on the motivations and results of their gender swapping.

## LITERATURE REVIEW AND HYPOTHESES

Gender swapping can be easily achieved in the virtual worlds of gaming. The findings from an online survey conducted in the United States reveal that 54% of male players and 68% of female players swapped their gender in online games (Hussain and Griffiths, 2008). As for the reasons for changing genders in games, existing research has provided the following explanations: to express the real self (Huh and Williams, 2010), to express the other self or the "second self" (Kafai et al., 2010), for fun (Hussain and Griffiths, 2008), and to obtain practical benefits (Bartle, 1996; Song and Jung, 2015). Some scholars have studied gender swapping from an impression management perspective (DeAndrea et al., 2012), while others have regarded it as the behavior of sexual minorities in virtual spaces (Huh and Williams, 2010).

However, as mentioned earlier, the existing gender swapping related studies have mainly focused on the gender change behaviors of male gamers, but the reasons for gender swapping among males do not necessarily apply to women. For example, Song and Jung (2015) argued that female players might have different motivations and behave differently after gender swapping. According to Huh and Williams (2010), females are

more likely than males to change gender online as a way of in-game identity exploration to challenge traditional gender norms and stereotypes of females in the real world.

## Avatar and Gender Role

According to Goffman, the body serves as an intermediary between self-identity and social identity. In virtual worlds, "our social identities tend to be governed by a general desire to present ourselves as "normal" people worthy of playing a full part in society" (Shilling, 1993, p. 86). In online games, bodies are expressed through customized avatars. An avatar is "the virtual embodiment of users in online games" (Banakou and Chorianopoulos, 2010, p. 4). However, an avatar is not just a "costume" in many cases, but considered as an "entire self-representation" (Yee and Bailenson, 2007) or a "second self" (Kafai et al., 2010) of the player. Players create avatars to reflect their offline identities, and each avatar has the player's own personality (Kafai et al., 2010).

Gender roles refer to "behaviors, expectations, and role sets defined by society as masculine or feminine which are embodied in the behaviors of the individual man or woman and culturally regarded as appropriate to males or females" (O'Neil, 1981, p. 203). In other words, gender roles are stereotypes that require a person to act in a certain way based on society's expectations related to gender. The varying degrees of power that men and women hold in society can be connected to gender roles. For instance, men are expected to experience greater power (masculine or dominant roles) than women in society (Blackstone, 2003, p. 337; McKeen, 2005).

Researchers have shown that traditional gender-role oriented individuals were more likely to avoid cross-gender behavior, even at monetary costs (Bem and Lenney, 1976). Gender-role orientation was defined as "the extent to which individuals' self-perceptions conform to the culture's definitions of maleness and femaleness" (Bem, 1981, p. 355; Lee, 2007, p. 518).

Based on the above studies, it is reasonable to assume that a female player is more likely to choose a male avatar in online games if she perceives herself as having those traits that are considered masculine by mainstream social norms, such as forcefulness, dominance, risk-taking, and leadership abilities.

Hypothesis 1: Females with less traditional gender-role orientations are more likely to engage in gender swapping in online games.

## Sexual Orientation and *Tanbi* Tendency

Previous studies have shown that the sexual orientation of certain players plays a crucial role in their gender-swapping behavior in online games. For example, a survey conducted on 6,122 players in EverQuest II (a MMOG designed by Sony) reveals that virtual gender swapping is more common among players who report same-sex attraction (Huh and Williams, 2010). However, some scholars argue that this behavior arises from a desire to appreciate the physical attractiveness of opposite sex characters (Hussain and Griffiths, 2008; Fahs and Gohr, 2012).

In this study, the appreciation of the beauty of the opposite sex refers to females' aesthetic perception of males since we

take female gender swappers as research subjects. In this regard, we decided to use the term “*Tanbi*” instead of the term “aesthetics” because “*Tanbi*” is suitable to cover both situations. *Tanbi* refers to a psychological indulgence in enjoying novels, comics, or series on love and sex between attractive males, which is not only associated with same-sex tendencies, but also with the strong aesthetic demand for the physical beauty of males (Wang, 2011). Combined with previous research, *Tanbi* tendency is likely to be another important factor leading to gender swapping.

The word “*Tanbi*” originates from the Japanese word “耽美,” which originally meant aesthetic or romantic indulgence in the beauty of art. Later, it became a term that refers to indulging in the beauty of love between handsome males without involving reproduction. In the 1960s, novels, especially comics, depicting love between attractive males, appeared in Japan, with large groups of young female readers, who called themselves *Fujoshi* (腐女子), a term used to describe women who have a special hobby of reading comics or novels about romantic love stories between attractive men. In the late 1980s, *Tanbi* comics spread to China, which led to the further development of *Tanbi* culture in China. *Tanbi* novels created by Chinese writers appeared online in the 1990s (Wang, 2011), and literature of this genre in China also focuses on romantic relationships between men. *Tanbi* literature has always been written by women, and there is a sizable audience for it. However, this does not necessarily mean that the authors or the readers of this genre are sexually attracted to people of the same sex. Women who write or are passionate about *Tanbi* are known as “*Fujoshi*.”

A few Chinese scholars have studied and elaborated on the development of *Tanbi* in China and its influence on women. Some scholars conclude that women who are passionate about *Tanbi* are sexually attracted to people of the same sex (Ruan, 2008). Other researchers, however, believe that it has nothing to do with sex orientation. Instead, they believe that these women are expressing their inner wishes and expectations through the male “body,” implying that the passion for *Tanbi* among women is motivated by a desire for purer love, secret sexual urges, or psychological needs such as curiosity. The fantasy of *Tanbi* is a conduit for women to express their wants through depictions of same-sex feelings or sexual expressions, as well as a desire for a society with greater equality and freedom (Wang and Liu, 2008). Therefore, it may be seen as a resistance to the traditional patriarchal society and heterosexual power. In *Tanbi* related works, for example, same-sex love is no longer treated as perverse, but as normal as heterosexuality. The openness, interactivity, and anonymity of the modern internet have also aided in the proliferation of *Tanbi* culture in China.

Despite the proliferation of *Tanbi* culture in China, *Tanbi* and same-sex related topics are still taboo in public. People who are unable to reveal their secret hobbies in real life can interact socially through the internet, seek pleasant interactions, and find their “utopia” in virtual worlds. The anonymity of the online world provides them with a more secure and welcoming environment, devoid of discrimination, external pressure, or condemnation for not fitting social moral standards. The MMOG world has provided a convenient place for *Fujoshis* to construct

and experience their own *Tanbi* game roles. Not only can they portray their feelings for the same sex, but they can also play the male roles themselves, interact closely with other male players, and seek a welcoming environment to air their views freely.

In sum, sexual minorities, such as females with lesbian or *Tanbi* tendencies, can easily make use of gender swapping to avoid discrimination and external pressure associated with their sexual orientation or preferences, to appreciate gazing at men rather than being gazed at, and even to create more ideal male images according to their own aesthetic standards and construct the relationships between men in the online game world. In contrast, sexual majorities are less likely to have these motives. Therefore, the following hypotheses can be reasonably put forward:

Hypothesis 2: Female players with lesbian tendencies have a higher degree of gender swapping behavior than female players with heterosexual orientation.

Hypothesis 3: Female players with heterosexual orientation have a lower degree of gender swapping behavior than female players with lesbian tendencies.

Hypothesis 4: Female players with *Tanbi* tendencies have a higher degree of gender swapping behavior.

## Perceived Benefits

Men employ female avatars for specific benefits, according to current studies on gender swapping in online games. Male players in virtual worlds are motivated by the desire to gain more practical benefits, such as more money or weapons, to be treated more politely, or to avoid being targeted and attacked by other players (Hussain and Griffiths, 2008; Song and Jung, 2015). In male-dominated online gaming environment, although female identities have many disadvantages, such as being perceived as incompetent for competitive tasks (Kaye et al., 2017; Perry, 2021), their identities also have their positive social advantages. An example of such advantage is that male players tend to be friendlier to female players.

While existing research focuses on male players, whether female players swap gender for similar motives remains a research gap. According to an online survey conducted on 293 respondents from 30 countries, women in online games face both general and sexual harassment. Some women may withdraw from games due to such treatments. This leads to the adoption of masculine screen names and avatars to avoid being abused or harassed by male players (Fox and Tang, 2016). Males are more likely than females to engage in harassment in online video games. And female avatars are the very targets of sexual harassment in most cases. To avoid being harassed, female players may swap their gender and play in disguise (Tang et al., 2019).

In most online games, female characters are often designed as sexy beauties, often scantily dressed, indicating that they are only treated as “vases” rather than competitive players. For female players, the gender label is more visible than their gaming skills or competence, which are often underestimated just because of their gender. And the females may even

be subjected to gender humiliation or harassment by other players due to their gaming mistakes (Huh and Williams, 2010; Fox and Tang, 2016).

Previous studies reveal that gender inequality has been embedded in online games in multiple ways. Male dominance in video games is mirrored in game design and production, as well as the definition and classification of gamers (Cote, 2018; Vilasis-Pamos and Pires, 2021). Cote (2018) noted that video games are still a “masculinized technology.” Females, on the other hand, are often “hyper-sexualized and relegated to disempowering roles” (Perry, 2021, p. 1).

In order to overcome gender restrictions on women similar to those in real life, or to prevent male players from belittling, attacking, or harassing them, female players may swap their gender for more equal treatment and a better gaming experience (Hussain and Griffiths, 2008; Huh and Williams, 2010). In other words, a female player may perceive certain benefits of playing as a male character, although these benefits may not be material or practical, but other types of rewards. Thus, the more a female player perceives the benefits of gender swapping, the more likely she is to use a male avatar.

Hypothesis 5: Perceived benefits positively predict gender swapping for female players.

## Perceived Environmental Safety

Players’ perceptions of social tolerance for gender swapping and the security of anonymity are particularly important in relation to the adoption of gender swapping as a behavior that may cause negative treatments. The first is the perceived social tolerance for gender swapping in online games. Players may experience embarrassment or difficulty as a result of gender swapping. Male players who use female avatars, for example, may face discrimination from other players, particularly if they conceal their true gender and attempt to engage in online romantic relationships in order to be cared for and helped by other male players. Gender swapping may be considered as a form of deceit. Swapping genders might be deemed gay or mentally gender dislocated. Gender swappers in the virtual world, like sexual minorities in the real world, are frequently the target of criticism. Failure to follow gender roles can result in poor impressions and assessments from others, as well as criticism and punishment. Therefore, the acceptance or tolerance of gender swapping by the external environment could be an opinion climate valued by gender swappers.

The second is the perceived security of anonymity in online gaming environments. Song and Jung (2015) pointed out that anonymity is a prerequisite for gender swapping. Compared to offline reality, virtual worlds may provide a more anonymous and secure environment. Although from a certain aspect, the lack of identity clues may make social relationships in virtual worlds seem empty and fragile, the anonymity of the internet allows them to safely shed their real-world identities and experience alternative identities in the virtual world.

Hypothesis 6: The higher the perceived tolerance for gender swapping, the higher the degree of gender swapping.

Hypothesis 7: The higher the perceived anonymity of the environment, the higher the degree of gender swapping.

## Proteus Effect and Hyper-Masculinity

Bartle (1996) implied gender differences in the way gamers play. He argued that men are more likely to be achievers and women are more likely to be socializers. Yee (2006) further confirmed that female gamers play games primarily for social purposes and are keen to make new friends. The question is whether the player’s conduct will alter as a result of changing gender.

Deindividuation theory states that when individuals are in an anonymous environment that lacks personal information such as identity clues, they may behave differently than usual. Yee and Bailenson (2007) found that regardless of their actual image, players who adopted tall, handsome male avatars appeared more confident and intimate in their interactions with other players in online games. They also appeared more confident and powerful when it came to negotiating tasks, just as a tall, attractive man would do in the real world. Yee and Bailenson (2007) defined this pattern of behavior as the Proteus Effect, meaning that individuals tend to act according to their digital self-representation, regardless of how others perceive them. According to this proposition, when gamers use different avatars, they tend to act in ways that match the personality traits of their avatars.

Yee and Bailenson (2007) also pointed out that there may also be a gender-based Proteus Effect in online games. Men, for example, will act in ways that are more in line with feminine norms when they utilize female avatars. Subsequent studies have provided some evidence to support this claim. According to Huh and Williams (2010), female gender swappers exhibit more masculine behavior patterns, even more so than male players. For example, female gender swappers take part in more PvP combat and less text chatting than female non-swappers. Whereas, female non-swappers chat more than any other group, female gender swappers chat the least of any group, including the men, suggesting that the female swappers are engaging in hyper-masculine behaviors to act their role as males (Huh and Williams, 2010). Even though male gender swappers keep their own masculine features in terms of combat behavior patterns, such as jumping, they replicate conventional feminine gestures and imitate their assumed female speech style, according to a study on gender swapping of male gamers (Martey et al., 2014).

Lehdonvirta et al. (2012) argued that traditional gender role descriptions as perceived by players shape their expectations of individuals and thus influence their behavior. When playing a new gender role, gender swappers may speculate on the behavioral characteristics of the other gender and often follow social stereotypes about being male or female, so they tend to overstate gender differences and reinforce gender stereotypes. In this sense, virtual worlds may become a place where “hyper-masculinity” and “hyper-femininity” grow. Hyper-masculinity refers to exaggerated “masculinity,” specifically the desire for aggression, violence, and dominance (Scharrer, 2004). Based on the Proteus Effect hypothesis and



existing research on the consequences of gender swapping in online games, this paper further proposes the following hypothesis:

Hypothesis 8: The higher the degree of gender swapping behavior, the stronger the hyper-masculinity of female players in the game.

## MATERIALS AND METHODS

### Participants and Procedure

The purpose of this study is to explore the gender swapping behaviors of female players, so a popular massively multiplayer online game (MMOG) known as “Final Fantasy XIV” (referred to as “FF14” for short) was chosen as the research site. Square Enix, a Japanese game company, released the game in 2010 and launched it in China in 2014. According to the official website of FF14, the game has over 25 million players worldwide and a 9.5/10 IGN rating. The Chinese server 5.57 version of FF14 has eight races, including: Hyur, Elezen, Lalafell, Miqu’te, Roegadyn, Au Ra, Viera, and Hrothgar. Each race, with completely different appearances, has its own unique characteristics, such as attractive Lalafell, towering Elezen, fierce Au Ra, mysterious Miqu’te, etc. Players can freely experience up to 29 different fates in this game. FF14 offers a variety of communication channels for social engagement, including private chat, creating teams, chatting, yelling, and shouting.

Because of its cinematic storyline, non-pornographic character setup style, and a wide range of societal themes, the game has attracted a wide range of female users in recent years. There was an even split between male and female players of the game as of 2017 (Gibson, 2017). The gaming character in FF14 is known as the Warrior of Light. The Warrior of Light is frequently depicted as a man in official settings and promotional materials. Players may also use the “Fantasia vial” (a potion that grants users the opportunity to change the appearance or gender of the avatar in FF14). Since the price of a Fantasia vial is relatively low, and there are multiple channels for obtaining it, gender swapping is easy to achieve, and it is also relatively common in FF14.

After conducting a small pilot study using the in-depth interview method, an online survey of FF14 users was conducted in China in April 2019. The questionnaire was publicized and distributed through the FF14-related Weibo accounts “Aiziya Joke Station” and “Talk to Haidelin” operated by the players themselves. At the same time, a small number of lottery tickets were given as rewards. The questionnaire was reposted 1,703 times spontaneously, with 133 comments. A total of 4,377 valid samples were gathered using a voluntary convenience sample that permitted players to repost for snowball sampling, all of whom were FF14 game users. The total sample included 719 male users and 3,658 female users. This study uses the 3,658 female respondents obtained as the research subjects.

Our samples are all from China. Among the 3,658 female respondents, 75.5% were under the age of 24, 60.0% were

students. 42.2% claimed themselves as heterosexual, 6.5% as gay, 37.3% as bisexual. Out of all the valid samples, 2,860 reported gender swapping behaviors in FF14, accounting for 78.0% of the overall data, indicating that gender swapping is a common behavior in FF14.

## Measures

### Gender Swapping

In this study, gender swapping was operationally defined as the length and frequency of use of male avatars by female gamers. It consisted of two items on a 5-point scale: “I spend more time using male avatars in online games,” and “I use male avatars more often than female avatars in online games.” The Pearson’s correlation coefficient was 0.883 ( $M = 3.53$ ,  $SD = 1.291$ ), indicating good internal consistency.

### Gender-Role Orientation

The Bem Sex Role Inventory (BSRI) has been widely used to measure gender roles. BSRI includes three measurement parts: masculine items, feminine items, and neutral items (Lee, 2007). Since this study only examined the effect of female players’ masculinity, a typical manifestation of less gender-role orientation (non-gender-typed), on their gender swapping behavior, only 20 items in the BSRI about masculinity were selected. Respondents were asked to rate the extent to which a set of masculinity-related adjectives or phrases applied to them, using items on a 5-point scale. Using principal component factor analysis, three factors with good reliability and validity were extracted from the 15 items: autonomy, leadership, and aggressiveness. Autonomy included “self-reliant,” “willing to take a stand,” “independent,” “self-sufficient,” “individualistic,” “makes decisions easily,” and “assertive,” with a Cronbach’s alpha of 0.872 ( $M = 3.63$ ,  $SD = 0.815$ ). Leadership included “acts as a leader,” “leadership ability,” “dominant,” “willing to take risks,” and “competitive,” with a Cronbach’s alpha of 0.839 ( $M = 2.44$ ,  $SD = 0.842$ ). Aggressiveness included “aggressive,” “forceful,” and “ambitious,” with a Cronbach’s alpha of 0.794 ( $M = 2.85$ ,  $SD = 0.930$ ).

### Sexual Orientation and *Tanbi* Tendency

Sexual orientation was a nominal variable. Respondents chose from the following five options: heterosexual (1,543, 42.2%), homosexual (237, 6.5%), bisexual (1,366, 37.3%), asexual (273, 7.5%), and other (239, 6.5%). The *Tanbi* tendency was measured by four 5-point scale items: “I enjoy the appearance and body of male avatars,” “I like stories associated with *Tanbi* themes,” “I want to write or have written blogs or novels with *Tanbi* themes,” and “I often fantasize about developing a romantic relationship with other men (real or imaginary).” The Cronbach’s alpha was 0.734 ( $M = 3.67$ ,  $SD = 0.845$ ).

### Perceived Benefits

Perceived benefits for female gender swappers were measured by two items: “I think the use of male avatars is less restrictive and freer than using female avatars,” and “When I use a male avatar, my gaming experience is better than using a female avatar.” The Cronbach’s alpha was 0.777 ( $M = 2.68$ ,  $SD = 1.061$ ).

## Perceived Environmental Safety

Perceived environmental safety measured the perception of anonymity and other players' tolerance of gender swapping in online games, indicating gamers' perceptions of the safety of the external environment for gender swapping. The items measured were modified from two items by Song and Jung (2015): "I think my actions or decisions are concealed in online environments ( $M = 3.47$ ,  $SD = 1.004$ )," and "I think other players in the game don't care about my real physiological gender ( $M = 3.88$ ,  $SD = 0.898$ ). The corresponding variables were "perceived anonymity" and "perceived tolerance."

## Hyper-Masculine Gaming Behaviors

Six items were used to measure hyper-masculine gaming behaviors, and three main components were generated, namely "aggressiveness," "dominance," and "competitiveness," representing three types of hyper-masculine gaming behaviors. "Aggressiveness" contained three 5-point scale items: "Compared with chatting or hanging up in the games, I prefer to play game instances or other combats," "I always go through levels to play the current difficult level," and "I like to study game strategies to improve my operation and output." The Cronbach's alpha was 0.719 ( $M = 3.22$ ,  $SD = 0.941$ ). "Dominance" contained two 5-point scale items: "Through my own efforts, I achieved what most players did not achieve," and "Most of the time, I am the commander of team activities," indicating a player's benchmark achievement and dominant characteristics. The Pearson's correlation coefficient was 0.658 ( $M = 2.30$ ,  $SD = 0.893$ ). "Competitiveness" included one item: "I love

to beat other players in PVP and enjoy winning ( $M = 2.69$ ,  $SD = 1.19$ )."

## RESULTS

### The Influencing Factors of Female Players' Gender Swap

To explore the reasons for gender swapping among women, a hierarchical multivariate regression analysis was conducted using gender-role orientation, sexual orientation and *Tanbi* tendency, perceived benefits and safety as three sets of independent variables. The results showed that all three sets of independent variables had significant predictive power for gender swapping and could explain the overall variation in the dependent variable by 30.3%. The collinearity diagnosis results were acceptable with values of tolerance ranging from 0.501 to 0.898. The detailed results are presented in Table 1.

### The Impact of Gender Role on Gender Swapping of Female Players

Among the three dimensions of masculinity, only "autonomy" had a statistically significant effect on gender swapping ( $\beta = 0.079$ ,  $p < 0.001$ ). However, "leadership" and "aggressiveness" had no significant effect on gender swapping. Hypothesis 1 was partially confirmed. In general, the explanatory power of gender-role orientation on gender swapping behavior was only 1.8%, indicating that from a practical perspective, gender-role orientation had little influence on women's gender swapping.

**TABLE 1 |** Multivariate regression analysis for predicting gender swapping.

Independent variables	Dependent variable: gender swapping					
	Unstandardized coefficients		Standardized coefficients	t-value (sig.)	Collinearity statistics	
	B	Std. error	Beta		Tolerance	VIF
(Constant)	0.131	0.180		0.732		
<b>Gender-role orientation</b>						
autonomy	0.128	0.033	0.079	3.853***	0.676	1.479
leadership	-0.016	0.036	-0.010	-0.437	0.520	1.923
aggressiveness	0.001	0.034	0.001	0.038	0.501	1.995
$R^2$ (%)	1.8***					
<b>Sexual orientation and <i>Tanbi</i> tendency</b>						
SO1 (1 = heterosexual)	-0.118	0.047	-0.045	-2.542*	0.898	1.114
SO2 (1 = same-sex)	0.347	0.086	0.073	4.045***	0.891	1.122
<i>Tanbi</i> tendency	0.389	0.028	0.253	13.962***	0.873	1.145
Increased $R^2$ (%)	14.0***					
<b>Perceived benefits and safety</b>						
Perceived benefits	0.468	0.022	0.381	21.113***	0.884	1.132
Perceived anonymity	0.063	0.024	0.049	2.641**	0.847	1.180
Perceived tolerance	0.113	0.026	0.078	4.281***	0.863	1.159
Increased $R^2$ (%)	14.8***					
$R^2$ (%) total	30.6***					
Adj. $R^2$ (%) total	30.3***					

$N = 2,428$ ; \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

## The Influence of Sexual Orientation and *Tanbi* Tendency on Gender Swapping

The results confirmed the negative effect of heterosexual orientation on gender swapping ( $\beta = -0.045$ ,  $p < 0.05$ ), the positive effect of same-sex orientation on gender swapping ( $\beta = 0.073$ ,  $p < 0.001$ ), and the positive effect of *Tanbi* tendency on gender swapping ( $\beta = 0.253$ ,  $p < 0.001$ ). Hypotheses 2, 3, and 4 were confirmed. Sexual orientation and *Tanbi* tendency had relatively strong explanatory power for gender swapping, which accounted for 14% of the total variation of the dependent variable. Among them, the influence of *Tanbi* tendency was particularly important, and its standardized regression coefficient reached 0.253.

## The Impact of Perceived Benefits and Safety on Female Gender Swapping

Multivariate regression analysis results revealed that perceived benefits and safety were the strongest predictive independent variables set for gender swapping and could explain 14.8% of the total variation in gender swapping. Among them, perceived benefits had the strongest explanatory power for gender swapping ( $\beta = 0.381$ ,  $p < 0.001$ ), and the effects of both perceived gender swapping tolerance and perceived environmental anonymity were statistically significant, with standardized regression coefficients of  $\beta = 0.078$  ( $p < 0.001$ ) and  $\beta = 0.049$  ( $p < 0.01$ ), respectively. Hypotheses 5, 6, and 7 were confirmed.

## Gender Swapping and “Hyper-Masculinity” of Female Players

Existing studies suggest that gender swapping might cause players to adopt more exaggerated and stereotyped behaviors (Hussain and Griffiths, 2008; Song and Jung, 2015). This paper examined the relationship between gender swapping and “hyper-masculine” game behaviors of female players (see **Table 2**). Pearson product-moment correlation analysis showed that gender swapping was not statistically correlated with competitive behavior, but was positively correlated with aggressive and dominant behavior. Hypothesis 8 was partially confirmed.

Among the variables, the correlation coefficient between gender swapping and aggressive behavior was 0.043 ( $p < 0.05$ ),

and the correlation coefficient between gender swapping and dominant behavior was 0.039 ( $p < 0.05$ ). According to the criterion for judging the degree of association in correlation analysis (Elliot and Woodward, 2016), the absolute values of the above two correlation coefficients were much lower than 0.40, indicating that the associations between gender swapping and aggressive and dominant behaviors were very weak. Given the large sample size of this study, the statistical significance of the correlations may not be reliable enough. Considering their weak coefficients, these correlations may not be of much practical value.

## CONCLUSION AND DISCUSSION

### Several Explanations for Why Women Take on Male Personas in the Game World

In the MMOG world, avatars display clues to a player's self-identity and orientations. The results of this paper indicated that perceived benefits and *Tanbi* tendency are the most important factors for gender swapping among female players in FF14. In addition, sexual orientation, perceived environmental anonymity, perceived tolerance for gender swapping, and the autonomy dimension in masculinity, which represents a less gender-role orientation for females, also had a significant impact on the degree of female gender swapping in the game.

However, it should be noted that in this research, the operationalization of practical benefits of gender swapping refers to female players' avoidance of and resistance to gender stereotypes that exists both online and offline. Thus, the definition of “perceived benefits” in this study differs significantly from that in prior studies, which focused on the “tricky” practical goals among male players, such as acquiring extra money or weaponry, or avoiding being attacked by other gamers. It is safe to conclude that men are more likely to change gender in games to gain practical benefits, while women are more likely to change gender for more “pure” goals, such as to break through the bondage of gender roles or stereotypes, which implies a certain degree of gender liberation.

Perceived anonymity and perceived tolerance positively predicted gender swapping, suggesting that overt gender swapping is still seen as socially risky by gender swappers, who still worry about being identified or not being accepted. The anonymity of the online world enables players to conceal their real offline identity clues, allowing players to experience male identity more freely in the virtual game space. Under the protection of online anonymity, women can experience the freedom and superiority of male identity. However, the online world is obviously not a utopian gender-free space. Behind the facades and anxiety is silent and deep-rooted discrimination.

Another notable finding was the influence of *Tanbi* and sexual orientation on female gender swapping. *Tanbi* and same-sex tendencies positively predicted gender swap, while heterosexuality negatively predicted gender swap. Previous research has confirmed the influence of aesthetic needs to

**TABLE 2 |** Correlation analysis summary of gender swapping and three types of hyper-masculine behaviors.

Variables	Gender swapping	Aggressive	Dominant	Competitive
Gender swapping	1 (2,860)	0.043* (2,860)	0.039* (2,860)	−0.011 (2,860)
Aggressive	0.043* (2,860)	1 (3,658)	0.562*** (3,658)	0.298*** (3,658)
Dominant	0.039* (2,860)	0.562*** (3,658)	1 (3,658)	0.267*** (3,658)
Competitive	−0.011 (2,860)	0.298*** (3,658)	0.267*** (3,658)	1

Sample sizes are shown in the brackets; \* $p < 0.05$ , \*\*\* $p < 0.001$  (2-tailed).

appreciate the physical beauty of the opposite sex on gender swapping (Hussain and Griffiths, 2008; Fahs and Gohr, 2012), and some studies have examined the influence of same-sex orientation (Huh and Williams, 2010), but the discussion on the influence of sexual orientation is still relatively preliminary, and this factor has not been taken into account in many studies. The reason for this paper to specifically bring up the influence of *Tanbi* tendency is actually based on the findings of the in-depth interviews we conducted prior to the survey. *Tanbi* fantasy was a theme that naturally emerged in our interviews. This study examined the strong influence of *Tanbi* fantasy, which is closely, but not identically, related to physical beauty needs and same-sex orientation.

Moreover, gender role may not have as much of an impact on female gender swapping as expected. Only the impact of the autonomy dimension of masculinity has been confirmed, while leadership and aggressiveness have not. In other words, females with autonomous and independent traits are more likely to choose male avatars, while the traits around leadership or ambition have nothing to do with gender swapping. Earlier, Song and Jung (2015) found that gender schema had no significant influence on gender swapping. Combined with the finding of the influence of perceived benefits, they put forward that gamers' motivation for gender swapping is more related to obtaining practical benefits, rather than personal identity. The current research partially supports the influence of gender roles.

## Gender Swapping and the Reproducing of Gender Inequality

The conclusions of existing studies are inconsistent on whether gender swappers have gender stereotyped behavioral patterns. Song and Jung (2015) confirmed it by revealing that male gender swappers showed greater interest in social behaviors such as chatting, socializing, and teamwork in games, which had been regarded as typical behavioral characteristics of female players. The Proteus Effect can be used as a good explanation for this phenomenon: male players reproduce stereotypes in games based on imagined female images and behaviors. Huh and Williams (2010) showed that gender swappers and non-swappers did not behave differently in games; that is, men who adopted female avatars did not act or interact in a more feminine way. However, they also found that female players disguised as males and female players with female avatars showed great differences in behavior: female players who chose male avatars were less likely to chat, fight monsters or hunt for treasure; instead they were more likely to engage in confrontational combats and high-level PVP than those who did not swap genders in the game. In other words, women who pretended to be men acted in more masculine ways.

The results of this study showed that female gamers who chose male avatars tended to display more aggressive and dominating behaviors, which were consistent with male stereotypes in the real world and the overall image of male gamers. Avatars of different genders performed different patterns of behavior in gender-typed ways: "Male" roles are more likely to be driven by the desire to achieve or to manipulate, while female roles are more likely to be driven by relationship factors. Neither competitiveness nor

the joy of beating others had anything to do with the gender change of women. This proved to some extent that women do not choose male avatars to gain practical benefits such as winning the game or reaping material benefits. In other words, females who use male avatars do not use it as a game strategy to obtain game benefits.

The higher the degree of gender swapping, the more aggressive and dominant the women are, which means, the more masculine they are. This may objectively strengthen gender stereotypes, however, regardless of their subjective intentions. As Shilling (1993, p. 86) pointed out, "the way we understand, categorize, and evaluate the female and the male body is undoubtedly an important factor in legitimizing and reproducing social inequality." How people play their roles is largely based on their imaginations and gender-typed perceptions of the opposite sex. This enables them to interact and act accordingly in virtual worlds. As a result, although female players may choose to change their gender in games to avoid the negative images and difficulties that women face in the real world, they may actually further strengthen stereotyped gender norms through their conscious imagination and deliberate imitation of men when playing and interacting with male avatars.

## Limitations and Suggestions

FF14 has more female characters due to its story and character setting. Thus, FF14 cannot stand for all types of MMOGs, and the conclusions drawn in this paper could not necessarily be applicable to other game scenarios. For example, the *Tanbi* tendency might not have much explanatory value in games like World of Warcraft. Research on gender swapping in other MMOGs is still needed in the future. In addition, a user may have multiple avatars across multiple games. Will this affect the choice of avatar gender? Again, this study is based on a volunteer sample, which may not reflect the overall female user base of MMOGs. Future studies can employ more representative samples, diverse game cases, cross game observations, and alternative data sources such as official data on players' actual in-game behaviors and personal profiles.

Moreover, this study found a weak correlation between gender swapping and hyper-masculine behavior. Regardless of the low correlation coefficient between the two variables, it is insufficient to test the Proteus effect with correlation analysis rather than causal analysis. The Proteus effect in this case refers to whether the gender swapping of female players will lead them to behave according to the established gender stereotypes, which in turn further deepens gender stereotypes in the society. Further research into this important issue is expected to be done in the future.

Furthermore, the measurement of some variables in this study needs to be further improved. For example, both variables of perceived anonymity and perceived tolerance were measured with only one item, which could dent the validity to some extent. And the Cronbach's alpha value of some variables was less than ideal.

Meanwhile, the proportion of bisexuals among the respondents was as high as 37.3%, and it is uncertain whether this was due to sample bias. However, studies have found that



female players are three times more likely to be bisexual than males, and these bisexual players are also “hardcore” gamers because of how much time they spend on online games (Huh and Williams, 2010). Combined with the current research results on the influence of sexual orientation and *Tanbi* tendency, future research may pay more attention to the gender culture of young people.

In addition, the findings of this study are based on the data of female gamers, which does not prove that the behavior patterns described in this paper are exclusive to female gamers. We hope that more prudent comparative research can be developed to target this problem.

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## ETHICS STATEMENT

The studies involving human participants were reviewed and approved by School of Journalism and Communication, Wuhan

University, China. The patients/participants provided their written informed consent to participate in this study.

## AUTHOR CONTRIBUTIONS

LZ, NH, and CB wrote the manuscript. CB and LZ collected the data. LZ, SH, and ZX conceived of and performed the study. LZ analyzed the data. All authors have read and agreed to the published version of the manuscript.

## FUNDING

This research was supported by the School of Journalism and Communication, Wuhan University, China (Project No. 2021XWZY008).

## ACKNOWLEDGMENTS

We would like to thank the reviewers and editor for their invaluable comments and suggestions in improving this article. Additionally, we would like to thank Tong Zhang for her work in the initial data collection.

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# An Empirical Study of the Effects of Incidental Vocabulary Learning Through Listening to Songs

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## OPEN ACCESS

### Edited by:

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### Specialty section:

This article was submitted to  
Educational Psychology,  
a section of the journal  
Frontiers in Psychology

**Received:** 07 March 2022

**Accepted:** 14 April 2022

**Published:** 18 May 2022

### Citation:

Nie K, Fu J, Rehman H and  
Zaigham GHK (2022) An Empirical  
Study of the Effects of Incidental  
Vocabulary Learning Through  
Listening to Songs.  
Front. Psychol. 13:891146.  
doi: 10.3389/fpsyg.2022.891146

Most studies have shown that reading is an important source of incidental vocabulary learning, and repeated reading may have a positive effect on learning gains. However, the study of incidental vocabulary learning through listening is still limited, and the immediate and long-term effects on different vocabulary knowledge dimensions are unclear. Furthermore, no empirical studies have been conducted to investigate the association between learning gains and preexisting vocabulary knowledge in listening. This article examines the effects of listening to English songs on unintentional vocabulary learning and vocabulary retention through three different vocabulary knowledge dimensions: word recognition, meaning association, and grammar identification. A total of 114 Chinese college students participated in the study, and they were given vocabulary evaluations at different times based on three separate components of vocabulary knowledge. The effects of repeated listening (one, three, and five times) and learners' prior vocabulary knowledge were also investigated. According to the findings, listening to songs can improve vocabulary knowledge, particularly in the area of word recognition, which can be retained 4 weeks later. Furthermore, the effect of listening three times (with exposure frequencies ranging from three to nine) was superior than listening one or five times, which provides teachers and learners with guidance for teaching or learning vocabulary more effectively. Finally, for low, intermediate, and high-level learners, there was an immediate and positive effect on the dimensions of word recognition and meaning connection after listening, and this knowledge is likely to be preserved 4 weeks later.

**Keywords:** incidental vocabulary learning, English songs, vocabulary knowledge, frequency of exposure, prior vocabulary knowledge

## INTRODUCTION

Learning vocabulary has long been regarded as an indispensable component of mastering a second language. According to Schmitt (2008), a large vocabulary is required to function in English, and the lexical numbers for both reading and oral discourse set to be learned should be high. However, due to the short amount of time available for instruction, students are unable to acquire large numbers of vocabulary items in the classroom (Cunningham, 2005). So, social media can be

considered an alternative language learning technique for learners, particularly for those who live in monolingual societies (Kerekes, 2014; Bano et al., 2019; Kakar and Khan, 2020; Raza et al., 2020; Khan, 2021b). As Schmitt (2000) study pointed, vocabulary can be acquired either intentionally or incidentally; students should take full advantage of incidental lexicon learning, too. Given the importance of vocabulary in language learning, there have been numerous studies on accidental vocabulary learning in second language acquisition (e.g., Dupuy and Krashen, 1993; Horst et al., 1998; Paribakht and Wesche, 1999). According to these studies, the vast majority of researchers (e.g., Brown et al., 2008; Hatami, 2017) have looked at the extent to which vocabulary information can be addressed by reading, whereas few researchers have looked at the acquisition of incidental vocabulary through listening (Vidal, 2011; Van Zeeland and Schmitt, 2013; Hatami, 2017). For example, Vidal (2011) discovered that listening to academic lectures can result in incidental vocabulary learning. Furthermore, Van Zeeland and Schmitt (2013) demonstrated a positive effect by listening to a variety of spoken input sources, including talk shows, television interviews, and informal lectures. Regardless of the approaches to listening described above, listening to songs also plays a significant role in our lives, and songs can supply large amounts of language input (Schwarz, 2013). Nonetheless, apart from Medina's (1993), Maneshi's (2017), and Pavia et al.'s (2019) studies, no empirical studies have been conducted on listening to L2 songs as a method for vocabulary learning.

The current study focused on incidental vocabulary acquisition through listening to two pop songs and attempted to see if three areas of vocabulary knowledge (word recognition, meaning connection, and grammar) were retained 4 weeks after exposure, which was a drawback of prior listening studies. Additionally, because people like to listen to the same music repeatedly (Lems, 2001; Tegge, 2018), the impact of listening to the same song (one, three, or five times) on learning gains was investigated. Besides, for learners with a range of lexical sizes (Khan and Khan, 2019), the association between diverse prior vocabulary knowledge and incidental vocabulary growth was also examined.

## LITERATURE REVIEW

### Vocabulary Knowledge

Despite the need to know many vocabulary items, learners must also understand the “depth” of vocabulary knowledge, which is just as essential as the number of items (Schmitt, 2008). Lexicon knowledge is multifaceted, and there are various sorts of lexical components that can be acquired (Schmitt, 1994; Nation, 2013). For instance, orthography, syntax, grammar, collocation, and meaning recall are all independent components of lexicon knowledge (Webb, 2005, 2007). However, vocabulary learning is an incremental process, and different components of vocabulary knowledge may develop in different ways (Schmitt, 1994). For example, a recent empirical study by Teng (2018) examined the consequences of reading while listening, *via* graded readers acquiring different dimensions of vocabulary knowledge (word

recognition, grammar identification, meaning associations, and collocations), and the findings revealed 65, 43, 30, and 20% gains, respectively. While vocabulary knowledge is a crucial part and reliable factor of learners' proficiency in second language learning, most studies have focused on reading, and little research has addressed this issue with regard to listening (e.g., Bonk, 2000).

### Incidental Vocabulary Learning

When learners unintentionally expand new aspects of their L2, this is known as incidental learning (Van Zeeland and Schmitt, 2013). The acquisition of new vocabulary information through accidental learning, also known as incidental vocabulary learning, has long aroused the curiosity of researchers (Van Zeeland and Schmitt, 2013). Generally, incidental vocabulary learning is the understanding of by-product activity, which is not specifically planned to teach vocabulary (Hulstijn, 2001). As Webb and Nation (2017) point out, learning vocabulary incidentally may occur when encountering various L2 spoken and written discourse inputs that enable learners' vocabulary growth. However, the majority of research on accidental vocabulary learning has focused on acquiring new words through reading, such as graded readers, stories, newspapers, textbooks, etc., and there is a consensus that reading is an effective way to expand one's vocabulary (e.g., Krashen, 1989; Rott, 2007). For example, Webb and Chang (2015a) improved the effectiveness with 44.06% of recognition, and 36.66% of meaning recall after reading ten graded readers. Furthermore, Pellicer-Sánchez and Schmitt (2010) investigated form recognition, grammatical class recall, and meaning association while reading an authentic novel. They found that learners could perceive the meaning and form for 84 and 76% of words, individually, but remembering the meaning and word class for 55 and 63% of words. Moreover, social and mobile media also have been mentioned as a source of learning and performance outcome in past studies (Pitafi et al., 2018; Ali et al., 2019; Khan, 2021a; Khan et al., 2022).

### The Role of Audio Input in Incidental Vocabulary Learning

Listening also helps in the acquisition of accidental vocabulary (Brown et al., 2008). For example, Medina's (1993) research was an initial empirical study to explore L2 vocabulary development through listening. It was found that children's songs can help with L2 vocabulary development, but the amount of lexicon learned from listening to songs is not specified, and the dimensions of vocabulary knowledge are not mentioned. Furthermore, Vidal (2011) asserts that listening to academic lectures might result in incidental vocabulary learning. In an immediate posttest, considerable learning improvements of 15.5% were observed by listening, and learning growth of 7.8% remained 4 weeks later. As English as a Foreign Language (EFL) learners do not have a wide range of input environments to choose from, academics are increasingly interested in unintentional vocabulary learning by listening to sources of knowledge that are accessible to learners in circumstances with restricted input, especially in a more entertaining way. For example, Van Zeeland and Schmitt (2013) study looked into several types of spoken input, including audio talk shows, interviews, and informal



lectures. Overall, both immediate and 2-week delayed tests revealed vocabulary acquisition growth of 29.2% (7.05 words) and 19% (4.58 words), respectively. Furthermore, Pavia et al.'s (2019) research found that listening to L2 songs contributed to vocabulary learning and repeated listening had a positive effect on vocabulary gains. However, prior vocabulary knowledge was not taken into account in the study, which found a strong link between vocabulary size and vocabulary gains (Vidal, 2003, 2011; Peters et al., 2016). Besides, a recent experimental study looked into incidental vocabulary acquisition through song listening, and the results showed that learners can acquire vocabulary knowledge very immediately after listening, particularly in the dimension of word recognition. However, the delayed posttest results indicated an increase from the immediate posttest across both experimental and control groups, which cannot be used to guide or contribute to future research (Maneshi, 2017). What is more, song lyrics can benefit L2 learners by exposing them to forms, syntax, lexical items, segments, and suprasegmentals (Abbott, 2002). As a result, it is important to investigate the magnitude of incidental vocabulary learning through listening to songs, particularly for language learners in low-input environments.

## The Role of Frequency of Exposure in Incidental Vocabulary Learning

Frequency of exposure is a popular research area that has gained many researchers' attention, and the results vary across different studies. Most studies illustrate that the more frequently learners are exposed to target words, the more likely they are to be learned (Reynolds and Wible, 2014). Moreover, Maneshi (2017) research also found that repeated listening improved vocabulary knowledge gains, with the effect of listening five times outperforming listening once and three times, especially in the areas of word recognition and meaning association. As Penno et al.'s (2002) study points out, participants could attain more vocabulary items as the number of encounters increased in a listening to a story activity, and learners were able to utilize words more precisely in a story retelling task. However, Webb and Chang (2015a) findings for the association between number of occurrences and vocabulary acquisition differ from those of prior studies (Saragi et al., 1978; Horst et al., 1998; Webb, 2007; Vidal, 2011). Webb and Chang (2015a) surprisingly found that vocabulary gains did not have a strong relationship with the number and distribution of occurrences in reading. The posttest relationship between relative gain and exposure frequency ( $r = -0.03$ ,  $p = 0.78$ ,  $n = 100$ ) was determined to be relatively low and non-significant. The connection between relative gains and exposure was not statistically significant in a delayed posttest ( $r = -0.17$ ,  $p = 0.09$ ,  $n = 100$ ). This is probably because the time between reading and testing was relatively long, ranging from one to 13 weeks. The findings of Webb and Chang's study appear to support Nation and Wang (1999) assertion that no one number of exposures could guarantee acquisition, and the link between exposure and vocabulary learning is complicated by a variety of additional factors (Saragi et al., 1978). For example, to investigate the association between word understanding and

exposure frequency, learners may require different frequencies of exposure to assimilate different types of vocabulary knowledge. Furthermore, in Pavia et al.'s (2019) study, the researchers found that listening to songs repeatedly improved the vocabulary knowledge of word recognition, meaning connections, and collocations, however, the acquisition of vocabulary knowledge in meaning connection and collocation may be less than word recognition. Moreover, Pigada and Schmitt (2006) assert that the meaning recognition of a word requires a wider range of encounters than just spelling.

## The Role of Prior Vocabulary Knowledge in Incidental Vocabulary Learning

Some researchers found a strong relationship between learner's prior vocabulary knowledge and learning gains in incidental vocabulary learning. For example, Murphy et al.'s (2021) study indicated that, due to prior vocabulary knowledge disparities, the achievement of incidental vocabulary learning varied among learners in the activity of reading. Besides, other researches have also claimed that students with greater vocabulary knowledge benefit more from incidental vocabulary learning while reading (Pulido, 2003, 2007; Webb and Chang, 2015b). However, due to the fact that vocabulary learning increases in listening are substantially smaller than in reading (e.g., Vidal, 2011), academics have paid less attention to the topic of the link between learners' preexisting vocabulary knowledge and learning achievement through listening. There were little studies looked into the relationship between learner's prior vocabulary sizes and learning gains. For example, Vidal (2003, 2011) research found a favorable association between vocabulary size and learning growth through academic listening and repeatedly reading. What is more, other researchers found that learners with higher vocabulary sizes being more likely to learn new words than those with smaller vocabulary sizes through watching television (Peters et al., 2016; Peters and Webb, 2018). On the contrary, Rodgers (2013) study found no evidence that learners with bigger vocabulary sizes could obtain more vocabulary from watching television than learners with smaller vocabulary sizes.

## The Present Study

To date, while research has shed light on the quantity and quality of vocabulary learned *via* reading, empirical evidence for how listening aids L2 learners' vocabulary acquisition through hearing is still lacking. Songs can provide a lot of verbal input (Schwarz, 2013). As a result, the aim of this study was to look into this further and see if there was a link between the amount of L2 learners' vocabulary and their vocabulary knowledge aspects by listening to songs. Spoken-form recognition, grammar recognition, and meaning recall are the three dimensions of vocabulary knowledge that will be measured. Furthermore, people like to listen to the same songs repeatedly (Tegge, 2018), and the number of encounters with unfamiliar words may affect incidental learning gains (Webb and Chang, 2015a), so the effect of repeated listening to songs (one, three, or five times) on learning gains was also investigated.

## Research Questions

To what extent does listening to songs increase vocabulary knowledge of spoken-form recognition, grammar recognition, and meaning recall?

To what extent does frequency of exposure affect incidental vocabulary learning through listening to songs?

To what extent does participants' prior vocabulary knowledge affect incidental vocabulary learning through listening to songs?

## METHODOLOGY

### Participants

The participants were 114 Chinese EFL learners who were first-year undergraduate students, and their ages ranged from 18 to 20 years. The participants had similar educational backgrounds, and all of them had studied English for at least 9 years, with a similar level of proficiency generally. In order to analyze the relationship between participants' previous vocabulary size and incidental lexicon gains, all students completed a Vocabulary Level Test (VLT), and the vocabulary test results indicated that almost all the students were familiar with the first 4,000 words, 25% of the students less than the first 4,000 words (low level), 48% of the students from 4,000 to 5,900 words (intermediate level), and 27% of students more than the first 6,000 words (high level). The students were reassigned into four groups: a control group, E1 (listening to songs once), E3 (listening to songs three times), and E5 (listening to songs five times). Each group contained a similar number of students, with eight high-level students, 14 intermediate-level students, and seven low-level students, respectively.

### Instruments

#### Listening Materials: English Songs

The research's learning material consisted of two English songs. The first song was Jason Mraz's "Have it all" (Song A), while the second song was Billy Joel's "Piano Man" (Song B). When choosing songs and target words, a number of factors were taken into account. First and foremost, it was critical to ensure that the participants had not heard the songs before. This contributed to the study's validity by ensuring that learning improvements could be assigned to the learning circumstances. Second, the singers of both songs needed to have accurate pronunciation and a consistent beat, so song genres like Rap and R&B were avoided. Third, learners' existing vocabulary had to account for 95% of vocabulary for optimal acquisition.

The lyrics of the songs are 593 and 283 words long, respectively. There were 876 words in all. Range (Heatley and Nation, 2002) and Nation's (2017) British National Corpus/Corpus of Contemporary American English (BNC/COCA) word family lists were used to examine the lyrics of the two songs. Range analysis determines the vocabulary level of each song at a certain level based on the lexical frequency of its phrases (Nation and Webb, 2011). According to the analysis, the participants needed to know at least the most frequent 2,000 word families to achieve around 93% lexical coverage of the songs, but their lexical levels were more than

2,000 frequent words, putting them in the best position for unassisted incidental vocabulary learning (see **Tables 1, 2**).

### Test of Prior Vocabulary Knowledge

The participants took an English and Chinese language version of the VLT to assess their past vocabulary knowledge. There are 140 multiple-choice questions in all, with 10 questions from each 1,000-word family level. The 140-item test is effective because it covers a wide range of frequency levels, comprises a large number of items, and the items have been meticulously prepared. To determine learners' entire receptive vocabulary size, their total score is multiplied by 100. The following website has bilingual versions.<sup>1</sup>

### Target Words

Twenty-six target words and 13 distractors were included for two songs. The inclusion of familiar terms was intended to encourage participants to complete the entire exam rather than give up when they realized that the majority of the words were unknown. Due to grammar identification being one form of vocabulary knowledge investigated during the tests, the vocabulary types in the choices had to be in various forms, such as nouns, verbs, and adjectives. However, adverbs were not utilized as target words because they are straightforward to identify with others. The 13 target words appeared 1–3 times on average, with word levels ranging from 2,000 to 7,000. Even though there were some vocabularies from lower word levels, none of the target words had been learned by the participants prior to the study (see **Table 3**).

### Vocabulary Knowledge Tests

Following Webb's (2005, 2007) and Pavia et al.'s (2019) testing design, there were 78 multiple-choice items included in total. Throughout the whole study, there were three tests included to follow and compare the development of the students: a test before listening, a test immediately after listening, and a test 4 weeks later. Each assessment contained three sections

<sup>1</sup><http://www.victoria.ac.nz/lals/staff/paul-nation.aspx>

**TABLE 1 |** Lexical frequency profile: "Have it all."

Word list families	Tokens/%	Types/%
One-thousand (157)	829/89.14	184/72.73
Two-thousand (30)	34/3.66	30/11.86
Three-thousand (2)	4/0.43	2/0.79
Off-lists	63/6.77	37/14.62
Total (189)	930	253

**TABLE 2 |** Lexical frequency profile: "Piano man."

Word list families	Tokens/%	Types/%
One-thousand (111)	268/88.16	132/79.52
Two-thousand (13)	13/4.28	13/7.83
Three-thousand (1)	1/0.33	1/0.60
Off-lists	22/7.24	20/12.05
Total (304)	166	125

**TABLE 3** | Frequency of occurrence, and word level of target words.

Song A	Frequency	Word level/1,000	Song B	Frequency	Word level/1,000
Esteem	1	6	Shuffle	1	5
Paved	2	3	Tonic	1	7
Infinite	3	3	Gin	1	6
Slap	1	4	Melody	2	4
Bracelet	1	7	Estate	1	2
Clutter	1	6	Carnival	1	6
Chaos	1	4			

The 13 distractors were as follows: deficit, condense, beneficial, accelerate, resent, peculiar, prospect, adjust, commence, sensible, radical, asset, and barrier.

that identify different areas of vocabulary knowledge, such as recognition, meaning recall, and grammar. Due to the fact that listening to songs is an aural activity, the measurements were also presented in aural form to suit listening behavior. The participants were instructed to listen to the recordings for questions and alternatives in multiple-choice assessments and then choose their answers from an answer sheet. Each question contained four alternatives: one correct answer, two distractors, and one “I don’t know” choice. When creating distractors, a number of factors were taken into account. First, the words are usually confused with original ones by most students. Second, the parts of speech for each word should be comparable. Third, for recognition distractors, the initial letters of words are generally modified to make them seem like actual English terms. Before starting the study, all the instructions and examples were explained in Chinese (native language) to ensure that all participants fully understood the test.

### Spoken-Form Recognition

The first component of the test focused on single-word item identification in spoken form. This section included seven and six multiple-choice items for Song A and Song B, respectively. Besides, the remaining 13 multiple-choice items were designed to encourage students to use words they already knew. All the distractors were nonsense words, which were created by altering the initial letters of words to make them sound like real English terms, but easily confused by students since they shared similar parts of speech and syllables to the target vocabulary. For this section, all participants listened to the tape once, with a 2-s stop between choices and a 4-s pause between items. The time break for each choice and item was adapted from Van Zeeland and Schmitt (2013) study. An example question is presented below:

#### Spoken-Form Recognition Testing

*The Participant Sees on Paper.* 指令：听录音，请识别出正确的英语单词。

A. B. C. D. I don’t know

The participant hears on the recording:

“No.1 [1 second] A, esteemed [2 seconds] B, gasteemed [2 seconds] C, presteemed [2 seconds].”

### Form-Meaning Connection

A recall exam was used to assess knowledge of meaning in the second section. It was chosen because it assesses students’ comprehension of listening, and the test looked at the connection between form-meaning and single-word items. This part also

contained seven and six multiple-choice items for two songs individually, and the rest were 13 multiple-choice items to motivate the students with words they were previously familiar with. Participants were then asked to tick the relevant Chinese translations of the alternatives on the answer sheet after hearing the target words for the first time. The distractors were responses to other exam items. The participants were given ten seconds for each item, with a four-second interval between them. An example question is presented below:

#### Form-Meaning Connection Testing

*The Participant Sees on Paper.* 指令：听单词选出对应的中文意思。

1). A.拖欠 B.赤字 C.缺点 D. I don’t know

At the same time the participant hears on the recording  
“Number one [1 sec.] Shuffle.”

### Grammar Recognition Testing

A multiple-choice test was used in the third section to assess receptive knowledge of grammatical functions. Song A had 7 multiple-choice items, Song B 6 multiple-choice items, and the rest of the 13 multiple-choice items were to motivate students with words they already knew. The structure of the testing followed Webb’s (2005, 2007) research. Students were asked to tick the corresponding part of speech for each item, such as a noun, verb, or adjective, on a piece of paper as well as in a recording. Since adverbs are easily recognized, there was no adverb option supplied as an alternative. Furthermore, three sentences with target words were provided after each item, and students were asked to identify the sentence with correct grammar. The function of a short sentence for each option is to help participants comprehend how a noun, verb, or adjective can be used in context. Each item was allotted six seconds, giving participants adequate time to recognize the grammar of words. The following is an example question:

#### Grammar Recognition Testing

*The Participant Sees on Paper.* 指令：从选项里选出正确的单词词性。

1). Deficit (a) It is a deficit. (b) It deficits. (c) It is very deficit.

The participant hears a recording at the same time.

“No.1 [1 sec.] deficit.”

### Procedure

Participants (except the control group students) listened to the songs and performed assessments in one-on-one sessions. In week 1, all the participants were required to complete a bilingual

version of the VLT (English and Chinese) at the outset, and they were assigned to three different levels of students (high, intermediate, and low-level students). As a result, preexisting classes were divided into four groups in total, which were one control group (C) ( $n = 29$ ) and three experimental groups: E1 ( $n = 29$ ), E3 ( $n = 29$ ), and E5 ( $n = 27$ ), each with similar proportions of high, intermediate, and low-level students. Next, all the participants (including control group students) finished a pretest for two songs before listening.

In week 2, the experimental participants were asked to listen to the songs once at the beginning, and they were told that they would be asked some questions related to the songs afterward. The purpose of the listening comprehension test was to ensure that all of them could comprehensively understand the context of the songs and make incidental vocabulary learning happen. Next, after listening to two songs, the experimental group (E1) was required to complete a posttest immediately. Finally, the experimental groups (E3 and E5) differed in the number of times they listened to the music, with the E3 group listening three times and the E5 group listening five times. The control group, on the other hand, had to complete the immediate posttest without listening to the songs.

Four weeks later, all participants took a delayed posttest for both songs.

## Data Analysis

The data were analyzed using SPSS (Version 25). Non-parametric tests were performed to address the study questions as a Kolmogorov-Smirnov test gave a negative result for a normal distribution. To answer these three study questions, all data were scored dichotomously, with 0 representing an incorrect answer and 1 a correct answer. For the first research question, a Mann-Whitney U Test was used to compare results within each group (control and experimental) on three dimensions (recognition, meaning, and grammar) at various times of testing (pretest, immediate posttest, and delayed posttest). To evaluate the relationship between vocabulary knowledge (recognition, meaning, and grammar) and the frequency of exposure (one time, three times, and five times) participants listened to the songs accordingly, and repeated Kruskal-Wallis Tests were performed. Finally, repeated Friedman M Tests were used to investigate the link between vocabulary size and the three dimensions of vocabulary knowledge (recognition, meaning, and grammar) after listening to the songs in order to address the third study question.

## RESULTS

**Tables 4–6** show descriptive data for vocabulary learning gains, frequency of exposure, and prior vocabulary knowledge of each aspect during vocabulary assessments. In order to address these three research questions, repeated measurements from Mann-Whitney U Tests, Kruskal-Wallis Tests, and Friedman M Tests were used, respectively, to compare the results for three dimensions of vocabulary knowledge within control and experimental groups at various testing times.

## The Effect of Listening to Songs on Incidental Vocabulary Learning

The first study issue addresses the extent to which word recognition, grammar identification, and meaning associations of vocabulary knowledge are addressed by listening to English songs. For each knowledge category, independent samples of Mann-Whitney U Tests were used to compare scores on a pretest, immediate posttest, and delayed posttest. The findings revealed that there was a significant difference in the immediate posttest ( $z = -3.725$ ,  $p = 0.001$ ) and the delayed posttest ( $z = -2.465$ ,  $p = 0.014$ ) for spoken-form recognition, but no significant difference in the pretest. For the form-meaning connection of the test, there was a significant difference in the immediate posttest ( $z = -3.783$ ,  $p < 0.001$ ), but no significant difference in the pretest and delayed posttest. For grammar recognition, there was a significant difference in the immediate posttest ( $z = -2.673$ ,  $p = 0.008$ ), but no difference in the pretest and delayed posttest. Overall, the three aspects of vocabulary knowledge showed significant differences after listening to the songs immediately, and the difference in spoken-form recognition was more significant than form-meaning connection and grammar recognition, with data for the percentiles being 15.39, 7.69, and 7.7%, respectively. However, only spoken-form recognition revealed a significant difference in the delayed posttest, whereas form-meaning connection and grammar recognition showed no significant differences (see **Table 7**).

## The Effect of Frequency of Exposure on Incidental Vocabulary Learning

The second study question concerns the impact of exposure frequency on incidental vocabulary learning through music listening. According to the immediate posttest hypothesis test, repeated Kruskal-Wallis tests revealed that all three aspects of vocabulary knowledge exhibited essential differences, with  $p < 0.001$  in each case. The results of frequency recognition pairwise comparisons revealed a significant difference in frequency from 0 to 3 times only ( $p < 0.001$ ), with percentiles of 5.00 and 8.00, respectively (see percentiles in **Table 8**). In the meaning pairwise comparisons of frequency, the data showed that there were critical differences from 0 to 3 times ( $p < 0.001$ ), 0 to 5 times ( $p = 0.005$ ), and 1 to 3 times ( $p = 0.002$ ), with the same percentiles from 3.00 to 5.00. In the grammar pairwise comparisons of frequency, the findings showed that there were significant differences from 0 to 3 times ( $p = 0.001$ ), with percentiles from 6.00 to 8.00, and 5 times to 3 times ( $p = 0.014$ ), with percentiles from 6.00 to 8.00. However, according to the post-delayed test hypothesis test, only recognition rejects the null hypothesis ( $p = 0.003$ ), with the frequencies of 0 to 3 times and 5 times to 3 times exhibiting significant differences at  $p = 0.004$  and  $p = 0.030$ , respectively. In the recognition pairwise comparisons of frequency, the data showed that there were significant differences from 0 to 3 times and from 5 to 3 times, with the same percentiles from 5.00 to 8.00 (see percentiles in **Table 8**).



**TABLE 4 |** Descriptive statistics for vocabulary knowledge.

Time of testing	N	Mean	SD	Minimum	Maximum	25th	50th (median)	75th
Recognition								
1	114	3.80	1.896	0	8	2.00	4.00	5.00
2	114	6.57	3.001	0	13	5.00	6.00	8.25
3	114	6.36	2.618	1	12	4.00	6.50	8.00
Meaning								
1	114	2.69	1.834	0	8	1.00	2.00	4.00
2	114	4.15	2.301	0	10	2.00	4.00	6.00
3	114	4.86	2.534	0	12	3.00	5.00	6.25
Grammar								
1	114	6.52	2.179	0	12	5.00	7.00	8.00
2	114	6.67	2.209	0	13	5.00	7.00	8.00
3	114	7.27	2.088	0	11	6.00	7.00	9.00
Groups	114	0.75	0.437	0	1	0.00	1.00	1.00

Test time: 1, retest; 2, immediate posttest; 3, delayed posttest.

**TABLE 5 |** Descriptive statistics for frequency of exposure.

	N	Mean	SD	Minimum	Maximum	Percentiles		
						25th	50th (median)	75th
Immediate posttest								
Recognition	114	6.57	3.001	0	13	5.00	6.00	8.25
Meaning	114	4.15	2.301	0	10	2.00	4.00	6.00
Grammar	114	6.67	2.209	0	13	5.00	7.00	8.00
Frequency	114	2.20	1.910	0	5	0.00	1.00	3.00
Delayed posttest								
Recognition	114	6.36	2.618	1	12	4.00	6.50	8.00
Meaning	114	4.86	2.534	0	12	3.00	5.00	6.25
Grammar	114	7.27	2.088	0	11	6.00	7.00	9.00
Frequency	114	2.20	1.910	0	5	0.00	1.00	3.0

## The Effect of Prior Vocabulary Knowledge on Incidental Vocabulary Learning

The third research question investigated how participants' pre-existing vocabulary knowledge influenced incidental vocabulary learning while listening to songs. Friedman M Tests revealed that between a pretest, immediate posttest, and delayed posttest, there was a statistically significant difference in vocabulary knowledge of spoken-form recognition for low, intermediate, and high level students, with (Chi-square = 11.676;  $p = 0.003$ ), (Chi-square = 41.883;  $p < 0.001$ ), and (Chi-square = 19.976;  $p < 0.001$ ), respectively. Furthermore, for post hoc comparisons, a Bonferroni test was used for spoken-form recognition, and the results showed that all low, intermediate, and high level students showed a statistically significant difference between the pretest and immediate posttest ( $p = 0.022$ ;  $p < 0.001$ ), between the pretest and post delayed test ( $p = 0.017$ ;  $p < 0.001$ ;  $p = 0.003$ ), but no significant difference between the immediate test and post delayed test

( $p = 1.000$ ;  $p = 1.001$ ;  $p = 1.000$ ). For vocabulary knowledge of meaning connections, low, intermediate, and high level students' hypothesis results also all indicated an overall statistically significant difference between the pretest, immediate posttest, and delayed posttest with (Chi-square = 20.366;  $p < 0.001$ ), (Chi-square = 34.503;  $p < 0.001$ ), and (Chi-square = 20.447;  $p < 0.001$ ), respectively. Also, post-hoc comparisons used a Bonferroni test for meaning connection, and the results showed that all low, intermediate, and high level students indicated a clear difference between a pretest and an immediate posttest ( $p = 0.001$ ;  $p < 0.001$ ;  $p = 0.003$ ), a pretest and a post delayed test ( $p < 0.001$ ;  $p < 0.001$ ;  $p = 0.001$ ), but no significant difference between an immediate test and a post delayed test ( $p = 1.000$ ;  $p = 1.000$ ;  $p = 1.000$ ). However, for vocabulary knowledge of grammar, low, intermediate, and high level hypothesis results showed no statistically significant difference between a pretest, immediate posttest, and delayed posttest with (Chi-square = 2.893;  $p = 0.235$ ), (Chi-square = 1.972;  $p = 0.373$ ), and (Chi-square = 5.297;  $p = 0.071$ ), respectively.

**TABLE 6 |** Descriptive statistics for prior vocabulary knowledge.

							Percentiles		
	Time of testing	N	Mean	SD	Minimum	Maximum	25th	50th (median)	75th
Low-level									
Recognition	1	20	2.35	1.631	0	6	1.25	2.00	3.75
	2	20	4.55	2.585	0	9	2.25	4.50	6.75
	3	20	4.70	1.922	1	8	3.25	4.50	6.50
Meaning	1	20	1.45	1.099	0	5	1.00	1.00	2.00
	2	20	3.15	1.644	0	6	2.00	3.00	4.00
	3	20	3.75	2.268	1	11	2.00	3.00	5.00
Grammar	1	20	6.00	1.717	3	10	5.00	6.00	7.00
	2	20	6.20	1.673	3	9	5.00	6.00	7.00
	3	20	7.05	2.089	2	10	6.00	7.00	8.00
Intermediate-level									
Recognition	1	41	3.98	1.666	0	7	3.00	4.00	5.00
	2	41	7.54	2.847	3	13	5.00	6.00	11.00
	3	41	6.90	2.478	1	11	5.00	7.00	9.00
Meaning	1	41	2.46	1.614	0	6	1.00	2.00	3.50
	2	41	4.59	2.291	0	9	3.00	4.00	6.00
	3	41	4.59	2.398	0	10	3.00	5.00	6.00
Grammar	1	41	6.80	1.990	2	11	5.00	7.00	8.50
	2	41	6.66	2.198	2	10	5.00	7.00	8.00
	3	41	7.39	1.986	3	11	6.00	8.00	9.00
High-level									
Recognition	1	24	4.71	1.829	1	8	4.00	5.00	6.00
	2	24	8.75	2.674	4	13	7.00	8.50	11.00
	3	24	8.04	2.562	3	12	7.00	8.00	10.75
Meaning	1	24	4.21	2.064	1	8	2.25	4.00	5.75
	2	24	5.92	2.358	2	10	4.25	5.00	8.00
	3	24	7.04	2.293	2	12	5.00	7.00	8.75
Grammar	1	24	7.25	2.327	4	12	5.00	8.00	9.00
	2	24	8.25	2.172	4	13	7.00	8.00	9.75
	3	24	7.78	2.092	3	11	7.00	8.00	9.00

Test time: 1, pretest; 2, immediate posttest; 3, delayed posttest.

## DISCUSSION

### To What Extent Does Listening to Songs Increase Vocabulary Knowledge of Spoken-Form Recognition, Grammar Recognition, and Meaning Recall?

In terms of the first research question, the findings revealed that listening to songs resulted in substantial gains in three dimensions (recognition, meaning, and grammar) in an immediate posttest, while only spoken-form recognition demonstrated significant acquisition in a delayed posttest. This finding is partly consistent with that of Van Zeeland and Schmitt (2013). Both studies found that participants advanced in three aspects of knowledge, recognition > grammar > meaning, immediately after listening to songs. A first possible reason for learners' preference for spoken-form recognition over meaning connection is that spoken-form recognition is the first and most straightforward dimension to master after listening. According to Van Zeeland and Schmitt (2013), the acquisition of meaning

recall requires a greater number of exposures than spoken-form recognition. Second, knowledge of meaning connections is a very complex element, since most vocabulary words have more than two meanings, and these meanings vary in different contexts, which makes it difficult for learners to identify and recall them after listening.

However, given the result of the delayed posttest, the current finding is not consistent with previous studies of incidental vocabulary retention of three vocabulary knowledge aspects (e.g., Van Zeeland and Schmitt, 2013). The present study found that both meaning recall and grammar recognition showed no significant difference in a delayed posttest, while spoken-form recognition did reveal a significant difference 4 weeks later. Nevertheless, Van Zeeland and Schmitt (2013) research found that meaning recall showed no obvious difference between an immediate posttest and a delayed posttest, although there was attrition of both grammar and recognition over the course of 2 weeks. These variations in findings are most probably related to time interval differences, because the current post-delayed test duration is substantially longer than in

**TABLE 7 |** Mann–Whitney U Test statistics.

Participant subgroups	Spoken-form recognition			Form-meaning connection			Grammar recognition		
	Pretest	Immediate posttest	Delayed posttest	Pretest	Immediate posttest	Delayed posttest	Pretest	Immediate posttest	Delayed posttest
Control (percentiles)	4 (2.5–5)	5 (4–6)	5 (4–6.5)	3 (1.5–4)	3 (2–4)	4 (3–6)	6 (4–8)	6 (5–7)	7 (6–8)
Experimental (percentiles)	4 (2–5)	7 (5–10)	7 (4–8.)	2 (1–4)	4 (3–6)	5 (3–7)	7 (5–8)	7 (5.5–8.5)	8 (6–9)
Z	–0.056	–3.725	–2.465	–0.285	–3.783	–1.551	–1.591	–2.673	–1.602
Significant	0.955	0.000195	0.014	0.776	0.000155	0.121	0.112	0.008	0.109

**TABLE 8 |** Percentiles for frequency.

Frequency	Immediate posttest Percentile (mean)	Delayed posttest Percentile (mean)
Recognition		
0 time	5	5
1 time	6	7
3 times	8	8
5 times	6	5
Meaning		
0 time	3	4
1 time	3	5
3 times	5	5
5 times	5	5
Grammar		
0 time	6	7
1 time	7	7
3 times	8	8
5 times	6	8

Van Zeeland and Schmitt (2013) investigation, so meaning recall and grammar were almost lost 4 weeks later. Generally, these findings suggest that learners can learn the spoken forms and meaning forms, and perform grammar recognition of single-word items incidentally while listening to songs. However, except for spoken-form recognition, which remained at 15.39% 4 weeks later, vocabulary knowledge of meaning and grammar were not easily retained.

## To What Extent Does the Frequency of Exposure Affect Incidental Learning Through Listening to Songs?

In answer to the second study question, the findings revealed that three dimensions of vocabulary knowledge demonstrate positive effects after listening to songs repeatedly. According to the findings, there was a strong correlation between the number of exposures and learning increases for all three dimensions after listening to songs three times, with the frequency of exposure to target words ranging from three to nine times.

The findings of this study are similar to those of earlier research. Pavia et al. (2019) study also found a strong association between the number of exposures and learning gains for spoken-form identification after listening to songs three times, where the frequency of exposure to target words ranged from three

to 18 times. However, the current study unexpectedly found that listening five times revealed no lexical improvement for experimental groups. There are probably two reasons: first, many factors may affect learners' vocabulary acquisition, such as learners' motivation, concentration, the complexity of words, etc., and frequency is only one of these. So, repeated listening might improve vocabulary knowledge, but this does not imply that the larger the more times a song is heard, the greater the total amount of vocabulary information obtained. As a result, listening to songs five times did not have the positive effect as most people expected. Second, the time taken to listen to two songs five times was quite long (over 30 min), and students already knew they would listen to the songs five times at the outset. According to the researchers' observation, most participants did not really concentrate on the songs while listening, and they may have paid more attention to the music than the lyrics. As a consequence, when the number of times students listened to songs was raised to five, their vocabulary knowledge did not continue to grow, and their recognition and grammatical learning improvements were nearly identical to those of the control group (zero times). Furthermore, the results of the post-delayed test revealed that only vocabulary knowledge of recognition showed retentive memory for students who listened to the songs three times, and knowledge of meaning connections and grammar recognition showed no difference between a pretest and a post delayed posttest for all students after 4 weeks.

In general, listening to English songs three times increases L2 vocabulary knowledge in the areas of word recognition, meaning connection, and grammatical recognition, with word recognition information likely to be preserved after 4 weeks. However, when the number of times that learners listen to songs rises, students become distracted and find it harder to concentrate on vocabulary items while listening, resulting in little vocabulary knowledge being attained.

## To What Extent Does Participants' Prior Vocabulary Knowledge Affect Incidental Vocabulary Learning Through Listening to Songs?

In response to the third study question, the data imply that low-proficiency, intermediate-proficiency, and high-proficiency learners all showed significant achievement in word recognition and meaning recall after listening to songs, which lasted for 4 weeks, but there was no progress in grammar recognition.

There are several possible explanations for the positive findings for word recognition and meaning recall for all levels of students. To begin with, spoken-form recognition is easier to acquire than form-meaning connections and grammar (Van Zeeland and Schmitt, 2013). Besides, listening to music is a joyful activity that can motivate students (Richards, 1969; Tegge, 2018). So, students feel it is enjoyable and less stressful to attain this element of vocabulary knowledge after listening to music, and their positive learning gains can be retained several weeks later. Second, music adds to the understanding of lyrics by allowing listeners to sense positive and negative signals while listening. According to Thompson and Russo (2004) research, the sound of music influences the understanding of meaning and emotion in song lyrics, and it can influence the perceived meaningfulness of lyrics with repeated song exposure. As a result, vocabulary knowledge of meaning connections also results in effective improvement for all students after listening to songs, and this will probably be remembered 4 weeks later. However, there was little statistically noteworthy difference between the pretest, intermediate, and delayed posttest results across all students' knowledge of grammar recognition. Students were not consciously aware of the function and characteristics of grammar (Hulstijn, 2003), so there was no progress in grammar recognition for all students after listening to songs.

## Limitations and Future Directions

Several restrictions should be considered while evaluating our data. First, only two pop songs were employed in this study; thus, more research with more songs and various types of songs is encouraged to analyze which types of songs best accelerate vocabulary acquisition.

Second, in the current research, all the participants were college students with most having a restricted vocabulary of 4,000–5,900 words. Besides, an earlier study found a favorable correlation between vocabulary size and learning gains in accidental vocabulary acquisition Vidal (2003, 2011). Thus, to acquire a better understanding of how listening to songs could benefit different levels of L2 learners, future research should investigate incidental vocabulary learning while listening to songs, particularly with individuals with smaller or larger vocabulary sizes.

Third, vocabulary knowledge covers different areas, such as a word's spoken or written form, collocations, semantic network of associations, etc. (Nation, 1990). However, this study focuses solely on word recognition, meaning recall, and grammar. As a result, it would be beneficial to study other aspects of vocabulary knowledge after listening to songs in future studies.

Fourth, learning efficiency is a metric for academic accomplishment that takes into accounts both performance and the amount of time a student spends learning. However, the difference in learning efficiency among students with different degrees of prior vocabulary knowledge was not considered in this research (Xiongfei et al., 2021; Khan, 2022; Mehmood et al., 2022). It is worthwhile to investigate in future language learning studies.

Fifth, in the present research, only the learner-internal factor was considered during the investigation. However, there are many other factors of individual difference to examine, such as

working memory, motivation, age, enjoyment, etc. (see Elgort and Warren, 2014; Lee and Pulido, 2017; Koda and Miller, 2018; Malone, 2018; Xiongfei et al., 2019; Bahadur et al., 2020; Pitafi et al., 2020). Some studies have looked at the role of working memory in reading and found a strong link to reading comprehension (Varol and Ercetin, 2016). Thus, it would be useful to investigate these different factors of individual differences in future incidental vocabulary research, especially in listening.

## CONCLUSION

The current research provides extensive empirical support for the possibility of incidental vocabulary learning through listening to songs. The results demonstrate that learners may acquire the spoken and meaning forms, and perform grammatical identification of single-word items by listening to songs. The effect of word recognition, on the other hand, was superior to the other two elements, and it was maintained 4 weeks later. Furthermore, repeated listening to English songs may promote vocabulary learning, but it was surprising to find that the more times a song was heard, this did not guarantee a greater total amount of vocabulary information being obtained. As a result, the data show that listening to songs three times (with exposure frequency ranging from three to nine times) was the most beneficial for L2 learners, with word recognition information likely to be preserved after 4 weeks. When the learner-internal component was taken into account, it was surprisingly found that low, intermediate, and high-proficiency learners all showed a beneficial influence on vocabulary knowledge of work-form recognition and meaning connection after listening to songs. As music has the ability to spark learners' interest and make learning happen subconsciously, listening to songs can be an excellent way to learn new vocabulary, particularly for low-proficiency students who are usually reluctant to attend English learning activities.

## PEDAGOGICAL IMPLICATIONS

This new research provides further empirical evidence supporting the favorable impact of listening to songs on vocabulary learning. It is advisable, then, for language teachers to use "listening to English songs" as another teaching strategy to improve students' vocabulary knowledge in the classroom. This could also have the double impact of exposing students to the style of information that best matches their learning preferences, and encourage them to learn outside the classroom using their chosen source of input, which is especially important for low-level students who are not interested in traditional vocabulary learning and struggle to learn receptive knowledge of word recognition and meaning recall. Furthermore, the repeated concurrence of single-words from three to nine times throughout the song may benefit learners most. After repeated exposure, the three dimensions of vocabulary knowledge (word-recognition, meaning recall, and grammar) may improve after listening, and word recognition will remain 4 weeks later. As a result, instructors and learners can use "listening to songs three times" as a criterion for efficient vocabulary teaching and learning.



## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## ETHICS STATEMENT

Ethical approval was not provided for this study on human participants because it was not mandatory to take ethical approval first, however, all procedures were followed by the

ethical guidelines of the university and international institutions. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

## AUTHOR CONTRIBUTIONS

KN constructed the manuscript overall. JF was responsible for conducting experiments. HR helped in the write-up. GZ helped in improving, data analysis, and proofreading. All authors contributed to the article and approved the submitted version.

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# Immersive Media Presentation and Preschoolers' Prosocial Behaviors: The Mediating Role of Theory of Mind

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## OPEN ACCESS

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### Specialty section:

This article was submitted to  
Educational Psychology,  
a section of the journal  
Frontiers in Psychology

Received: 04 March 2022

Accepted: 19 May 2022

Published: 03 June 2022

### Citation:

Chen T and Jin CL (2022) Immersive  
Media Presentation and  
Preschoolers' Prosocial Behaviors:  
The Mediating Role of Theory of  
Mind.  
Front. Psychol. 13:889475.  
doi: 10.3389/fpsyg.2022.889475

Although scholars have asserted that it is necessary to explore the effect of immersive media presentation on preschoolers' prosocial behaviors, the empirical research, as well as the moderating roles of this link, remained limited. One hundred and twenty preschoolers (mean age = 5.4 years) were involved in three experiments of four waves. This study empirically examined the effect of media presentation, including immersive media presentation and traditional media presentation, on preschoolers' prosocial behaviors and the moderating effect of theory of mind (ToM) on such links. After the experimental intervention, we find that the extent to which traditional media presentation and immersive media presentation impact preschoolers' prosocial behaviors is different. First, the results show that preschoolers, who have been involved in traditional media presentation, do not notably reveal the development of their prosocial behaviors. However, in the group of high ToM, we find that traditional media presentation positively and significantly relates to preschoolers' prosocial behaviors. That is to say, the positive influence of traditional media presentation depends on ToM. Second, the results also show that immersive media presentation positively and significantly relates to preschoolers' prosocial behaviors whether ToM is high or not. Furthermore, ToM encourages the positive influence of immersive media presentation on preschoolers' prosocial behaviors.

**Keywords:** prosocial behaviors, immersive media presentation, traditional media presentation, theory of mind, empirical research

## INTRODUCTION

Prosocial behaviors, the voluntary physical reactions intending to benefit others (Dunfield and Kuhlmeier, 2013; Yu et al., 2020), are widely regarded as a critical topic in developmental psychology and educational psychology (Newton et al., 2014; Paulus, 2014; Imuta et al., 2016; Benish-Weisman et al., 2019; Wu et al., 2020; Zeng et al., 2020). Guidelines for Kindergarten Education, issued by the Ministry of Education of China in 2001, puts forward four goals about the development of preschoolers' prosocial behaviors, such as the willingness to comfort, cooperate, help, and share (Dunfield and Kuhlmeier, 2013). This policy points out the importance of the research on preschoolers' prosocial behaviors. In addition, prior studies indicated that

preschoolers' prosocial behaviors positively relate to their future development (Lohndorf et al., 2019), interpersonal harmony (Zeng et al., 2020), and social implications (Malonda et al., 2019). Therefore, it is essential to explore how to promote preschoolers' prosocial behaviors (Yu et al., 2020).

Prior studies indicated that media presentation may impact the development of preschoolers' prosocial behaviors. For example, Chang et al. (2011) indicated that traditional media presentation has potential influence on preschoolers' prosocial behaviors (Franklin, 2004), because media technology enables the information conveyance and storage (Sanchez and Fairfield, 2003). The study of Flook et al. (2015) also contended that the curriculum with a mindfulness-based kindness can promote preschool children's prosocial behaviors, such as the behaviors of helping and learning from each other. With the development of immersive media technologies (i.e., Virtual Reality, 360° Imagery or Video, and 3D Content), scholars in domain of developmental psychology and educational psychology called for more grainy research about the relationship between the use of immersive media technologies and preschoolers' development. For example, Widowati (2018) documented that the alignment of watching animations and role-play games in immersive virtual environments will generate a better effect on learning outcomes. Ma (2020) proposed that immersive stories have a positive influence on students' prosocial attitudes and willingness to help. Although prior scholars noted that the use of advanced immersive technique plays a critical role in enhancing preschoolers' helping and sharing behaviors (Ferguson, 2015; Benish-Weisman et al., 2019), the empirical investigation on the effect of immersive media presentation on preschoolers' prosocial behaviors still remains limited. In this study, we differentiate the effect of immersive media presentation on preschoolers' prosocial behaviors from the traditional media presentation to response to scholarly calls and propose our first research question as follow:

**RQ1:** How immersive media presentation and traditional media presentation affect preschoolers' prosocial behaviors? And what are the differences?

Additionally, previous research indicated that the degree to which media presentation impacts students' behaviors depends on their cognitive capability (Imuta et al., 2016), such as the theory of mind (ToM). ToM refers to an individual cognitive ability to understand psychical states. Such cognitive ability can facilitate preschoolers to understand others' affection and intention, as well as to predict and interpret others' behaviors (Wellman et al., 2001; Lecce et al., 2014; Bigelow et al., 2021). ToM was widely regarded as a critical enabler of social living and social reasoning (Meins et al., 2002; Peterson and Wellman, 2019). Prior study revealed that preschoolers' ability to understand others' feelings and behaviors may improve the effect of teaching approaches on preschoolers' learning progress (Imuta et al., 2016). In this logic, we contend that for preschool children, ToM may encourage the effect of media presentation on their prosocial behaviors. That is to say: ToM, a typical cognitive capability, may play a critical moderating effect on the relationship between media presentation (i.e., immersive media presentation and traditional

media presentation) and preschoolers' prosocial behaviors. However, few empirical studies have investigated the moderating role of ToM in this link. Thus, we propose another research question:

**RQ2:** How ToM moderates the relationship between the media presentation (i.e., immersive media presentation and traditional media presentation) and preschoolers' prosocial behaviors?

To untangle the two research questions, we used the data deriving from our three experiments of four waves to empirically examine the effect of media presentation (i.e., immersive media presentation and traditional media presentation) on preschoolers' prosocial behaviors and the moderating role of ToM in such link. We make two key contributions in this study. First, we enrich the research about the relationship between immersive media and preschoolers' prosocial behaviors through empirically exploring how immersive media presentation impacts preschoolers' prosocial behaviors, and differentiating that from the effect of traditional media presentation on preschoolers' prosocial behaviors. Second, we also expand the contingencies of the relationship between media presentation, including immersive media presentation and traditional media presentation, and preschoolers' prosocial behaviors through empirically investigating the moderating effect of ToM. We thus respond to the scholarly call for more research on preschoolers' prosocial behaviors (Lockwood et al., 2014; Lohndorf et al., 2019). In our study, we find that after the experimental intervention, the extent to which traditional media presentation and immersive media presentation impact preschoolers' prosocial behaviors is different. First, the results show that preschoolers who have been involved in traditional media presentation do not notably reveal the development of their prosocial behaviors. However, in the group of high ToM, we find that traditional media presentation positively and significantly relates to preschoolers' prosocial behaviors. That is to say, the positive influence of traditional media presentation depends on ToM. Second, the results also show that immersive media presentation positively and significantly relates to preschoolers' prosocial behaviors whether ToM is high or not. Furthermore, ToM encourages the positive influence of immersive media presentation on preschoolers' prosocial behaviors. Our findings thus provide the teachers or managers of kindergarten with underlying approaches to facilitate preschoolers' prosocial behaviors.

## HYPOTHESIS DEVELOPMENT

Prosocial behaviors refer to the voluntary physical reactions intending to benefit others (Dunfield and Kuhlmeier, 2013; Yu et al., 2020). Prior studies showed several antecedents of preschoolers' prosocial behaviors, such as parents' discourse about emotions with their young children (Brownell et al., 2013), parents' values (i.e., self-enhancement values, self-transcendence value, and self-conservation values; Benish-Weisman et al., 2019), peer influence and status (Choukas-Bradley et al., 2015), interpersonal synchrony (Cirelli et al., 2014),



moral perfectionism (Zeng et al., 2020), and parental sensitivity (Newton et al., 2014). Besides these factors, prior scholars also indicated that appropriate training and education can enhance the preschoolers' intentions of prosocial behaviors. For example, Ferguson (2015) noted that children's prosocial behaviors can be guided when they are watching video-games. Flook et al. (2015) and Hafenbrack et al. (2020) reported that the mindfulness-based kindness courses promotes preschool children's prosocial behaviors. However, few researches have empirically explored the effect of media presentation, especially immersive media presentation, on preschoolers' prosocial behaviors.

Immersive media presentation refers to a teaching presentation involved in immersive virtual technologies (Ma, 2020), while traditional media presentation reflects a teaching presentation synchronized with images, words, audios, and videos (Yetlen and Nunamaker, 1991; Patrick, 2015; Widowati, 2018). Children's prosocial orientation can be promoted when they consciously copy the behaviors from the videos or cartoons that they have watched whether using traditional media technologies or immersive media technologies (Carpenter et al., 2013). Watching videos or cartoons using different media technologies may have distinct effect on facilitating the tendency of preschoolers' prosocial behaviors (Helt et al., 2020). Immersive media, such as virtual reality, augmented reality, and 360° video, offers preschoolers so high a degree of vividness that they can better understand what have been conveyed. In addition, immersive media technologies can also help to reduce the cognitive and psychological difficulties through amplifying the feeling of spatial presence; thus, compared with traditional media presentation, watching cartoons embedded with immersive media technologies have a stronger positive influence on children's tendency to mimic what they have learned (Widowati, 2018). Following these logic, we contend that the effect of immersive media presentation on preschoolers' prosocial behaviors is stronger, compared with the impact of traditional media presentation. Based on the argument above, we propose three hypotheses as follows:

*Hypothesis 1:* Both immersive media presentation and traditional media presentation related positively to the development of preschoolers' prosocial behaviors. Furthermore, the effect of immersive media presentation on preschoolers' prosocial behaviors is stronger than that of traditional media presentation.

Prior scholars noted that preschoolers' development of ToM related positively to their executive functioning (Carlson et al., 2002, 2004; Sabbagh et al., 2006), children's language development (Astington and Jenkins, 1999; Ruffman et al., 2002; Milligan et al., 2007), moral judgments (Gonultas et al., 2021). For example, Kim et al. (2021) have noted that ToM skills relate to discourse understanding and the relationship between ToM and narrative understanding is more stronger than the relationship between ToM and informational text understanding. Prior psychological scholars also indicated that the social behaviors acceptable results from the continuous interactions of social affective and social cognitive processes, considering

these processes are executed by separable and independent area of brains (Preckel et al., 2018). In addition, children's theory of mind plays an essential positive role when they reading and understanding others' feelings and behaviors (Kidd and Castano, 2013). Follow this logic, we propose the hypothesis as follow:

*Hypothesis 2:* Preschoolers' ToM ability strengthens the positive influence of media presentation (including traditional media presentation and immersive media presentation) on their development of prosocial behaviors.

## METHODOLOGY

In our study, we focus on the preschoolers located in the China's Yangzi River Delta. First, before the preschoolers attended the training courses, we measured their original prosocial behaviors through watching them. Second, the preschoolers chosen would be arranged to watch the teaching materials prepared in advance. We then watched and recorded their change in such behaviors. Third, after experimentation, we would compare their behavior between before and after experimentations.

## Participants

Two hundred and eighteen preschoolers were randomly selected from several kindergartens located in Yangtze River Delta of China. Before the formal experiment, we conducted an experiment regarding preschoolers' prosocial behaviors, and 45 % of these preschoolers showed such behaviors. Then, we choose the rest, 120 preschoolers, who failed the prior test as our research sample and divided them into two groups. One group was arranged to participate in the courses with immersive virtual technologies to investigate the effect of immersive media presentation on preschoolers' prosocial behaviors, and the other group was settled to take part in the courses with traditional media technologies to explore the effect of traditional media presentation on preschoolers' prosocial behaviors.

## Measures

### Prosocial Behaviors

We adapted the research of Newton et al. (2014) and Lohndorf et al. (2019) to measure the development level of preschoolers' prosocial behavior. We first set up two hypothetical scenarios for every category of prosocial behaviors, including the behaviors of helping, comforting, sharing, and cooperating, added up to 8 scenarios. Then, we observed and recorded their behaviors. Two points would be scored when children have the spontaneous prosocial behaviors. One point would be scored if they showed the prosocial behaviors only with the experimenters' linguistic hints. Otherwise, we would mark this item as zero point. The aggregate scores of the eight items revealed the level of prosocial behavior development, ranging from 0 to 16. Furthermore, in order to avoid common method bias, we differentiated the hypothetical scenarios in post-test from those in pre-test. Similarly, all the selected scenarios are consistent with the

level of preschoolers' cognitive development, and the scoring criteria is the same.

### Theory of Mind

We adapted the research of Melot and Angeard (2003) and Misailidi and Kapsali (2020) to measure the ToM. This measurement included five items covering the test of unexpected-location tasks (two items), unexpected-content tasks (two items), and appearance-reality task (one item). If the subjects respond to each item correctly, they would be scored one point. The aggregate scores of the five items are five points.

### Media Presentation

We first adopted the teaching methods of traditional media presentation. Eight clips from domestic animations with scenarios for helping, cooperating, sharing, and comforting were selected and evaluated by several scholars who specializes in prosocial behaviors. We then aligned these eight animation clips into teaching schemes. Forty subjects were arranged to watch two animation clips every week. The whole experiment lasted for 4 weeks. We also adopted the teaching methods of immersive media presentation. The subjects wearing head-mounted displays watched eight animation clips and their subsequent behaviors were evaluated by the scholars who specializes in preschoolers' prosocial behaviors. The theme of these animation clips is also related to the prosocial behaviors, such as the behaviors of helping, cooperating, comforting, and sharing. This experiment also lasted for 4 weeks.

## Research Procedure

### The Pre-test of Preschoolers' Prosocial Behaviors

The research process of our study is divided into four waves. In the first wave, based on the sample pool of two hundred and eighteen subjects, we conducted a pre-test in which our research assistants were arranged to observe whether the chosen preschoolers showed the tendency of prosocial behaviors, such as the ones to help or comfort others. According to the alignment of our on-site observations and subsequent analyses, we labeled the ones who have not revealed the prosocial behaviors. The whole pre-test lasted 5 days and we got 120 samples for subsequent experiments.

### The Experimentation of Theory of Mind

In the second wave, after the pre-test, based on 120 preschoolers who failed the pre-test, we conducted another experimentation about ToM which used to examine the cognitive capability to understand others' emotions and behaviors. In such experimentation, we collected and recorded the data about preschoolers' capability to understand others' feeling and behaviors. According to the scores of this experimentation, we divided the subjects into two parts, namely high ToM and low ToM. The data were used to analyze the contingent effect of ToM on the relationship between media presentation (including traditional media presentation and immersive media presentation) and preschoolers' prosocial behaviors. This experimentation lasted 2 days.

### The Experimentation of Media Presentation

In the third wave, the 120 preschoolers who have not showed prosocial behaviors in the pre-test were randomly divided equally into three groups. First, for the 40 preschoolers in group one, we conducted an experimentation on traditional media presentations. This experimentation would last 4 weeks, in which the chosen preschoolers would be involved in watching eight animation clips. During the process, our research assistant would watch and record the preschoolers' behaviors. Second, at the same time, based on another 40 subjects in group two, we simultaneously conducted the experimentation on immersive media presentation lasting 4 weeks. In this 4 weeks, the chosen preschoolers were involved in watching eight animation clips with the elements of prosocial behaviors through wearing head-mounted displays. Our research assistants are also required to observe and document the subjects' actions. Third, the rest 40 preschoolers were arranged into the controlling group that would not be involved in the experimentation of media presentation.

### The Post-test of Preschoolers' Prosocial Behaviors

In the fourth wave, after the experiments of ToM and media presentation, based on the 120 subjects, we subsequently conducted a post-test of prosocial behaviors. To alleviate the common method bias, we adopted another measurement in the post-test. The standards and procedures in the post-test are the same with those in the pre-test. This test lasted for 2 days.

## RESULTS

### Media Presentation and Preschoolers' Prosocial Behaviors

Having finished all experiments, we applied SPSS 26.0 software to process and analyze the data collected in four waves (Jin et al., 2022). We anticipated that the preschoolers who were involved in the experimentation of media presentation, including traditional media presentation and immersive media presentation, are more likely to show the prosocial behaviors than those who have not.

Specifically, in terms of the relationship between the behaviors of comforting others and media presentation, the result of covariance analysis shows that the effect of immersive media presentation and traditional media presentation on preschoolers' behaviors of comforting is different ( $F=11.087$ ,  $p<0.001$ ). We further conducted a *post hoc* examination to verify the results. The results show that after the intervention, the scores of the group who have taken the courses with immersive media presentation are  $0.869(p<0.001)$  higher than the scores of controlling group and are  $0.656(p<0.05)$  higher than that of the group who have taken the courses with traditional media presentation, while the score difference between the group who have taken the courses with traditional media presentation and the controlling group is insignificant.

In terms of the relationship between the behaviors of cooperating others and media presentation, the result of covariance analysis shows that the effect of immersive media

presentation and traditional media presentation on preschoolers' behaviors of comforting is different ( $F=12.543$ ,  $p<0.001$ ). We further conducted a *post hoc* examination to verify the results. The results show that after the intervention, the scores of the group who have taken the courses with immersive media presentation are 0.860 ( $p<0.001$ ) higher than the scores of controlling group and are 0.600 ( $p<0.05$ ) higher than that of the group who have taken the courses with traditional media presentation, while the score difference between the group who have taken the courses with traditional media presentation and the controlling group is also insignificant.

In terms of the relationship between the behaviors of helping others and media presentation, the result of covariance analysis shows that the effect of immersive media presentation and traditional media presentation on preschoolers' behaviors of comforting is different ( $F=21.602$ ,  $p<0.001$ ). We further conducted a *post hoc* examination to verify the results. The results show that after the intervention, the scores of the group who have taken the courses with immersive media presentation are 1.082 ( $p<0.001$ ) higher than the scores of controlling group and are 0.692 ( $p<0.001$ ) higher than that of the group who have taken the courses with traditional media presentation. Meanwhile, the scores of the group who have taken the courses with traditional media presentation are 0.390 ( $p<0.05$ ) higher than the scores of the controlling group.

In terms of the relationship between the behaviors of sharing with others and media presentation, the result of covariance analysis shows that the effect of immersive media presentation and traditional media presentation on preschoolers' behaviors of comforting is different ( $F=30.176$ ,  $p<0.001$ ). We further conducted a *post hoc* examination to verify the results. The results show that after the intervention, the scores of the group who have taken the courses with immersive media presentation is 1.095 ( $P<0.001$ ) higher than the scores of controlling group and is 0.430 ( $p<0.05$ ) higher than that of the group who have taken the courses with traditional media presentation. Meanwhile, the scores of the group who have taken the courses with traditional media presentation are 0.665 ( $P<0.001$ ) higher than the scores of the controlling group.

In H1, we predict that both immersive media presentation and traditional media presentation positively related to preschoolers' prosocial behaviors and that the effect of immersive animation presentation on prosocial behaviors is stronger than that of traditional media presentation. According to research results mentioned above, although immersive media presentation can both promote four types of prosocial behavioral development, traditional media presentation only facilitates the helping and sharing behaviors. Furthermore, the effect of immersive media presentation on preschoolers' prosocial behaviors (e.g., the comforting, cooperating, helping and sharing behaviors) is stronger than that of traditional media presentation. Thus, H1 is partly supported (see Table 1).

## The Moderating Role of ToM

In the second wave, according to the scores of ToM, the subjects were labeled as high ToM (ToM\_H) or low (ToM\_L). The

results of covariance analysis show that the extent to which media presentation impacts preschoolers' prosocial behaviors depends on the role of ToM. After the intervention of media presentation, the preschoolers with high ToM show an even stronger tendency of prosocial behaviors. Specifically, in terms of the effect of media presentation on the behaviors of comforting, when ToM is higher, after the intervention of immersive media presentation, preschoolers are more likely to show the behaviors of comforting ( $F=16.975$ ,  $p<0.05$ ) comparing with the intervention of traditional media presentation (see Table 2). Considering the effect of media presentation on the behaviors of cooperating, when ToM is higher, after the intervention of immersive media presentation, preschoolers are more likely to show the behaviors of cooperating ( $F=11.79$ ,  $p<0.05$ ,  $\eta^2=0.169$ ) comparing with the intervention of traditional media presentation (see Table 2). Considering the effect of media presentation on the behaviors of helping, when ToM is higher, after the intervention of immersive media presentation, preschoolers are more likely to show the behaviors of helping ( $F=14.026$ ,  $p<0.05$ ,  $\eta^2=0.195$ ) comparing with the intervention of traditional media presentation (see Table 2). Considering the effect of media presentation on the behaviors of sharing, when ToM is higher, after the intervention of immersive media presentation, preschoolers are more likely to show the behaviors of sharing ( $F=19.414$ ,  $p<0.05$ ,  $\eta^2=0.251$ ) comparing with the intervention of traditional media presentation (see Table 2). Thus, consistent with our expectation, the role of ToM encourages the positive effect of media presentation, including immersive media presentation and traditional media presentation, on preschoolers' prosocial behaviors; thus, H2 is supported.

## DISCUSSION

Our experimentation results reveal that those preschoolers who have participated in the courses with the immersive media presentation are more likely to show their prosocial behaviors, such as the ones to comfort or help others and the ones to share or cooperate with others. That is to say, the teaching approaches of media presentation using immersive virtual devices enable preschoolers' prosocial behaviors. Furthermore,

**TABLE 1 |** Results of the relationship between media presentation and prosocial behaviors.

		Immersive media presentation	Traditional media presentation	Controlling group
		Model 1	Model 2	Model 3
Comforting	Pre-test	1.60 ± 1.74	1.47 ± 0.60	1.62 ± 0.67
	Post-test	2.53 ± 1.18	1.78 ± 0.92	1.67 ± 0.86
Cooperating	Pre-test	1.78 ± 0.80	1.65 ± 0.66	1.48 ± 0.64
	Post-test	2.60 ± 1.03	1.90 ± 0.87	1.50 ± 0.96
Helping	Pre-test	1.13 ± 0.72	1.15 ± 0.70	1.35 ± 0.66
	Post-test	2.30 ± 0.97	1.63 ± 0.87	1.38 ± 0.81
Sharing	Pre-test	1.73 ± 1.01	1.70 ± 0.94	1.63 ± 0.77
	Post-test	2.75 ± 1.06	2.30 ± 0.99	1.57 ± 0.84

**TABLE 2 |** Results of moderating effect of ToM in the relationship between media presentation and prosocial behaviors.

		Immersive media presentation		Traditional media presentation		Controlling group	
		Model 1 ToM_H	Model 2 ToM_L	Model 3 ToM_H	Model 4 ToM_L	Model 5 ToM_H	Model 6 ToM_L
Comforting	Pre-test	1.65 ± 0.81	1.55 ± 0.69	1.56 ± 0.73	1.42 ± 0.50	1.58 ± 0.84	1.67 ± 0.48
	Post-test	3.30 ± 0.73	1.75 ± 1.02	2.50 ± 0.63	1.29 ± 0.75	1.89 ± 0.94	1.48 ± 0.75
Cooperating	Pre-test	1.80 ± 0.77	1.75 ± 0.85	1.88 ± 0.72	1.50 ± 0.59	1.58 ± 0.51	1.38 ± 0.74
	Post-test	3.30 ± 0.80	1.90 ± 0.72	2.38 ± 0.72	1.58 ± 0.83	1.79 ± 0.71	1.24 ± 2.09
Helping	Pre-test	1.25 ± 0.72	1.00 ± 0.73	1.06 ± 0.68	1.21 ± 0.72	1.21 ± 0.71	1.48 ± 0.60
	Post-test	2.40 ± 1.10	2.20 ± 0.83	2.25 ± 0.77	1.21 ± 0.66	1.32 ± 1.00	1.43 ± 0.60
Sharing	Pre-test	1.75 ± 1.07	1.70 ± 0.98	1.94 ± 0.85	1.54 ± 0.98	1.84 ± 0.76	1.43 ± 0.75
	Post-test	3.00 ± 1.12	2.50 ± 0.95	2.81 ± 0.83	1.96 ± 0.95	2.05 ± 0.78	1.14 ± 0.65

we also find that the immersive media presentation has a stronger effect on preschoolers' prosocial behaviors than that of traditional media presentation. A possible explanation is that immersive media (e.g., 360° imagery or video, virtual reality, and 3D content) can make the teaching materials more comprehensible and be used to reduce the psychological and cognitive gap. Thus, this approach is more advisable.

Our study also explores the moderating role of ToM in the relationship between different approaches of media presentation and preschoolers' prosocial behaviors. The experimentation results reveal that both immersive media presentation and traditional media presentation have a stronger influence on preschoolers' prosocial behaviors when their ability to sense and understand others' emotions and behaviors is higher. That is to say, the ToM has a positive contingent effect on the relationship between media presentation and preschoolers' prosocial behaviors. A possible explanation is that the external knowledge or information need to be processed by internal cognitive capability, especially for preschoolers whose ability to understand others behaviors varies with each individual.

## Theoretical Implication

In our study, we integrate the role of media presentation and ToM to explore how to facilitate preschoolers' prosocial behaviors. Our research team makes two theoretical contributions. First, we enrich the understanding of how to guide preschooler's prosocial behaviors based on teaching methods using immersive media technologies and traditional media technologies. Scholars in education management called for more empirical investigation about the role of immersive media in promoting preschoolers' prosocial behaviors. Focusing on media presentation, we empirically explore the effect of immersive media presentation and traditional media presentation on preschoolers' prosocial behaviors, which respond in part to the scholarly call. In addition, we contribute to the studies of contingent factor in the relationship between media presentation and preschoolers' prosocial behaviors. We find that the extent to which the media presentation impacts preschoolers' prosocial behaviors relies on preschoolers' capability to understand others' behaviors (Wellman et al., 2001). Our research confirms the necessity to realize the importance of training preschoolers' cognitive abilities while improving teaching approaches. We thus also

extend the understandings of the contingent conditions of the research of preschoolers' prosocial behaviors.

## Practical Implication

Our study supplies three primary implications with parents, kindergartens, and the society. First, for kindergartens and preschoolers' parents, they should deepen the understanding that preschoolers' prosocial behaviors play a critical role in promoting their healthy development and these behaviors can be trained through taking appropriate teaching courses. Furthermore, comparing with the teaching method using traditional media technologies, using immersive media technologies will generate a better positive effect. Thus, both kindergartens and families should highlight the daily collection of ideal teaching materials with the elements of prosocial behaviors, especially those cartoon materials. Second, considering the teaching materials, such as the animations and cartoons with the elements of prosocial behaviors, can direct preschoolers' behaviors effectively, and because of the relative deficiency in the development of domestic cartoons compared with several developed countries, it is essential for our society to encourage the creation and distribution of superior domestic animations. Furthermore, the details of the cartoons should be under the strict supervision (Fedorov et al., 2018). Third, our study also finds that the extent to which media presentation affect preschoolers' prosocial behaviors depends on the theory of mind. Preschoolers' capability to sense and understand others' feelings and behaviors plays a critical role in the positive effect of media presentation on their prosocial behaviors. Thus, to guide the preschoolers' behaviors in a greater extent, all the teaching units, including kindergartens, families, and the society, should not only focus on taking the immersive-media-embedded and traditional-media-embedded teaching measures but also should emphasize on enhancing preschoolers' capability to sense and understand others' feelings and behaviors at the same time.

## Limitations and Future Research

Three limitations suggest directions for future research. First, the samples of our study are confined to kindergartens in China. Thereby, it may be risky to generalize our research conclusions to other countries and regions. Future research covering more regions may enrich our research. Second, although



our experimentations are consisted of the data of four waves, the sample size remains to be enlarged. Efforts to enlarge the size of samples, as well as the size of research team, may be extend our findings. Third, our research team only explores the contingent roles of preschoolers' capability to understand others' feelings and behaviors. Future research may contribute to our study by investing the potential moderating influence of social and environmental factors on the relationship between media presentation and preschoolers' prosocial behaviors.

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors.

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## AUTHOR CONTRIBUTIONS

TC involved in conceptualization, methodology, and writing—original draft preparation. CLJ took part in methodology, writing—reviewing and editing, and funding acquisition. All authors have read and agreed to the submitted version of the manuscript.

## FUNDING

This study was supported by Education Department of Anhui Province (grant numbers gxbiZD2021018 and gxyq2021046), Anhui Xinhua University (grant numbers 2019rw013 and 2021jy005), and Department of Hefei Science and Technology (grant number 2020005).

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The Reviewer J-BL declared a shared affiliation with the authors to the handling editor at the time of review.

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# Mediating Role of Optimism Bias and Risk Perception Between Emotional Intelligence and Decision-Making: A Serial Mediation Model

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## OPEN ACCESS

### Edited by:

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### Specialty section:

This article was submitted to  
Educational Psychology,  
a section of the journal  
Frontiers in Psychology

Received: 07 April 2022

Accepted: 02 May 2022

Published: 03 June 2022

### Citation:

Chen C, Ishfaq M, Ashraf F,  
Sarfaraz A and Wang K (2022)  
Mediating Role of Optimism Bias  
and Risk Perception Between  
Emotional Intelligence  
and Decision-Making: A Serial  
Mediation Model.  
Front. Psychol. 13:914649.  
doi: 10.3389/fpsyg.2022.914649

The commodity market plays a vital role in boosting the economy. Investors make decisions based on market knowledge and ignore cognitive biases. These cognitive biases or judgment errors have a significant effect on investment decisions. Therefore, this study aimed to investigate the effect of emotional intelligence on decision-making. In addition, optimism bias and risk perception are the intervening variables between emotional intelligence and decision-making. So, this study contributes to the body of knowledge by examining the mediating role of optimism bias and risk perception. The data were collected from the respondents of the commodity market and the 370 questionnaires were distributed among the investors, of which 337 respondents gave their feedback. The convenience base sampling technique is used due to the easy access of respondents, time factor, and cost factor. Data entered into the SPSS Statistics Version 26 and PROCESS macro model 6 were used for serial mediation. AMOS was used for the validity and model-fit analysis. The results of this study aligned with the literature that there is a significant effect of emotional intelligence on decision-making. It also observed that optimism bias has a positive effect on decision-making. The finding of this study will be helpful for the brokers, the government, and especially the investors. This study also proposed that future studies on the stock exchange and real estate market comparative analysis can be conducted.

**Keywords:** emotional intelligence, optimism bias, risk perception, investment decisions, commodity market

## INTRODUCTION

Over time, the paradigm of behavioral finance has moved the attention away from traditional finance. According to the classical financial paradigm, researchers explain investors' decisions by focusing on behavioral finance reactions (Sartori et al., 2017). Behavioral finance focuses on judgment errors that deal with the irrational behavior of investors. Investors have other mental biases that can severely prevent them from growing their wealth (Shefrin and Statman, 2000). In traditional finance, decision-makers estimate all possible results that are presented as the

foundation for creating the conventional prospect in finance. Finance speculations assume that these rational individuals are unwilling to take the risk (Jackson and Jabbie, 2019). Traditional decision theory believes that individuals are the logical decision-makers who are self-seekers in the existence of restraints.

Behavioral finance focuses on how the investor's psychology influences the decisions that may be positively or negatively (Zhuo et al., 2021). In behavioral finance, investors make decisions based on emotions and cognitive biases. The study of psychology that influences investor's decisions and the marketplace is known as behavioral finance (Shefrin and Statman, 2000). According to the behavioral finance models, rather than just market data, individual personality, thinking, emotions, and judgment errors are all affected by investment decisions. Investors' actions are not necessarily rational; they can be motivated by psychological or attitudinal factors.

Salovey and Mayer (1990) proposed the "Emotional Intelligence" concept. Emotional intelligence is referred to as the use of information to influence one's thinking and behavior and the ability to be aware of one's feelings (Salovey and Mayer, 1990). A five-dimensional emotional intelligence model is proposed by Goleman (1998): social skills, empathy, motivation, self-regulation, and self-awareness, all of which are necessary qualities (Goleman, 1998). The researchers looked into how incidental emotions differ from scenario to circumstance and how they influence decisions about the normative approach, which is artificial to that mood or feeling (Campos and Keltner, 2014). The trip of an ordered reaction that crosses the subsystems of psychology, motivational, experimental, and cognition, is referred to as emotion.

Investors' judgments are influenced by cognitive bias, which is a systematic inaccuracy in thinking. Some of these biases are memory related; how you recall an event might be skewed for various reasons, resulting in judgment errors and decision-making errors. On the other hand, cognitive biases are linked to the roles performed by different types of experience and knowledge (Bodnaruk and Simonov, 2015). Psychological feelings have been defined as a component of perception in general. As a result, they are inescapable and can be found in many settings and assignments (Murata et al., 2015). According to the researchers, the rationality of investors is severely limited. Simon (1955) coined the term "bounded rationality" to describe his skepticism of anticipated utility theory's assumption that decision-makers are fully rational (Von Neumann and Morgenstern, 1947).

Investors who think positively always act optimistically and become inspired to invest (Anderson and Galinsky, 2006). On the other hand, the less motivated investor always makes decisions based on market trends, and if the investor believes the market is performing well, they will invest. When a speculator constructs his venture/capital formation, he is idealistic in light of reality and believes that future outcomes will occur without fail (Galanti and Gaël, 2017). When investors are optimistic, they put their money into portfolios to maximize their profits (Moamen et al., 2016).

Risk perception is a critical element in decision-making (Singh and Bhowal, 2010). Risk is a complex and important factor (Cristofaro, 2018). Values are preferred by speculators with a high

level of budgetary proficiency, while bank shops are preferred by financial specialists with a low level of money-related knowledge. Furthermore, as mentioned in the literature, men have a higher level of advanced financial education than women. As per the chance of profit or loss, risk perceptions are considered. The severity of individuals and risk features are measured by risk perception. Risk perception is a decision-making process that is based on an individual's lifetime frame of reference, among other things (Robinson and Marino, 2015).

Commodity exchanges are located in many nations around the world, and they serve as a marketplace for sellers and buyers to trade commodities. Mercantile exchange is a frontier market that deals with four key assets: metals, agriculture, energy, and financial futures (Nguyen and Rozsa, 2019). Dutta et al. (2017) investigated the existence of uncertainty in the financial market and how this uncertainty affects the commodity market (Limongi and Ravazzolo, 2019). Inoue and Hamori (2014) also examined the efficiency of the market with respect to commodities' future market and how the future market affect the prices of shares.

According to the prospect theory (Tversky and Kahneman, 1992), rather than a perceived risk of loss, investors prefer to make decisions based on the perceived possibility for gain when an outcome is uncertain (Baker et al., 2019). Investors behave rationally and use all the available information. Drawing mainly from the prospect theory, this study fills the gap by studying the effect of emotional intelligence on the decision-making. Moreover, considering the lack of research on the impact of cognitive bias on risk perception, this study contributes to the body of knowledge by investigating the effect of optimism bias on risk perception and decision-making. Risk perception refers to a subjective judgment that deals with individuals' perception of the severity of a risk. Ishfaq et al. (2020) also examine the mediating effect of the risk perception between cognitive biases and investment decisions. Simon et al. (2000) also investigated that risk perception mediates the relationship between cognitive biases and the decision to start a venture. Keeping in view the recent studies, the objective of this study is to investigate the effect of emotional intelligence on decision-making with the mediating effect of optimism bias. So, the research question is also aligned with the objective of this study: "How emotional intelligence affects decision-making *via* the mediating effect of optimism bias and risk perception."

## LITERATURE REVIEW

### Theoretical Background Prospect Theory

Expected utility theory states that investors are included in decision-making, compared with their expected utility value, and distinguishes between risk and uncertain consequences. Tversky and Kahneman (1989) proposed an alternative model (prospect theory) because the expected utility theory model is an expressive decision-making model under risk. An alternative model can clarify the risk in multiple outcomes. The prospect theory focuses on the potential outcome before attaining a result. For explaining the investors' decision, literature supported that investors'



judgment errors, emotions, and personalities reflect the decision outcome. As the prospect theory is based on the uncertainty factor (risk) and the judgment errors (preferred to gain profit even it is nominal), so based on this theory, hypotheses are generated by focusing on the emotional intelligence, optimism bias (judgment error), and risk perception. Investors usually make decisions based on possible losses/gains, and when the same selections are available in various forms, their preferences are unpredictable. According to a prospect theory by Tversky and Kahneman (1989), losses are associated with profits due to investors' common and irrational propensity. In a speculation market, loss is nominal, and investors act in moving toward profits more than losses.

## Hypotheses Development

### Emotional Intelligence and Decision-Making

In the way how the individuals think, carry on, and make investment decisions, it has been stated that emotions are unpredictably bound up in financial markets. The capacity to know about one's own feelings and others' feelings is referred to as emotional intelligence (Brettschneider et al., 2021). The effect of emotions on the decision-making process is supported by many significant investigations (Mitchell et al., 2019). Emotional intelligence can comprehend the components, how they fluctuate, and therefore see about feelings; it is also used to handle the issue and recognize one's own and others' emotions. In the decision-making process, emotional intelligence is a significant determinant.

**H1:** Emotional intelligence has a significant effect on investment decisions.

### Risk Perception and Decision-Making

Risk perception is an influencing variable and works as an intervening variable in the literature. Moreover, Ishfaq et al. (2020) also examined the mediating role of risk perception between cognitive biases and investment decisions. Simon et al. (2000) also reported risk perception as an intervening variable in the capital and venture formation business. They also mentioned that other influence factors like cognitive biases should be examined and their effect must be checked on the decision-making. Nguyen and Rozsa (2019) examined that risk factors (perception and tolerance) significantly impact investment intentions. Cognitive biases or judgment errors significantly affect investment decisions (Ishfaq et al., 2020). In addition, a partial effect is examined between the behavioral biases and investment intentions through the mediating effect of risk perception. Risk perception shows a generative mechanism through which cognitive biases influence decision-making (Pandey and Jessica, 2019).

**H2:** Risk perception has a significant effect on decision-making.

### Optimism Bias and Decision-Making

Most of the time, individuals invest in stock markets to earn, but most people do not know that the choice to invest in those stocks is affected by traditional and behavioral finance.

There is the presumption that the investors are much more rational in conventional finance. They assemble or get all the data they require, and their choices are based on that information (Trevelyan, 2008). In this manner, traditional finance essentially states that investors do not make financial choices based on their personal feelings and emotions. On the other hand, behavioral finance clarifies that individuals are optimistic and unreasonable and their feelings play part while making investment choices (Rasheed et al., 2018). Several efforts were made to understand which factor primarily influenced the individual's decision-making process. Decision-making is the most complicated task for investors when investing in financial markets.

**H3:** Optimism bias has a significant effect on decision-making.

### Emotional Intelligence and Optimism Bias

Hopeful individuals could not care about the complex situation as they can undoubtedly face problems. When people are approached to anticipate constructive and pessimistic occasions, they are strikingly biased and remark in a specific heading. Whether circumstances are sure or negative, bias can develop contingent (Siegrist, 2021). To control a person's emotional life and achievement, the idea of emotional intelligence is considered. Emotional intelligence is characterized as sorting out life to advance it, creating sympathy with others, and a person getting together his sentiments.

Under five fundamental themes, Goleman (1998) recorded intelligence. Emotional intelligence and social aptitude are critically connected. People can adjust with their present circumstances, defeat more issues very effectively, and have an emotional state of intelligence. In this manner, people feel less focused when they are facing distressing circumstances while having abnormal emotional intelligence (George and Mallery, 1999).

**H4:** Emotional intelligence has a significant effect on optimism bias.

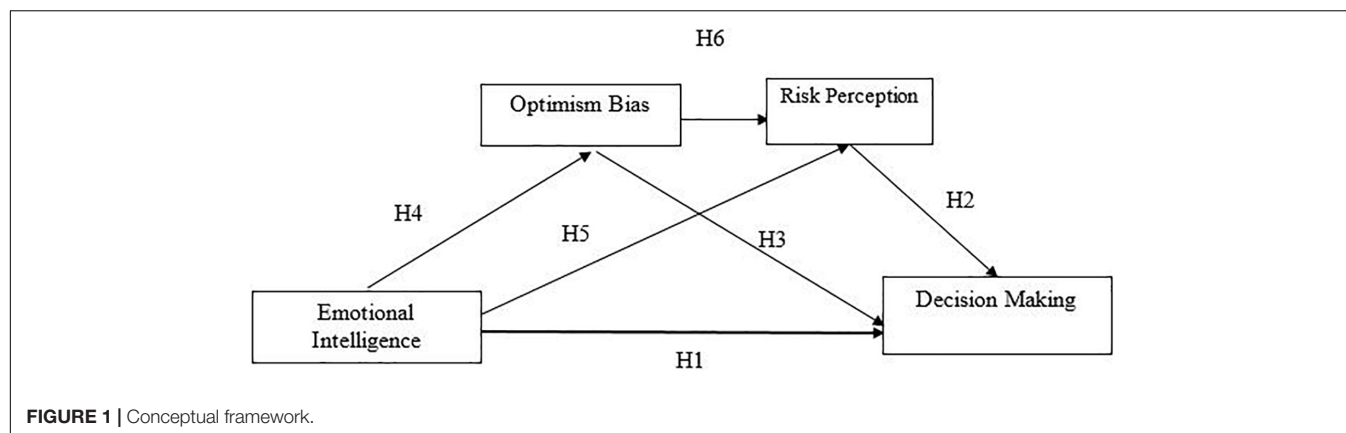
### Emotional Intelligence and Risk Perception

Ingram et al. (2019) stated that emotional intelligence (EI) has two distinct methodologies: character quality and various emotional preparation abilities. Social intelligence is defined as understanding the gender (men and women) to act wisely in their relations. Salovey and Mayer (1990) first defined emotional intelligence as "the ability to monitor one's own and others' feelings and emotions, discriminate among them, and use this information to guide one's thinking and action." From their original definition, Salovey and Mayer (1990) investigated that emotional intelligence consists of self-emotional appraisal, other emotional appraisals, and regulation and use of emotions.

**H5:** Emotional intelligence has a significant effect on risk perception.

### Optimism Bias and Risk Perception

Financial experts at institutions have a good sense of whether the economy is in a good place. For example, if stock exchanges are dependable and institutional financial specialists' customers



gain, they may be less likely to lose their positions, even if their exhibition lags market returns. Institutional financial investors may have a reason to be optimistic about future economic conditions. One of the features of constrained rationality is information selection bias, which leads to optimism (Simon et al., 2000). People tend to be optimistic about the future, underestimating the likelihood of bad events while overestimating the probability of positive events. When a person feels that they are less likely than others to experience a negative occurrence, optimism bias occurs (Suchanek, 2021). Optimism bias is commonly quantified using risk determinants (Neal et al., 2022). Individuals are asked to evaluate their chances of experiencing a negative event vs. another person's options of sharing the same unfavorable occurrence (Liu et al., 2018).

**H6:** Optimism bias has a significant effect on risk perception.

**H7:** Optimism bias and risk perception mediate the relationship between emotional intelligence and investment decision.

Political conditions, market information, and rumors impact the investor's decision and the volume of shares traded differently. So, the anomalies and biases may also affect the investment decisions. Optimism bias and risk perception related to the investment align with the prospect theory and significantly affect investment decisions. This conceptual framework (Figure 1) depicts that emotional intelligence affects decision-making via the mediating role of optimism bias and risk perception.

## METHOD AND ANALYSIS

### Target Population and Sample Size

Ordinary people make irrational decisions based on judgment errors. The commodity market is the most influential and significantly affects investment decisions. The target market of this study is the individual investors of the commodity market. The total number of items is 31, so according to Hair et al. (2011), there must be a minimum of 10 respondents against each item.

Therefore, to generalize the results on the commodity market investors, 370 questionnaires were distributed to investors.

### Data Collection

The questionnaires were distributed among the investors in the commodity market of developing countries. A pilot study is conducted to check the content and face validity of the instrument. The questionnaire is distributed to the 30 respondents, and the Ph.D. faculty/behavioral experts and stock market investors are involved in checking the content and face validity. The experts edited the following items: 2nd item, emotional intelligence; 5th item, decision-making; and 3rd item, optimism bias. After incorporating the changes, the final questionnaire (Table 1) is distributed among 370 respondents, of which, 15 questionnaires were discarded as the respondents did not answer the questionnaires. Eighteen questionnaires were not received from the respondents. The final 337 respondents' data were entered in the SPSS. The final response rate was 91.08. In addition, due to the time factor, cost factor, and easy accessibility (respondents are not easily available), the convenience base sampling method is used as this method provides the highest response level while saving resources and timely feedback (Etikan et al., 2016).

### Measurement

Questionnaires are distributed to the respondent of the commodity market. Data were collected from the five-point Likert scale as 1 depicts "strongly disagree" and 5 indicates

**TABLE 1 |** Breakdown of questionnaire.

Composition of questionnaire		
Particulars	No. of questionnaires	Percentage (%)
Questionnaires distributed	370	
Questionnaire completed	337	91.08
Questionnaire discarded	18	4.86
Questionnaire not received	15	4.05

*Total 370 questionnaires are distributed and 337 respondents' data are entered in the SPSS 26.*

“strongly agree.” Emotional intelligence is measured by the scale of Davies et al. (2010) consisting of 10 items. A sample item is “I know why my emotions change.” Decision-making is the outcome variable, and it is also measured on the Likert scale proposed by Scott and Bruce (1995) consisting of 5 items related to the irrational behavior of the investor. A sample item of decision-making is “When making an investment, I trust my inner feelings and reactions.” Optimism is a first-order mediating variable consisting of 12 items, based on the 5-point Likert scale from strongly disagree to strongly agree. A sample item of optimism bias was “In uncertain times, I usually expect the best,” which was developed by Scheier and Carver (1985). The risk perception is a second-order mediating variable consisting of 4 items. A sample item of risk perception is “I invest 10% of my annual income in moderate growth securities,” which was developed by Weber et al. (2002).

## Reliability Analysis

Cronbach's alpha is a statistical formula that is used to measure the internal consistency between the items. It is a very useful model fit that measures if the scale is perfectly good or not. According to Tavakol and Dennick (2011), the minimum allowed value under the Cronbach's alpha is 0.70, and if the value is lower than that, then the reliability of scale (internal consistency) is not a model fit. The results of this study indicated that Cronbach's alpha values of all the variables are in the satisfactory range (Table 2).

## Demographic Variables

Descriptive statistics (Table 3) showed the respondents' age, gender, and education characteristics. Results reported that the maximum number of investors involved in the commodity market's trading activity is 34.42% and the minimum number of investors more than 40 years is 7.71%. In addition, results also indicated that the male respondents are more interested in investing in the commodity market than the female investors, and the percentage of male respondents was 86.64%. The investors' financial literacy (knowledge about financial products) is very low. As for the concern of ordinary education, only 29.08% of investors are bachelors.

## Statistical Technique

Regression analysis measures the intensity of predictors on the outcome variable. The statistical technique for mediation is performed in PROCESS macros (Hayes and Scharkow, 2013). Model 6 of PROCESS macro is used to analyze the results as

**TABLE 2 |** Reliability statistics.

	Cronbach's alpha	No. of items
Decision-making	0.712	05
Emotional intelligence	0.810	10
Optimism bias	0.830	12
Risk perception	0.753	04

Cronbach's alpha > 0.70; satisfactory.

proposed by Hayes (2017). AMOS is used for convergent and discriminant validities along with model fit analysis. It is a calculating technique that is used to analyze the conditional effect under the SPSS statistical technique.

In Table 4, validity is performed and checked through the composite reliability (CR), average variance extracted (AVE), and maximum shared variance (MSV). The reliability values for all variables fell within the acceptable range of 0.7–0.9 (Hair et al., 2011). In addition, for convergent validity, the AVE score is greater than 0.5, which is in the acceptable range (Fornell and Larcker, 1981), and the MSV value is also less than the AVE value. The square root of AVE also determines that the validity must be greater than its paired correlation.

Table 5 depicts the model fit analysis, namely, absolute fit, incremental fit, and parsimonious fit (Hair et al., 2011). According to Hu and Bentler (1999), the RMSEA value must be near 0.05 and not more than 0.08. Researchers have proposed three categories of fit indexes: absolute, incremental, and parsimonious fit (Hu and Bentler, 1999; Hair et al., 2011). It has also been proposed that at least one fit index from each category must be included to confirm a model's fitness. Table 5 presents the threshold level and model fit indexes, with the data showing that the structural model fits the data as CMIN/DF = 2.132, GFI = 0.908, CFI = 0.92, 0.943, NFI = 0.901, PCFI = 0.806, and PNFI = 0.764 so as to meet the criteria of the threshold level.

**TABLE 3 |** Descriptive statistics.

	Frequency	Percent
<b>Age</b>		
25–30	28	8.30
31–35	167	49.55
36–40	116	34.42
More than 40	26	7.71
<b>Gender</b>		
Women	45	13.35
Men	292	86.64
<b>Education</b>		
Matric	54	16.02
Intermediate	76	22.55
Bachelors	98	29.08
Masters	82	24.33
Post graduate	27	8.01

Frequency distribution of respondents; age, gender, and education.

**TABLE 4 |** Validity.

	CR	AVE	MSV	EI	OB	RP	DM
EI	0.912	0.776	0.604	<b>0.881</b>			
OB	0.897	0.637	0.224	0.07	<b>0.798</b>		
RP	0.87	0.532	0.438	0.064	0.474	<b>0.729</b>	
DM	0.925	0.756	0.604	0.777	0.121	0.048	<b>0.87</b>

$n = 337$ . Bolded values on the diagonals are the square root values of AVE. AVE, average value extracted; MSV, maximum shared variance; CR, composite reliability; EI, emotional intelligence; OB, optimism bias; RP, risk perception; DM, decision-making.

**Table 6** depicts predictors' direct and indirect effects on the outcome variable. The results showed that emotional intelligence has a significantly positive ( $p < 0.05$ ) effect on decision-making and that the influence factor of emotional intelligence on decision-making is 25.3%. Moreover,  $\beta = 0.273$  indicated that the positive change occurs in the outcome variable (decision making) by a change in emotional intelligence. The second hypothesis investigated the effect of risk perception on decision-making. The results ( $p < 0.05$ ,  $\beta = 0.191$ ) indicated that risk perception has a positive significant effect on decision-making. The effect of optimism bias on decision-making (third hypothesis) was also investigated. The results showed a significant positive effect of optimism bias on decision-making. Moreover,  $R^2 = 0.048$  indicates the effect of optimism bias on decision-making as 4.8%. The fourth hypothesis investigated the effect of emotional intelligence on optimism bias. The results showed a significant effect of emotional intelligence on optimism bias. The fifth and sixth hypotheses (emotional intelligence and optimism bias effect to risk perception) were also investigated by the regression effect; both predictors had a significant ( $p < 0.05$ ) effect on risk perception. The unstandardized value showed the positive effect on risk perception, i.e.,  $\beta = 0.221$  and  $\beta = 0.122$ . Model 6 of PROCESS macro was applied to examine the effect of emotional intelligence on decision-making *via* the intervening effect of optimism bias and risk perception. The results (**Table 7**) showed a significant effect of the intervening variables between emotional intelligence and decision-making. Moreover, it was also observed that there is a partial mediation between emotional intelligence and decision-making *via* the mediating effect of optimism bias and risk perception, respectively.

## DISCUSSION

Behavioral finance researchers state that psychological feelings influence an individual's decisions and they are irrational (Nguyen and Rozsa, 2019). Behavioral finance's psychology and theories identified deviations from standard finance. The laypeople have no information about irrational behavior (Mellios et al., 2016). This study analyzes the serial mediation effect, namely, optimism bias and risk perception between emotional intelligence and investment decisions in the commodity market.

Hypothesis 1 stated the effect of emotional intelligence on investment decisions. The results revealed that emotional intelligence significantly affects investment decisions and aligns with the previous literature as Mayfield et al. (2008) also examined that emotional intelligence has a strong relationship with virtue and investment performance. Thus, the prospect theory is applied to this hypothesis as cognitive psychology influences decision-making rather than market information. Hypothesis 2 examined the effect of risk perception on decision-making. Nguyen and Rozsa (2019) observed that risk perceptions mediate the relationship between cognitive biases and investment decisions. Hypothesis 3 stated that emotional intelligence significantly affect risk perception. The results of this hypothesis are also aligned with the prospect theory because of the effect of uncertainty (risk) during decision-making. The results ( $\beta = 0.221$ ,  $p < 5\%$ ) revealed a significant effect of emotional intelligence on risk perception. Hypothesis 4 stated that emotional intelligence significantly affects risk perception. Campos and Keltner (2014) also examined that emotional intelligence strongly relates to virtue and investment performance under risky investment. Hypotheses 5 also supported the effect of emotional intelligence on risk perception. Wang et al. (2011) also reported that emotional intelligence significantly affects risk perception. Hypothesis 6 stated that optimism bias significantly affects risk perception. The results ( $\beta = 0.122$ ) also reported that optimism bias positively affects risk perception. This hypothesis also contradicts traditional finance due to the effect of optimism bias (judgment error) in the decision-making process. The behavioral finance reported that cognitive biases are involved in the decision-making process *via* the mediating role of risk perception. Ingram et al. (2019) also examined the mediating effect of risk perception between cognitive biases and decision-making on venture capital.

This study will help the investors understand an investor's behavioral effect. Moreover, this study will support commodity market investors and potential investors by highlighting their behavioral biases and the importance of risk perception. Several kinds of research have examined behavioral biases and their effects on decision-making. However, relatively little has been written about the relationship between investment

**TABLE 5 |** Model fit.

Category	Indexes	Value of index	Threshold level
Absolute fit	RMSEA	0.062	<0.06
	CMIN/DF	2.132	<3.0
	GFI	0.908	>0.90
Incremental fit	CFI	0.921	>0.90
	TLI	0.943	>0.90
	NFI	0.901	>0.90
Parsimonious fit	PCFI	0.806	>0.50
	PNFI	0.764	>0.50

**TABLE 6 |** Model summary.

Model	R	R <sup>2</sup>	Sig	Unstandardized coefficients
Emo → DM	0.503	0.253	0.000	0.273
RP → DM	0.428	0.183	0.019	0.191
OPT → DM	0.219	0.048	0.000	0.295
Emo → OPT	0.436	0.190	0.000	0.140
Emo → RP	0.563	0.316	0.000	0.221
OPT → RP	0.372	0.138	0.000	0.122
Emo + OPT → RP → DM	0.4475	0.200	0.000	0.235

Regression analysis; significant, if  $p < 5\%$ ; unstandardized coefficient =  $\beta$ .



**TABLE 7 |** Model summary.

Hypotheses	Relationship/effect	Accepted/rejected
H1	Emo → DM	Accepted
H2	RP → DM	Accepted
H3	OPT → DM	Accepted
H4	Emo → OPT	Accepted
H5	Emo → RP	Accepted
H6	OPT → RP	Accepted
H7	Emo → OPT → RP → DM	Accepted

Emo, emotional intelligence; DM, decision-making; RP, risk perception; OPT, optimism bias.

decisions and behavioral bias in the commodity market. Vasileiou (2021) identified the gap that, although rational decision affects investment decisions, fewer investigations have been made on behavioral finance. Given the scarcity of research on the intervening mechanisms (optimism bias and risk perception) of the relationship between emotional intelligence and decision-making, the present study is timely and relevant.

## CONCLUSION

Economic, political, and behavioral changes influence an investor's buying and selling patterns. However, share market prices are affected by global economic fluctuations. Investors' decisions are influenced by various factors, including changes in share prices caused by different circumstances. Most investors are irrational in business activities (Pfnür and Wagner, 2020). They invest in stocks only based on their previous experience. They do not understand why share prices are reflected or vary due to the lack of business knowledge. A financial analyst who is both a chartered accountant and a CFA analyst is hired by many investors. Business students have a rudimentary understanding of how practical decisions are made and how the market fluctuates.

## Practical Implications

Timely decisions are always a key element for investors. Various factors affect the investment decisions through the market information and judgment errors called cognitive biases. Meanwhile, the literature also addressed that managers' decisions are based on personality types and emotional intelligence. This study is very timely and relevant as the investors must consider that, rather than the market, their emotional intelligence also influences decision-making. The present study results will improve the investors' decisions by combining emotional intelligence and market information. This study will also be very helpful for the educational institutions as they can revise the course curriculum by keeping in mind the traditional and classical financial decisions. In addition, most investors rely on brokerage houses for decision-making. Investors must show their keen interest in the decision-making by considering their emotional intelligence, optimism bias, and risk perception. This study is also crucial regarding the institutional/financial houses as they are internationally involved in the commodity market.

## Theoretical Implications

This study has numerous theoretical contributions in the literature on the irrational decision-making of investors. First, complicated decisions are based on investors' intuition, perceptions, emotions, and thinking (Kahneman and Riepe, 1998). Still, these decisions are often irrational as cognitive biases are involved and complete information is ignored. So, this study focuses on investigating the emotional intelligence of an investor and its effect on decision-making. Second, the study highlights the impact of optimism bias on the investor's decisions. As Costa et al. (2017) examined, investors' decisions are based on irrational behavior rather than market information. Investors follow the optimism approach when they are positive about their confidence. Based on positive thoughts as well as reality, optimistic investors make decisions. Some investors allocate the resources in a short-term period and others go for the long-term investment (Englmaier, 2010). These investment opportunities also vary with the change in economic situations. Investors get optimal satisfaction in both types of investment by utilizing the best investment decision (Sattar et al., 2020). Third, the prospect theory proposes that investors' decisions are based on the uncertainty factor called risk. So, this study contributes to the body of knowledge by studying risk perception as a mediating variable between optimism bias and decision-making. Still, limited studies address investors' behavioral aspects in the commodity market; investors are unaware that they rely too much on the managers and depend upon them. If investors have high emotional intelligence, they can better perceive the risk and make better decisions. Unfortunately, in the commodity market, these factors are ignored, so this study contributes to the literature by studying the emotional intelligence, optimism bias, and risk perception of an investor.

## Limitations and Future Recommendations

This research study considers the commodity market investors with the behavioral aspect. Time-lag study must be conducted to analyze investor behavior. Moreover, future studies can be performed on the stock exchange and real estate sector. This study only considers the quantitative approach, uses a close-ended questionnaire, and ignores the qualitative approach through interviews (open-ended questions). The respondent's feedback can be utilized to make better decisions through qualitative research. Data were gathered from investors and only focused on the commodity market and may not be considered by the other segments of the population. Future studies on the comparative study of commodities and stock exchange investors can be done. In addition, future research can also explore the real-estate segment with the investor's behavior. Financial literacy plays a vital role in decision-making, so future studies should be made on the moderating effect of financial literacy between cognitive biases and decision-making. Moreover, investors' decisions can be changed under the short- and long-term investment intentions. So, future studies can be done under short- and long-run periods.

## DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

## ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Management Sciences Department of Riphah University. The patients/participants provided

their written informed consent to participate in this study.

## AUTHOR CONTRIBUTIONS

CC identified the problem statement. MI filled the research gap and developed hypotheses. FA wrote the introduction section. AS wrote the methodology. KW wrote the result discussion and conclusion. All authors listed have made a substantial, direct, and intellectual contribution to the work, and approved it for publication.

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# Emotional Intelligence and Personality Traits Based on Academic Performance

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## OPEN ACCESS

### Edited by:

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### Specialty section:

This article was submitted to  
Cognition,  
a section of the journal  
Frontiers in Psychology

**Received:** 11 March 2022

**Accepted:** 22 April 2022

**Published:** 14 June 2022

### Citation:

Dong X, Kalugina OA, Vasbieva DG  
and Rafi A (2022) Emotional  
Intelligence and Personality Traits  
Based on Academic Performance.  
Front. Psychol. 13:894570.  
doi: 10.3389/fpsyg.2022.894570

The purpose of this study was to examine the role of personality traits on academic performance. Furthermore, this study also aims at exploring the effects of virtual experience (mediator) and emotional intelligence (moderator) between personality traits and academic performance of the students. The findings imply that personality traits are the strong predictors of better academic performance. However, several personality traits do not have a positive impact on the academic performance. The study further suggests that students who have emotional abilities and virtual experience are more likely to perform well in their academics. The population of this research consists of students in various colleges and universities in developing regions. Thus, the sample consists of bachelor's and master's students. Existing scales are adopted with minor changes to make it more suitable and understandable within the study context. A total of 319 questionnaires were distributed. Among these 365 questionnaires, 234 questionnaires were received and further used for the purpose of data analysis. This shows an encouraging response from the targeted sample. Education and productivity of the students are influenced by their personality as well as their emotional intelligence abilities. The findings imply that being extrovert is a strong predictor of student achievement and should be prioritized in intervention strategies. This personality feature is responsible for performance in addition to virtual learning experience. Despite its low overall relative value, agreeableness is a significant driver of student achievement. Along with ability and aptitude assessments, personality evaluations might be utilized as a secondary screening tool to identify adolescents at risk of underperformance and academic performance failure. Therefore, learning emotional skills would be beneficial to cope the modern challenges of the competitive educational environment. Virtual experience and being emotionally sound can help students to learn quickly and to be more adaptive into the new world of digitalization. The conclusions of the current study have significant consequences for educators and policymakers. They must accept that boosting emotional intelligence levels through teaching or training is a significant objective of contemporary education. The emotional intelligence abilities of the students related to culture may be shown in a variety of ways, from expectations toward students to interpersonal interactions with students, and from teaching techniques to evaluation methods.

**Keywords:** virtual experience, emotional intelligence, personality traits, academic performance, students performance



## INTRODUCTION

It has been observed that virtual reality, which is the most accurate representation of manufactured reality, is becoming increasingly popular. In more detail, virtual reality depicts events or things that are knotted to computer technology in order to create the illusion of an interactive, three-dimensional world in which objects that have the appearance of spatial presence can be seen. Critically speaking, virtual experience predominantly has different aspects to interpret the virtual experience eventually (Burdea and Coiffet, 2003). On the contrary, virtual reality has a great influence on emotional intelligence (EI). The ability to sense, control, and assess emotions is referred to as EI. Some academics believe that EI can be taught and improved, while others believe it is a natural trait.

Furthermore, EI is built on the foundation of three complimentary competency modules, namely, psychological, social, and pragmatic. There is also a grave and unavoidable relation of virtual experience and EI. Interestingly, virtual experience and EI have a core relation with personality traits principally. Talking about personality traits, personality is the set of thoughts (Back and Kandler, 2020), attitudes, and emotional attributes (Markiewicz et al., 2020), which bonds to social actions that create influential environment. Personality is a significant determinant of life outcomes (Almlund et al., 2011) and traits of personality can be evaluated while probing the academic performance eventually. It has also been observed that the role of personality traits is very much sway to the academic performance (Mammadov, 2022). Academic performance is regarded as crucial for job pathways, individual life trajectories, and long-term success. It is also regarded as important as a societal effect. Personality is one of the non-cognitive characteristics that have been systematically linked to academic achievement.

Moreover, there is a significant relation of personality traits that have an important impact on academic performance, and is currently being vital. Continuing the theme, virtual experiences have a major impact on academic performance as well. Furthermore, EI is likely to mediate the interplay between students' personality traits and virtual experiences that convey persuasiveness and motivation. More research is needed to determine how conscientiousness, a personality attribute linked to higher academic success, is linked to academic performance.

It is a pragmatic fact that academic performance is well influenced by the personality traits eventually (Gatzka and Hell, 2018). Moreover, it could be more appropriate to conceive of strengthening productive personality as a more beneficial intervention during the early years of education. More objectives of the personality traits can also have more impacts on the academic performance of the students. Universal five big personality traits, such as consciousness, openness, agreeable, neuroticism, and extraversion, has an impression on the academic performance in different approaches.

Some personality traits, such as extraversion, agreeableness, and openness to new experiences emerged as important predictors of EI. Conscientiousness and neuroticism had no effect on EI eventually. Ultimately, EI has a great impact on academic performance (Kokkinos and Vlavianou, 2021) that

is evaluated as a moderate role in academia. Based on the academic performance, EI is thought to contribute to the advancement of thinking and the ability to control emotions in stressful situations. However, according to the trait EI theory, the construct should not have a significant and direct association with cognitive capacity or its close proxies, such as academic accomplishment (Petrides and Mavroveli, 2018).

Personality traits and academic performance are directly related (Mavroveli et al., 2009; Clark and Schroth, 2010). A previous study by Webb (1915), who minutely scrutinized academic performance, is considered to be vital. Moreover, HEXACO is a vital tool through which traits of personality can be ascribed well and it would be really convincing while correlating it to virtual experience and academic performance.

The prognostic influence of personality on preferences for academic attainment concludes the approaches of the high impact. Personality and preferences may act as indicators of future performance, so policymakers can assist children with negative personality traits or preferences. According to Fariba (2013), there is a link between personality qualities and learning styles, which could contribute to higher levels of learning and, as a result, a greater sense of self-satisfaction and enjoyment of the learning process. Predominantly, some learning outcomes are deliberated concerning to learning styles that highlight the core impacts of personality traits while connecting to academic performance.

This manuscript surrounds the academic performance and personality traits that have much of an influence based on academic performance. In this sense of understanding, five factor model (FFM) of personality trait is focusing at all. All the five major personality traits have a direct impact on academic achievements. Two among all the major personality traits, Conscientiousness and Emotional Stability, are vital ones, and rest of the three are merely discussed based on their reflection to the academic performance. It is known that cognitive ability always has a direct influence on whether academic performance is high or moderating. Moreover, individual tasks are well recognized by the cognitive ability and EI, which concerns the tasks within the team. These considerations can be best tools while doing research on personality traits and academic performance.

Ultimately, student's cognitive capacity may indicate what he or she can do, whereas a student's personality traits may replicate what they will do. Except cognitive capacity, cognitive ability, the relation of both conscientiousness and emotional stability, means a lot while approaching to academic achievements. The FFM is the most prevalent model of personality structure in contemporary work examining personality traits and academic achievement. Extraversion, Neuroticism, Openness to Experience, Agreeableness, and Conscientiousness are assumed to encompass all of the more limited personality traits that occur at lower levels of the personality hierarchy in this paradigm. More focusing on conscientiousness, this research focuses on the academic performance, as conscientiousness is directly related to achievements.

Furthermore, McElroy et al. (2007) also test UTAUT and TAM to highlight personality traits and academic performance based on relationship of technology with the mentioned variables. It is clearly denoted that personality traits have a relation with technology and the UTAUT model already confirmed it. There is different responsiveness of the personality traits with the accordance of different conditions. Professionals with a high conscientiousness score are goal-oriented and more inclined to accept and apply new technology. Moreover, the conscientiousness, among all other personality traits, shows a significant relationship with academic performance and its impact is high compared with other traits.

According to our analysis of the research, if the content is rich and applications of the technology are upright as well as up to the mark regarding students' inclination toward learning, technology plays a vital role concerning personality traits and academic performance (Jacques et al., 2009). There is much competition of the technology and its application if academic performance is targeted to enhance in academia. There is also a trendy approach of the technology as an intervention that blended math and science educational videos with infrastructure changes, which are the best tools to improve the educational performance. Furthermore, technology can help learners in rural locations have access to education. The evidence for these programs is promising. Even remote education is handy while relating technology to academic performance.

## RESEARCH QUESTIONS

When it comes to virtual experience and its relationship with EI, how and by what means personality traits have a substantial impact on academic performance is still being sought out. Continuing with the discussion, virtual experiences have a significant impact on academic performance. Such a phenomenon, which indicates another critical consideration, such as the fact that both emotional intelligence and academic performance are observed to be in a predominantly positive relationship, is particularly vulnerable to discussion. Furthermore, EI is expected to have a role in moderating the interaction between personality traits and virtual experiences of the students that portray persuasiveness and motivational characteristics of the students.

## Novelty of the Research

In this research study, the best ground is that we strongly focus EI and its relationship with virtual reality based on academic performance. In this light, three sub-dimensions of EI, namely, managing relationships, integrity, and self-development, have a high positive link with academic performance, and ultimately, virtual reality is related to this phenomenon. EI has been associated with more pro-social behavior, improved academic performance, and more empathy for students in this study.

In academia, EI has been significantly observed, and it has an excellent relationship with academic performance. Furthermore, the value of virtual experience in mediating intelligence quotient or overall mental capacity is well understood when it comes to professional performance. Along with virtual experience

and emotional intelligence, academic performance, which is commonly regarded as a critical component of academic success for pupils, is also highly regarded. A lot of elements are still important to be highlighted considering the essence to EI and academic achievement. Similarly, it is vital to carve-out virtual experience while correlating it into the dual phenomenon of EI and academic performance predominantly; it has also been assumed that conscientiousness, one of the personality traits, is the best predictor of academic achievement across the board, accounting for five times as much variance in grades as the intelligence quotient. Overall academic success is predicted by agreeableness, conscientiousness, and openness while glancing into the important facts about virtual experience ultimately.

Moreover, different models and theories are also candid aspects of this research. The Honesty-Humanity, Extraversion, Agreeableness, Conscientiousness, and Openness to Experiences (HEXACO) is a vital tool through which traits of personality can be ascribed well and it would be really convincing while correlating it into virtual experience and academic performance. Importantly, academic performance theory, model of EI, and moderation role of EI are innovative features of this research and are also valuable. With the conduction of this research, strong relationship of the personality traits, academic performance, and virtual experience are important aspects to be considered ventures.

## Literature Review

It has been observed that talking about different thinking pattern, actions, and feelings, personality traits count well into it (Blickle, 1996; Soutter et al., 2020). Regarding personality traits and definite structure, then, the conversational Big Five personality traits are a perfect source to be considered (Roccas et al., 2002; O'Connor and Paunonen, 2007). There is wholesome of the personality traits and essence of the academic performance while observing both with the help of stipulated models. Openness is defined as a person's proclivity for intellectual curiosity, active imagination, and responsiveness to feelings, and aesthetic sensibility (Saklofske et al., 2012). The disposition to be orderly, ambitious, determined, dependable, and purposeful is known as conscientiousness.

Major et al. (2006) observed that the three personality traits, such as conscientiousness, openness, and extraversion, are best that consolidate as being predicted motivation for learning and, contrary to it, there is an unappealing as well as an uninviting relation of the neuroticism based on learning attitude. Neuroticism is linked to a person's proclivity for unpleasant emotions such as guilt, rage, fear, disgust, grief, and shame. The propensity to be chatty and aggressive, extraversion is another trait with different essence of learning phenomenon. Talking about consensus on this approach in terms of cooperativeness and altruistic nature, it has different conscientiousness with the context of learning attitude based on academic performance. One of the most widely accepted personality models is the Five Factor Model (Barrick et al., 2003). One of the most significant benefits of employing the Big Five model is that personality does not change significantly and remains steady across age groups

over a 4-year period. There have been numerous studies on the relationship between academic success and personality.

According to Hodson et al. (2009), the model is unique and has been considered by researchers while connecting it to personality traits. Furthermore, multiple studies have found that the Big Five personality traits have a considerable impact on student academic achievement because of the many methodologies used to measure academic success around the world. Similarly, there are regional disparities in the intervals used to measure academic performance and personality traits. Students pursuing different degree programs or from different nations, locations, or situations may have distinct aptitudes, personalities, and learning behaviors.

According to Simpraga et al. (2021), personality traits are the patterns of thoughts, feelings, and behaviors that people have. The basic dimensions of traits of the persons are highlighted in the trait theory. In this sense of understanding, consistency, individual differences, and stability are the vital judgmental tools as well. Sigmund Freud, a famous psychiatrist, established the psychoanalytic personality theory. A person's personality, according to Freud, is the sum of their intrinsic inclinations and familial influences. Katherine Cook Briggs and Isabel Briggs Myers, a mother and daughter, created the humanistic personality theory. The necessity of self-growth in developing healthy personality qualities is highlighted by humanistic personality theory. The exam was created by the researchers in order to better understand personality characteristics.

Hughes and Smith (1990) believe that academic performance is the assessment of a student's ability in a variety of academic areas. Personality qualities were found to be highly connected to academic achievement. Furthermore, conscientiousness was the most important predictive variable, accounting for the variance in academic attainment. Moreover, Elger (2007) developed the theory of academic performance. Six core concepts are emphasized in the theory to establish a framework that may be utilized to explain performance as well as performance improvements. Producing valuable results is what it means to perform.

*H1: Personality traits has a positive significant impact on academic performance of the students.*

"Virtual reality is the computer-generated version of real life. Computer programmes deliver a visual environment through a TV headset that may pixel-perfectly match the actual world—or show a wholly fictional one". Virtual reality differs from augmented reality, which combines computer-generated information such as photos, text, movies, animation, and music with a real-world, real-time image (viewed through a cellphone camera; Lund and Agbaji, 2018).

Many areas, including medical research, engineering, architecture, product development, and geology, have utilized virtual reality to visualize and analyze abstract ideas (Portman et al., 2015; Alhalabi, 2016; Tudor and Minocha, 2018). According to this study, employing virtual reality as a teaching tool enhances students' knowledge of ideas and test results dramatically.

Libraries focus on integrating learning-friendly technology to everyday instructional activities, enhancing access to research help, and expanding available information resources to users as part of their essential mission of generating chances for learning and promoting education in society (MacWhinnie, 2003). The feasibility has been investigated by a number of researchers. In libraries, virtual reality is being used. Poulter (1993) introduced the idea of an online catalog—a virtual reality library—that would allow users to search for books online. Within a computer-generated environment, users may explore an information area and order things from shelves. This online catalog gave consumers access to information resources that either did not have a physical repository or did not have one that was physically accessible to them (such as in off-site storage). After Second Life, an online virtual world that allows people to interact with one another, a virtual library project—the Virtual Library Project—was established in 2003, and it allows educational institutions to perform teaching and research activities. Alliance Library System and OPAL launched Second Life Library 2.0 (Swanson, 2007). It offered a variety of library services, including synchronous and asynchronous access to library collections and databases, as well as to real-world individuals *via* their virtual avatars. Communication that is not synchronous. The users of this service expressed a high level of satisfaction.

*H2: Virtual experience is likely to mediate the relationship between personality traits and academic performance.*

Users might utilize the catalog to access information resources that either did not have a physical repository or did not have one that was up to date. Controlling one's emotions under atypical settings is a key component of emotional intelligence. Emotional intelligence is now commonly recognized as a significant barrier to professional success and the growth of one's personality. Urquijo and Extremera (2019) explain that when emotions are added up, you get personality traits ultimately. Emotional intelligence has recently been studied by another psychologist, Goleman and Gurin (1993). Emotional intelligence can now be measured and correlated with a person's performance, thanks to new research. It is a set of skills, attitudes, talents, and competencies that determine the individual's behavior, reactions, state of mind, coping style, and communication style.

Moreover, knowing persons' quality and psychological outcomes, some theories are best sources to study on. Acting, feeling, and essence of working are the prominent aspects of the persons' personality (Weiner, 2005). With the help of different theories related to personality traits, different modes of the emotions and personality positions can also be judged. Generally, personality's angles are stable, but some other angles of outer variables can amend the personality traits. Different personality can also be judged while trying to determine all aspects of the personality. In this sense of understanding, there are some important personality theories that highlight the personality trait well, such as trait perspective, psychoanalysis, humanistic, trait perspective, and behaviorist theory. Through these personality theories, the personality development, different aspects of personality, and stimulation can be denoted perfectly.

On the contrary, EI is also vital, as it has a direct relation with personality traits and academic performance, as emotional determination is accurate personality judgment that denoted best tools (Chrusciel, 2006). For driving inner thoughts in others' personalities, the people with high EI can also observe other emotional consideration. The definition of EI proposed by Mayer et al. (2008) tries to fit EI into the traditional criteria for a new intelligence. The model by Daniel Goleman emphasizes EI as a broad set of talents and skills that drive leadership effectiveness.

*H3: Emotional intelligence is likely to influence academic performance.*

The five primary EI structures are outlined in Goleman's model. Goleman also highlights all kinds of abilities of the persons' emotions and some of the emotional skills can also let the persons approach toward extraordinary outcomes. Individuals are born with a general EI, according to Goleman, which determines their ability to gain emotional competences. Self-awareness, self-regulation, motivation, empathy, and social skills are the five components of Daniel Goleman's EI hypothesis (Goleman, 2001, 2014). EI can be used to achieve objectives and build a happier and healthier workplace atmosphere.

Our manuscript prolongs the personality traits and its impact on academic performance. In this sense of understanding, personality traits and their connection with academic performance is the focus of this research as well. Accompanied by personality traits, EI and useful models can also predict this unique research. Personality traits' model, theories, academic theories, models of EI are also added to furnish this research predominantly.

*H4: Emotional intelligence is likely to moderate the relationship between personality traits and academic performance.*

## METHODOLOGY

The population of this research consists of college and university students studying in developing regions. Thus, the sample consists of bachelor's and master's students. Existing scales are adopted with minor changes to make it more suitable and understandable within the study context. For instance, the scale for academic performance is selected from George and Rappaport. For measuring emotional intelligence, 15-items scale of Kidwell et al. (2011) is adapted. For personality traits, NEO-PI 15-items scale is used. Finally, virtual experience scale is adapted from Chertoff et al. (2010). Several questions regarding demographics were included in the questionnaire. Hence, this research study used non-probability sampling in which further convenient sampling is selected. However, before using this questionnaire, Reliability and Validity were established in the local context. A Google-form based questionnaire was designed, and the link was shared with the students. Moreover, data have also been obtained with the consent of multiple colleges/universities in developing regions. The authenticity of the data was confirmed by the participants who were involved in the student community. There were many complexities faced during collection of the data due to the outbreak of

COVID-19. However, the consistent follow-ups have helped the researchers to collect 234 filled questionnaires from the students studying in different colleges and universities of developing regions. The first two authors, who are currently residing in developing regions, suggested that fellow academic students from developing regions colleges/universities participate in the survey and share the link with other users on their regular community meet-ups. Because of these frequent meet-ups and the backing of the academic community, the current study was able to achieve a high response rate. Demographics and Normality of the data is checked with the help of Statistical Software of Social Sciences (SPSS) version 21. Once the data normality is confirmed, composite reliability, Convergent validity, Discriminant validity, and hypotheses testing is done with the help of Structural Equation Modeling. For mediation analysis, mediation assumptions by Baron and Kenny are followed.

## RESULTS AND ANALYSIS

A total of 365 questionnaires were distributed. Among these 365 questionnaires, 234 questionnaires were received and further used for the purpose of data analysis. This shows an encouraging response from the targeted sample. Most of the respondents come in the age range of 25–35 years, which uses these social media platforms once in 6 months. Reliability and normality of data is examined with the help of SPSS version 21.

### Scale Validity and Reliability

The construct reliability and convergent validity are examined with the help of statistical software AMOS version 20. Big Five personality traits is examined on a 15-item scale and the factor loadings were quite good except second items of Neuroticism dimensions. Composite reliability and average variance extracted values for each personality trait are well above the minimum criteria. For academic performance, the convergent validity is also above the minimum criteria; the value for average variance extracted is 51%, which is quite above the minimum criteria of 50%. Emotional intelligence concept is measured on newly developed 15-item scale; however, the items which have low factor loading scores are excluded from the final analysis. Finally, for virtual experience, the concept is measured on a 6-item scale, and the factor loading scores, reliability, and validity are quite good. The value for composite reliability is 0.854, and average variance extracted is 0.595 as shown in **Table 1**.

The discriminant validity is examined with the help of square root of AVE, and it must be greater than the correlation values between the latent variables. For instance, the discriminant value for virtual experience is 0.771 and it is above the correlation values between latent variables. Similarly, personality traits discriminant validity value is 0.936 and Emotional intelligence discriminant value is 0.715; these values are well above the correlation values between latent variables as shown in **Table 2**. Hence, the convergent and discriminant validities are statistically significant for this scale.



**TABLE 1 |** Factor loadings.

Variable	Item code	Loadings	Composite reliability	AVE
Neuroticism	NEU1	0.807	0.879	0.785
	NEU3	0.959		
Extrovert	EXT1	0.870	0.907	0.765
	EXT2	0.820		
	EXT3	0.931		
Openness	OPEN1	0.903	0.884	0.718
	OPEN2	0.900		
	OPEN3	0.728		
Agreeableness	AGREE1	0.762	0.833	0.624
	AGREE2	0.770		
	AGREE3	0.836		
Conscientiousness	CON1	0.850	0.827	0.622
	CON2	0.901		
	CON3	0.576	0.862	0.610
	COP1	0.762		
	COP2	0.854		
	COP3	0.733		
	COP4	0.770		
Academic performance	AP1	0.514	0.721	0.512
	AP2	0.642		
	AP3	0.615		
Emotional intelligence	EM6	0.641	0.893	0.513
	EM7	0.766		
	EM8	0.752		
	EM9	0.710		
	EM10	0.692		
	EM11	0.743		
	EM12	0.796		
Virtual experience	EM13	0.609		
	VP1	0.709	0.854	0.595
	VP2	0.779		
	VP3	0.807		
	VP4	0.767		

## Structural Model Analysis

Regression analysis explains the impact of independent variable on the dependent variable. In this particular research study, Big Five personality traits (SMM) is taken as an independent variable, whereas academic performance is taken as a dependent variable. First hypothesis is about the impact of personality traits on academic performance. Result revealed that personality traits have a positive significant impact of 79%, whereas the (Sig. < 0.05) impact on student's academic performance. The results also showed a positive significant relationship between virtual experience and academic performance. In simple words, if the virtual experience is enhanced by 1%, it would have a positive significant impact of 66%, whereas the (Sig. < 0.05) positive impact on academic performance of the students. In the third hypothesis, mediation impact of virtual experience between personality traits and academic performance is examined. Results confirmed partial mediation effect of virtual

**TABLE 2 |** Discriminant validity.

Variable	(1)	(2)	(3)	(4)
Virtual experience (1)	0.771			
Personality traits (2)	0.362	0.936		
Academic performance (3)	0.664	0.779	0.715	
Emotional intelligence (4)	0.179	0.218	0.246	0.716

*Diagonal elements (bold figures) are the square root of the AVE (the variance shared between the constructs and their measures). Below-diagonal elements are the correlations among variables.*

**TABLE 3 |** Hypothesis testing.

Hypothesis	B	T	p-value	Statistical decision
H1: PT → AP	0.785	19.301	0.000	Supported
H2: VE → AP	0.664	13.513	0.000	Supported
H3: PT → VE → AP	0.715	18.667	0.000	Supported
H4: EI → AP	0.467	8.051	0.000	Supported
H5: PT*EI → AP	0.712	15.425	0.000	Supported

*PT, personality traits; AP, academic performance; VE, virtual experience; EI, emotional intelligence.*

experience between personality traits and academic performance. In fourth hypothesis, direct impact of emotional intelligence on academic performance of the student is examined. Results revealed that emotional intelligence has a positive significant impact of 47%, whereas the (Sig. < 0.05) on academic performance of the students. Finally, the moderating role of emotional intelligence is examined between personality traits and academic performance. Emotional Intelligence contingent impact enhanced the relationship between personality traits and academic performance of the students.

## DISCUSSION AND CONCLUSION

Results revealed that emotional intelligence has a positive significant impact of 47%, whereas the (Sig. < 0.05) on academic performance of the students as shown in Table 3. However, extroverted people are high-energy and talkative, and they like it. Extroverts are continuously seeking to meet new people; they do not hesitate to introduce themselves to strangers, and their energy level is quite high. They rarely avoid uncomfortable circumstances for the fear of messing up or encountering academic pressure. Highly extroverted people enjoy socializing with others; they are comfortable to expose their self in a group situation and frequently experience positive emotions such as excitement and enthusiasm. Similarly, this personality trait describes people who are cooperative, sociable, and sympathetic. Warmth, friendliness, and tact are typical characteristics of someone with a high level of agreeableness. They often have a positive outlook on other people and are eager to collaborate with them. They are willing to set their own interests aside for the sake of others. Low agreeableness makes people uncooperative, unfriendly, and distant. They always prioritize their own interests

over the interests of others. Individuals who are disagreeable have a lesser concern for others and for the social rules of politeness.

Furthermore, people who are conscientious are dependable and punctual. It symbolizes productivity and accountability; highly conscientious people desire order and organization in their work in order to attain their goals. People with high conscientiousness are eager and devoted to completing their duties, whereas those with low conscientiousness are calm, relaxed, and show little motivation to finish their duties and tasks.

On the one hand, while introvert are those people who always try to escape from offices and their homes, they are quiet, calm, and low extroversion. They keep themselves away from social gathering. On the other hand, findings also suggest that people who are very creative and continually striving to open new doors have a strong desire to take on new tasks and learn new things. People who have a high level of this attribute appreciate trying new things and going on adventures. Therefore, the findings suggest that students with this personality traits are likely to have a slight positive impact on their academic performance.

This study compared the perceptions of a virtual experience procedure to “live” class formats in terms of learning level, sense of coherence, and social and task interaction. Since the “comparison with live course” was done on a five-point Likert scale, divergence of replies from the mean in questions has a middle value of “roughly the same.” It is possible to measure a position that is “roughly the same.” This clearly reveals that participants’ assessments of feeling of coherence, social contact, and task interaction are much lower than those of a “live” class. However, assessments of capacity to acquire new information differ only little from those in the “live” class. Simply expressed, there is a noticeable reduction of social processes in virtual experience designs; nevertheless, this degradation did not have a major impact on perceived learning capacity.

It was expected that emotional intelligence and academic success of students would have a statistically significant beneficial association. Higher levels of emotional intelligence, agreeing to previous research, should predict higher academic grades (*via* the capacity to cope with stresses such as assessment and evaluations, group dynamics, and the social and emotional demands of academic life). These data support prior research contention that EI is a distinct, quantifiable kind of ability. This intelligence may always correspond well with academic intelligence. Furthermore, the findings of this research study suggested that a high level of emotional intelligence can also improve learning from virtual experiences, which can positively affect the overall academic performance of the students.

## CONCLUSION

Education and productivity of the students are influenced by their personality as well as their emotional intelligence abilities. The findings imply that being extrovert is a strong predictor of student achievement and should be prioritized in intervention strategies. This personality feature is responsible for performance in addition to virtual learning experience. Despite its low overall relative value, agreeableness is a significant driver of student

achievement. Along with the ability and aptitude assessments, personality evaluations might be utilized as a secondary screening tool to identify adolescents at risk of underperformance and academic performance failure. Therefore, learning emotional skills would be beneficial to cope with the modern challenges of the competitive educational environment. Virtual experience and being emotionally sound can help students to learn quickly and to be more adaptive into the new world of digitalization.

## Practical Implications

The conclusions of the current study have significant consequences for educators and policymakers. They must accept that boosting emotional intelligence levels through teaching or training is a significant objective of contemporary education. Emotional intelligence abilities of the students related to culture may be shown in a variety of ways, from expectations toward students to interpersonal interactions with students, and from teaching techniques to evaluation methods. Furthermore, personality traits have a huge influence on the academic performance. As this research study suggested that several personality traits have a positive influence on academic performance, *vis-a-vis*, there are some personality traits that might have a negative impact on the academic performance of the students. However, proper counseling and guidance can help to cope with personality-related issues, and hence can improve their overall personalities. This illustrates that the creation of virtual experiences may have a large and favorable impact on students’ academic achievement. To the university classroom, bring your personality traits and experiences.

## Significance of the Study

It is significant to authenticate the HEXACO personality traits model. Furthermore, because of the many methodologies used to measure academic success around the world, the association of the EI and academic performance is unanimous undoubtedly. Students pursuing different degree programs or from different nations, locations, or situations may have distinct aptitudes, personalities, and learning behaviors. This study is an important resource for determining the relationship between virtual experience and EI based on academic performance. Furthermore, depending on academic success, EI and cognitive ability are important. Students’ academic achievement or performance has a strong link to their personality attributes.

Furthermore, the majority of research suggests that personality traits have a significant impact on the academic performance. Specifically, conscientiousness is linked to consistent connection toward academic achievement/performance, which is really essential. Based on virtual experience and its relationship with personality traits improvement as well as enhancement in academic performance, it is really a great venture if involving the virtual experience into the said aspects of this research. This research is exclusive, as the core of the personality traits, specifically conscientiousness, agreeableness, and openness with their impacts on academic performance are the focusing aspects through the consideration of virtual experience.

The most powerful predictor, conscientiousness, which is one of the important personality traits that strongly connects to the academic achievements, is also concentrated. The findings of this research would definitely provide a key regarding how conscientiousness is related to academic achievements and sustained in its essence while considering academic performance. Here, personality traits model HEXACO is a key to venture it.

## Limitations and Future Research Directions

Although the results of this current study are very promising, but it has few limitations, for instance, first, this study consists of cross-sectional data collected during the period of COVID-19. Therefore, it is suggested to reconduct the same study once the COVID-19 pandemic is over. Second, reporting own emotional abilities maybe biased; therefore, Goleman emotional intelligence model can also be tested in students' academic performance context. When examining student academic performance, researchers can no longer ignore the problem of competition. A recent study has found links between culture, competition, and performance, as well as the relationship between competitiveness and performance. Additional research examines conscientiousness, a personality trait that has been shown to be associated with superior academic success, and specifically how conscientiousness has been shown to be associated with academic performance eventually. Another study identified significant cultural variations and demonstrated the importance of competitive mindset in driving performance. Therefore, future research must be conducted with these directions in another region to have a better understanding of this theoretical model.

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

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## ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

## AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

## FUNDING

This study was supported by 2021 Guangdong Provincial Educational Science Planning Project (Higher Education Special) - Three-Micro Integration Research on the Life-based Teaching of Ideological and Political Courses in Colleges and Universities (No. 2021GXJK170) and Zhuhai University of Science and Technology 2020 Innovation Ability Cultivation Project Key Cultivation Project (Humanities and Social Sciences Class) - Research on the Innovation of College Students' Ideological and Political Education Model in the 'Post-epidemic' Era (No. 2020XJCQ014). The publication is prepared within implementation of the state assignment 2021 for the Financial University under the Government of the Russian Federation.

## ACKNOWLEDGMENTS

The publication is prepared within implementation of the state assignment 2021 for the Financial University under the Government of the Russian Federation.

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# The Value of Immersive Media in Expanding Chinese Public Cultural Participation and Its Realization Path From the Perspective of Cultural Education

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## OPEN ACCESS

### Edited by:

Xuesong Zhai,  
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### Specialty section:

This article was submitted to  
Educational Psychology,  
a section of the journal  
Frontiers in Psychology

**Received:** 08 April 2022

**Accepted:** 30 May 2022

**Published:** 28 June 2022

### Citation:

Cai W and Liu Y (2022) The Value of Immersive Media in Expanding Chinese Public Cultural Participation and Its Realization Path From the Perspective of Cultural Education. *Front. Psychol.* 13:915913. doi: 10.3389/fpsyg.2022.915913

This paper mainly introduces the application of immersive media in Chinese public cultural participation from the perspective of cultural education, as well as the important value of the application of immersive media in expanding the breadth, accuracy, and depth of education and thereby improving the quality of education. On this basis, the realistic path of the role of immersive media technology in further realizing public cultural participation is discussed. First of all, through a questionnaire survey, it analyzes the problems existing in Chinese public cultural participation from the perspective of cultural education and the application of immersive media in Chinese public cultural participation. Secondly, from the aspects that the application of immersive media can extend the space of cultural participation, enrich the content of cultural participation and strengthen the value recognition of cultural participation, it demonstrates that immersive media helps to solve the dilemma of Chinese public cultural participation as a whole and thus improve the quality of education. This will bring new possibilities for expanding Chinese public cultural participation and promoting public social education and cultural quality education. Finally, it discusses the further development of immersive media technology in the field of cultural education from the aspects of optimizing the ecology of immersive media development, promoting the R&D and application of immersive media technology, and promoting the integration of immersive media with cultural participation space and cultural education content.

**Keywords:** cultural education, immersive media, public cultural participation, cultural participation spaces, value

## INTRODUCTION

In the broadest sense, public cultural participation encompasses the activities and processes by which citizens enjoy public cultural services or participate in governmental public cultural decision-making and public cultural construction. Culture has important knowledge attributes, and public cultural participation can empower civic education. In this era, with the increasing status and role of culture in economic and social development and people's lives, expanding public participation in culture so as to enhance the public's cultural awareness, to raise the public's sense

of cultural subjectivity and subject presence, to strengthen the public's recognition of national and ethnic culture, to improve the public's cultural literacy and quality of life and integrate education into people's lives in a culturally nourishing way. Particularly in a country like China, where cultural identity is the core of the basic social order, it is of great value to expand public cultural participation, effectively safeguard citizens' cultural rights, enhance their sense of cultural acquisition and cultural confidence and promote the integration of their cultural life and education by working on the supply of basic public cultural services and the creation of a public cultural ecology. However, the current situation of public cultural participation in China is generally not very satisfactory, and the supporting role of modern information technology in public cultural participation has not been fully played.

The application and development of immersive media (IM) can maximize the close connection between public cultural venues and sites, as well as public cultural affairs and the public, reduce the psychological and cognitive distance between the public and public culture, and allow culture to be better integrated into citizens' lives through media and medium and better play the educational function of culture, which includes such as 3D content, virtual reality, augmented reality, 360° images or videos. It becomes an inevitable choice to further highlight the role of immersive media in dealing with realistic social science problems and effectively enhance the cultural participation of the Chinese public.

## THE MAIN ISSUES OF PUBLIC CULTURAL PARTICIPATION AND THE APPLICATION OF IMMERSIVE MEDIA IN CHINA FROM THE PERSPECTIVE OF CULTURAL EDUCATION

### Data Description

The data in this article comes from the research activities of "Culture on the Front-line" organized by the National Institute of Cultural Development in Wuhan University in summer 2018. A total of 201 researchers were recruited and selected from college students to visit 28 provinces (including municipalities directly under the Central Government and autonomous regions) to investigate the current situation, demands and satisfaction of public participation in public cultural services through questionnaires. The study involved a total of 32,652 questionnaires from residents of a total of 28 provinces in China, including 10,398, 10,491, and 11,763 from the east, central and west, respectively, with 23,994 valid questionnaires and 73.48% valid questionnaire rate.

In this article, the valid questionnaires were statistically analyzed using SPSS 24.0 software, and the results are as follows. In terms of the gender structure of the participants, 44.9% were male and 55.0% were female. In terms of age, 17.8, 38.9, 23.9, 15.7, and 3.5% of each age group were 17 years old and below, 18–26 years old, 27–40 years old, 41–64 years old, and 65 years old and above, respectively. In terms of occupation, the majority

of respondents were students, accounting for 44.4%. Employees of enterprises accounted for nearly one-fifth (18.7%). Civil servants and employees of public institutions, and freelancers accounted for 12.4 and 8.6%, respectively, fluctuating around 10%. Farmers accounted for the lowest percentage which was only 2.0%. Other self-employed businesses, retired people, temporary or unemployed and other occupations accounted for a small proportion of 13.7%.

In terms of education, junior college and bachelor's degree groups are the most numerous, accounting for 50.3%, secondary and post-secondary education accounts for 40.8%, and the proportion of primary school and below and graduate and above education is smaller, at 3.3 and 5.4%, respectively. In terms of income, the proportion of non-income groups is the highest, accounting for 40.0%, the proportion of low-income groups (less than 3000 yuan) is 23.2%, the proportion of middle-income groups (from 3001 to 5000 yuan) and well-off groups (more than 5001 yuan) are 18.6 and 17.9%, respectively.

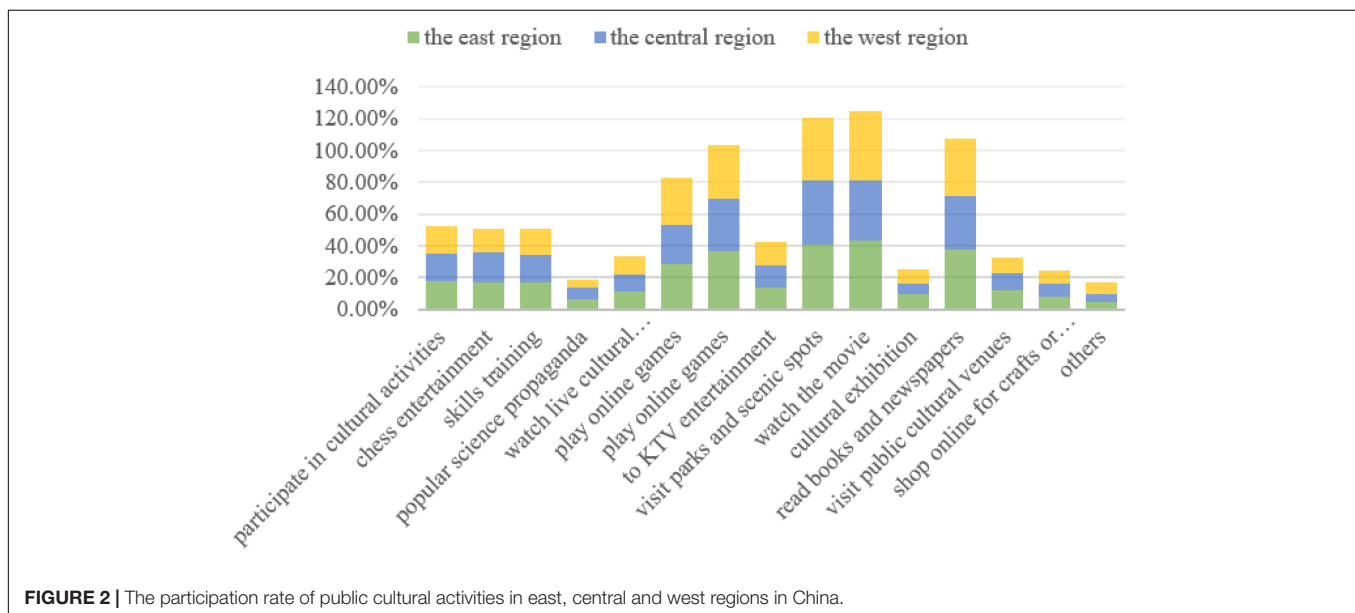
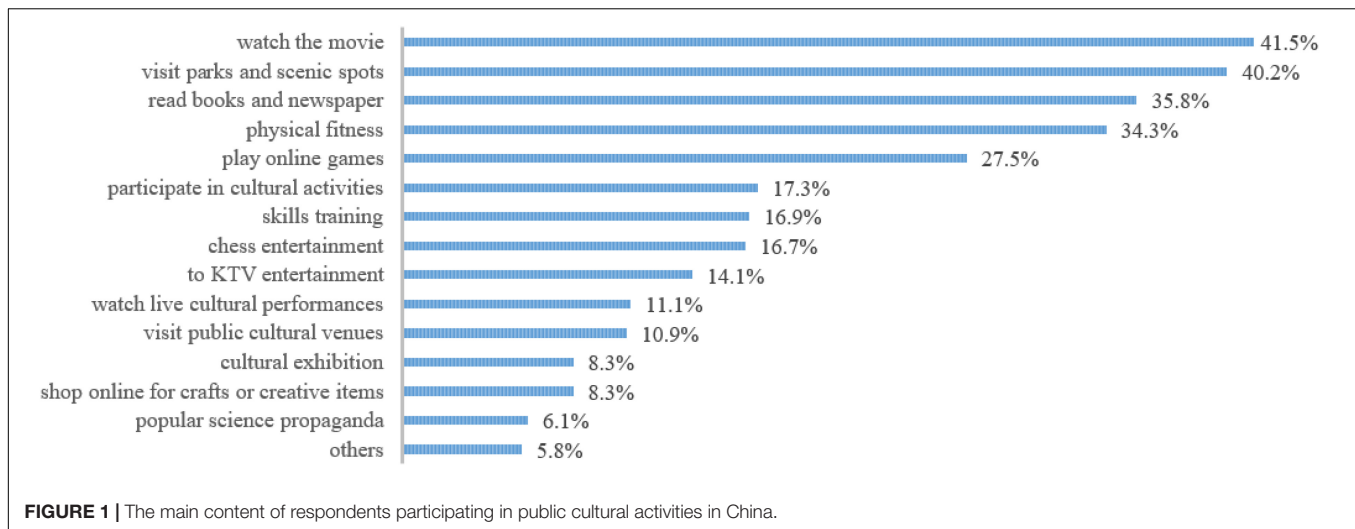
## The Main Problems of Public Cultural Participation in China

According to the investigation, with the continuous development of China's public cultural service system and the increasing protection of cultural rights in China, the public cultural participation in China is increasing both in the breadth and depth, and the educational function of culture has a realistic foundation for further realization. However, there are certain problems in China's public cultural participation, among which the following two aspects are particularly prominent.

### The Overall Quality of Public Cultural Participation Is Not High

In recent years, as the construction of public cultural facilities in China has been increasing and the degree of public cultural participation has been improving. But, on the whole, the quality of public cultural participation in China is still not very high, which is mainly reflected in the low rate and frequency of public cultural participation, and it mainly focuses on enjoyment-oriented cultural participation, while construction-oriented cultural participation is relatively lagging behind.

Specifically, the overall rate of public cultural participation in China is not very high, take **Figure 1** as an example, and the participation rate for all types of public cultural activities is less than 50%. Moreover, the public culture participation is mainly based on leisure and entertainment-oriented public culture activities such as "watch the movie" (41.5%), "visit parks and scenic spots" (40.2%), "read books and newspaper" (35.8%) and (34.3%); The participation rate of knowledge-oriented public cultural activities, such as "popularizing science" (6.1%), "cultural exhibition" (8.3%), visiting public cultural venues (10.9%) and skill training (16.9%), is relatively low. At the same time, the frequency of participation in public cultural activities is also low. The frequency of participation in public cultural activities is mainly "once or twice a month" (35.0%), "once or twice a week" and "more than three times a week" account for 30.3 and 20.8%, respectively.

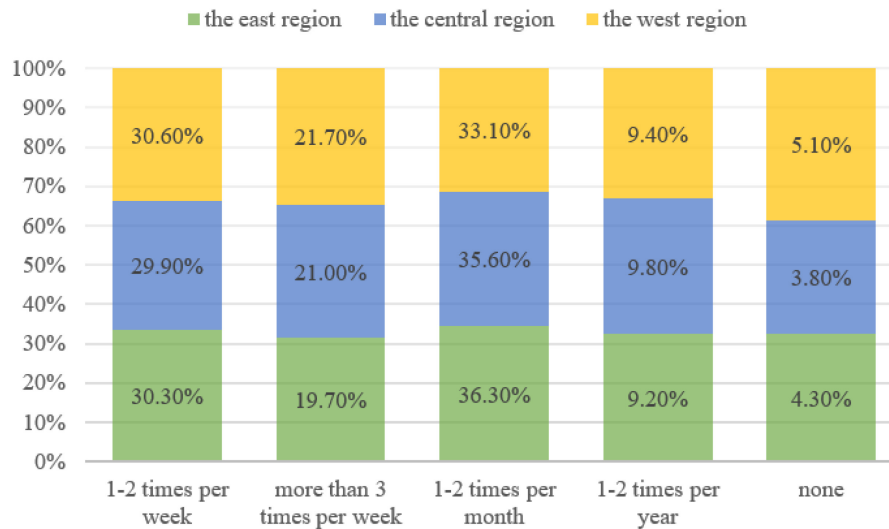


In addition, as the participation of Chinese citizens in public cultural policies and public cultural construction lags behind, the construction-oriented public cultural participation is far lagging behind the enjoyment-oriented public cultural participation (Cai, 2017), so public cultural participation is mainly manifested as citizens' participation in public cultural activities and enjoyment of public cultural services.

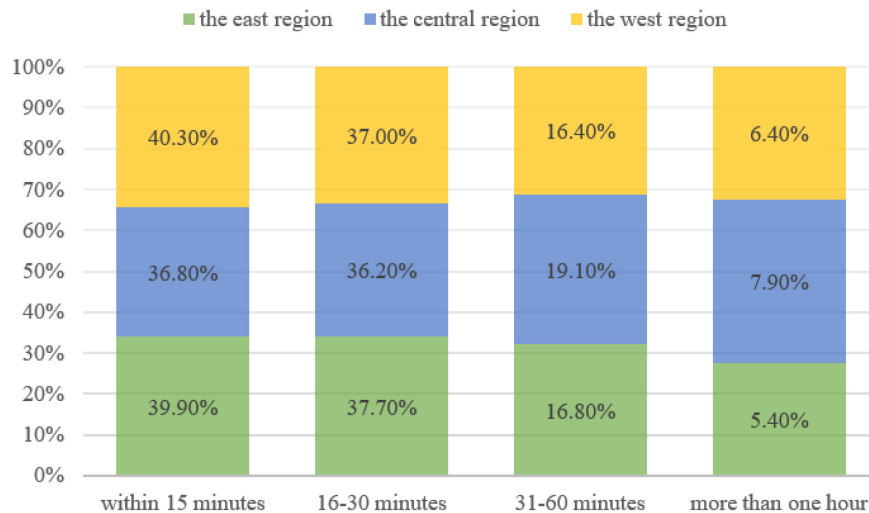
### There Is a Certain Imbalance in Public Cultural Participation

There is still obvious unevenness in public cultural participation in China between urban and rural areas, and between regions. Among them, there are certain gaps in the public cultural participation rate, frequency of public cultural participation, and public cultural participation environment among residents in east, central and west China. Correspondingly, there are also certain regional differences in the coverage of cultural education.

In terms of public cultural participation rates, the eastern regions basically have slightly higher participation rates than the central and western regions in both leisure and entertainment-oriented public cultural activities as well as educational and knowledge-oriented public cultural activities. As shown in **Figure 2**, in the activity of "visiting parks and scenic spots" with a higher overall public participation rate, the participation rate in the eastern region (40.7%) is higher than that in the central region (40.5%) and the western region (39.6%). The participation rate in activities such as "physical fitness" and "reading books and newspaper" is also significantly higher in the eastern region than in the central and western regions. Especially in terms of "cultural exhibition" and "visiting public cultural venues" etc., the participation status of the eastern region is significantly better than that of the central and western regions. For example, in the "cultural exhibition" activities, the eastern region (9.7%) is above the central region (6.7%) and the western region (8.7%). The



**FIGURE 3 |** The frequency of public cultural participation in east, central and west regions in China.



**FIGURE 4 |** The public cultural participation environment in east, central and west regions in China.

eastern region (12.1%) is higher than the central region (10.9%) and western region (9.9%) in “visiting public cultural venues.”

In terms of the frequency of public cultural participation, as shown in **Figure 3**, “once or twice a month” is the highest, with 36.3% in the eastern region, 35.6% in the central region and 33.1% in the western region.

In public cultural participation environment, as shown in **Figure 4**, 77.6% of respondents in the eastern region said they could get to public cultural facilities and venues in less than 30 min, higher than 73.0% in the central region and 77.3% in the western region. More than 90.0% of respondents in the East, Central, and West regions said they could reach the public cultural venues they regularly participate in within an hour. This shows that most current public cultural venues and facilities in China are relatively close to public living places, and it is quite

convenient for the public to enjoy public cultural services, but relatively speaking, it is more convenient in the eastern regions than in the central and western regions.

In other words, the coverage of cultural education in the eastern region is more extensive than that in the central and western regions, and it also has a better realistic foundation for further realizing the educational function of culture.

## The Application of Immersive Media in Chinese Public Cultural Services From the Perspective of Cultural Education

With the development of Internet technology, China has attached great importance to the integration of culture and online information technology, and has increasingly applied



information technology in the construction of public cultural venues and facilities in an effort to provide high-quality public cultural services to the Chinese public. However, in terms of practical significance, the proportion of digital technology, especially immersive media, is still low in China's public cultural venues and public cultural activities. However, the Chinese public has shown stronger expectations for the application of digital information technology and immersive media in the field of public cultural services.

Research data on the public's demand for public cultural services shows that more than half (51.3%) of the surveyed people hoped local organizations to organize online cultural information lecture, and 59.0% of the public hoped local organizations to organize science and technology training. From the research data, we can see that in the current Internet information era, the Chinese public has a high demand for cultural technology and cultural information technology. Additionally, more and more people have placed expectations on media technologies that can enhance the sense of experience in the publicity, delivery and presentation of public cultural information.

However, in general, the current application of network information technology in public cultural services is not sufficient, and the application ratio of immersive media is even lower and it is only applied in some public cultural venues in some regions, which has greatly affected the current Chinese public's satisfaction with public cultural services.

The mean value of respondents' overall satisfaction with local public cultural services is 3.25 (with a maximum value of 5), as indicated by the Likert five scale statistics, which means that most of the public have low overall satisfaction with current public cultural services, and there is still a big gap between the current supply of public cultural services and public expectations and needs. Among them, 87.3% of the respondents said that the local public cultural services were already supported by technologies and contents such as e-reading, Internet and WiFi. But the mean value of the respondents' satisfaction rating is 3.21 (with a maximum value of 5), which is not high. In addition, according to the results of the questionnaire research, most of the interviewed groups indicated that their local areas have been covered by public cultural service venues such as libraries, museums and art galleries, but the public's satisfaction evaluation of these venues is not high.

For example, the satisfaction ratings of galleries and mass art centers (or cultural museums), and science and technology museums, and intangible cultural heritage exhibition are 2.68, 2.67, and 2.86, respectively, which are much lower than the overall satisfaction ratings of public cultural services. Actually, with the development of immersive media in China in recent years, public cultural venues such as museums, galleries, technology halls and intangible cultural heritage exhibition are exploring and expanding the application of immersive media in public cultural services which also reflects that the immersive media in China's public cultural services has been attached importance and has great potential in expanding public cultural participation and responding to public cultural needs of the public.

As far as the practical significance is concerned, the widespread application of immersive media in the participation of Chinese public culture has a good practical basis. On the one hand, according to the China Internet (2021), China had 989 million internet users by the end of 2020, and the Internet penetration rate reached 70.4%. In particular, the total number of mobile internet users exceeded 1.6 billion; the number of 5G network users exceeded 160 million, accounting for 89% of the total number of 5G users worldwide (China Internet, 2021). The popularization of Internet provides a good technical basis for the application of immersive media. On the other hand, at present, many local governments and public cultural venues in China have actively explored the application of digital information technology and immersive media in the field of public culture, which provides a favorable practical basis for immersive media to widely serve the Chinese public's cultural participation and promote the realization of lifelong education for all.

## THE VALUE OF IMMERSIVE MEDIA IN EXPANDING PUBLIC CULTURAL PARTICIPATION FROM THE PERSPECTIVE OF CULTURAL EDUCATION

Immersive media is an important medium for realizing the function of cultural education and an indispensable element of the knowledge dissemination system under the "Internet + Education" model, representing the trend of modernization of educational media. The application of immersive media helps to extend the space of cultural participation and thus expand the breadth of education, enrich the content of cultural participation and thus improve the accuracy of education, strengthen the value recognition of cultural participation and thus enhance the depth of education. And on this basis, immersive media helps to solve the dilemma of Chinese public cultural participation as a whole and thus improve the quality of education, so as to bring new possibilities for expanding Chinese public cultural participation and promoting public social education and cultural quality education.

### Immersive Media Helps to Extend the Space of Cultural Participation and Thus Expand the Breadth of Education

Public cultural participation must exist in a certain space, which is not only limited to physical spaces providing social education such as museums and libraries, but also may extend to institutional spaces that ensure citizens' cultural participation. Only when citizens have a certain cognition of these cultural participation spaces, can the public demand for cultural participation be stimulated. And the value of immersive media is to allow the wider range of citizens to understand and approach cultural spaces that undertaking public education function more vividly, fully and distinctly through technical forms such as 3D and virtual reality, so that education is more widely available to more people and thus expand the breadth of education.

First of all, the traditional cultural participation space is the physical space for public cultural participation, which generally refers to the physical field composed of public cultural facilities, places and activities, etc. (Chen and Hou, 2017), and it is an important carrier of public cultural participation. Thus, the public cultural space equipped with immersive media is a realistic space of immersive scenes (Hu and Cheng, 2021).

Immersive media provides convenience for the public to understand the physical space of public cultural participation from the perspective of sensory experience, “enabling users to achieve immersive and resonant experience” (Yu and Zhang, 2020). The public cultural space represented by museums, libraries, cultural centers, etc., are rich in historical and cultural values. With the gradual application of emerging cultural communication forms such as VR, AR, mobile APP, and webcasting to the digital communication of public cultural spaces, the public can get a more personalized, immediate and ubiquitous sense of cultural experience, which is more effective in playing the educational and communication functions of public cultural space, and also better to highlight the historical and cultural values of cultural relics and artworks. In the immersive physical space, the combination of the audience’s senses with immersive experience can effectively narrow the distance between the public and the physical space, strengthen the meaningful emotional connection with the public, thereby attracting the public within the service area of the public cultural space to engage in daily cultural participation activities.

However, with the continuous development and improvement of immersive technology, its application can break through the constraints of time and space to a certain extent. The public cultural participation environment created by immersive media can break the limitations of traditional cultural participation in the integration of time and space, and create a digital virtual cultural space for the public that is not bound by space and time. With the support of immersive media, public cultural participation has the characteristics of “low threshold, openness, and virtuality” (Fu and Zhang, 2020), which enables the public to transcend the limitations of region, urban and rural, and time, reduces the economic and opportunity costs of public participation. Therefore, immersive public cultural participation can effectively make up for the current situation that public cultural participation in backward areas is far away in space and cultural activities are difficult to meet public demand, and to a certain extent can make up for the cultural education resources in backward areas and maximize the coverage of public cultural education. For example, immersive media can guarantee the institutional space of public cultural participation.

The public’s demand for cultural participation is not only reflected in physical space, but also reflected in the public’s desire to have an in-depth understanding of public cultural activity information, participate in the construction of public cultural service system and participate in public cultural decision-making through a normalized and institutionalized way. These needs are essentially the expectation of the public for the institutional space of public cultural participation. The application of immersive media is not only conducive to enhancing the public’s understanding of various institutional information and

institutional ways of public cultural participation, but also can break through the restrictions of traditional channels of public cultural construction and public cultural decision-making system, and form a new, more convenient and accessible institutional platform and channel for public cultural participation. On the one hand, governments and public cultural institutions can more comprehensively and intuitively present various policies and information in the field of public culture through immersive media platforms. It also shows institutionalized ways and channels for the public to participate in public cultural decision-making, donate to public cultural venues, serve as public cultural service volunteers and other constructive matters. On the other hand, online media platforms and other immersive media can become innovative and institutional channels for regular communication, feedback and interaction between the government and the public, as well as between public cultural institutions and the public on public cultural decision-making and public cultural construction. The expansion from offline publicity and guidance to online active participation can enable the realization of a joint education mechanism for public participation in public cultural affairs, the expansion of institutional approach and space for public cultural participation, and the enhancement of the depth and quality of public cultural participation.

Education is both the process and the goal of public cultural participation. Today, “education is no longer the privilege of some distinguished talents or a prescribed activity for a certain age” (The International Education and Development Committee of UNESCO, 1996), but is increasingly oriented to include “the whole of society” (The International Education and Development Committee of UNESCO, 1996). In other words, we need to carry out Education For All, promoting the realization of the breadth of education. The international education field has proposed “Lifelong Education” (Lengrand, 1985) in the last century, from a spatial point of view, it breaks the traditional perception of education as school education and extends education to all aspects of society. Various types of immersive media applied to public cultural participation can gradually narrow the regional digital gap, develop non-formal education such as social education outside of school education through the information extension of cultural space, and finally promoting the inclusiveness of education, the fairness of education and the breadth of education.

### **Immersive Media Helps to Enrich the Content of Cultural Participation and Thus Enhance the Accuracy of Education**

Expanding the breadth of education lies in the extension of the space for cultural participation, while the core and root of enhancing the accuracy of education lies in the supply of attractive cultural participation content. Immersive media has become a new learning resource because of its immersive sensory experience (Liu et al., 2022), which has significant advantages in enhancing the cultural and educational value of public cultural content and gradually increasing public participation. The application of immersive media can enrich the content

of cultural participation, provide personalized cultural services for different groups of the public, and innovate the public cultural participation model to make constructive public cultural participation possible, so that the public can be exposed to and aware of the cultural participation content to a certain extent, form their own understanding and interest in the corresponding content, inspire their own enthusiasm for cultural participation, and gain a good cultural education experience in the process of cultural participation.

Firstly, immersive media helps to provide personalized cultural engagement content.

Immersive technology has three main characteristics: immersion, interactivity and autonomy. Under the atmosphere created by immersive technology, audiences can feel immersive; at the same time, audiences can manipulate objects in virtual space and get certain feedback from human-computer interaction; in addition, audiences can stimulate their active learning interest and enthusiasm in the virtual or virtual-real environment on the basis of human-computer interaction. Immersive technology has distinctive advantages in designing and developing educational resources and forming personalized teaching methods. It can provide the public with suitable personalized learning situations according to their individual differences, and also provide them with suitable cultural participation contents according to their group differences, so as to effectively enhance learners' individual feasible abilities and learning motivation, thus achieving the important goal of improving educational accuracy.

Immersive media helps to innovate content production methods and enrich the content of cultural participation while continuously integrating a large number of scientific and technological achievements. The combination of technology integration and content innovation has facilitated the emergence of immersive products of media education and promoted the science of immersive media education. Interactive and immersive technologies can make it easier and more convenient for students to access beneficial environmental settings, which has a broader appeal (Barton et al., 2020). In recent years, digital reading has shown significant advantages in enhancing the public's cultural and aesthetic experience and strengthening the educational guidance function of works (Xia, 2017). For example, immersive technology combined with picture book education is applied to AR interactive picture books in public libraries and other cultural education spaces, allowing children to scan and present their doodles in three dimensions on smart terminals with animation and sound effects, stimulating children's interest in the experience and improving their hands-on skills. Besides, the combination of immersive media and educational games, which integrating the educational reform concept of "teaching for fun" into cultural education, plays a role in knowledge skills teaching, simulating experiments and thinking training, and helps to enhance the effectiveness of cultural participation. In addition, immersive media can be used in distance education for people in remote and backward areas. In the cultural education for the public in remote and backward areas of central and western in China, a "cloud classroom" based on VR system can be created, where students can intuitively experience macroscopic or microscopic

simulation scenes through VR headsets, at the same time, teachers can adjust classroom teaching activities through central control equipment. In the process, transmitters and receivers of knowledge can interact and communicate to make the perceptual experience of learners more realistic (ProQuest, 2019). The application of Head-Mounted Display Virtual Reality in Post-secondary Education and Skill Training brings convenient, engaging, and interactive choices to the traditional classroom environment, and provides additional capability over traditional methods (Concannon et al., 2019). This "two-way, real-time, interactive" (Zhao and Hao, 2018) form of education helps to enhance the effect of cultural participation, and alleviate the current problem of insufficient educational resources in remote and backward areas to a certain extent, realizing customized services for public cultural education.

Secondly, immersive media not only makes it more convenient for the public to enjoy public cultural services, but also innovates the mode of public cultural participation, promotes the public's constructive cultural participation, thereby enriching the content of cultural participation and enhancing the public's cultural participation experience in specific cultural education contexts.

As an important channel for the dissemination of public information and the formation of public issues, immersive media can play a role as a bridge linking private and public domains. With immersive media, it is possible to create a multidimensional, experiential educational context. In the virtual environment created by immersive media, the expression of public opinions breaks through the boundaries of space and time, forming a specific "public discourse space" (Habermas, 1989), and "realizes the extensive expression of individual opinions through peer-to-peer interactive communication" (Wang, 2019), improving the autonomy of the expression subject and expanding the influence of public opinion as well as the timeliness of cultural education. For example, with the development of fusion media, popular topics related to China's "Sanxingdui Archeology" have formed public cultural issues in the fermentation of multiple platforms. This public cultural issue forms a synergy through TV media, short videos, small programs to realize information sharing among groups, build media communication matrix and form the cumulative effect among media. Then it has helped stimulate public discussion on key issues such as archeological excavation, cultural heritage protection and cultural relics activation and utilization.

At the same time, immersive media helps to promote active public participation in cultural building initiatives. As an important carrier for cultural communication and social education, immersive media can stimulate the public's sense of self-perception and interactive sharing in the new scenarios it constructs, "integrating every individual's knowledge, enthusiasm and wisdom into it and enabling people to realize sharing in the aggregation space with the largest individual choice" (Yu, 2007). Thus, it can maximize the promotion of people's action on public cultural construction. At the same time, the creation of an educational environment for participation and sharing through immersive media is conducive to the cultivation and promotion of public cultural literacy and public spiritual realm,

so as to more effectively drive the public consensus action on public cultural construction. Thus it can promote China's current superficial public cultural participation to self-built shared cultural participation, management decision-making cultural participation and other deeper levels of cultural participation (Chen and Cui, 2017). The creation of such a cultural and educational environment is of great significance to the overall improvement of public cultural literacy and the enhancement of national cultural soft power.

## Immersive Media Helps to Strengthen the Value Recognition of Cultural Participation and Thus Enhance the Depth of Education

Public cultural participation is not only a cultural activity, but also an educational activity with characteristics such as equality and democracy, in which the public can reshape their spiritual world and enhance their cultural consciousness and cultural self-confidence. By carrying out rich public cultural education activities, public cultural venues and institutions can enhance the public's cultural cognition and value judgment, further improve the social education function of culture, satisfy the public's cultural desire, cultivate the public's sentiment, enhance the public's cultural identity, promote social fairness and harmony, and make the value of cultural participation deeply rooted in the hearts of the people, thereby enhancing the depth of education.

Firstly, public cultural participation contains inherent equality. Through immersive media, the public's realistic feelings of cultural rights is enhanced.

Cultural rights refer to the rights and freedoms held by citizens, individually or collectively, to participate in cultural activities, to enjoy cultural resources and achievements, to share cultural benefits, and to promote cultural inheritance and development (Cai, 2014). Article 27 of the Universal Declaration of Human Rights clearly states that "Everyone has the right to freely take part in the cultural life of the society, to enjoy the arts and to share scientific progress and the benefits it produces" (The United Nations, 2008). This means that the core of cultural rights is to realize citizens' equal participation and equal acquisition to cultural achievements and benefits, reflecting equality and fairness (Wang, 2015). The application of immersive media is to promote the equal and fair realization of cultural rights based on a broad guarantee of people's right to cultural participation, thus better guaranteeing the fairness and equality of education. In the digital age with 5G technology, immersive media can expand the scope of the realization of cultural rights, enabling the public to break through the constraints of time and space, break down regional differences in the realization of cultural rights, enjoy public cultural services equally, and enjoy the fruits of cultural progress and innovation. For example, in recent years, more and more Chinese people can easily access cultural heritage and cultural scenes across the country by traveling to museums, art galleries and other educational public cultural venues on the cloud. They can also interact with public cultural venues and institutions, as well as with the public through live

webcasts, messages, re-tweeting and discussions on online social media platforms.

At the same time, under the condition of immersive media technology, the public can participate equally in public cultural affairs and achieve freedom of cultural expression. Then the public can quickly respond to the expression and participation of the public through immersive media. In addition, the virtual space created by immersive media is a place for the expression of individual discourse, which reveals the inner world of the public in a unique way, hides and extends the public body, finds an ideal "cultural field" for the public, and promotes the expression and growth of civil rights awareness. Furthermore, in the process of application and experience of immersive media, the public will form a clearer, more intuitive and deeper cognition, feeling and understanding of cultural rights centered on participation. It is in the space and context combining virtual and reality that the public's cultural rights can be more fully and comprehensively realized through various online or offline cultural participation activities, and the public can have a more practical experience of the equality of public cultural education.

Secondly, public cultural participation is democratic. With the help of immersive media, it is conducive to awakening the public's subjective awareness of participating in public cultural decision-making.

In cultural engagement, the public is the subject of public cultural activities and affairs, and has the right to freely participate in various cultural activities, express their opinions and demands. Then they can influence and determine the direction of public cultural decision-making and the construction and development of public culture. In this process, the application and development of immersive media can construct the media space as a democratic platform for public participation, so as to promote the public from passive acceptance of public cultural services to active selection of public cultural service content and participation in public cultural decision-making. On traditional media platforms, elites and opinion leaders are more likely to "instill" their own values into the audience from top to bottom, which is essentially a neglect of the public's right to express and know.

However, on the immersive media platforms represented by the Internet, the public has gained the opportunity to express themselves openly, and their right of discourse on cultural participation has been greatly enhanced. The right of discourse on public culture has shifted from "top-down" to "bottom-up," and the public has a greater sense of participation in the expression of their opinions. The virtual spaces created by immersive media expands the field of current democratic practice. Web-based immersive media enables any organization or individual to express their positions, views and opinions freely through the Internet. As McLuhan points out, "What the mass media shows is not the size of the audience but the fact that everyone participates at the same time" (McLuhan, 2001).

Finally, public cultural participation can reshape the public's spiritual world. Relying on immersive media, it helps to enhance the public's cultural self-awareness and cultural self-confidence.

Cultural self-awareness and cultural self-confidence are the endogenous motivation of public cultural value identity.



Immersive media has the function of knowledge dissemination and cultural education. Through its powerful communication advantages, immersive media can display and disseminate China's excellent culture more comprehensively and deeply. It not only enhances Chinese people's cognition and recognition of national and national culture, but also enhances their cultural awareness and cultural confidence.

In terms of reality, through the interactive display of immersive media, many "hidden" cultural relics in the museum come into the public's view, realizing zero-distance interactive experience with the public, and enhancing the public's awareness of cultural relics protection and inheritance of excellent traditional Chinese culture. The public's recognition of the national tides and cultural museums is also gradually increasing. Nowadays, with the application of 5G and other new technologies, cultural variety shows such as National Treasure and China in Classic Books lead the public through the ancient and modern times and into the history by means of film-oriented expression and *trans*-temporal dialogue. The public has strengthened their cultural confidence in the process of "following dramas." As well as the "Duanmen Digital Virtual Experience Hall" project by the National Palace Museum and the "Dunhuang Animation Drama" by the Dunhuang Research Institute, these projects showcase the charm of Chinese outstanding traditional culture in a three-dimensional manner, allowing the public to further participate in the preservation of cultural heritage while at the same time to enhance their confidence and trust in Chinese culture. In short, the application of immersive media has opened up new ways for the dissemination and display of Chinese culture, giving new impetus to the Chinese public's cultural awareness and cultural confidence.

### **Immersive Media Helps to Solve the Dilemma of Chinese Public Cultural Participation as a Whole and Thus Improve the Quality of Education**

The sense of experience and presence constructed through immersive media can, to a certain extent, solve the current problem of low quality and uneven participation of Chinese public cultural participation in general.

On the one hand, the application of immersive media can break through the limitation of public participation time to a certain extent, allowing the public to use immersive media as a medium to experience and enjoy public cultural services at any time, which will help to greatly improve the proportion and frequency of public cultural participation. On the other hand, the application of immersive media can break through the limitation of space to a certain extent. Relying on immersive media, people enjoy public cultural services or participate in public cultural decision-making and commit to the construction of public cultural service system without necessarily going directly to the participating venues or being limited to the public cultural venues within the administrative areas. Instead, they can be "on-the-spot" anytime and anywhere through immersive media technology. In this way, a series of problems such as inconvenient

venues, insufficient time, and inadequate construction of public cultural facilities can be solved to a certain extent in the process of public cultural participation, thus enhancing the degree of public cultural participation and enabling the public to receive the nourishment and edification of cultural education under a wider range of spatial and temporal conditions. This communication medium has innovated the way the public used to perceive and understand the world, and has had a significant impact on the current practice of socialized education.

The use of immersive media can promote the equitable allocation of social education resources and further strengthen the equity of education. The advantages of open and free cultural participation can greatly meet the public's learning and education needs. On the other hand, immersive media encompasses almost all symbolic forms as well as new elements such as interaction and sharing, which greatly enhance the interest and attraction of education. Immersive media also provide conditions for lifelong education. In the era of knowledge economy, the in-depth integration of new media and the concept of lifelong education provides a broad development space for the public's continuing education. Under this perspective of lifelong education, immersive media can reduce the cost of knowledge dissemination, and the public can be able to obtain educational resources with lower transaction costs and opportunity costs of participation, or even near zero costs. Public education of different regions, ages, and occupations will transcend the limitations of family education and school education, which is also in line with the future development direction of social education. So while cracking the dilemma of cultural participation, immersive media is also pushing the in-depth development of education, making it more three-dimensional and in-depth along with people's cultural life.

### **A REALISTIC PATH TO FURTHER ENHANCE THE ROLE OF IMMERSIVE MEDIA IN PUBLIC CULTURAL PARTICIPATION FROM THE PERSPECTIVE OF CULTURAL EDUCATION**

Immersive media has a profound value and role in expanding public cultural participation and enhancing cultural education functions in China, but its application in China's cultural sector is still relatively short. It is necessary to work on optimizing the development ecology, applying technological innovation and promoting integration development, to further improve the value and role of immersive media in public participation in China.

#### **Optimize the Development Ecology of Immersive Media**

The media ecological environment refers to the environment for the survival and development of mass media organizations (Wang, 2014), and the policy environment is crucial to the creation of a healthy development ecology for the media. After all, media policy affects the media ecology (Zhong, 2013).

From the perspective of communication control analysis, as a disseminator of information, any mass media agency's communication behavior is always under the deep control of a social's specific political systems, policies and regulations, and cultural paradigms (MBA Think Tank Encyclopedia, 2015). As a new direction of development and application in the context of media convergence, immersive media is highly valued and actively supported by Chinese government. The State Council of China has issued a series of policies to support the development of immersive media and industry.

In September 2020, the State Council of China issued the "Opinions on Accelerating the Deep Integration of Media Development" (CPGPRC, 2020a), which proposed to make good use of the achievements of information technology revolutions such as 5G, big data, cloud computing, Internet of Things, blockchain and artificial intelligence, strengthen the forward-looking research and application of new technologies, and promote independent innovation of key core technologies. In November 2020, the State Council of China issued the "Opinions on Promoting the High-Quality Development of the Digital Cultural Industry" (CPGPRC, 2020b), proposing the development of immersive business formats, guiding and supporting the application of technologies such as Virtual Reality (VR), Augmented Reality (AR), 5G+4K/8K ultra-high-definition in the cultural field. It also proposed to develop holographic interactive projection, night light show and other products, promote the transformation of existing cultural content into immersive content, and enrich virtual experience content. In addition, it supports cultural and cultural relic units to develop immersive experience projects with cultural resources and develop digital exhibition halls, online exhibitions and other services.

In addition, China's "14th Five-Year Plan and Outline of Long-Term Goals for 2035" (CPGPRC, 2021) and the "14th Five-Year National Informatization Plan" (China Securities Journal, 2021), currently being formulated by China's National Internet Information Office have all proposed to accelerate digital development. All of these policy documents aim to optimize the policy environment for the development of immersive media technology and provide good policy guidance and support for the application and development of immersive media.

However, there are still great deficiencies in the hierarchy, pertinence and systematicness of China's policy support for immersive media. In order to further optimize the ecological environment for the development of immersive media in China, it is necessary to make efforts from the following aspects: On the one hand, we should further improve the level and strength of policy support for immersive media, especially introduce special laws and regulations to support the application and development of immersive media, support the research and development (R&D) of immersive media technology in the form of laws and regulations, and support the development of the application of immersive media technology in expanding public cultural participation. On the other hand, Chinese cultural authorities, network information management departments and other relevant departments should formulate (or jointly formulate) plans to promote the application and development of

immersive media in the cultural field, and issue a series of targeted policies-based on the current development basis of immersive media and the needs of Chinese public cultural participation. In addition, we should establish and improve the fund to guide and support the development of immersive media in the cultural field, guide and support the construction and development of relevant enterprises and social organizations, and let social forces become a powerful force to promote the application and development of immersive media in the public cultural field.

## Promote the Research and Development and Innovative Application of Immersive Media Technology for Public Cultural Participation and Cultural Education

In terms of the current overall development status, immersive media technology in China is at an early stage of development, with both technical maturity and market maturity yet to be enhanced. In response to the need to expand public cultural participation in China, to meet the needs of building a public digital cultural service system and to achieve social education goals, it is necessary to promote the development and application of deep immersive media for public cultural participation in the following ways.

First, efforts should be made to develop new infrastructure for immersive media, as well as support hardware equipment to improve the performance of immersive media. The construction of key facilities and equipment should be promoted, especially the new basic design and equipment construction supporting 5G and VR technologies.

Taking VR technology as an example, from the perspective of hardware equipment, VR is similar to 3D, and you need to wear glasses to watch. The difference is that VR glasses are generally bulky and inconvenient to wear. If we can develop lightweight VR glasses without affecting the display effect, it will surely bring an upgrade of the experience effect for exhibitions in cultural and educational venue. As for 5G Technology, it needs the support of hardware equipment. With the large-scale deployment of 5G base station equipment in China, it is also necessary to develop cameras, game consoles and VR glasses that can support 5G network technology, so as to promote the wide application of 5G technology in public cultural venues, facilities and activities. In addition, there is an urgent need to accelerate the R&D and manufacturing of high-end cultural equipment related to laser playback, high-definition production and broadcasting, optical capture, performance special effects, performance interaction, and so on (Zeng, 2019).

Second, the research and development of related technologies and the production and innovation of related content should be strengthened. On the one hand, a high-quality immersive experience requires the support of multiple core technologies. The R&D of emerging technologies such as high-precision projection technology, sensing technology, 5G powerful transmission network, AI large-scale computing power, machine learning, intelligent robot, real-time 3D technology, and automation engineering should be strengthened. On the other hand, immersive content production in China is still in the

experimental stage, without mature production methods and tools, making it difficult to produce (Ozgur et al., 2019). At present, it is time to break through the constraints of traditional content production methods and focus on improving the ability to tell stories and produce high-quality content in 360° environment. In addition, it is necessary to update and improve the immersive technology equipment and educational resources. China should vigorously support the R&D and investment of digital education resources, focus on the construction of information infrastructure in the central and western regions and other backward regions, and popularize mobile devices, so as to break the geographical time and space limitations, eliminate the “digital divide” and build an immersive digital education platform for all (Fu and Zhang, 2020).

Third, the innovative application of immersive media technology in public cultural participation as well as cultural education should be strengthened. In the future, with the mass popularization of 5G, deep immersive media is expected to see a full explosion in the near future. Therefore, the application of immersive media technology-related products and services in expanding public cultural participation and public education should be well planned, designed and developed. In particular, we should promote immersive media to link the cultural scenes in the social life of the Chinese people, respond to the problems and the expected direction of public cultural participation in China, promote more cultural participation and cultural education applications toward immersion and online, and create more immersive public cultural participation scenes that are closer to the needs of the people, more vivid and more diversified. Through the gradual cultural penetration from “form” to “content,” the educational function of culture is realized, and the spiritual guidance to the public is achieved from the superficial to the profound, so that the public can gain psychological pleasure and improve their inner cultural literacy through immersion experience.

## Promoting the Integration and Development of Immersive Media and Cultural Participation Space and Cultural Education Content

The key to giving full play to the value and role of immersive media in expanding public cultural participation lies in integrating immersive media technology into public cultural participation space and cultural education content, and becoming an integral part of public cultural space and cultural education content, and thus promoting the construction of the education system for all.

With the advent of 5G Internet era, cyberspace has dispelled the traditional mode of public cultural places, thus constantly changing the public's lifestyle and cultural experience form. The emergence of immersive media is the necessity of the development of the information age. With the advent of the information age, public cultural places in the traditional sense can no longer meet the needs and expectations of the public. Only by closely combining public cultural places, public cultural education service content and emerging immersive

media technology, can they meet the psychological needs of the public to the greatest extent and meet the needs of social education. Under the technical condition of 5G + AI + XR, it is possible for the public to be fully immersed and interact seamlessly in the narrative scene between the virtual world based on immersive media and the real physical environment, and all of these changes represent a step toward a more immersive, intelligent, and interconnected future.

To a large extent, this future is the full integration of immersive media technology and public cultural services. In terms of reality, China has made breakthroughs in big data, VR, AR, 5G, and other technologies, and has also made a series of integration explorations in the field of public culture.

In recent years, the rise of public culture in China, including “Cloud” performing arts, “Cloud” exhibition, “Cloud” concert, VR live broadcast, is the integration of immersive media technology and public cultural services preliminary results. However, this kind of integration still remains at the superficial level. Overall, the integration of immersive media and public cultural services, and the integration of the public's cultural participation space and cultural education content, has broad prospects for development. It will gradually become an important field in the development of media technology and the construction of China's public cultural service system, and will bring many unprecedented changes to the public's psychology, cognition and behavior.

Therefore, there is still a need to continue to deeply expand the scope of immersive media and public cultural participation space and cultural education content integration, to strengthen the integration, to let history shine into reality, to interpret culture with technology, and to give new life to technology with culture.

With the efficient use of culture + technology, we will let immersive media technology support the construction of public cultural space, create public cultural space with innovative consciousness and artistic expression, and expand the application scope of immersive media in public cultural education places in Chinese cities. For example, we can learn from the experience of Montreal's “Urban Memory” project, open up the scientific and technological boundaries of digital media, VR / AR, interactive devices, big data and smart tourism, and integrate the experience of cultural activities and site activation into the immersive experience segments of daily life. Urban public cultural space, as an important carrier of urban character and cultural self-confidence, represents regional identity and cultural values. The application of immersive media in public space can enhance the city image, convey the spirit of the place, create an immersive experience, and guide the public's cultural participation behavior, so as to enhance the public's sense of satisfaction and pleasure in cultural enjoyment activities and cultural construction actions, and realize the quality education and democratization education for the public in this process.

## CONCLUSION

In short, immersive media has great theoretical and practical significance for expanding Chinese public cultural participation,

safeguarding people's cultural rights, and promoting the integration of education into people's lives in a culturally empowering way so that cultural education becomes an integral part of civic education. Although the current development of immersive media in China is still in its infancy, there are many difficulties in technology, cost, and content production that have not yet been broken through. However, standing on the cusp of 5G, culture is empowering immersive media technology, and immersive media technology is supporting the construction of China's public cultural space, which can break through time, space and resource constraints. Thus, it provides the public with open, interactive and interesting public cultural experiences and services, bringing cultural education out of the constraints of traditional school education and classroom education, prompting the public's knowledge acquisition and education improvement to shift from passive participation to active participation, from superficial participation to high-quality and deep participation in public cultural activities, and even making public cultural participation and cultural education a way of life for the Chinese people. Of course, there is still a long way to go in the application and development of immersive media technology in public cultural participation in China, and how to mobilize the enthusiasm of all parties and form a diversified development ecology is an important issue that needs to be further studied.

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## DATA AVAILABILITY STATEMENT

The original contributions presented in this study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

## ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the (patients/participants or patients/participants legal guardian/next of kin) was not required to participate in this study in accordance with the national legislation and the institutional requirements.

## AUTHOR CONTRIBUTIONS

WC: design the concept and outline, draft the main part of the manuscript, make important modifications to the manuscript, and approve the final manuscript to be published. YL: data collection and analysis and draft the part of the manuscript. Both authors contributed to the writing of the article.



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- Conflict of Interest:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.
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# Investigating the Parental and Media Influence on Gender Stereotypes and Young Student's Career Choices in Pakistan

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## OPEN ACCESS

### Edited by:

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### Specialty section:

This article was submitted to  
Educational Psychology,  
a section of the journal  
Frontiers in Psychology

**Received:** 06 March 2022

**Accepted:** 23 May 2022

**Published:** 28 June 2022

### Citation:

Hassan M, Luo Y, Gu J,  
Mushtaque I and Rizwan M (2022)  
Investigating the Parental and Media  
Influence on Gender Stereotypes  
and Young Student's Career Choices  
in Pakistan.  
Front. Psychol. 13:890680.  
doi: 10.3389/fpsyg.2022.890680

The study aimed to examine the impact of parental influence and media richness on gender stereotypes and career decisions among students at the secondary level in Pakistan. The sample size was 200 students, selected through a simple random sampling technique from government and private schools. Four questionnaires were used to gather data. The data was analyzed quantitatively using the Statistical Package for the Social Sciences (SPSS). Regression analyses were used to investigate the impact of parental influence ( $\beta = 0.50$ ) on gender stereotypes and media richness influence ( $\beta = 0.26$ ) on gender stereotype beliefs. Furthermore, parental, media, and gender stereotype behavior all have a significant impact on students' career choices ( $R^2 = 0.694$ ). On the scale of the parental influence and media richness, no significant gender differences were found. It is concluded that parental influence has a greater effect on students' gender stereotyping behavior and career choices.

**Keywords:** parental influence, media richness, gender stereotype, career choice, secondary school students

## INTRODUCTION

In the twenty-first century, more students have demonstrated an interest science, technology, engineering, and mathematics (STEM). Female students outnumber male students in various STEM fields, including biology, medicine, Physics, and chemistry (Wieman, 2013). Many gender differences in subject and job choice, according to study, are related to social prejudices rather than intelligence differences between men and women (Cheryan et al., 2017). Girls and boys undergo different socialization processes, (Bian et al., 2017) such as the gender stereotypes they face in their contexts, and television programs may constitute gender stereotyping endorsement among children's (Wille et al., 2018). According to stereotype threat research, the stereotype that females perform worse in STEM than males can harm girls' STEM performance and motivation, but the stereotype that males perform better in STEM can help boys' STEM performance (Spencer et al., 2016). According to HESA's most recent data (2017–2018), 35% of women enrolled in STEM subjects in higher education in the United Kingdom, yet they continue to be underrepresented in comparison to men (Stem Statistic, 2021). Women enrolled in only 17% of Engineering and Technology programs and 19% of Computer Science programs in 2016–17, but 75% of Medicine, Dentistry, and Veterinary Science subjects (Scottish Funding Council, 2018). In Scotland, the gender disparity in essential STEM jobs held by women is narrowing slightly, growing from 39% in 2010 to 42% in 2016. As

with other subjects in education, the amount varies significantly amongst STEM fields. Numerous professions continue to be dominated by men; only 19% of engineers in Scotland and only 3% of licensed civil engineers are female (Close the Gap, 2018). Similarly numerous economic and social decisions are influenced by our attitudes toward ourselves and others. Von Hippel et al., 2011 men and women's abilities are frequently found to be distorted by such stereotypes. Women are less confident in their mathematical and scientific ability than men, which contribute to economically important disparities in financial decision-making, academic accomplishment, and career choices (Buser et al., 2014). A significant change is school children were found after the gender stereotype related knowledge and endorsement in United Kingdom. Gender stereotyping is ubiquitous, with male and female categorization emphasized to children in particular as a dominant societal framework, despite growing public support for equal opportunities for boys and girls (Ellemers, 2018).

Career choice is a crucial decision that will impact the remainder of an individual's life. Career exploration is the process of examining and weighing various work opportunities. According to El-Hassan and Ghalayini (2019) says that investigating job opportunities before to making a commitment boosts future professional achievement and contentment. Parental attachment is related to job exploration. They discovered a link between parental attachment and vocational exploration. Similarly, Lee et al. (2012) observed a positive relationship between parental attachment and professional maturity, which is defined as an adolescent's readiness to make career decisions. Professional exploration is an important stage in the career development process.

Kirdök and Korkmaz (2018) parenting teenagers is generally portrayed as a difficult task. Before becoming adults, teenagers go through a number of developmental changes, including biological, cognitive, emotional, and social changes. Effective teen parenting necessitates a thorough understanding of these natural developmental shifts. Knowing that their parenting style is a basis for many favorable adolescent developmental outcomes might be beneficial to parents. Understanding the various parenting styles and how they affect the parent-teen relationship can assist parents and their adolescent children in navigating adolescence (El-Hassan and Ghalayini, 2019).

The pandemic of Coronavirus Disease in 2019 (COVID-19) has put educational systems and students under unprecedented strain (Mushtaque et al., 2021). Furthermore, the epidemic had an impact on students' plans for their future careers. One-fifth students reported that COVID-19 cause inclination to choose to be a doctor, on the other side COVID-19 pandemic improved students' willingness and determination to specialize in respiratory medicine and infectious diseases. Females were more influenced by the epidemic in terms of key decisions, such as being frightened of change and taking chances. Following the college admissions exam, the majors chosen by medical students are determined by their parents, social orientation, and professional income. Female college students' customary role expectations run counter to modern egalitarian culture, which places a premium on self-realization. They are easily able to transfer majors when confronted with enormous challenges

such as the COVID-19 pandemic (Deng et al., 2021; Gong et al., 2021). Throughout the first lockdown, fathers assumed the major caretaker role in many United Kingdom households, inverting conventional gender roles. However, in certain houses, traditional gender roles were more established, with mothers being obliged to stay at home during the second lockdown while men were permitted to work (Hupkau and Petrongolo, 2020).

Prior study indicates a causal relationship between gender stereotyping behavior and occupational choices. Knowledge endorsement has a significant favorable effect on the modification of career stereotypes. However, new phenomena such as COVID-19 induced stress, necessitating a thorough understanding of the mechanisms activated by stereotypes under stressful settings. Stereotypes play a unique role in influencing our judgment of good and wrong. It establishes gender roles and has a significant impact on socialization. In the current study we examined the Pakistani population to examine the variable. The purpose of the study was to explore the influence of parental and social media richness on adolescent gender stereotype beliefs and their career choices in Pakistan. Specifically, the study sought to know about the available knowledge of career information among secondary school students and sought to identify different sources of career information for students. The impact of parental influence and media richness on students' gender stereotype perception was also examined. The choice of career among students was investigated with parental influence, media richness, and their perception of gender stereotypes.

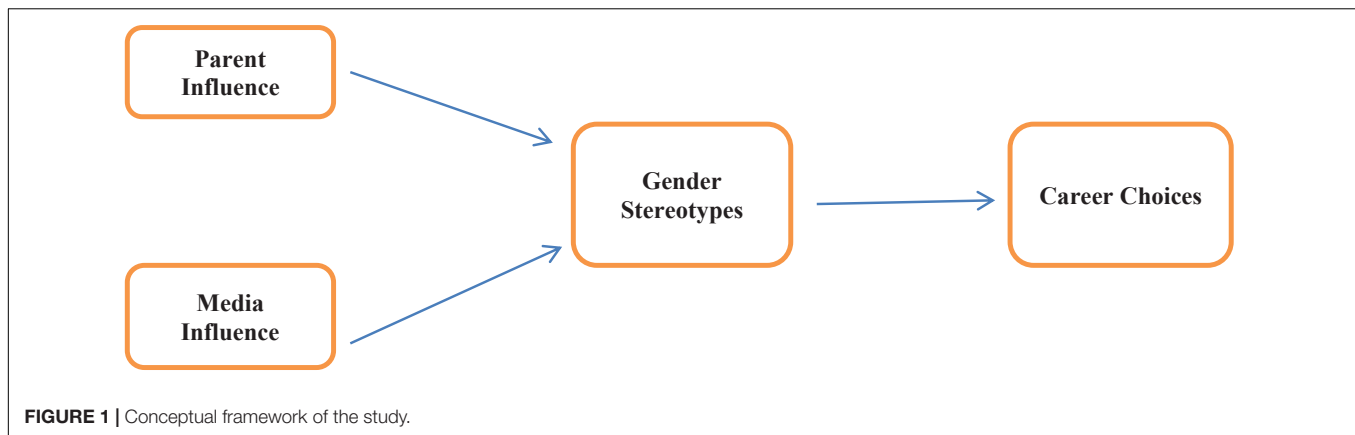
## THEORETICAL FRAMEWORK

### Social Cognitive Career Theory

Social cognitive career theory (Lent et al., 1994) has been found to be a valuable framework for examining job choice processes in previous studies. As demonstrated by Cunningham et al. (2005) and Alexander et al. (2010), SCCT provides a social and heuristic framework for assessing academic and professional decisions. The gender gap in STEM has been studied extensively (Park et al., 2018). A description of Bandura and Cervone (1986) broad social cognition theory's three key tenets: self-efficacy, expectations, and goal representations (Bandura, 2002; Lent and Brown, 2013).

### Social Learning Theory

American scholars created the social learning theory (SLT). This idea says four things impact career choices. These are genetics, environment, learning, and task-approach skills. Gender, ethnicity, color, IQ, particular ability, and so forth are all examples of genetic endowment. Environmental influences include family, teachers and resources, technology, training possibilities, occupational factors, labor market, and so on. The factors influencing a person's professional choices are largely out of their control. Instrumental and associative learning experiences can influence career choices. Task approach skills include learning skills, goal setting, and getting occupational knowledge. According to the SLT, a person's profession choice is influenced by self-reported interests, abilities, and capabilities,



as well as assumptions about the workplace (Barletta, 1999; Krumboltz and Worthington, 1999; Di Palma and Reid, 2021).

The purpose of the study was to investigate the influence of parental and social media richness on adolescent gender stereotype beliefs and their career choice in Pakistan. Specifically, the study sought to know about the available knowledge of career information among secondary school students, and seek to identify different sources of career information for students. The impact of parental influence and media richness is indicative of students' gender stereotype perception; also the choice of career among students was investigated with parental influence, media richness, and their perception of gender stereotype. Gender differences concerning parental influence, media richness, and gender stereotype perception were also a purpose of the study. The main purpose of the research was to study the parental and social media inspiration on gender stereotype perception and career choice among students.

## Hypothesis of the Study

- H1. Parental influence is likely to predict gender stereotyping behavior among students.
- H2. Media influence is likely to predict gender stereotyping behavior among students.
- H3: parental influence, media influence, and gender stereotype all influence students' career choices.
- H4: There are likely to be gender differences on the scale of parental influence, media influence, gender stereotypes and career decisions.

## Methodology

This study was carried out to investigate the effect of parental influence and media richness on gender stereotyping and career choice among secondary school students in Pakistan. The quantitative approach was used to obtain data from students. A quantitative approach is the best choice to gather objective information and helps to generalize the outcomes of the study. The current study is based on a correlational design. The simple random sampling technique was used as Random sampling guarantees that the results

obtained from the sample are close to results obtained if the full population was surveyed (Shadish, 2002). The simplest random sample gives each unit in the population an equal probability of being chosen. Perhaps the most important benefit to selecting random samples is that it enables the researcher to rely upon assumptions of statistical theory to conclude from what is observed. The sample size consists of 200 students, ages ranged 16–21 years who were enrolled in different private and government schools. The level of confidence is 95% for this study. A simple random sampling technique was used to approach students. Statistical Package for Social Science (SPSS) software was used to analyze data. Descriptive and inferential statistics were used to proceed with the results.

## Instruments

The instrument consists of six scales to gather data.

- (1) **Parental Influence scale** was developed by Wong and Liu (2010). Six-item scale use to measure the degree of parental influence. Higher scores indicate a higher level of parental influence. A 5-point Likert scale ranging from (1) strongly disagree to (5) strongly agree was used to record the response rate of students.
- (2) **Media Richness scale** was developed by Kohring and Lin in 2010. Response rates were on a 5-point Likert scale, ranging from 1 = strongly disagree to 5 = strongly agree.
- (3) **Traditional Gender Stereotypes scale** was developed to measure stereotyping gender roles as associating women with warmth, and men with competence (Runge et al., 1981). Responses are on a 5-point Likert scale, anchored 1 = "applies more to men," 5 = "applies more to women," (Cronbach's  $\alpha = 0.83$ ).
- (4) **Career-related Stereotype scale** was developed by Fuegen and Endicott in 2010. It is used to measure stereotype perception related to career choice.

## RESULTS

The findings were presented by the use of descriptive and inferential statistics.



**TABLE 1 |** Choice of career.

Professions	Frequency	Percent
Army	18	9.0
Engineering	43	21.5
Doctor	58	29.0
Teacher	31	15.5
Pilot	25	12.5
Law	11	5.5
Accounting	14	7.0
Total	200	100.0

**TABLE 2 |** Source of career information ( $N = 200$ ).

Professions	Frequency	Percent
Print media	23	11.5
Fiends	34	17.0
Electronic media	54	27.0
Parents	52	26.0
Teachers	17	8.5
Twitter	9	4.5
Role model	11	5.5
Total	200	100.0

## Identification of Various Professions/Career

The objective is to know about the knowledge students have about the different types of professions at the secondary school level. The students were asked to circle or tick the profession they want to adopt in later years. A list of seven professions was provided and students have to mark one profession that they want to choose in their life for themselves.

The frequency table shows the greatest percentage goes with doctor/medical career [29.0% preference, followed by engineering, (21.5%), pilot (12.5%), army 9.0%], accounting (7.0%), and then law (5.5%), respectively. The students were aware of these professions and plan to pursue a certain career of their choice.

## Source of Career Choices

In the follow-up question, students were asked to indicate their sources of career information. A list of seven sources was provided and students were asked to tick the source of their preferable career choice.

The frequency table shows the greatest percentage goes with electronic media (27.0%), then parents (26.0%), friends (17.0%), print media (11.5%), teachers (8.5%), role models (5.5%), and Twitter (4.5%). The findings show the major source of career information are electronic media and parents, as some students do not have the choice of the internet and social media hence they rely on their parents, teacher, and friends in selecting their careers. Students are active on Facebook and Instagram but not very active on Twitter therefore their career choice is mostly dependent on electronic media.

**TABLE 3 |** Multiple regression of parental influence and media richness on gender stereotype among students ( $N = 200$ ).

Predictor	<i>B</i>	Std. error	Beta	<i>t</i>	<i>p</i> -value
(Constant)	10.149	2.228		4.555	0.000
Parental influence	0.676	0.079	0.506	8.570	0.000
Media richness	0.120	0.026	0.269	4.560	0.000

$R^2 = 0.314$ , Adjusted  $R^2 = 0.308$ .

**TABLE 4 |** Multiple regression analysis of parental influence, media richness, and gender stereotypes on career choice among students ( $N = 200$ ).

Predictor	<i>B</i>	Std. error	Beta	<i>t</i>	<i>p</i> -value
(Constant)	5.764	3.692		1.561	0.120
Parental influence	1.368	0.146	0.435	9.390	0.000
Media richness	-0.325	0.044	-0.310	-7.449	0.000
Gender stereotype	1.186	0.112	0.504	10.563	0.000

$R^2 = 0.694$ , Adjusted  $R^2 = 0.689$ .

**TABLE 5 |** Mean, standard deviation, *t*-value, and scores of parental influence, media richness, gender stereotype, and career choice among students ( $N = 200$ ).

Variables	Gender	<i>N</i>	<i>M</i>	<i>SD</i>	<i>df</i>	<i>t</i> -test	<i>p</i> -value
Parental influence	Male	135	19.5556	3.65829	198	-1.802	0.074
	Female	65	20.4462	3.07221			
Media richness	Male	135	56.8370	10.11738	198	1.164	0.247
	Female	65	54.9385	11.12272			
Gender stereotype	Male	135	29.6444	4.59309	198	-2.986	0.003
	Female	65	31.7077	4.54396			
Career decision	Male	135	48.6074	11.32893	198	-3.790	0.000
	Female	65	54.6923	9.00507			

## Impact of Parental Influence and Media Richness on Gender Stereotypes

Table 3 shows the impact of parental influence and media richness on gender stereotypes among students. A multiple linear regression was calculated to predict gender stereotypes based on parental influence and media richness. A significant regression was found with  $r^2$  of parental influence ( $r^2 = 0.31$ ) and media richness ( $r^2 = 0.30$ ). Young students predicted that gender stereotypes increased by 0.67 due to parental influence. While young students predicted that gender stereotypes affected 0.12 due to media richness, which is less from parental influence. As a result, the findings confirm that young children learn patterns from their parents. These results also support the theory of social learning; children learn and perform the actions that they see their parents do.

## Impact of Parental Influence, Media Richness, and Gender Stereotypes on Career Choice

Table 4 shows the impact of parental influence and media richness on career choice among students. A multiple linear regression was calculated to predict career choices based on

parental influence, media richness, and gender stereotype. Young students predicted that career choice decisions were due to parental influence (1.36), media richness (-0.32) and gender stereotypes (1.18). The results revealed that the career decisions of the students depended on their parents' choices and the students' own perceptions regarding gender stereotypes. The results show that the media did not have a significant contribution to shaping the students' decisions regarding their career choices in developing countries like Pakistan.

## GENDER DIFFERENCES IN PARENTAL INFLUENCE, MEDIA RICHNESS, GENDER STEREOTYPE, AND CAREER CHOICE

**Table 5** describes the mean differences in parental influence, media richness, gender stereotypes, and career choice among students concerning their gender (male and female). The comparisons with respect to gender were found to be insignificant ( $P > 0.05$ ) on the parental influence and media richness scales, while the results were found to be significant with respect to gender stereotypes ( $t = -2.98, p = 0.003$ ) and career decisions ( $t = -3.79, p = 0.000$ ) among students at the secondary level. Male has low mean score on the scale of gender stereotype while female has high score on the scale of gender stereotyping behavior. It was found that female students had more gender stereotypes and were surer of them when making career decisions than male students.

## DISCUSSION

The findings of students' career choices show secondary school students' preferences for various careers. The majority of students want to be doctors (Gaurav and Sheikh, 2020), with engineering coming in second (Vrtič and Šorgo, 2022). Although these two occupations have been famous for decades and are often regarded as the most respected and well-paid, there is no doubt that they are excellent options (Eagly and Wood, 1999). However, there are several developing professions with high prestige and salaries. Even though not every student has the ability to pursue these careers, they are the most popular among students. The teaching profession was not a high-career choice, which is alarming because good and knowledgeable teachers are needed. The most important sources of career information are electronic media and parents (Ulrich et al., 2018). Students are unaware of other career choices available at this time and they have limited sources of career information. There is no proper career counseling facility available for children. While at this stage of life, they need proper occupational counseling that helps to choose the right career/profession according to their abilities and aptitude. Results indicate that some students had no access to journals, newspapers, or the internet, so they relied on teachers and parents (Owen et al., 2020). Social media promotes every type of career choice without providing further details about the input during the career-related degrees (Makela and Hoff, 2019). Furthermore, parents have limited knowledge

about various professions and attempt to pursue the child solely by observing a few role models in specific careers. Parental influence (Eisend, 2019) and media richness predict gender stereotypes at a significant level. Students mostly interact with their parents and spend time on social media. The stereotype perception about gender is not innate; it's learned over time. Parental influence and media richness (Cao et al., 2021) are two factors that are responsible for gender stereotype perception among students. There are gender stereotypes in daily life, in career choices, in social strata, and in every sphere of life. For example, males do not want to be nurses in society, and parents and peers do not think it's right for males to be nurses. Similarly, females are perceived to have low intelligence in mathematics and science subjects. These gender stereotypical perceptions limit the capabilities of the younger generation. The impact of parental influence, media richness, and gender stereotypes on career choice is massive. These variables predict career choice among students. The students are aware of their assigned gender roles and of their career preferences. It means students know to differentiate their gender roles and pursue some sort of career. Therefore, traditional career choice is predicted by parental influence (Venant et al., 2021), media richness (Kumar and Nanda, 2019), and gender stereotype perception. Gender stereotypes and career decisions were found to be more prevalent in female students than in male students. There is no difference in parenting styles between men and women. Pakistan has a collective culture, and parents try to impose their will on their children. They try to teach their children directly or indirectly at this stage of life, so their influence on children is similar regardless of the child's gender. In the case of media richness, the availability of content is similar for males and females. Gender stereotypes and career choices reveal significant gender differences. Males have masculine career preferences, whereas females have stereotypically feminine career preferences. Females perceive gender stereotypes more strongly than males. Similarly, at the secondary school level in Pakistan, females have higher career choice preferences than males.

## CONCLUSION

The persistent impact of parental influence, media richness, and gender stereotypes was found on students' career choices at the secondary level. Students know about different careers and most students want to pursue medical, engineering, and pilot careers as their future career choices. The top three sources of information according to children are electronic media, parents, and friends. Regression analysis shows a significant impact of parental influence and social media influence on gender stereotypes and, in turn, career choice. The study found no gender difference in parental influence. It might be the reason that parents try to treat their children equally and try to influence their children regardless of their gender. Similarly, media richness shows non-significant gender differences, which might be because the media richness is for all individuals regardless of their gender. On the other hand, gender differences in gender stereotype perception and career choice were found to be significant. Based on the findings of the study, parental influence, media richness, and

gender stereotypes predict career choices among secondary school students in Pakistan.

## Practical Implications

The current study, carried through cross-sectional design, explored the influence of parenting and media richness. This article indicates the impact of parental influence and media richness on gender stereotypes and career choices. According to empirical studies, gender stereotypes influence how people pay attention to, perceive, and recall information about themselves and others. By considering the cognitive and motivational functions of gender stereotypes, we can better comprehend the influence of gender stereotypes on implicit beliefs and communication about men and women. Knowledge of the literature on this topic might help people make more informed decisions in settings where gender stereotypes are likely to be present. These findings add to our knowledge of the roles of parental influence and media richness in determining adolescent profession choices and show that gender stereotypes have a cumulative effect on career choices.

## Limitations of the Study

The current study is informative yet contains many limitations. The cross-sectional research design for this study is limited in its generalization power. Another limitation is the sample size, as researchers have constrained resources. Additional important information on parents and families that may impact parental school experiences, such as parents' gender, geographic location, or school type (e.g., urban, rural, or suburban), was not included in the available data. One limitation is that the credibility of information on social media has not been considered.

## Direction for Future Studies

A longitudinal study with a larger sample size is needed to investigate the impact of parents on gender stereotypes and career

choices. As a result, it is suggested that the study be repeated with different parenting styles. Parents should practice not passing on gender stereotypes to their children. Similarly, pupils must be taught that they may succeed in various vocations and in society regardless of their gender. Parents will be expected to take steps to teach their children not to distinguish between biological and gender roles. Secondly, parents and social media are identified as the primary sources of professional choice due to the lack of career guidance at the school level. It is suggested that career counseling sessions be introduced to educate not only students but also their parents from various sources. Finally, rigorous study with a holistic approach to analyze numerous aspects of gender stereotyping behavior and profession choice will be advised.

## DATA AVAILABILITY STATEMENT

The original contributions presented in this study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

## ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study was provided by the participants or their legal guardian/next of kin.

## AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work, and approved it for publication.

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## SPECIALTY SECTION

This article was submitted to  
Educational Psychology,  
a section of the journal  
Frontiers in Psychology

RECEIVED 14 February 2022

ACCEPTED 24 June 2022

PUBLISHED 22 July 2022

## CITATION

Liu W (2022) A teaching design  
of ecological class based on immersive  
virtual reality spatial fusion.  
*Front. Psychol.* 13:874101.  
doi: 10.3389/fpsyg.2022.874101

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# A teaching design of ecological class based on immersive virtual reality spatial fusion

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This study investigated the effectiveness of the teaching design scheme called the Immersive Virtual Reality Teaching Model (IVRTM) on a small learner population at the researcher's university. The study was based on one-term experimental teaching among the undergraduates. An ecological class was set up, extending classroom teaching to 3-layer teaching space, including a physical layer (classroom-based), an information layer (internet-based), and a virtual-reality layer (VR-based). The research aimed (1) to create an online-offline spatial ecological learning environment for higher learning efficiency with a series of learning activities, (2) to uncover the learning effectiveness of VR assistance in oral English, and (3) to acquire the students' attitudes toward the IVRTM. The study approaches involved literature review, empirical method, questionnaire, interviews, and data analysis. The findings would have a positive significance for the promotion of new technology applications in SLA teaching and provide novel and preliminary references for teachers pursuing an effective teaching design of ecological classes based on IVR spatial fusion.

## KEYWORDS

teaching design, IVR, IVRTM, spatial fusion, ecological class

## Introduction

Digital technology is helpful to stimulate learners' visual, auditory, and tactile perceptions for improving their learning efficiency (Yang and Gou, 2020). It could promote students' comprehensive literacy in education, such as autonomous learning ability, cognitive ability, and thinking ability (Zhang, 2011). Big Data has been used widely in some aspects of education, such as academic performance evaluation, education policy guidance, and personalized demand according to data analysis (Jayashankar, 2018). Data analysis enables teachers to comprehensively evaluate students' academic performance, giving them feedback and instructing them in personalized learning (Zhang and Li, 2013). Online-offline fusion teaching is also booming in China, especially in the post-epidemic era of COVID-19. Currently, immersive virtual reality convergence technology is increasingly developing as a tool for education and promoting educational innovation (Hu et al., 2021). Zhen (2017) attempted to construct a model of online-offline ecological English classes in high schools in China. Many researches have been conducted from the perspective of VR technology itself. Currently, some

educators begin to have some VR teaching experiments, which are still in their infant stage and there are few research results in this field, not to mention the combination of online–offline fusion with VR assistance. The study made significant contributions to the attempt of three-dimensional multi-spatial fusion teaching combining class-based, internet-based, and VR-based spaces through its unique teaching design, which has a novel and positive significance for the promotion of new technologies in education.

The Immersive Virtual Reality Teaching Model (IVRTM for short) conducted in this research aimed to create an online–offline ecological class with VR assistance for students. An ecological and spatial fusion class was set up in the IVRTM, extending classroom teaching to three-layer multi-space, including classroom teaching, online teaching, and VR-assisted teaching. VR-assisted teaching as part of the IVRTM was adopted in oral English practice. The exploratory study aimed (1) to create an online–offline multi-spatial ecological learning environment for higher learning efficiency with a series of learning activities, (2) to uncover the learning effectiveness of VR assistance in oral English, and (3) to acquire the students' attitudes toward the IVRTM. The theoretical and empirical methods combined together compose the research framework of this paper, including literature review, empirical method, questionnaire, interviews, and data analysis. The IVRTM as a teaching model in SLA is based on Multimodal Learning Theory (Wang and Mao, 2021) and Production-Oriented Approach (POA for short) (Wen, 2015). To test the effectiveness of the IVRTM, an empirical method was conducted and 109 students were recruited randomly to participate in the teaching experiment over a term. Class 1 as the control group was instructed by the traditional teaching model without a digital learning platform and VR technology support, and Class 2 as the experiment group followed the IVRTM with the VR and learning platform assistance both digitally and technologically. The students in two were asked to complete a variety of teaching activities according to the teaching plan. The final exam results were analyzed to test the significance of the IVRTM. Apart from it, data analyses of the questionnaire and Big Data on the learning platform were adopted to prove the hypotheses of the research. The findings, limitations, and suggestions were discussed at the end of the thesis. The findings would have a novel and positive significance for the promotion of new technological applications in SLA teaching and provide preliminary references for teachers pursuing an effective teaching design of ecological class based on IVR spatial fusion.

## Literature review

According to the existing research and the research protocol, this study employed a systematic and comprehensive review approach to search, select, and analyze the relevant literature

published in recent years to achieve the research goal. The research is based on the following two theories, one is Multimodal Learning Theory (Wang and Mao, 2021), and the other is Production-Oriented Approach (POA for short) put forward by Wen (2015). VR-assisted teaching is applied to the pilot study.

## Multimodal theory

The rapid development of artificial intelligence and wearable devices not only promotes educational innovation but also contributes to the application of multimodal theory in teaching research. Typically, humans perceive information and pass it to the brain through multiple senses. Each perceptual source or media form is called “mode.” Modality is the communication between human beings through various senses and the external environment. One sensory communication is called a single modality. And three or more are called multimodality, which refers to the resources of discourse symbols that encode meanings with multiple symbolic modes simultaneously (Wang and Mao, 2021). Modes are experienced in different ways by each of the senses – usually visual, auditory, and tactile, which often interact with each other, creating a dynamic learning experience for students. For instance, an educational video might include speech, image, music, and text – all of which can enhance a student's learning experience. The multimodal theory is to study multimodal learning that makes full use of various human perceptions to optimize the learning experience in a fusion environment (Wang and Mao, 2021). It can also refer to texts that conform to the discourse specification with images, charts, etc., to perform multiple encoding to achieve meaning and people could transfer through various ways including voice, text, gesture, and other modes of communication between human beings through various senses and external environment. Multimodality emphasizes the use of pictures, videos, gestures, body language, and other different modes to convey different knowledge and stimulate learners' multisensory channels so as to meet the needs of students in language, and knowledge, and thinking (Milicevic et al., 2017). In language teaching, it is usually presented in a synergy of interaction, innovation, and dynamic process involved in multimodal senses of auditory, visual, and tactile modes, including image, gesture, speech, writing, models, spatial, and bodily codes (Zhang and Li, 2013). Some methods commonly used in multimodal theory include phonetics of speech, video clips, physiological tests, eye-tracking records, and digitized logs for deeper insight into learners' behaviors, cognition, and motivation. The researcher obtains broad evidence according to the learners' learning behaviors, styles, emotions, and modes. And multimodal data can be collected and analyzed for understanding learners' learning process. Educators combine the empirical paradigm study with

multimodal analytics to obtain continuous, embedded, and real-time feedback on ongoing learning through data (Zhang and Li, 2013; Milicevic et al., 2017). The findings of data analysis are used for reasoning and decision-making in educational reform (Wang and Mao, 2021).

The IVRTM was put forward in this research based on the multimodal theory. Multimodal modes are triggered through a series of online- offline teaching activities as a result of learning efficiency improvement (Zhan, 2019). At present, studies lack multimodal teaching research on spatial fusion classes with VR assistance. The IVRTM teaching aims for mobilizing students' multisensory perceptions for better learning effectiveness with VR assistance. The study aims to stimulate and activate learners' multisensory channels in a highly immersive virtual reality setting (Anua et al., 2022). Students employ their information-processing sensory modes in the IVR learning environment. In the teaching scenario, a quantity of multimodal learning data from VR-assisted training can be captured, fused, and analyzed, which verified the learning effect through a comparison with multimodal data between the control class and experiment class and better understood the learning process so as to take some positive measures to intervene teaching if necessary (Hu et al., 2021). According to the research, educators would have more reliable references for processual evaluation and comprehensive evaluation of students' performance and students could get continuous, embedded and real-time feedback on their ongoing learning (Zhang, 2011). VR-assisted teaching research is a support for the multimodal theory, which will be potential for understanding procedural learning in the future.

## Production-oriented approach theory

The Chinese scholar (Wen, 2015, 2018) created the theory of Production-Oriented Approach (POA) based on her early theoretical research on Output-Driven Hypothesis (Wen, 2015, 2018) and Output-Driven Input Facilitation Hypothesis (Wen, 2015, 2016). Wen (2015, 2016, 2021) also set up the POA theoretical system from the perspectives of methodology and SLA. The POA theoretical system had three parts including teaching design, teaching procedures, and theoretical hypotheses (Wen, 2015, 2016, 2018; Figure 1).

The first part was the guiding ideology of teaching in the view of methodology, which consisted of learning objective, learning content, learning method, and assessing system. The second part is composed of three basic steps to achieve the POA teaching objectives motivating, enabling, and assessing. Basically, there were a number of "motivating-enabling-assessing" cycles in the teaching procedures (Wen, 2015, 2016, 2018). Wen (2018) elaborated on the POA tasks and requirements of teaching procedures and proposed evaluation standards for each procedure. Four hypotheses were put forward as theoretical bases and concepts from the

perspective of SLA. They were Output-Motivated Hypothesis, Input-Motivated Hypothesis, Select Learning Hypothesis, and Assessing-Motivated Learning Hypothesis (Cumming, 2001; Marsh and Boag, 2013; Wen, 2015, 2021). SLA depended on learning objectives, learning contents, learning methods, and assessing systems motivated by a series of teaching activities and input and output tasks (Rubin, 2005; Zhu and Bai, 2019). Motivating, enabling, and assessing are closely relevant, but independent of each other, acting together to contribute to students' comprehensive language competence (Wen, 2015, 2016, 2018).

On the other hand, the POA theory involves three educational philosophies including Learning as Center, Integration of Learning and Use, and Whole-Human Education. Learning as Center indicates that learning is the basic and core behavior in the learning and teaching process. By contrast, students' core status in the teacher-centered class may be neglected, whereas teachers' leading role in student-centered class tends to be ignored in practice (Wen, 2015, 2016). The concept of Learning as Center emphasizes that students and teachers should corporate equally and complete a variety of activities and tasks cooperatively in order to achieve teaching objectives. That is to say, both teachers and students are equally important in teaching, and they play equal roles in the teaching and learning process. Integration of Learning and Use advocates for students to improve their language competence through language input and output (Zhan, 2019; Zhu and Bai, 2019). According to the students' academic proficiency and learning styles, teachers assign them some personalized and differentiated input and output tasks for practice (Fiore and Rosenquest, 2010; Hu et al., 2021). Learning style as one of the determinants is non-linear, dynamic, interactive, and open, enabling students to complete personalized tasks independently. The goal of Whole-Human Education emphasizes the whole growth of students instead of focusing on their specific experience or mastering some skills themselves only. Therefore, the POA theory emphasizes cultivating students' comprehensive literacy and balanced development regarding cognition, emotion, and quality. The following Figure 2 shows the relations of three parts among the teaching concepts, the teaching hypotheses, and the teaching procedures (Wen, 2015).

The POA theory has been accepted and welcomed by a great many university teachers in China. These teachers could understand and accept the learning-centered concept of the theory and had some fruitful teaching research, such as some teaching designs and empirical experiments under the guidance of the POA theory (Li and Fan, 2018). And a series of motivating-enabling-assessing teaching cycles were created and carried out in the teaching designs. Some preliminary findings have initially shown positive results from the POA teaching experiments (Yang and Gou, 2020). Wang et al. (2021) made some research on motivating, enabling, and assessing,

## View of Methodology

## View of Second-Language Acquisition

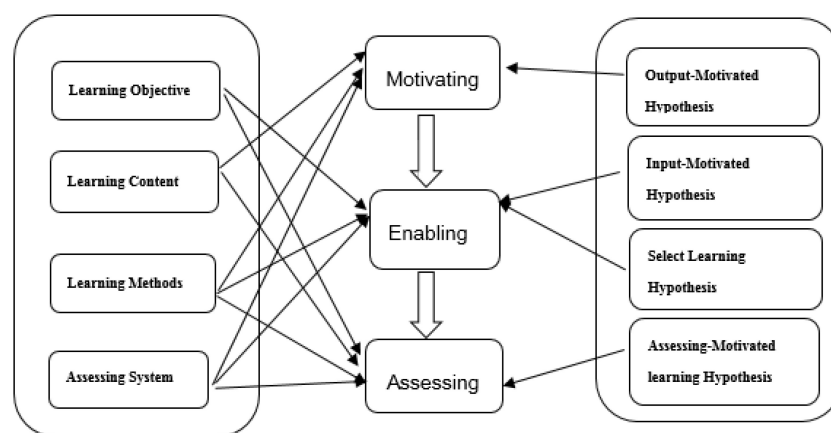


FIGURE 1  
The POA theoretical system.

respectively, in teaching and proved that the motivating-enabling-assessing procedures were connected to each other without any strict bounds in the teaching process. They fully affirmed its theoretical advantages in teaching design and adaptation of textbook, especially in the promotion of learning motivation and goal achievements (Zhan, 2019). Moreover, the POA theory has an influence on the international academic circle as well. Wen (2016) made a report on the application of the POA theory for Chinese adults' SLA in China's English teaching at the 7th International Conference. And she completed the 7th chapter – *The Production-Oriented Approach: A Pedagogical Innovation in University English Teaching in China* in the book of Students, Teachers and Pedagogy edited by Wong and Hyland in 2017. In May of the same year, the POA team held a high-end forum to introduce the theory among the top overseas scholars in Beijing. In October, they also held some international academic seminars to discuss the feasibility of the POA theory throughout the world. And extensive attention was paid to it by the experts attending the seminars. Generally, the POA theory has been already used by more and more Chinese college teachers and is gradually known and accepted by more language experts, scholars, and educators throughout the world.

## Virtual-reality application in the immersive virtual reality teaching model

As an immersive learning experience, VR-assisted teaching makes it possible with the help of digital animation, interactive images, and wearable devices. Basically, there are two main categories of IVR devices. One is a large fixed visual device

with a circular wall display with high cost often used in large projects. The other is a kind of convenient, portable, wearable, and hand-held equipment with visual recognition function, by which learners can interact with simulation characters in the immersive virtual space. Generally, the latter is recommended by creating a smart class.

Virtual-reality used in SLA teaching could activate students' multisensory modes, especially in the immersive human-computer interaction through listening, speaking, reading, and writing in oral English practice. The research on VR technology has been achieved greatly, and more attention to VR teaching is paid by more and more educators (Duan, 2019). The research of VR-assisted online-offline fusion English teaching is still few. The IVRTM in this research creates a three-layer learning environment for students between virtuality and reality in an attempt to higher learning effectiveness by stimulating students' multisensory modes, such as visual, auditory, and tactile perceptions. The VR-assisted teaching focuses on the students' experiential learning in the learning process. Smart Room has two sections for computer desktop training and field training, which are open regularly. Before class, the teacher assigns communicative tasks according to the teaching objective. Students first had desktop training to learn and imitate some communicative situations through IVR videos and then experienced them in the training field before class. In class, the teacher would divide the students into several groups and ask them to practice the related communicative tasks in reality. After class, students could practice more in the training field of Smart Room if they would like to. Take the topic "Asking the Way" for example, the students could choose different destinations of communicative tasks, learn the relevant words and sentence patterns first, and then invite a virtual figure



online to make a catechetic dialogue. Their speeches could be recorded and kept for later oral improvement and evaluation of pronunciation, intonation, fluency, and accuracy. English teaching aims for not only mastery of the language, but also its humanistic qualities, such as culture, cultural awareness, cultural adaptation, and humanistic spirits. The purpose of oral practice among peers in the traditional teaching aimed for sentence pattern usage, whereas VR-assisted oral practice could show students appropriate speech, culture diffusion, and different ways of thinking. Specifically, language course has the instrumental and humanistic goals to cultivate students' comprehensive literacy based on the goal of whole-human education. All teaching activities are learning-centered and closely linked input to output. Students searched for input-driven materials by output objective and did the task-driven exercises to improve learning efficiency. In fact, there is no boundary between input and output, and "learning" and "use" are integrated into teaching and learning, which followed the POA philosophy of Integration of Learning and Use (Zhu and Bai, 2019; Chacon et al., 2021). Multiple evaluation methods would be also employed in the oral test, such as machine evaluation, teacher's evaluation, peer's mutual evaluation, and self-evaluation. Students as peer assessors could also learn from each other's advantages and disadvantages. The joint assessment among machine, student, and teacher is worth recommending especially in the spoken and writing evaluation.

Currently, online-offline blended teaching has been promoted extensively in China in the past several years because of COVID-19. More and more universities began to pay attention to the application of VR technology in English teaching, but multimodal and multi-spatial fusion teaching in SLA was still lack of research and practice (Yang and Gou, 2020). And there is even less research on VR-assisted online-offline fusion teaching. Students have a totally different learning experience in a VR-assisted ecological fusion environment. Virtual Lab/Smart Room is one of the most important IVR experiment classes and its display and interaction with real-time feedback can increase students' learning interest and enthusiasm (Xie, 2019). More virtual teaching experiments in the IVR lab will be conducted and some related curriculum projects will be developed and have broad prospects in the future (Hu et al., 2021).

## Research methodology

The related literature of the IVRTM was reviewed in the previous parts concerning the theoretical framework of the research. The research methodology was discussed further in detail in this part, including research questions, participants, research methods, instruments, and data statistics analysis to clarify the fact that the IVRTM with new technologies is better than the traditional teaching method for higher learning

efficiency, and the acceptability of the novel teaching model in the ecological environment based on the spatial fusion would be proved—which are elaborated upon below.

## Research questions

According to the previous literature review and some related theories, it was a fact that few studies have been conducted on the combination of online-offline fusion teaching with VR assistance. Therefore, the IVRTM was put forward by the researcher, aiming for a more effective English teaching model with new technologies. Three research questions would be explored in this study as follows:

- (1) Is there any effect of the IVRTM or it is better than the traditional teaching method?
- (2) Can students' oral English practice with VR assistance promote students' communicative ability?
- (3) What are the students' attitudes toward the IVRTM?

## Participants

The number of 109 participants was recruited randomly from first-year undergraduates from the university at which the researcher worked. Class 1 ( $n = 53$ ) as the control group was instructed by the traditional teaching method without internet-supported learning platforms and VR assistance, but they shared the same teaching plan with the same periods, pre-class warm-up questions, discussion topics, and role-plays, and after-class assignments. Class 2 ( $n = 56$ ) followed a different teaching method—IVRTM, an interactive hybrid teaching method with the support of internet-supported learning platforms and VR technology.

## Methods

This study adopted the research method of teaching empirical study between Class 1 (control group) and Class 2 (experiment group) for a term. They were distributed to the basic-level English classes according to their English scores on the College Entrance Examination (CEE) under 90 marks (150 marks for perfect scores). Their CEE scores were collected and analyzed as a pre-test of their English mastery level before the teaching experiment. After one-term's experiment, the scores of their final exams were recorded and analyzed as post-test to examine the significance of the experiment results. The same teacher taught the two classes bilingually, half Chinese and half English. The research lasted one term, including 13 weeks, 12 weeks for teaching, and 1 week for the final exam. The teaching plan includes 4 periods (45 min/period)

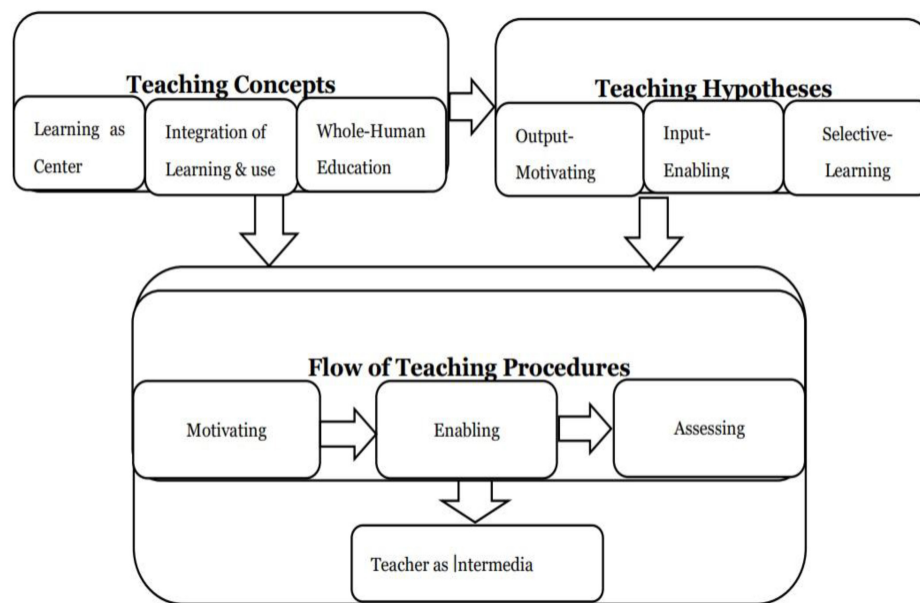


FIGURE 2  
Relations of three parts in POA system.

TABLE 1 Comparison of teaching plan in two classes.

	Periods	Teaching plan	Text-book	Final Exam	Teacher	VR assistance	Superstar platform	Teaching methods
Class 1	Same	Same	Same	Same	Same	No	No	Different
Class 2	Same	Same	Same	Same	Same	Yes	Yes	Different

for in-class presentation and 2 periods for pre-class and after-class autonomous learning in each module, completion of six modules per term, and 120 min for the final exam (Table 1).

## Instruments

### Test

In the empirical experiment teaching, Class 1 as the control group followed the traditional teaching model, while Class 2 as the experiment group adopted the IVRTM for a term. Their CEE acted as a pre-test and the final exam was a post-test. All 109 participants took the final exam after a one-term teaching experiment, and the scores would be collected and analyzed to test the significance of the experiment results. SPSS was used for data statistics and analysis in the research. Sig. value < 0.05 was considered statistically significant.

### Questionnaire

In order to acquire the students' attitudes toward the IVRTM and the application of VR technology in teaching, the researcher designed and adopted a questionnaire to investigate their acceptability of the IVRTM and VR technology used in teaching.

## Interviews

The researcher made an interview with five students selected randomly from the experiment group who thought the IVRTM couldn't decrease their learning anxiety. Open questions were also available for the students' views on the IVRTM.

Q1: What do you think of the IVRTM?

Q2: Why did you think the new teaching couldn't decrease your learning anxiety?

## Big data analysis of learning platforms

Big data on the learning platforms were used for research on the students' academic performance in the learning process. There were numerous Big Data available on the learning platforms related to the students' learning situations, such as online study duration, completion rates, and numbers of posts, sharing, and discussions, which could be used as references for educational management, assessment, and research (Zhang and Li, 2013). The procedural evaluation of pre-class, in-class, and after-class learning would be of importance. An analysis of qualitative statistics was also used for students' attendance and completion rates of learning tasks and the feasibility and acceptability of the IVRTM.

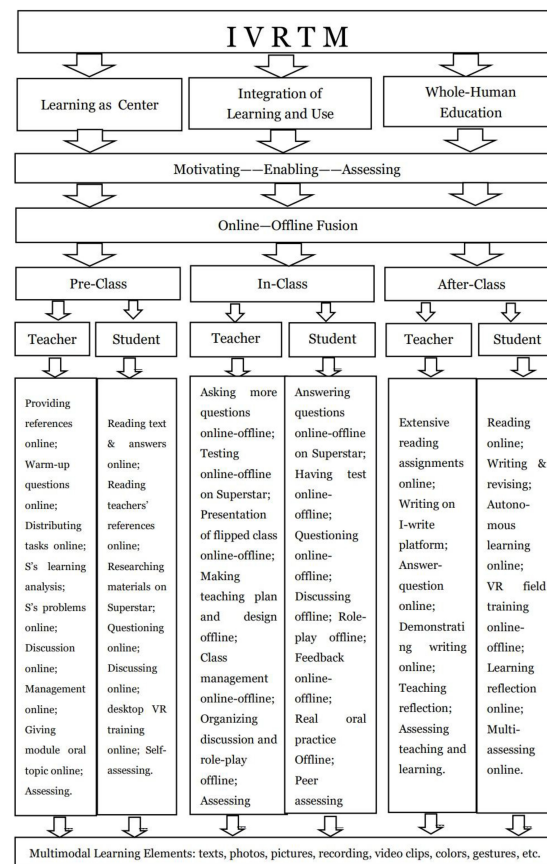


FIGURE 3  
The flowchart of the POA theory.

## Implementation of the immersive virtual reality teaching model

The teaching procedures of the IVRTM has three sections, including pre-class output-oriented prevision, in-class tasks-driven and problem-driven presentation and after-class revision and writing demonstrations. The Flowchart of the POA Theory (Figure 3) represents the teaching procedures and activities of the IVRTM.

Pre-class learning as an actual preparation for further study was performed online on the learning platform called Superstar Learning Platform, referred to as Superstar. The learning platform has some functions and a lot of learning resources. Generally, it has five functional sessions:

- (1) Pan construction course for building courses and uploading learning resources;
- (2) Online output-led and task-driven teaching activities;
- (3) Projection screen teaching for screen teaching and activate classroom activities;
- (4) Diverse assessment, especially an emphasis on procedural evaluation;
- (5) Learning management.

It provided the students with book-related background information, questions, exercises, tests, and extensive activities helpful for their pre-class preparations, in-class interactive activities, and after-class revision. The activities consisted of text-related warm-up questions, exercises, and audio-visual clips, which fully mobilized students' auditory, visual and tactile perceptions in the forms of listening, watching, speaking, reading, writing, translating, and imitating. The students had an all-round educational experience on the multimodal learning platform. Since university environments had diverse student populations with a wide variety of learning styles, the multimodal activities helped each student achieve their personalized learning experience on their own, which followed the POA philosophy of Learning as Center and students as the main learning body. Selective learning concerned the students' personalized learning characteristics according to students' different levels, orientations, and styles to achieve learning objectives and improvement of each student. During the practice, the students were motivated by the output objective, integrating learning into use to achieve the learning goal. In the pre-class online learning process, the teacher was in charge of references sharing, tasks attribution, assignments, analysis of students' proficiency, problem collection, online

teaching and learning management, oral topic release and data collection for assessment. He led and instructed the students' automatic learning online regularly if necessary. The students would preview the text and related words and expressions. And they could scan the QR code to get the audio recording of them. Besides, there were many audio-visual materials for exercises and references. More tasks include answering the warm-up questions, putting forward questions and challenges, and discussing problems with the teacher and other students on the forum of Superstar. VR oral desktop training could be done before class. Pre-class learning mainly depended on online learning. I-learning data was for assessment, which was helpful for the mastery of the students' learning process and strengthening of procedural assessment (Milicevic et al., 2017). Cooperative learning occurred when the students have some problems, they would post and discuss with their peers and the teacher on the discussion forum, which gave full play to the wisdom of the collective (Cumming, 2001; Rubin, 2005; Zhan, 2019).

In-class teaching was organized in the form of flipped classrooms with face-to-face and online-offline fusion teaching depending on the Superstar Platform in the class. The teacher used a projection screen for teaching and activated learning activities on the Yu Classroom of Superstar. He checked out the achievement of students' prevision by asking questions and a short quiz, made a presentation for major and difficult points, answered the students' questions, resolved their problems, organized discussion and role-play, and evaluated learning and teaching. The students answered the teachers' questions, completed quiz, discussed with peers, made role-plays, watched, listened to and feedbacked the teacher's presentation, put forward questions, and evaluated one another. The major points were often presented and interpreted through questions and PPTs in the flipped classroom (Wang et al., 2021). However, the IVRTM was totally different from the traditional teaching of PPTs presentation and interpretation one point after another. In the IVRTM, the teacher had no necessity to cover each point, some of the major points or difficult points in the flipped class were emphasized because the teacher had known what the students mastered according to their performance in pre-class tasks, questions, and discussion.

In class, the teacher adopted the following online-offline fusion teaching procedures. For instance, one or two students could be asked to answer the teacher's questions on the blob, while other students could post their answers on the platform forum. Sometimes they could thumb-up some excellent answers on the screen, and the teacher gave instant and interactive online-offline feedback. The students' posts would be recorded as their assessing references for classroom participation. What's more, group discussion was helpful for stimulating the students' imagination, cultivating their cooperative spirit, and improving their thinking ability. They usually brought out possibilities that individual members of the group had not thought of Cumming (2009). Students were divided into several groups

to discuss a topic related to the theme of the text, and the teacher as the teaching subject organized the discussion and gave them some necessary instructions and suggestions. After that, they were asked to practice the oral topic that had been given in pre-class by role-playing. And they had practiced similar situations on the desktop VR training. Ideas and values were conveyed through topic discussion, mutual assistance, and cooperation in the group activities as well as role-play (Wang et al., 2021). The philosophy of Whole-Human Education aimed for the cultivation of students' comprehensive quality, such as teamwork cooperation, innovation, and autonomous learning ability. During the learning process, the students integrated output-input, making the philosophy of Learning and Use possible. Moreover, multimodal learning changed teaching and learning styles using multiple information means and channels, including audio, speech, music, pictures, text, illustrations, imitation, writing, gestures, facial expressions, and colors. The students' perceptions were fully activated by speaking, listening, watching, discussing, questioning, and assessing in the learning process.

After-class revision aimed at the students' to consolidate what they had learned in the module. The teacher did a lot, including assignments (compulsory writing and selective tasks), online answer-question instruction, extensive materials sharing online, the reflection of teaching, and assessment. The writing was completed on the I-write Platform, a professional academic writing platform. The students revised their essays several times and got revising comments and different marks through computer evaluation. The repeated revision could improve the students' writing level greatly according to the scores. The highest marks would be acted as the final assessment scores of the writing. Besides, both the teacher and peers' evaluation on the platform could be done, too. Compared with the traditional teaching writing—handing in for the teacher's comments on the composition, the academic writing was more effective and efficient. Moreover, the traditional writing was graded and written only once, and usually assessed by the teacher. After that, the teacher often selected one or two excellent papers to illustrate how to organize writing. Multi-evaluation was adopted to promote the fairness of evaluation and encouraged students' participation in assessment, such as machine evaluation, teacher's evaluation, peers' mutual evaluation, and student's self-evaluation (Cumming, 2009). What's more, the teachers gave some instructions on writing online by demonstrating a few excellent compositions online (Chang, 2019). VR field training in the Smart Room in the students' spare time, which was open regularly. They could experience virtual-reality interaction in the immersive space.

More importantly, there are Big Data available on the learning platforms related to the students' online study duration, completion rates, frequency of posts, sharing, and discussions, which can be used as references for educational management, assessment, and research. For instance, teachers could monitor and instruct each student online and give



TABLE 2 Normality assumption test for pre-test.

Shapiro–Wilk test				
	Class	<i>F</i>	<i>df</i>	Sig.
Pre-test	1	0.990	53	0.942
	2	0.969	56	0.159

him/her some suggestions on learning methods and learning progress according to the Big Data. In addition, teachers could check out students' class engagement according to the Big Data. Moreover, teachers could set up the proportion of scores for each task. Generally, Big Data of platforms were helpful for procedural evaluation, and what students have done would be quantified and assessed in the whole learning process (Jayashankar, 2018). To date, data analytics has been used in education, and automated and scalable analytics tools with synchronous data would promote Big Data in teaching and learning management and evaluation greatly (Cumming, 2009).

## Results and analysis

### Results and analysis of pre-test

In the pre-test, according to the result of the Shapiro–Wilk test in Table 2, the values of sig. are 0.159 and 0.942, and they were both larger than 0.05, which were not considered statistically significant. It indicated that two sets of data were normally distributed.

Table 3 showed that the mean scores of the two classes were 67.25 and 67.18, which were similar from the perspective of descriptive statistics. According to the results of Levene's test of variance, when  $p = 0.003 < 0.05$ , the equal variance was not assumed. When Sig. (two-tailed) value =  $0.969 > 0.05$ , there was no statistical difference in the performance of the two classes, that is, they had similar English mastery levels before the experiment.

### Results and analysis of post-test

Descriptive and qualitative statistics of the final exam results were used to identify the significance of the IVRTM (Table 4). The statistics of post-test were shown as follows.

TABLE 3 Independent sample test of pre-test.

MS		SD		<i>F</i>	<i>P</i>	<i>t</i>	<i>f</i>	Sig. (two-tailed)	95% CI	
Class 1	Class 2	Class 1	Class 2						Lower	Upper
67.251	67.180	7.463	11.340	9.483	0.003	−0.039	108	0.969	3.7022	3.561

MS, mean scores; SD, standard deviation; CI, confidence interval.

TABLE 4 Normality assumption test for post-test.

Shapiro–Wilk test				
	Class	<i>F</i>	<i>df</i>	Sig.
Post-test	1	0.980	53	0.493
	2	0.979	56	0.433

In the post-test, the values of sig. were 0.493 and 0.433, both larger than 0.05 according to the results of the Shapiro–Wilk test in Table 4, which was not considered statistically significant. The test proved the fact that the two sets of data were normally distributed.

Table 5 showed that the mean scores of the two classes were 67.81 and 73.146. The scores of Class 2 were higher than those of Class 1 from the perspective of descriptive statistics. According to the results in the table,  $P = 0.001 < 0.05$ , which proved the fact that there was statistical difference in the performance of the two classes, that is, there was obvious significant difference between the scores of the two. In the experiment, the two groups had the same teacher, periods, books, final exam, and teaching plan except for the teaching methods. Therefore, it could be concluded that the difference in the exam scores between the two classes resulted from the different teaching models. That is to say, the IVRTM with learning platforms and VR assistance in the SLA teaching was obviously better than the traditional teaching method.

### Results and analysis of recording text in oral English practice

In the last oral English practice of the term, the students of the two classes were asked to do role-plays and complete an oral topic of the same situation within 3 min. All of the dialogues were recorded, and the data of recording text were taken statistically and analyzed (Table 6). Mean scores were from the average score of teacher's evaluation, peer's evaluation, and machine evaluation.

According to the statistics, the results of the comparative data indicated Class 2 did better than Class 1 in all of the aspects, including mean score, interaction frequency, speech speed, average interaction duration, average sentence length, and words ratio used in Band 4 College English Test vocabulary, in spite of the gap of average sentence lengths not particularly

TABLE 5 Independent sample test of post-test.

MS		SD		<i>F</i>	<i>P</i>	<i>t</i>	<i>f</i>	Sig. (two-tailed)	95% CI	
Class 1	Class 2	Class 1	Class 2						Lower	Upper
67.819	73.146	6.641	10.832	11.519	0.001	3.114	108	0.002	1.930	8.762

MS, mean scores; SD, standard deviation; CI, confidence interval.

significant. From the data, the blended teaching with VR assistance promoted the students' communicative ability.

## Results and analysis of questionnaire

The questionnaire on the students' attitudes toward the IVRTM was performed among the experiment group, and the statistics are shown in [Table 7](#).

According to [Table 7](#), the proportions of acceptability were 83.64, 72.73, 94.5, and 100% separately for the improvement of language competence, learning enthusiasm, learning efficiency, and learning engagement. As for Item 5 "be able to decrease learning anxiety," 56.36% of students took a positive attitude toward it. According to the statistics of Item 7, 80% of students accepted the IVRTM adopted in the SLA teaching and thought that it was better than the traditional teaching model. They preferred VR-assisted teaching in the online-offline fusion ecological environment.

As for the open question "Is the IVRTM conducive to improving your autonomous learning ability," 44 out of 56 students answered it positively; 80% of students thought that they searched materials on the internet, grouped them on their own, and shared them with their classmates, which were beneficial to cultivate their autonomous learning ability. What's

more, they discussed some questions with others online. They said that the learning model was completely different from the traditional one. They just had completed some written homework assigned by their teachers before. On the contrary, the IVRTM forced them to search for a lot of learning materials, sort them out and think independently. About 80% of the students accepted the IVRTM completely and thought that the flipped classroom in the IVRTM fully mobilized their learning enthusiasm and autonomy, and multimodal tasks improved their English comprehensive competence. And 20% of them thought of it oppositely. They claimed that online-searching information was time-consuming and laborious. They admitted that they sometimes drifted down to unrelated links uncontrollably and suggested that more supervision was needed in their learning process.

For another question "What do you think of VR technology used in the IVRTM," 100% of students thought that VR-assisted learning offered them a completely different learning experience, full of novelty and interest in learning. In addition, they could select some tasks for personalized learning. They also pointed out that the IVRTM had some positive effects on them. For example, compared with the previous relaxing learning style, they are accustomed to pre-lesson. If there were some problems, they would think independently and discuss with peers to discover the solutions to the problems rather than entirely relying on their teachers. They changed their learning concept from "learning how to learn" to "learning autonomously" ([Fiore and Rosenquest, 2010](#)). They admitted that the IVRTM needed more self-discipline and effort definitely.

## Results and analysis of big data on the platform

There were some Big Data OF the learning platforms collected and analyzed as follows ([Table 8](#)).

According to [Table 8](#), the student's attendance rate (98.5%) in Class 2 was obviously higher than that (82.8%) in Class 1, and it was the same in other aspects, such as study duration, discussion frequency, question frequency, and share frequency. The results of descriptive statistics indicated that the students in Class 2 were more engaged in the learning than those in Class 1 obviously. Therefore, a reasonable interpretation of the difference would contribute to the different teaching

TABLE 6 Analysis of oral English recording text.

Class 1	Class 2	Items
6.24	7.09	Mean scores
17.1	25	Interaction frequency
97.36	109.18	Speech speed
2.15	2.81	Average interaction duration
12.21	12.27	Average sentence length
13.4%	18.27%	Words used in Band 4 College English Test Vocabulary

TABLE 7 Data statistics of questionnaire survey.

Items	Questions	Acceptability index
1	Be able to improve language competence	83.64%
2	Be able to improve learning enthusiasm	72.73%
3	Be able to improve learning efficiency	94.50%
4	Be able to improve learning engagement	100%
5	Be able to decrease learning anxiety	56.36%
6	Approval of using VR-assisted Smart Class	100%
7	Better than traditional teaching model	80%

TABLE 8 Statistics of big data.

	Attendance rate	Study duration (weekly)	Discussion frequency (per period)	Question frequency (per period)	Share frequency (per period)
Class 1	82.8%	0.8–1 h	0.26 times	0.13 items	0.12 times
Class 2	98.5%	10.12–12.78 h	5.41 times	3.74 items	4.23 times

method—IVRTM, which activated the students' multimodal perceptions and learning enthusiasm for higher learning effectiveness. The students were motivated to work hard and efficiently under the guidance of the IVRTM in the VR-assisted spatial fusion learning environment. Most of the students in the experiment group accepted the IVRTM and made some progress in their academic performance. More importantly, the IVRTM had an effect on their learning styles, especially effective time management, learning cooperation, and autonomous learning.

## Results and analysis of interviews

The researcher made an interview with five students about the IVRTM and the reduction of learning anxiety. The following is the recording of their interviews.

*Participant 1: Of course, the VR-assisted teaching itself can lower our anxiety in oral practice. However, the pre-class, in-class and after-class preparations need more efforts. I spend much more time on autonomous learning, which puts a great pressure on me.*

*Participant 2: The VR-assisted learning offers me an interactive learning environment, full of real-time feedbacks and dynamic personalized learning. But I feel anxious. And sometimes the situation is counter-productive. It is difficult for me to keep up with the teaching schedule and complete all of the tasks because of my low English proficiency.*

*Participant 3: The IVRTM requires us to study independently and the fusion learning environment promotes me to work actively. In practice, I am forced to improve my time management skills and adapt myself to the new learning role from a passive knowledge recipient to an autonomous learner.*

*Participant 4: I think I should overcome some bad learning habits, like delay of homework, to keep up with learning schedule. I'm lack of self-discipline, texting to my friends and playing games online instead of learning English occasionally.*

*Participant 5: The IVRTM gives me a new experiential learning by using a new technology. VR assistance in teaching as an "easy to use," "helpful," and "enjoyable" tool (Shen, 2021) can reduce my psychological anxiety when practicing oral English. However, I still had a little interactive anxiety in real face-to-face situations. I guess it would be better after a longer time practice.*

To sum up, the students consistently admitted that VR-assisted could lower their anxiety definitely in oral English practice. They had a visual-real experience in scenario dialogue in an IVR setting, in which they experienced a "real" situation without any anticipatory anxiety as it was in the real one. The visual practice made them relaxed when making a human-computer conversation without face-to-face awkwardness in reality. The virtual characters taught them to use correct and accurate speech and proper communicative skills and awareness of cultural differences. In real situations, they would make use of the correct speech that they had acquired from the virtual situations.

As for the issue of decreasing anxiety with a low approval rate (56.36%), the students admitted that the pressure mainly came from the whole learning process instead of VR-assisted learning itself. Thanks to VR assistance, they had less communicative anxiety encouragingly. Learning stress and anxiety were due to the compacted online-offline learning arrangement under the guidance of the IVRTM. Therefore, good time management and autonomous learning habits were helpful for their catching up with the learning schedule.

## Conclusion

This study investigated the effectiveness of the teaching design scheme called the IVRTM on a small learner population at the researcher's university. The researcher made a teaching design of a spatial fusion environment, extending the physical classroom to a 3-layer ecological class involved in classroom teaching, online teaching, and VR-assisted teaching. It aims for the effectiveness of the IVRTM in a spatial fusion ecological class, uncovering the VR-assisted positive effect on oral English practice, and acquiring the students' attitudes toward the IVRTM. 109 participants in the empirical study completed the learning tasks over a term. The study approaches were adopted including literature review, empirical method, questionnaire, interviews and data statistics, and analysis. There were some findings as follows.

## Findings

- (1) The IVRTM was better than the traditional teaching method, which activated the students' multimodal perceptions to acquire higher learning efficiency. The

research would have a positive significance for the promotion of new technology applications in SLA teaching. It provided novel and preliminary references for teachers pursuing an effective teaching design of ecological class based on IVR spatial fusion, for there were few research on the combination of online-offline fusion with VR assistance. According to the questionnaire, the IVRTM was accepted by the majority of the students about 80% (44 out of 56) in Class 2, which indicated the fact that the students in the experiment group generally recognized the advantages of the IVRTM. What's more, the students' high learning engagement indicated the acceptability of the IVRTM, such as attendance rate, learning duration, and frequencies of posts, discussions, and questions. And the students made significant progress in the final exam and gained development in several aspects, like autonomous learning, cooperative learning, and independent thinking according to the interviews. It was true that the IVRTM enhanced high feasibility and acceptability in the experiment group, which implied its good prospect of further promotion in the future.

- (2) Through the research on the recording text of the students' oral practice, the participants in the experiment class performed better in all aspects, such as mean scores, interaction frequency, speech speed, average interaction duration, average sentence length, and words ratio of Band 4 College English Test vocabulary. VR assistance had a positive and significant effect on the students' spoken competence. According to Item 6 of the questionnaire, about 80% of students accepted and welcomed the application of VR technology in teaching.
- (3) Moreover, the students in Class 2 gained more learning styles, time management methods, autonomous learning habits, and novel thinking ways according to the interviews. The cultivation of comprehensive literacy in Whole-Human education was regarded as one of the most important advantages of the IVRTM.
- (4) VR-assisted learning could reduce the students' anxiety, especially in oral practice. Although the procedural learning of the IVRTM was tense and compacted, VR-assisted learning made them relaxed. According to the interview, the VR-assisted training avoided face-to-face interactions due to awkward incorrect language usage and use among peer students. VR digital technology could activate the students' multisensory modes for language acquisition (Hu et al., 2021), which fully mobilized their vision, hearing, taste, smell, and other senses to complete language acquisition in the novel, creative and immersive space, experiencing the interactive situations with "real presence" (Rubin, 2005). VR-assisted learning promoted the students' interest and enthusiasm, beneficial to learning efficiency in the SLA.

## Limitations

There were several limitations of the study.

- (1) The safety of online information should be taken into consideration. It is important for the students to establish an awareness of safety on the internet, especially in the application of new technology in the future.
- (2) Learning duration online is another important issue. Long-time online learning may be harmful to the students' health as a result of the diminution of vision, hypoplasia, and headache. So, limiting online learning time could avoid some negative effects on young people.
- (3) Further enlarging the study samples in scope and quantity would make the experiment results more valid and reliable, for only 56 students were recruited to participate in the experiment in the study. More samples should be selected from different grades and colleges to test the validity of the study. Therefore, a wider range of students would be recruited for the future study.
- (4) Financial support was necessary for the IVRTM promotion, for it needs a great deal of investment in devices, like Smart Class with VR equipment, projects, and related digital technology.
- (5) Last but not least, it was a lack of further duplicated IVRTM empirical teaching in the control group due to the time limit. More duplicated teaching experiments for different samples would be followed and more findings gained in the further research, which would provide more references for the validity and reliability of the IVRTM.

## Discussion

This study created the IVRTM and verified its significant teaching effectiveness among a small learner population of the two different classes. The students could get higher learning effectiveness under the guidance of the IVRTM based on POA theory. It uncovered the positive effect of VR and digital ecological technology in the SLA teaching in an ecological environment based on spatial fusion. VR-assisted teaching in oral English practice promoted the students' communicative competence. Most of the students (about 80%) accepted the IVRTM and new technologies used in teaching and learning according to the questionnaire. Multimodal teaching was helpful to stimulate learners' visual, auditory and tactile perceptions by listening, speaking, reading, writing, and imitating for improving learning efficiency. The research results supported and authenticated all the previous hypotheses of the study, answered the research questions raised in the preface and achieved the stated research goal.

Combined with the relevant literature references, the research results in this study were consistent with those in



their studies. For instance, the construction of ecological classes and a smart learning environment could make learning and teach more effective (Zhen, 2017; Xie, 2019). Big Data science and learning analytics in education made educators' master learners' learning status more convenient, especially helpful for the procedural learning management (Milicevic et al., 2017).

The IVRTM has broad research prospects in the learning process, learning management, and learning psychology. Big Data on the learning platform could be used in a variety of fields, gradually covering data analysis, education policy guidance, learning model development, personalized demand analysis, and application iteration (Jayashankar, 2018). VR assistance in the interdisciplinary cooperation mechanism also greatly promotes the narrative communication of the metaverse. It can also be viewed that each educational innovation needs thinking about how to realize the interconnection of various mass media in the embodied and digital times. A new chapter of multi-spatial education with new technologies is open in the new times. Take multimodal teaching, for example, research on photos, pictures, texts, etc., will be beneficial to learners' emotional changes in the learning process. Of course, there are still limitations of the IVRTM mentioned above, such as distraction from computer games, internet safety, and further research in depth and width. Not all schools have enough investment in smart teaching, so it is important to raise more money for education and achieve educational equality. In addition, the mastery of teachers' educational technologies is also very important, and educational technology training plays a key role in teachers' professional growth.

The study was based on one-term experimental teaching and uncovered the positive impact of the ecological environment. The research proved the fact that the IVRTM was better than the traditional class for higher learning effectiveness. Digital and VR technologies were helpful to stimulate learners' visual, auditory and tactile perceptions for promotion of learning efficiency (Yang and Gou, 2020) as well as students' comprehensive literacy (Zhang, 2011). Data analysis enabled teachers to comprehensively evaluate students' academic performance, giving them feedback and personalized instruction (Zhang and Li, 2013). The study made significant contributions to multi-spatial fusion teaching combining online-offline English teaching with VR assistance through its unique teaching model, which would have a novel and positive significance for the promotion of new technologies in education. The findings would be strong proof that the IVRTM was an effective teaching model of ecological class based on spatial fusion.

In the future, the "AI + Education" model will be integrated into multiple disciplines and a combination of multidisciplinary research, education management, and educational evaluation with educational technology. Furthermore, multi-linguistic research will become the trend of the SLA with the development of diversification in the world (Wen and Wang, 2004; Zhang, 2011). Faced with the new situations,

teachers' training is demanding and urgent, not only in educational technology but also in educational concepts (Marsh and Boag, 2013). The online-offline hybrid and technology-enhanced teaching and learning model breaks through the physical boundary and extends a three-layer fusion space. An ecological learning environment based on multi-space fusion is demanding in future education development (Zhang, 2011). Informatization, digitalization, and virtualization will constantly deepen technological application to promote the integration of smart teaching, smart management, smart evaluation, smart research, and Smart equipment in educational innovation (Xie, 2019).

## Data availability statement

The original contributions presented in this study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

## Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the patients/participants or patients/participants legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

## Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

## Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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# Early Detection of College Students' Psychological Problems Based on Decision Tree Model

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## OPEN ACCESS

### Edited by:

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### Specialty section:

This article was submitted to  
Cognition,  
a section of the journal  
Frontiers in Psychology

**Received:** 18 May 2022

**Accepted:** 20 June 2022

**Published:** 10 August 2022

### Citation:

Huang Y, Li S, Lin B, Ma S, Guo J and  
Wang C (2022) Early Detection of  
College Students' Psychological  
Problems Based on Decision Tree  
Model. *Front. Psychol.* 13:946998.  
doi: 10.3389/fpsyg.2022.946998

The paper starts with the research on the early discovery of college students' psychological problems. Besides, it analyzes the data of the general survey of college students' mental health in a certain university, the existing data of students with psychological problems, and the questionnaire data of students' basic information in school. By comprehensively using the decision tree model and Kendall correlation analysis and other methods, using Python and SPSS software to preprocess the data and realize the model, it can obtain a psychological problem prediction model based on the objective behavior data of college students. The model is actually analyzed, and it gets good results.

**Keywords:** ID3 algorithm, Python, SPSS, decision tree model, Kendall correlation coefficient, psychological problems

## INTRODUCTION

At present, people's lives are objectively confronted with the contradiction between the growing demand for a better life and the unbalanced and insufficient development. Psychological problems of varying degrees often occur due to pressure from various sources. Through the research on people's mental health status by Chinese scholars in the past 20 to 30 years, and the first blue book on mental health in China, "Report on the Development of Chinese National Mental Health (2017~2018)" shows that the psychological problems of different groups in China are increasing day by day." The report said that 11% had poor mental health and had mild to moderate psychological problems; 2–3% had poor mental health and may have moderate to severe psychological problems. For the college students in our country, this group has just entered adulthood and is about to enter the society. They often face pressure and confusion in terms of study, employment, love, family and other aspects. There is a high chance of lack of self-healing ability in times of stress. In recent years, vicious incidents caused by the mental health problems of college students have emerged one after another. The embarrassing extreme behavior of these college students is a devastating disaster for themselves and their families. It not only affects the normal teaching management of the school and the reputation of teaching and educating people, but also affects the surrounding classmates, teachers, and friends have serious psychological burdens, and they will spend a lot of time, energy, and personal wealth in the school to deal with crisis emergencies, and may become one of the sources of social disharmony and instability.

Therefore, in the management of college students, it is necessary to pay attention to the construction and improvement of the early warning mechanism for high-risk groups of psychological problems for college students. It actively does a good job in the prevention and intervention of high-risk groups of psychological problems. It is of great significance to enhance the physical and mental health of college students and promote the construction of a harmonious society (Pang, 2016).

The United States is the first country to pay attention to the psychological problems of college students and establish a psychological counseling center. In the 1870s, the University of Pennsylvania established the first psychological counseling clinic (Fayyad et al., 1996), which realized the combination of education and psychology, and enabled college students to pass the knowledge of psychology. If they come to receive mental health education, psychologists and students will become good teachers and friends. Psychologists discover the psychological problems of students in the process of communicating with students, so as to carry out psychological intervention. For the first time, it classifies different ages, genders and races to carry out targeted psychological. The research established a psychological book corner and a psychological counseling station for classmates, which greatly reduced accidents caused by psychological problems (Zhao, 2020).

Compared with developed countries, domestic college students' psychological research is relatively late. At the beginning of the 20th century, my country's colleges and universities achieved certain results in the early warning and intervention of college students' psychological crisis (Cheng, 2018). Guo Lan and Gong Yu established a psychological intervention system in "Essential Crisis Prevention and Crisis Beyond Crisis—Construction and Operation of College Students' Psychological Crisis Early Warning System" (Guo and Gong, 2008). Gao Lifang's "On the Construction of the Management Mechanism of College Students' Psychological Crisis Early Warning" (Gao, 2014) proposed the construction of a psychological intervention system at the home and school levels. Liu Jing's "Psychological Crisis Intervention of College Students and College Students' Psychological Archives" (Liu, 2015) greatly improved the real-time nature of psychological crisis intervention by constructing personal psychological archives.

At present, major colleges and universities basically have their own college students' mental health assessment system. After the college students' mental health assessment work is carried out every year, a large amount of data will be generated. Precise and effective psychological counseling and intervention is very likely to save a young life. However, due to the obvious discrepancy between the predicted results obtained by the general survey questionnaire on college students' mental health and the actual situation, the paper redesigned the questionnaire, and selected the decision tree classification algorithm in data mining (Sun, 2020) according to the actual situation of the university. The students' basic information questionnaire data in colleges and universities were analyzed and a mental health early warning model was obtained. According to the combination of ID3 algorithm

and decision tree model, early detection and effective intervention of psychological problems of college students can be achieved to prevent the occurrence of tragedies caused by psychological problems of college students (Zhang et al., 2008, 2011).

## DATA SELECTION AND PRE-PROCESSING

### Research Ideas

Firstly, it cleaned the missing and wrong data in the questionnaire data set. Then the attributes of the data set are assigned. Finally, the data is screened twice. Firstly, time removes the attributes that are weakly related to this research; Secondly, according to the Kendall correlation analysis and the significant attributes of this study were incorporated into the decision tree model (Wu et al., 2011).

### Analysis of the General Survey Data of College Students' Mental Health

The school has been using the general psychological health survey questionnaire for college students for analysis. According to the results of the data, students have psychological problems to talk to, so as to find out students with psychological problems and intervene. In the questionnaire, there are reasons such as avoidance, self-protection, perfunctory answering, and subjective judgment bias, resulting in a low degree of overlap between students who actually show psychological problems and those selected by the questionnaire, so it is necessary to redesign a set of questionnaires. The questions of the questionnaire are mostly direct questions about the emotional state of the respondents. In order to avoid inaccurate and ambiguous answers due to problems such as strong subjectivity and poor quantification, the types of questions involved in the new questionnaire should focus on students' objective information, behavioral performance and quantifiable principles, and the prediction model established based on reliable data research is imminent to warn college students' psychological problems (Wen et al., 2021).

### Research Objects

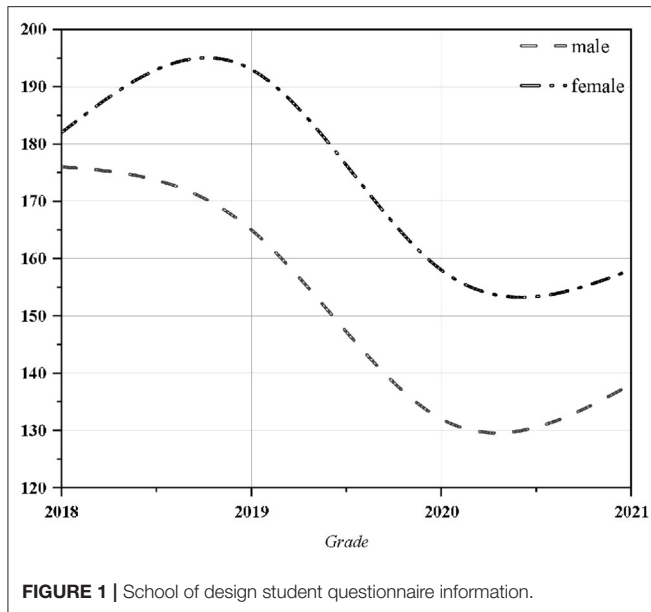
The data set of this research is collected from all students of the 2018–2021 design school of a university in Guilin. The data were obtained through psychological questionnaires organized by counselors in class meetings (Zhou and Guo, 2013; Xin et al., 2019). The specific information is as follows.

Statistics of the four grades of the School of Design were collected. As can be seen from the **Figure 1**, a total of 1,302 valid questionnaires were received, including 611 questionnaires for boys and 691 questionnaires for girls more balanced.

### Data Collection

After the data collection is completed, in order to facilitate the research, we have made custom assignments to the 30 variables in the following table (Yu and Wang, 2019), as shown in **Table 1**.





## Data Selection

In the questionnaires filled in, there are many attributes that are weakly related to this research. According to basic common sense and searching for relevant information, it deletes irrelevant factors such as class, student number, name, ethnicity, etc. Then it confirms the remaining attributes and Del (Kendall) correlation analysis (Zhang et al., 2000).

Using statistical analysis software *spss*, it selects Kendall correlation analysis, and gets the results as shown in **Table 2**.

According to the results of Kendall's correlation analysis (Zhang et al., 2000; Li et al., 2008), "Academic Performance," "Number of Leave Requests," "whether there is a Medical History," "whether there is a history of taking drugs," "whether you have experienced School Bullying," "whether you have The *p*-values of "Experience of School Leave," "Self-eating Pattern," and "Self-sleep Quality" were all  $<0.01$  (Xin et al., 2012), which was why they were included in the decision tree model. According to my country's 2020 Blue Book on Mental Health, "Report on the Development of Chinese National Mental Health (2019–2020)," nearly 20% of college students have different degrees of psychological problems. For this reason, we assign scores to the questionnaire. After sorting, in addition to students with actual psychological problems as positive samples, the top 20% of the data samples are taken as positive cases to construct the model (Wang et al., 2000; Xin et al., 2012).

The psychological scores of the students are shown in the **Figure 2**.

As can be seen from the above **Figure 2**, the highest score of students' psychology is 12 points, and the lowest score is 0 points. It is reasonable to take 4 points as the sample boundary. Therefore, students with actual psychological problems are excluded as positive samples, and students with psychological scores  $>4$  points are set. It sets as a positive case, and construct a decision tree model.

## III. DECISION TREE - EARLY WARNING MODEL OF COLLEGE STUDENTS' PSYCHOLOGICAL CRISIS

### Research Ideas

Firstly, through designing the questionnaire (Zhang, 2012) of the department, it uses the ID3 algorithm, the decision tree model is implemented to obtain the psychological problem data. Then the conclusion is verified according to the questionnaires of the students of the information department of the school. The specific implementation process is shown in **Figure 3**.

### Related Concepts

Decision tree is a basic classification and regression method (Zhang, 2012). We mainly use decision trees for classification. The decision tree model has a tree structure, and in classification problems (Ma, 2019), it represents the process of classifying instances based on features. When learning, use the training data to build a decision tree model. When predicting, the new data is classified by using the established decision tree model. The ideas of these decision tree learning mainly include ID3 algorithm (Qu et al., 2003), C4.5 algorithm (Li et al., 2013) and CART algorithm (Chen and Xia, 2011).

The algorithm of decision tree learning is usually a process of recursively selecting the optimal feature and dividing the training data according to the feature, so that each sub-data set has a best classification process. This process corresponds to the division of the feature space and the construction of the decision tree. Firstly, it builds the root node, selects the optimal feature of all training data, and divides the dataset into subsets according to this feature. So that each subset has a best classification under the current conditions; if it has been basically correctly classified, then build a leaf node divide these subsets to the corresponding leaf nodes; if there are still subsets that are not correctly classified, select new optimal features for them and continue to divide; then build corresponding nodes; until all training data subsets are correctly classified or end without the proper feature. Finally, a decision tree can be generated.

### Decision Tree Splitting Based on ID3 Algorithm

ID3, C4.5, and CART algorithms are the most common used algorithms in decision tree algorithms. For this article, we study mental health-related data. Due to the large number of discrete data and the small amount of attribute values, comprehensive consideration, the ID3 algorithm was chosen to classify this study. In the ID3 algorithm, the decision tree is constructed recursively by selecting features corresponding to the information gain criterion on each node. The process starts from the root node, calculates the information gain of all possible features, and selects the feature with the largest information gain as the node feature; then establishes child nodes with different values of this feature, and then uses the recursive method to call the above method to construct a complete the decision tree (Zhang and Ning, 2015).

In constructing a decision tree, it is necessary to determine its split nodes, and the determination of split

**TABLE 1** | Questionnaire attribute assignment table.

Variable	Assignment
1 Gender	Female = 0, male = 1
2 Year	Freshman = 1, Sophomore = 2 Junior = 3, Senior = 4
3 Is it a student cadre?	Yes = 0, No = 1
4 Have you ever received an award during college?	Yes = 0, No = 1
5 No punishment during college	No = 0, Yes = 1
6 Your academic performance is	good = 0, average = 1, poor = 2
7 What do you think your personality traits tend to be?	More extroverted = 0, more introverted = 1
8 What is the average number of requests for leave during the semester in college?	Less than 3 times = 0, more than 3 times = 1
9 What are the types of leave?	More personal leave = 0, more sick leave = 1
10 Family composition	Single parent = 0, double parent = 1, orphan = 2, divorced parent = 3
11 Is it an only child?	Yes = 0, No = 1
12 How is the family economy	generally = 0, rich = 1, poor = 2
13 What is the relationship between family members?	Generally = 0, disharmony = 1, harmony = 2
14 The degree of self-perceived learning pressure during university is relatively	small = 0, generally = 1, and relatively high = 2
15 Has there been or is a major family emergency	No = 0, Yes = 1
16 Whether there is domestic violence among family members	Never = 0, Ever = 1, Always = 2
17 Are you physically disabled?	No = 0, Yes = 1
18 Do you have any medical history?	No = 0, Yes = 1
19 No history of taking medication since	No = 0, Ever = 1, Always = 2
20 Have you ever experienced school bullying?	No = 0, ever = 1, always = 2
21 Has there been any conflict between teachers and students?	No = 0, once = 1, always = 2
22 Average absenteeism during the semester in college	No = 0, Occasionally = 1, Frequent = 2
23 Have you ever taken a leave of absence from school?	No = 0, Yes = 1
24 Average participation in various group activities during the semester in college	More than 3 times = 0, <3 times = 1, never participating = 2
25 Self-employment pressure	generally = 0, less = 1, greater = 2
26 Personal hygiene status	Don't care = 0, generally = 1, very important = 2
27 Contradictions in the dormitory	Good=0, Fair=1, Poor=2
28 Self-eating rules	Good = 0, Average = 1, Poor = 2
29 Are you keen on computer games?	Dislike = 0, generally = 1, like = 2
30 Self-sleep quality	Good = 0, average = 1, poor = 2
Psychological situation	Yang 1 if there is a psychological problem, and Yin 0 if there is no psychological problem

**TABLE 2** | Kendall analysis results.

Number	Influencing variable	Correlation coefficient	P-value
1	Academic performance	0.073	0.008
2	Number of leave requests	0.085	0.002
3	Is there a medical history	0.095	0.001
4	Whether there is a history of taking medication	0.151	0.000
5	Have you ever experienced school bullying?	0.070	0.012
6	Whether there is a leave of absence experience	0.065	0.019
7	Own diet	0.090	0.001
8	Own sleep quality	0.094	0.000

nodes needs to be divided by certain rules and attributes. In the ID3 algorithm, the attribute we refer to is mainly information gain.

Assuming that  $K$  is a training sample set, this sample set contains  $n$  samples of categories, then  $n$  different classes  $C_i$  ( $i = 1, 2, 3, \dots, n$ ) can be defined, and the probability of  $C_i$  is represented by  $p_i$ . The following formula can be derived:

$$Info(K) = - \sum_{i=1}^n p_i \log_2 p_i \quad (1)$$

$Info(K)$  is called entropy, it describes the purity of any sample set. Entropy can represent uncertainty. The greater the uncertainty of the variable, the greater the entropy value. The value of entropy ranges from 0 to 1.

Assuming that the  $K$  sample of is divided according to attribute A, then there  $K_j$  is the  $j$ th subset divided according to attribute A, then the following formula is obtained:

$$Info_A(K) = - \sum_{j=1}^m \frac{|K_j|}{|K|} Info_A(K_j) \quad (2)$$

$Info_A(K)$  called sample entropy, it expresses the expected information for dividing  $K$  based on attribute  $A$ .

Through the above two formulas, its information gain can be calculated, and the formula is as follows:

$$Gain(K, A) = Info(K) - Info_A(K) \quad (3)$$

$Gain(K, A)$  is for the information gain, it also known as the amount of information acquisition (Information Gain). Information gain is the information about the value of the objective function due to the value of a given attribute (Li et al., 2005).

In the process, we select the test attribute with the largest information gain as the root node of the decision tree. Then it

generates the first decision tree, and then recursively perform the above process for each leaf node. Finally, it obtains a complete classification decision tree.

## The Process of Building a Decision Tree

To build a psychological crisis prediction model, from the data screened above, there are 8 attributes to be added to the decision tree, namely academic performance, number of leave requests, medical history, medication history, campus bullying, school leave experience, eating patterns, sleep quality, and the value of its properties. The final dataset is used for model training. To keep the results clean and uncluttered, start by naming the eight attributes of its dataset with abbreviations, as show in Table 3.

In the obtained training set samples  $K$ , we pass the real results and add the assigned values, a total of 222 are positive, and 1,085 are negative, so the entropy of the training set is calculated as:

$$\begin{aligned} Info(K) &= -\frac{222}{1307} \log_2 \frac{222}{1307} - \frac{1085}{1307} \log_2 \frac{1085}{1307} \\ &= 0.6573721232057073 \end{aligned} \quad (4)$$

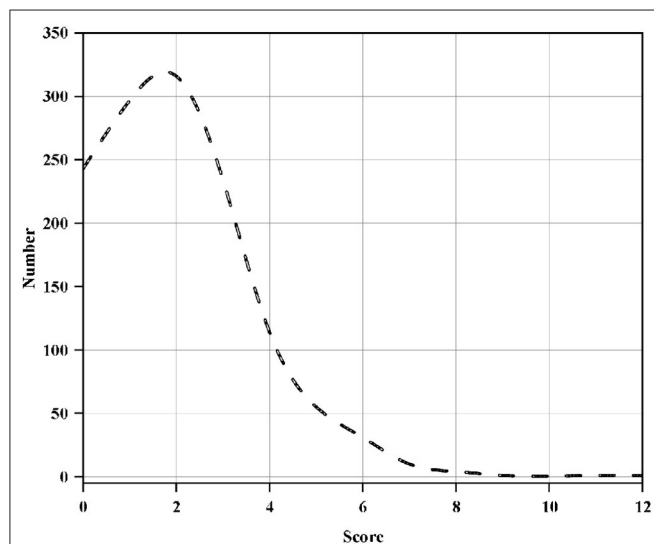


FIGURE 2 | Student psychological score pie chart.

TABLE 3 | Variable symbol description.

	Property	Abbreviation
1	Academic performance	CJ
2	Number of leave requests	QJ
3	Medical history	BS
4	Medication history	FYS
5	School bullying	BL
6	Leave of absence	XX
7	Diet	YS
8	Sleep quality	SM

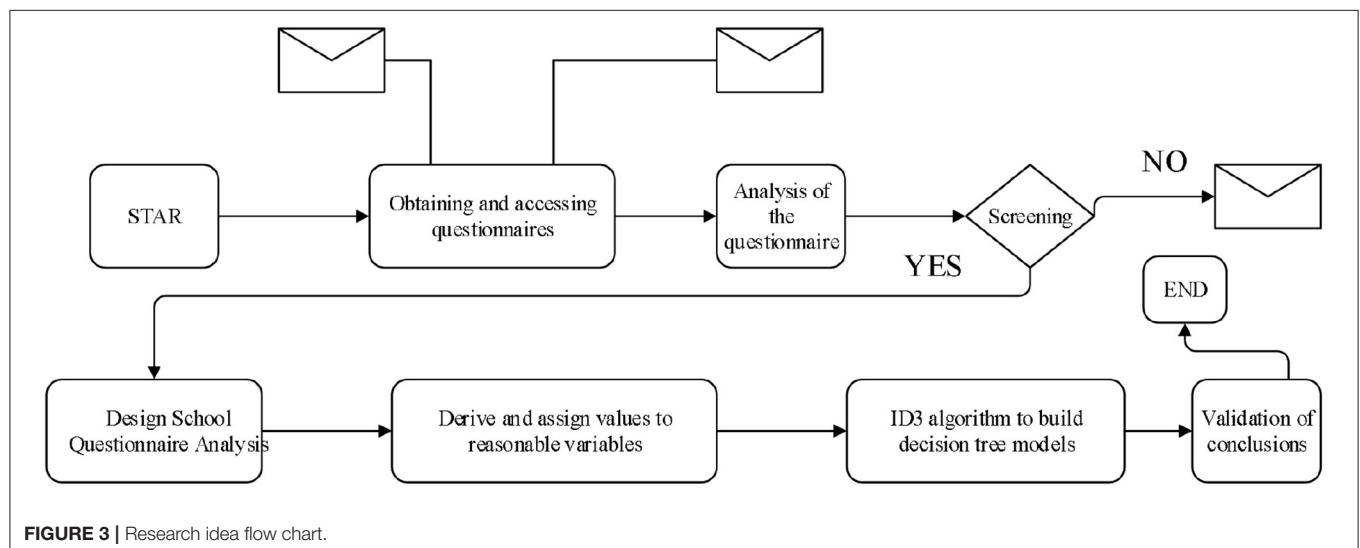
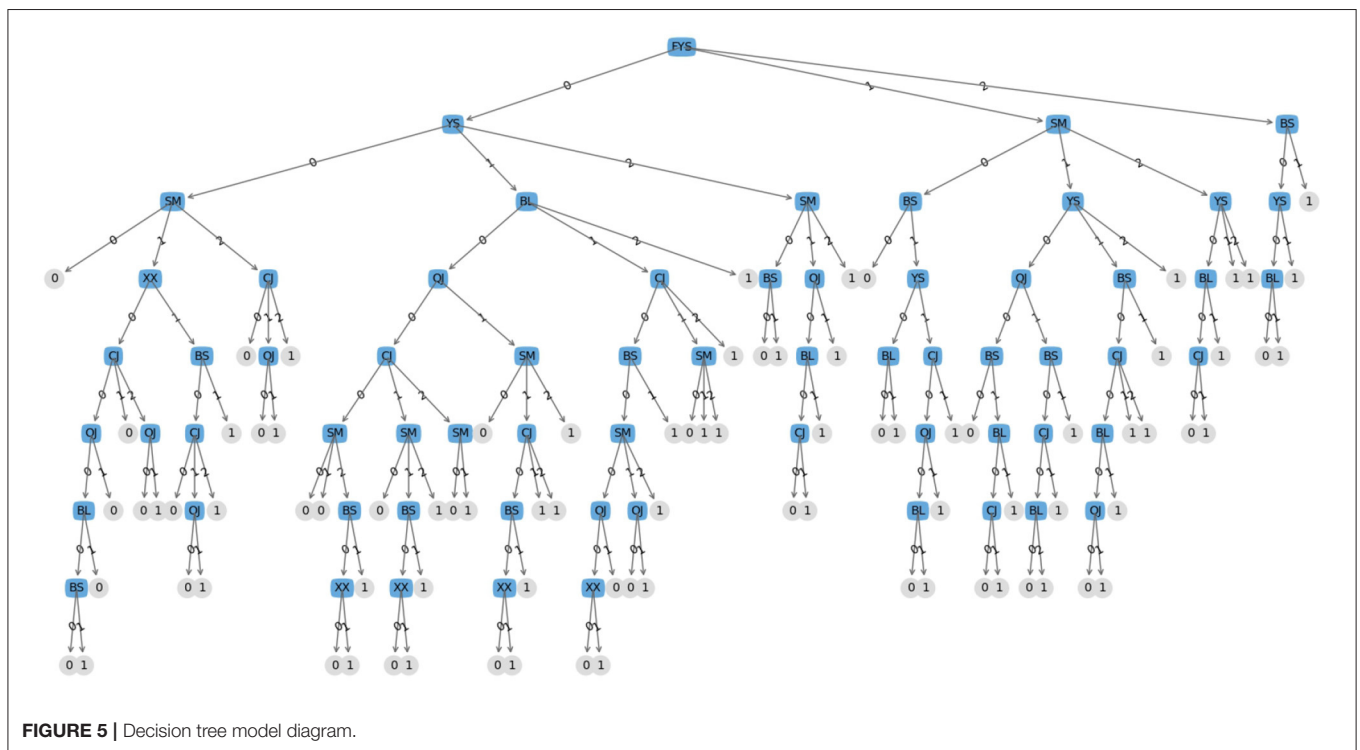
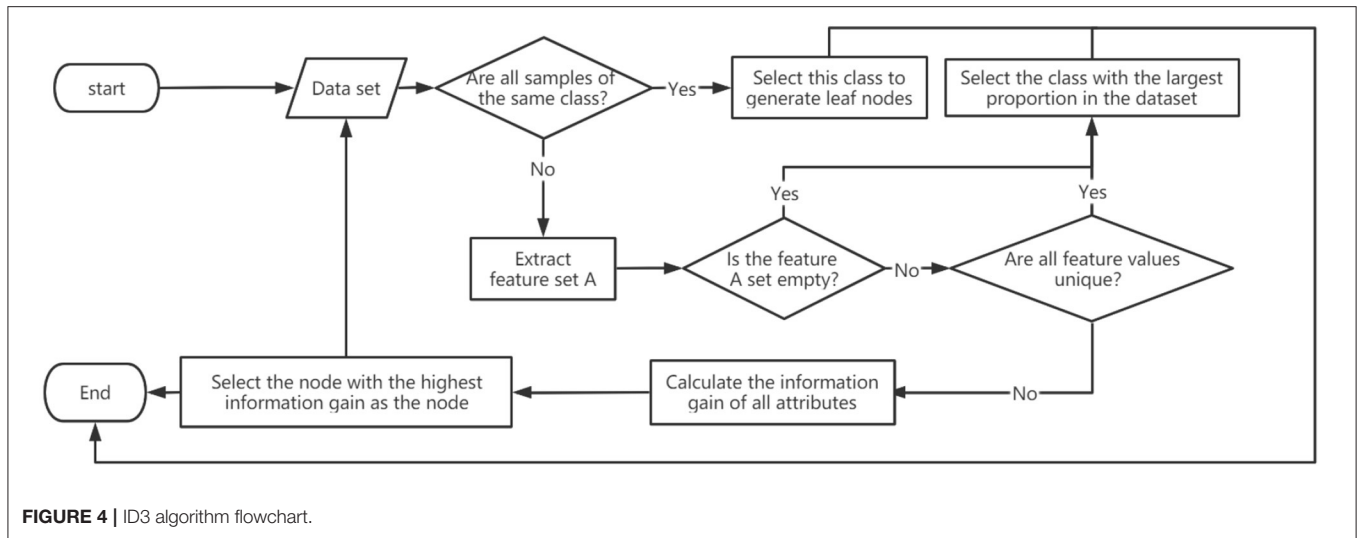


FIGURE 3 | Research idea flow chart.



The sample entropy and information gain corresponding to the attributes of academic performance, number of leave requests, medical history, medication history, school bullying, school leave experience, dietary pattern, and sleep quality are calculated below (Li and Xin, 2008).

In terms of academic performance, there are three attribute values 0, 1, and 2, and the sample data are 1,021, 258, and 28, respectively. There are 123 positives and 898 negatives of psychological crisis with attribute value 0; 83 positives and 175 negatives with attribute value 1; 16 positives and 12 negatives with attribute value 2. It calculates its sample entropy as:



**TABLE 4 |** Psychological crisis judgment **Table 1.**

Number	Rule
1	Medication history: none, dietary pattern: good, sleep quality: average, school leave experience: no, academic performance: good, number of leave requests: <3 times, school bullying: no, medical history: yes
2	Medication history: none, dietary pattern: good, sleep quality: average, school leave experience: no, academic performance: poor, number of leave requests: more than 3 times
3	Medication history: none, eating pattern: good, sleep quality: average, school leave experience: yes, medical history: no, academic performance: average, number of leave requests: more than 3 times
4	Medication history: none, eating pattern: good, sleep quality: average, school leave experience: yes, medical history: no, academic performance: poor
5	Medication history: none, dietary pattern: good, sleep quality: average, school leave experience: yes, medical history: yes
6	6 Medication history: none, dietary pattern: good, sleep quality: poor, academic performance: average, number of leave requests: more than 3 times
7	Medication history: none, eating pattern: good, sleep quality: poor, academic performance: poor
8	Medication history: none, dietary pattern: general, school bullying: none, number of leave requests: <3 times, academic performance: good, sleep quality: poor, medical history: no, school leave experience: yes
9	9 Medication history: none, dietary pattern: general, school bullying: none, number of leave requests: <3 times, academic performance: good, sleep quality: poor, medical history: yes
10	Medication history: no, dietary pattern: general, school bullying: no, number of leave requests: <3 times, academic performance: general, sleep quality: general, medical history: no, school leave experience: yes

**TABLE 5 |** Psychological crisis judgment **Table 2.**

Number	Rule
11	Medication history: none, dietary pattern: normal, school bullying: none, number of leave requests: <3 times, academic performance: normal, sleep quality: normal, medical history: yes
12	Medication history: none, dietary pattern: general, school bullying: none, number of leave requests: <3 times, academic performance: average, sleep quality: poor
13	Medication history: none, dietary pattern: general, school bullying: none, number of leave requests: <3 times, academic performance: poor, sleep quality: average
14	Medication history: none, dietary pattern: general, school bullying: no, number of leave requests: more than 3 times, sleep quality: general, academic performance: good, medical history: no, school leave experience: yes
15	Medication history: none, dietary pattern: normal, school bullying: none, number of leave requests: more than 3 times, sleep quality: normal, academic performance: good, medical history: yes
16	Medication history: none, dietary pattern: average, school bullying: none, number of leave requests: more than 3 times, sleep quality: average, academic performance: average or poor
17	Medication history: none, dietary pattern: general, school bullying: ever, academic performance: good, medical history: no, sleep quality: good, number of leave requests: <3 times, school leave experience: yes
18	Medication history: none, dietary pattern: general, school bullying: ever, academic performance: good, medical history: no, sleep quality: average, number of leave requests: more than 3 times
19	Medication history: none, dietary pattern: general, school bullying: ever, academic performance: good, medical history: no, sleep quality: poor
20	Medication history: none, dietary pattern: general, school bullying: yes, academic performance: good, medical history: yes

Through the same steps above, we can finally calculate the information gain of the eight attributes:

$$\begin{aligned}
 Info_{CJ}(K) &= \frac{1021}{1307} \left( -\frac{123}{1021} \log_2 \frac{123}{1021} - \frac{898}{1021} \log_2 \frac{898}{1021} \right) \\
 &+ \frac{258}{1307} \left( -\frac{83}{258} \log_2 \frac{83}{258} - \frac{175}{258} \log_2 \frac{175}{258} \right) \\
 &+ \frac{28}{1307} \left( -\frac{16}{28} \log_2 \frac{16}{28} - \frac{12}{28} \log_2 \frac{12}{28} \right) \\
 &= 0.6145741784450385
 \end{aligned} \quad (5)$$

The information gain of academic performance is as follows:

$$Gain(CJ) = Info(K) - Info_{CJ}(K) = 0.04279794476066878 \quad (6)$$

$$Gain(CJ) = 0.04279794476066878 \quad (7)$$

$$Gain(QJ) = 0.04692457281442097 \quad (8)$$

$$Gain(BS) = 0.10178147259099068 \quad (9)$$

$$Gain(FYS) = 0.13075980120050001 \quad (10)$$

$$Gain(BL) = 0.07277279223941935 \quad (11)$$

$$Gain(XX) = 0.01172718186654953 \quad (12)$$

$$Gain(YS) = 0.1192610978220714 \quad (13)$$

$$Gain(SM) = 0.12125218656041414 \quad (14)$$

**TABLE 6 |** Psychological crisis judgment **Table 3.**

Number	Rule
21	Medication history: none, dietary pattern: average, school bullying: ever, academic performance: average, sleep quality: average or poor
22	Medication history: none, dietary pattern: general, school bullying: ever, academic performance: poor
23	Medication history: none, dietary pattern: general, school bullying: always
24	Medication history: none, dietary pattern: poor, sleep quality: good, medical history: yes
25	Medication history: none, dietary pattern: poor, sleep quality: average, number of leave requests: <3 times, school bullying: none, academic performance: average
26	Medication history: none, dietary pattern: poor, sleep quality: average, number of leave requests: <3 times, school bullying: ever
27	Medication history: none, dietary pattern: poor, sleep quality: average, number of leave requests: more than 3 times
28	Medication history: none, dietary pattern: poor, sleep quality: poor
29	Medication history: yes, sleep quality: good, medical history: yes, dietary pattern: good, school bullying: yes
30	Medication history: ever, sleep quality: good, medical history: yes, dietary pattern: average, academic performance: good, number of leave requests: <3 times, school bullying: ever

**TABLE 7 |** Psychological crisis judgment **Table 4.**

Number	Rule
31	Medication history: ever, sleep quality: good, medical history: yes, dietary pattern: average, academic performance: good, number of leave requests: more than 3 times
32	Medication history: ever, sleep quality: good, medical history: yes, dietary pattern: average, academic performance: average
33	Medication history: ever, sleep quality: average, dietary pattern: good, number of leave requests: <3 times, medical history: yes, school bullying: no, academic performance: good
34	Medication history: yes, sleep quality: average, dietary pattern: good, number of leave requests: <3 times, medical history: yes, school bullying: yes
35	Medication history: ever, sleep quality: average, dietary pattern: good, number of leave requests: more than 3 times, medical history: no, academic performance: good, school bullying: ever
36	Medication history: ever, sleep quality: average, dietary pattern: good, number of leave requests: more than 3 times, medical history: no, academic performance: average
37	Medication history: ever, sleep quality: average, dietary pattern: good, number of leave requests: more than 3 times, medical history: yes
38	Medication history: ever, sleep quality: average, dietary pattern: average, medical history: no, academic performance: good, school bullying: no, number of leave requests: more than 3 times
39	Medication history: ever, sleep quality: average, dietary pattern: average, medical history: no, academic performance: good, school bullying: ever
40	Medication history: ever, sleep quality: average, dietary pattern: average, medical history: no, academic performance: average or poor

**TABLE 8 |** Psychological crisis judgment **Table 5.**

Number	Rule
41	Medication history: ever, sleep quality: general, dietary pattern: general, medical history: yes
42	Medication history: ever, sleep quality: average, dietary pattern: poor
43	Medication history: ever, sleep quality: poor, dietary pattern: good, school bullying: no, academic performance: average
44	Medication history: ever, sleep quality: poor, dietary pattern: good, school bullying: ever
45	Medication history: ever, sleep quality: poor, dietary pattern: average or poor
46	Medication history: always, medical history: no, dietary pattern: good, school bullying: ever
47	Medication history: always, medical history: no, dietary pattern: general
48	Medication history: always, medical history: yes

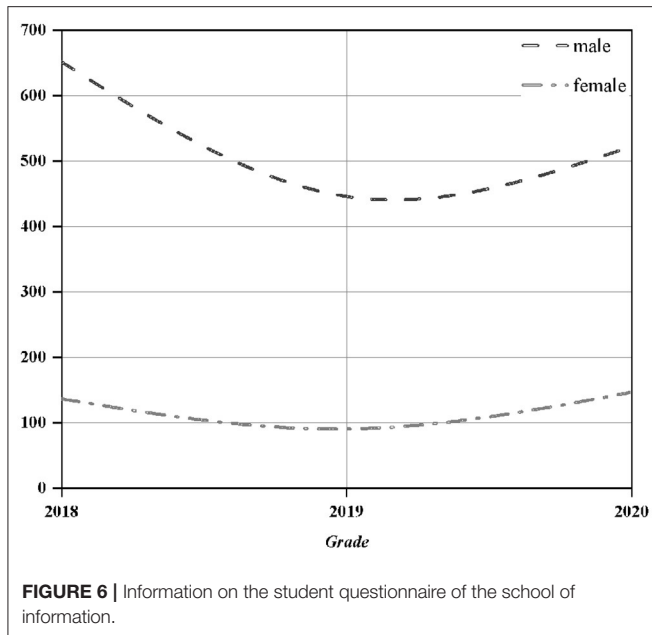
From the above calculation results, it can be seen that the information gain of whether there is a medication history is the largest among all attributes, so the presence or absence of medication history is selected as the test attribute of the root

node, and then the above process is recursively used for each node to generate the final decision tree (Gao et al., 2008) in the following **Figure 4**.

We use the ID3 algorithm to split the decision tree. Firstly, we filter the input data set, calculate the information gain of all attributes. Finally, we select the node with the highest information gain as the node, and continue the process to generate a decision tree. After processing the data and constructing a decision tree (Fan, 2004), and visualizing the obtained decision tree through machine learning actual combat codes are as show in **Figure 5**.

## Result Acquisition

According to the above process and the classification decision tree model, we extract the data with positive results. That is, the data that is finally judged to have a psychological crisis as show in **Tables 4–8**.



## MODEL VALIDATION

Through the construction of the above decision tree, a prediction model about the psychological problems of college students is obtained. The main conclusion is 48 pieces of psychological crisis data. In order to verify the practicability and accuracy of the conclusions, the information of all students in the School of Information Engineering of the school was collected to verify the model. The specific data are shown in **Figure 6**.

The School of Information has collected statistics on the questionnaires of students in three grades. It received a total of 1,950 valid questionnaires, including 1,581 for boys and 369 for girls. The ratio of male to female is in line with the normal ratio of male to female in science and engineering. Among them, psychological events or psychological problems have actually occurred. There are 19 students, and the proportion of males and females in the three grades is similar, which is more suitable as a verification sample.

Through data screening, all the data items in the questionnaire for the model were screened out, including options for eight groups of questions: academic performance, number of leave requests, medical history, medication history, school bullying, school leave experience, eating patterns, and sleep quality. By comparing the 48 psychological crisis data options obtained by the decision tree with the questionnaire data options of these 1,981 students, we finally came to the following conclusions.

The total number of students participating in the survey was 1,981, and 261 were found to need psychological warning through comparison. Among these 261 people, 10 people have actually experienced psychological problems or psychological events, accounting for about 53% of the actual psychological problems or psychological events. Therefore, the model

constructed by the decision tree has good accuracy and generality (Yao and Liu, 2008).

## CONCLUSION

In response to the early discovery of college students' psychological problems, we conducted correlation analysis on the results of the questionnaire, and screened out the attributes that have greater correlation with psychological crisis. Then we used the decision tree-based analysis of the results of the questionnaire to find out the results of academic performance, asking for leave the general relationship between the number of times, medical history, medication history, school bullying, school leave experience, dietary patterns, sleep quality and psychological crisis problems, we can use this questionnaire to understand the students, through the classification decision tree obtained 48 items the psychological crisis conclusion was used to screen out the students who need to focus on and understand. We obtained a psychological problem prediction model based on the objective behavior data of college students. The model was actually verified and analyzed, and the obtained 48 students were classified as possible psychological problems. Or students who may have a crisis event, and establish a file of students with psychological problems, improve the accuracy and effectiveness of psychological early warning, and prevent college students from tragedies due to lack of timely intervention for mental health problems.

## DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because It's confidential. Requests to access the datasets should be directed to yunpenghuang3207@sina.com.

## AUTHOR CONTRIBUTIONS

YH: conceptualization, methodology, software, investigation, formal analysis, and writing—original draft. SL: data curation and writing—original draft. BL: visualization, investigation, and software. SM: resources, supervision, and validation. JG: visualization and writing—review and editing. CW: conceptualization, funding acquisition, resources, supervision, and writing—review and editing. All authors contributed to the article and approved the submitted version.

## FUNDING

The work was supported by 2021 Ministry of Education Humanities and Social Sciences Research Special Task Project (21JDSZ3050), Nature and Science Foundation of Anhui (2008085QA08), and 2019 Project of Foundational Research ability enhancement for Young and Middle-aged University Faculties of Guangxi (2019KY1046).

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