ANTICIPATORY SYSTEMS: HUMANS MEET ARTIFICIAL INTELLIGENCE

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PUBLISHED IN: Frontiers in Psychology

frontiers Research Topics

frontiers

ISSN 1664-8714
ISBN 978-2-88971-288-5
DOI 10.3389/978-2-88971-288-5

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ANTICIPATORY SYSTEMS: HUMANS MEET ARTIFICIAL INTELLIGENCE

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Citation: Chen, M.-Y., Lughofer, E., Rubio, J. D. J., Wu, Y. J., eds. (2021). Anticipatory Systems: Humans Meet Artificial Intelligence. Lausanne: Frontiers Media SA.
doi: 10.3389/978-2-88971-288-5

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frontiers in Psychology

EDITORIAL
published: 08 July 2021
doi: 10.3389/fpsyg.2021.721879

Editorial: Anticipatory Systems: Humans Meet Artificial Intelligence

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Keywords: artificial intelligence, anticipatory systems, machine learning, deep learning, human-media interaction

Editorial on Research Topic

Anticipatory Systems: Humans Meet Artificial Intelligence

Humans require encouragement the advances of computing paradigms. Some examples of this are ubiquitous computing presenting higher mobility, cloud computing yielding better functionality, and social computing providing better interactivity. Each of these examples introduces an implicit or explicit requirement from humans and attempts to realize these requirements through specific methods. However, humans may investigate more with the applications. A chatting robot is one example, as this robot is used to maintain relationships with our social contacts when we do not have sufficient space or time to do so. To this end, it continuously interacts with our contacts by computing our thinking patterns, behaviors, and other important information. Of course, there are many interesting studies in this topic, which invites the discussion of a new computing paradigm, "Anticipatory Computing." This computing paradigm indicates a topic related to applications developed and able to anticipate specific user requirements. It is also utilized together with novel applications to perform an action in anticipation of a question of the user or to send a suggestion to the user. This is not only an example of artificial intelligence, it is one example of an innovation (i.e., prediction plus action). It can also be expressed as key to developing well-being within society, and a way to reach the ideal of "serve before you ask." This phenomenon will be considered as an opportunity to raise challenging problems within the topic of computer science.

Taking into account the invaluable crowd intelligence residing in the social network and big data content, opportunities emerge to enable promising smart technology to find individual requirements, generate company business models, and suggest optimal life development. Hence, the nature of big data also provides important challenges from multiple perspectives to methods and technology that rely on social big data. These consider algorithm effectiveness, computation speed, energy efficiency, user privacy, server security, and system scalability. The main goal of this Research Topic is to collect 14 manuscripts reporting original contributions related to deep neural networks or machine learning methods for building anticipatory systems.

The paper titled "A Book Interaction Scheme to Enhance Children's Reading Experiences and Preferences" by Zhang et al. researches the interaction between a book and 5–6 years old children, considering reading choices, measuring reading time, and emotional answer to increase their reading knowledge, and developing books in relation to these interactions.

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Specialty section:
This article was submitted to Human-Media Interaction, a section of the journal Frontiers in Psychology

Received: *07 June 2021*
Accepted: *18 June 2021*
Published: *08 July 2021*

Citation:
Chen M-Y, Lughofer E, Rubio JdJ and Wu YJ (2021) Editorial: Anticipatory Systems: Humans Meet Artificial Intelligence. Front. Psychol. 12:721879. doi: 10.3389/fpsyg.2021.721879

The paper titled "A priori Algorithm for the Data Mining of Global Cyberspace Security Issues for Human Participatory Based on Association Rules" by Li et al. is focused on the a priori approach in association rules; consequently, a total of 181 relevant rules are mined from 40 objective websites and 56,096 web pages are related with cyberspace security; in addition, this paper studies the support, trust, promotion, leverage, and reliability to reach a comprehensive data set.

The paper titled "Exploration of Social Benefits for Tourism Performing Arts Industrialization in Culture-Tourism Integration Based on Deep Learning and Artificial Intelligence Technology" by Zhang, studies the social advantage of the culture-tourism factory; hence, an intelligent model is built for the social advantage evaluation based on the descending gradient neural network and fuzzy model, considering the Yiyang Town as an example.

In the paper titled "Early Warning Method for Public Health Emergency Under Artificial Neural Network in the Context of Deep Learning" by Zheng and Hu, the objective is to decrease the substantial losses produced by public health emergencies in people; hence, the tuberculosis data from June 2017 to 2019 in a city are obtained, and the forecast model is built using the Convolutional Neural Network and Artificial Neural Network.

The paper titled "Measuring and Improving User Experience Through Artificial Intelligence-Aided Design" by Yang et al. suggests to collect user behavior data from logs of a mobile technology; in order to provide the privacy of users, the information is utilized to process the browsing and performing of mobile technology, the target of the proposed technique is to design a deep neural network model to simulate the user's experience in the processing of a mobile technology.

In the paper titled "The Talent Training Mode of International Service Design Using a Human-Computer Interaction Intelligent Service Robot From the Perspective of Cognitive Psychology" by Yang, the human-computer interaction (HCI) application and artificial intelligence are utilized to build the international service talent learning mode of the HCI intelligent service robot, this mode can be utilized to solve the existing teaching issues by utilizing new means to assure the quality of teaching.

In the paper titled "Can Students' Computer Programming Learning Motivation and Effectiveness Be Enhanced by Learning Python Language? A Multi-Group Analysis" by Ling et al., the main goal is to research about the Python algorithm performance on students' computing training; the junior students of two types in a college are the investigation participants, the training results in the Java algorithm and Python algorithm are compared to show the differences.

In the paper titled "A Meaning-Aware Cultural Tourism Intelligent Navigation System Based on Anticipatory Calculation" by Meng and Liu utilizes the theory of desired behavior to obtain the relation between tourists' attitude, experience behavior, and shows the information usage by taking the purple clay culture presentation as an example.

In the paper titled "Developing an Instrument for Assessing Self-Efficacy in Data Mining and Analysis" by Wang et al., the purpose is to design a device for evaluating self-efficacy in data mining and analysis based on the skills and abilities about performing data mining and study, and expert suggestions, the introduced device is important in evaluating the individual's abilities in performing data mining.

In the paper titled "Design and Implementation of Intelligent Sports Training System for College Students' Mental Health Education" by Wang and Park, an intelligent sports management model based on deep training method is developed by utilizing human-computer interaction and information application in artificial intelligence to determine the issues of poor physical fitness of university students and the low accuracy of university sport venues' performance.

In the paper titled "The Use of Deep Learning and VR Technology in Film and Television Production From the Perspective of Audience Psychology" by Tong et al., the design of artificial intelligence (AI) application, the deep-training (DT)-based Virtual Reality (VR) application, and DT application are used in human-computer interaction (HCI), and their results on TV works production, modern film, and audience thinking are analyzed.

The paper titled "Exploring the Influential Factors on Readers' Continuance Intentions of E-Book APPs: Personalization, Usefulness, Playfulness, and Satisfaction" by Liu et al. is focused on the influential factors on university students' continuance intention of e-book technology, this studied literature corresponds to the electronic book (e-book) technology and university students' continuous intention, and presents the reasons that encourage university students' continuous intention of using e-book technology.

In the paper titled "Exploring Computational Thinking Skills Training Through Augmented Reality and AIoT Learning" by Lin et al., a new AIoT training with Augmented Reality (AR) application is introduced and the results of CT skills are analyzed, the graduate utilizes AR technology to understand AIoT technology in application, considers the set of different AR sensors in recent scenarios, further generalization, and developed programs.

The paper titled "Attention-Based Deep Entropy Active Learning Using Lexical Algorithm for Mental Health Treatment" by Ahmed et al. is focused on the technology of individualized mental health interventions by utilizing the Natural Language Processing (NLP) and attention-based in-depth entropy active training; for this goal, authors introduce a technique based on synonym expansion by semantic vectors.

Last but not least, we finish this editorial by thanking all authors for their proposals to this Research Topic and to all reviewers for their voluntary revisions in the peer-review process to maintain a high standard of our Research Topic.

AUTHOR CONTRIBUTIONS

M-YC and JR: writing—original draft. EL and YW: review and editing. All authors have read and agreed to the published version of the paper.

ACKNOWLEDGMENTS

EL acknowledges the Austrian Science Fund (FWF): contract number P32272-N38, acronym IL-EFS. JR thanks the Instituto Politecnico Nacional, the Secretaria de Investigacion y Posgrado, the Comision de Operacion y Fomento de Actividades Academicas, and the Consejo Nacional de Ciencia y Tecnologia for their help in this research.

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.

frontiers in Psychology

ORIGINAL RESEARCH
published: 14 October 2020
doi: 10.3389/fpsyg.2020.02155

A Book Interaction Scheme to Enhance Children's Reading Experiences and Preferences

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The interaction between children and books is an essential part of the reading experience. Publishers all over the world are working to cultivate reading habits in children and attract attention to traditional books. Considering the invaluable nature of these early reading experiences. This paper investigated the effects of book interaction design on 5–6 years old children, taking into account reading preferences, measuring reading time, and emotional response to improve their reading experience and potentially design books according to these interactions. The results showed that preschool children (5–6 years old) prefer sensory interaction, and that book interaction design has a significant influence on reading time, affective experience, and subjective ratings. Girls around 5–6 years preferred folding interaction and pop-up interaction in reading. This study summarizes these results in order to provide practical guidelines for book publishers, enabling them to design better books for children.

Keywords: interaction design, user experience, usability, affective experience, reading preference

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Specialty section:
This article was submitted to Human-Media Interaction, a section of the journal Frontiers in Psychology

Received: *17 June 2020*
Accepted: *31 July 2020*
Published: *14 October 2020*

Citation:
Zhang M, Hou G, Chen Y-C, Zhang T and Yang J (2020) A Book Interaction Scheme to Enhance Children's Reading Experiences and Preferences. Front. Psychol. 11:2155. doi: 10.3389/fpsyg.2020.02155

INTRODUCTION

Book interaction scheme refers to the interaction style between human and book, which enable promising applications to meet the individual needs of readers, creating company business models and integrating smart technologies as part of book development. Interaction with and emotional responses to books are important for younger children's reading, with repercussions on book selecting, reading pleasure, and reading strategy. It is thus important to consider the interaction accessibility and emotional experience of books for younger children, and how this affects their decisions when choosing books, as younger children may struggle or switch their attention to other activities. This is especially important when we consider that in recent years, reading for pleasure has declined, especially among children (National Center for Education Statistics, 2001).

Children-book interaction design describes an interactive communication design process that takes into account the relationship children have with books and their reading processes. The interactive content includes interaction and operability. By interacting with books, children's visual, auditory, tactile, and other cognitive abilities are enhanced. Interaction increases children's interest and creativity in reading. There are two types of children's book interaction methods: behavioral interaction and sensory interaction. Behavioral interactions include page flipping, pop-up interaction, draw interaction, rotation interaction, and folding interaction, among others.

Sensory interaction includes visual interaction, audio interaction, tactile interaction, and olfactory interaction (Littleton et al., 2006). Audio interaction helps to improve children's phonological awareness and change reading strategies (Chera and Wood, 2003; Wood, 2010). In this study, we focused on the effects of tactile and olfactory interaction on children's reading preferences.

Reading preferences and interests evolve with age, for example, young children often prefer fictional stories that use the imagination, and older children are often interested in more realistic fiction (Fisher, 1988; Boraks et al., 1997). There were lots of studies focused on older children in middle or high school, but there is little research on younger children, even though early experiences of reading help to develop reading habits in later life (Cetin and Bay, 2014). Younger children in kindergarten/nursery are easily encouraged to interact with books, for example, they are attracted to the aesthetics pictures on the covers or in the contents (Fast, 2000). Therefore, this study focused on 5–6-year-old preschool children (preschool children for short) and investigated the effects of book interactions on their reading experience.

Compared with digital reading, traditional books help protect eyesight and are less dependent on computers (Jeong, 2012; Hou et al., 2020). More people have in recent years become addicted to digital reading, whether adolescents (Lee et al., 2014) or adults (Elhai et al., 2016). It is irresponsible to ask preschool children to do lots of digital reading in kindergarten, early education can be used as an opportunity to develop good reading habits and attract them to books. This study aimed to investigate the effects of interaction with books on the reading preferences of younger children, in developing educational guidelines for developing reading habits in preschool children.

Gender is another important factor that needs to be considered in early reading. It affects a child's preference for shapes, colors, and toys, with significant gender differences during infancy (Jadva et al., 2010; Hou and Lu, 2019). As they grow older, this gender difference becomes more obvious is often formed around gender-stereotypes, for example, the idea that boys prefer toys with so-called "male characteristics" such as cars and weapons or that girls prefer dolls and to "play house." The theory of social learning points out that gender differences arise from the ways in which male and female social roles are portrayed and represented through culture (Auyeung et al., 2009). In addition, studies on these culturally conditioned differences in terms of morphological preference have found that girls prefer flowers, butterflies, and figures, while boys prefer items such as cars, trains, and rockets (Langerman, 1990; Lytton and Romney, 1991). These gender stereotypes inform differences and interest in reading content. Previous studies have indicated that the preferences of girls and boys are different when selecting a book, for example, surveys of first-grade students in the elementary schools in Ohio, suggested that girls overwhelmingly prefer narrative texts while boys prefer nonfiction (Harkrader and Moore, 1997). These gender differences are significant when related to the social aspects of recreational reading, and perceived reading ability (Mohr, 2006). Thus, we hypothesize that gender may have a significant effect on interaction preferences.

Taken together, the reading experience is a complex process. Previous studies have used surveys or questionnaires rather than actual observation of children's reading interaction behavior. Many researchers have focused on a single aspect of books, such as aesthetics (the appearance of a book cover), the presence of illustrations, or the book's selecting. This study investigated book interaction and gender together and addressed the following research questions:

1. What kind of emotional experience do children expect when reading a book?
2. Which kind of interaction do younger children prefer, behavioral interaction or sensory interaction?
3. Is the effect of book interaction design significant for children's reading time, reading preferences, and emotional experience?
4. Is gender significant in reading time, interaction preferences, and emotional experience?

MATERIALS AND METHODS

The study involving human participants and was reviewed and approved by the Design Lab of Jiangnan University.

Materials

Six of the most common interaction styles in children's books were selected as experimental material, including behavioral interaction and sensory interaction (Detemple and Tabors, 1994). These are flip interaction, draw interaction, pop-up interaction, folding interaction, tactile interaction, and olfactory interaction. Page flip interaction means scrolling from left to right or right to left. Draw interaction means changing the content of the picture by pulling or drawing. Pop-up interaction means that the picture in the book will pop up when it is opened, and the stereo image will increase the sense of space. Folding interaction refers to changing the picture by folding to form a new reading content. Tactile interaction means knowing by touching, for example, there might be plastic, sand, or other materials in the book. Olfactory interaction refers to the addition of flavors associated with the content, such as flowers.

In order to exclude the influence of the content of the reading materials on participants, this study designed six children's books on the theme of human body structure. The reading materials are similar, and each reading material contains only one interactive form. Experimental materials are shown in **Figure 1**.

Materials Measurement and Emotional Reaction

The perception of each child participant was subjective and intuitive, with their emotions directly reflecting their preferences. Although there are many methods of measuring emotion, such as the self-report, autonomic nervous system measurement, startle response measurement, behavioral measurement, and brain measurement, there are few suitable methods of measuring these emotions in children. The most common methods of measuring emotions in children usually involve self-reports

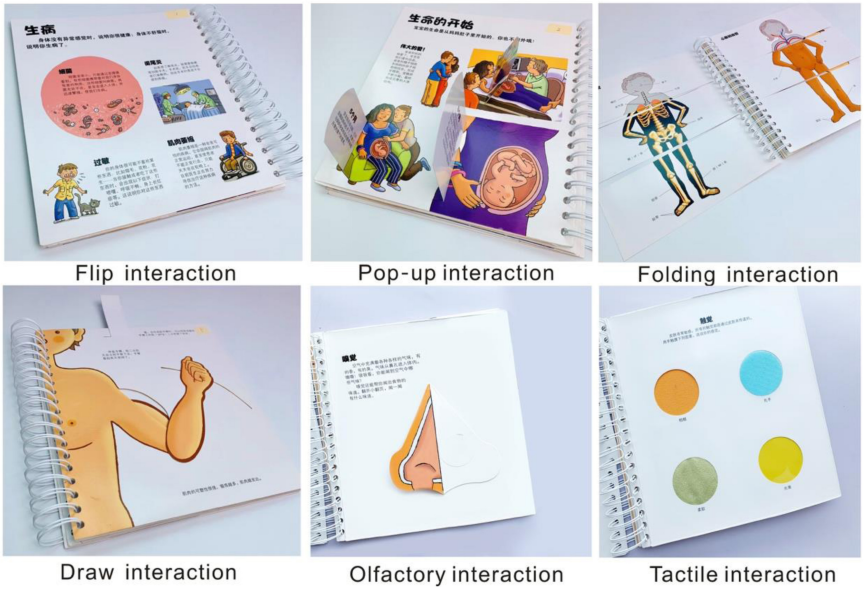

FIGURE 1 | Experimental materials.

and behavioral measurements. Self-reports include the positive-negative emotion scale (PNANS), the pleasure, arousal, and dominance scale (PAD), and Russell's circular emotional card (Russell, 1980; Desmet et al., 2001; Cheng et al., 2018). Behavioral measurements include facial expression recognition and volume changes, but behavioral measurements require a longer experiment time and are therefore not suitable for child participants. Russell's emotion card divides emotion into 8 types according to the PAD scale, measuring whether they enjoyed the experience and how much the reading experience engaged their interest. Each mood consists of 2 expression pictures and a total of 16 cards (Russell, 1980), as shown in **Figure 2**. The scale is intuitive, easy to read, and easy to identify. This method was more suitable for child participants as they only need to select one of the cards to express their feelings. Before the experiment began, we asked each child participant to read the emotional card and ensured that they understood each emotion in the picture and could confidently choose the picture that best reflected their mood.

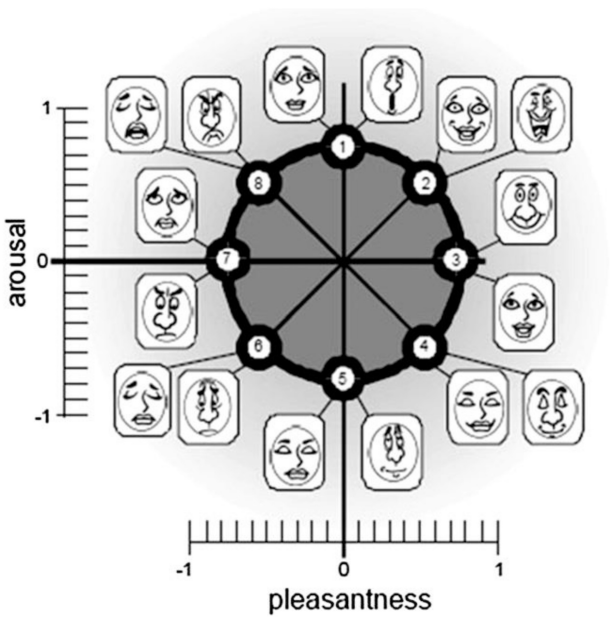

FIGURE 2 | 16 Russell's emotion card.

Experimental Design

This study used a two-factor experimental design within and between groups. Book interaction style and child gender were two independent variables. The book interactions included page flip interaction, pop-up interaction, rotation interaction, touch, and olfactory interaction, pull interaction, and folding interaction. Interaction style was a within-group factor, while gender was a between-group factor. Reading sequences were arranged according to the Latin Square Sequence.

Children's behavior and reading time were recorded by a camera. After each session, the participants completed the following tasks: firstly, they chose an emotional card to match their emotions; then secondly, they used 5 sticky stars to rate the reading materials.

Participants

The experiment was conducted in a kindergarten library for 2 weeks. A total of 40 kindergarten classmates were invited to participate in the experiment. The age of participants was around 5–6 years old, including 20 boys and 20 girls. Each student had a

study time of more than 2 h per week in the kindergarten library and extensive previous library reading experience, to ensure the smooth progress of this experiment. All children participating in the experiment had normal vision. Before the experiment, the teachers authorized each child's participation and carefully read the informed consent form, which confirmed that the study would cause no physical or psychological harm to the children.

According to the experimental design plan, the children were divided into two groups, male and female, with 20 people in each group. They read the reading materials according to a pre-set reading order.

Tasks and Data Collection

After the children entered the library, they listened to an introduction to the experiment, which outlined its content and its requirements. The researchers involved with his study taught participants how to read and distinguish Russell's emotional card of 16 pictures to ensure that participants understood these emotions. They were then asked to select the emotional experience they expected to have from reading. After that, the experiment started and participants read the experimental materials in turn. After they had finished, they chose a card to match their mood. The participants used the sticky stars to rate their preferred reading materials, with five stars indicating that they liked it very much, and one star representing that they did not like it at all.

Data from a total of 4 groups data was collected, including (1) each child's expected emotional experience from reading;(2) reading time; (3) each child's emotional experience after reading each material; and (4) the star ratings for each material. Each child had an unrestricted reading time, and the duration of reading began when they started reading and stopped when they were tired of reading. Data were analyzed by SPSS 19.0.

RESULTS

Expected Emotions and After Task Emotions

Expected Emotional Experience When Reading

The expected emotional experience in reading, as measured by Russell's emotional card before the experiment, revealed that most children expected to have a pleasurable emotional experience with a slight increase in their interest (based on the PAD scale), as shown in **Figure 3**. Over 70% of the children expected to have an enjoyable, positive reading experience. Approximately 15% of the children expected reading to be a highly engaging experience.

After Tasks' Emotional Experience in Reading

After reading the experimental materials, participants were asked to indicate the card that represented their emotional feeling. The emotions were induced by interaction style, including positive emotions (happiness or pleasure), and negative emotions (anger and sadness). This study focused on the positive emotions induced by book interactions. Over 80% of participants had a positive emotional experience by olfactory interaction, followed by tactile olfaction interaction, and 75% of participants perceived reading as a positive emotional experience. The page flip interaction induced the lowest positive emotional experience, which only accounts for 35% of participants. The results are shown in **Figure 4**. The color darkness in the figure represents the level of interest, and the black refers to a higher interest.

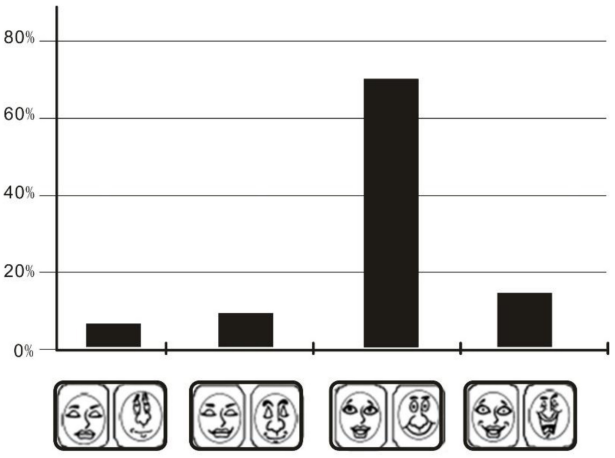

FIGURE 3 | Emotional ring card emotional distribution.

Compared with the expected emotional reading experience, the emotional experience induced by olfactory interaction was the most in line with the expected emotional experience. Followed by tactile and folding interaction.

Gender and Perceived Emotional Experience

A chi-square test of statistical results revealed that the positive emotional influence of the book interaction patterns induced significantly different responses ($\chi^2 = 6.93, p < 0.01$). In addition, the results showed that gender had significance ($\chi^2 = 4.19$, $p = 0.031$), with girls are more affected by pop-up and folding interactions than boys.

Reading Time, Subjective Rating, and Interaction Preferences

Gender Effects and Emotional Experience

The time it took for participants to read each experimental material is summarized in **Table 1**. These results indicate that participants spent the shortest amount of time on page flip interaction, with a mean reading time of about 21.05 s, while they spent longer on folding interaction, with a mean time of 66.35 s. This was followed by olfactory interaction, which had a mean of 58.1 s.

Two-way analysis of variance was used to analyze reading time. Results showed that the level of interaction with a book had a significant impact on reading time ($F = 13.54$, $p < 0.01$, $\eta_p^2 = 0.76$). Gender had no significant difference in reading time ($F = 1.14$, $p = 0.287$, $\eta_p^2 = 0.13$). We compared the reading time of each of the six interactions, and the difference between page flip interaction and pop-up interaction was not significant ($F = 1.08$, $p = 0.362$, $\eta_p^2 = 0.08$). Mean reading time in flipped

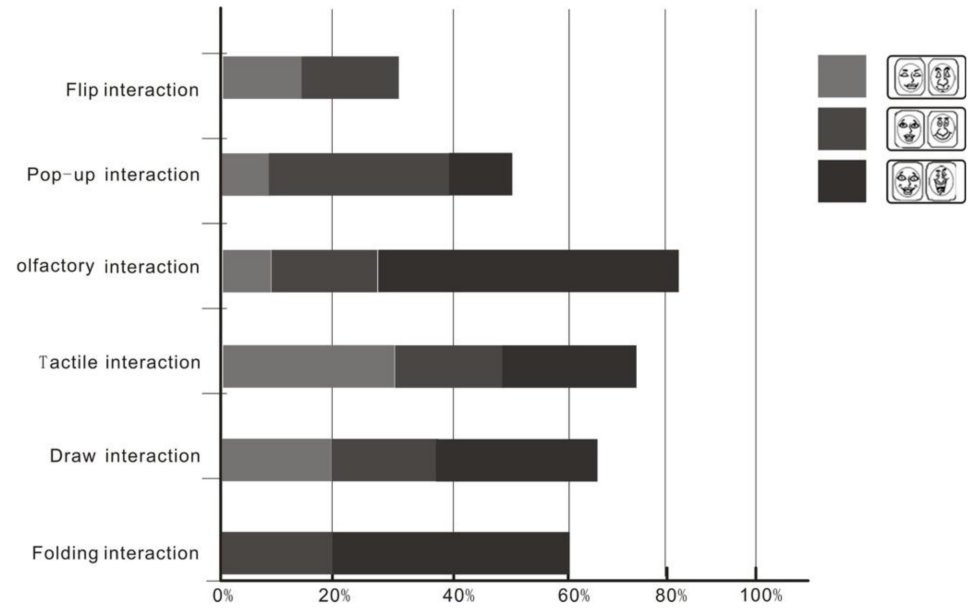

FIGURE 4 | Proportional distribution of positive emotions in participants by interaction style.

TABLE 1 | Distribution of child reading time and different book interaction modes.

Interactions	*N*	Mean	Standard deviation	Standard error	95% confidence interval for the mean		Minimum	Maximum
					Lower limit	Upper limit		
Page flip	40	21.0500	12.89012	2.88232	15.0172	27.0828	6.00	49.00
Pop-up	40	27.2500	12.85087	2.87354	21.2356	33.2644	4.00	51.00
olfactory	40	58.1000	31.20880	6.97850	43.4938	72.7062	10.00	148.00
Tactile	40	40.3500	19.40503	4.33910	31.2682	49.4318	20.00	99.00
Draw	40	35.6000	11.11377	2.48511	30.3986	40.8014	11.00	59.00
Folding	40	66.3500	30.70621	6.86612	51.9791	80.7209	27.00	142.00

interactive books is significantly lower than that of olfactory ($F = 9.91$, $p < 0.01$,$\eta_p^2 = 0.54$), tactile ($F = 7.57$, $p = 0.011$, $\eta_p^2 = 0.47$), draw ($F = 6.32$, $p = 0.025$,$\eta_p^2 = 0.32$), and folding interaction ($F = 11.25$, $p < 0.01$, $\eta_p^2 = 0.63$). The mean reading time spent on pop-up interactive books is significantly lower than interaction with olfactory ($F = 10.32$, $p < 0.01$, $\eta_p^2 = 0.59$) and folding ($F = 7.83$, $p < 0.01$, $\eta_p^2 = 0.51$). The mean reading time of olfactory interaction books was significantly longer than tactile ($F = 5.89$, $p = 0.038$, $\eta_p^2 = 0.29$) and draw interaction ($F = 9.33$, $p < 0.01$, $\eta_p^2 = 0.91$), and the difference between olfactory interaction and folding interaction is not significant ($F = 0.98$, $p = 0.825$, $\eta_p^2 = 0.01$). Participants' mean reading time for tactile interaction books was not significantly different from that of draw interaction books ($F = 0.77$, $p = 0.484$, $\eta_p^2 = 0.11$), but it was significantly lower than the reading time in folding interaction books ($F = 8.32$, $p < 0.01$, $\eta_p^2 = 0.82$).

Gender Effect on Perceived Emotional Experience

Once the reading task was completed, participants used the five-pointed stars to evaluate their interaction, with rating scores shown in **Table 2**. The highest mean score was obtained by olfactory interaction(M = 4.55, SD = 0.82), followed by folding interaction (M = 3.85, SD = 1.30), draw interaction (M = 3.88, SD = 1.36), tactile interaction (M = 3.35, SD = 1.13), pop-up interaction (M = 3.15, SD = 1.34), and flip interaction (M = 1.70, SD = 1.21). The mean rating score of olfactory interaction was the highest, and page flip interaction was the lowest.

Statistical analysis of the above scores found that the effect of book interaction on children's subjective evaluation was significant ($F = 12.59$, $p < 0.01$, $\eta_p^2 = 0.71$). The effect of gender on evaluation was not significant ($F = 0.363$, $p = 0.548$, $\eta_p^2 = 0.03$). A comparison of the subjective scores of the six interaction methods revealed that the flip interaction was lower than the other five interaction methods and that it was the most unpopular method of interacting with books. The subjective evaluation of the pop-up interaction was significantly lower than olfactory interaction ($F = 5.58$, $p < 0.01$, $\eta_p^2 = 0.41$), but the differences between pop-up interaction and tactile, drawing, or folding interaction were not significant. The subjective evaluation of olfactory interaction was significantly higher than that of flip ($F = 14.17$, $p < 0.01$, $\eta_p^2 = 0.77$), pop-up ($F = 8.42$, $p < 0.01$,

TABLE 2 | Participants' scores for interaction with reading materials.

Interactions	*N*	Mean	Standard deviation	Standard error	95% confidence interval for the mean		Minimum	Maximum
					Lower limit	Upper limit		
Flip	40	1.7000	1.21828	0.27242	1.1298	2.2702	0.00	4.00
Pop-up	40	3.1500	1.34849	0.30153	2.5189	3.7811	1.00	5.00
olfactory	40	4.5500	0.82558	0.18460	4.1636	4.9364	2.00	5.00
Tactile	40	3.3500	1.13671	0.25418	2.8180	3.8820	1.00	5.00
Draw	40	3.8000	1.36111	0.30435	3.1630	4.4370	1.00	5.00
Folding	40	3.8500	1.30888	0.29267	3.2374	4.4626	1.00	5.00

$\eta_p^2 = 0.62$), and tactile interaction ($F = 6.77$, $p < 0.01$, $\eta_p^2 = 0.47$), but the difference between drawing ($F = 3.34$, $p = 0.053$, $\eta_p^2 = 0.24$) and folding interaction ($F = 2.81$, $p = 0.071$, $\eta_p^2 = 0.19$) was not significant.

The Influence of Gender on Emotional Experience

The results showed that the most popular way for children to interact with books is sensory interaction, on which they dwell for a longer time [M(sensory) = 49.225 VS. M (behavioral) = 37.25], and was rated higher [M(sensory) = 3.95 VS. M(behavioral) = 3.13]. One-way ANOVA was used to analyze the difference between sensory interaction and behavioral interaction on reading time and subjective rating, and results showed that the time spent on sensory interaction was significantly longer than behavioral interaction ($F = 7.13$, $p = 0.01$, $\eta_p^2 = 0.58$). The rating for sensory interaction was significantly higher than behavioral interaction ($F = 4.81$, $p = 0.043$, $\eta_p^2 = 0.36$).

A gender difference analysis was performed on the ratings, and it was found that female children had a significant preference for pop-ups ($F = 5.217$, $p = 0.032$, $\eta_p^2 = 0.39$) and folding interactions ($F = 3.891$, $p = 0.050$, $\eta_p^2 = 0.28$) compared to male participants. It may indicate that gender influences a child's preferred interaction style.

DISCUSSION

Reading is an important part of life and it is crucial to ensure that young children developing good reading habits in preschool so that they can obtain knowledge, enhance their interests in learning, and cultivate life-long reading abilities. Children's choices when selecting books are not based on professional and academic standards and are instead dictated by vividness and liveliness, as they increase their interest (Fast, 2000; Cetin and Bay, 2014; Guo et al., 2015). The interactive form of books plays an important role in attracting interest. Thus, this study analyzed the influence of book interactions on reading time, emotional experience, and preference, and summarized these conclusions as suggestions for encouraging preschool children to read.

Resource Identification Initiative

Children expect a pleasant emotional experience when reading a book, which could be derived from story content, illustrations, and their surroundings. Preschoolers like to read colorful and beautiful pictures (Hargrave, 2001; Justice and Lankford, 2002) and listen to stories (Anvari et al., 2002). This study found that they do not only experience pleasure from the story, but that their enjoyment is also connected to their interaction and experience when reading books. This study found that olfactory interaction, tactile interaction, and folding interaction can induce positive emotions in line with their expectations. Hargrave (2001) found that preschoolers pay more attention to the form of books than to content. When new forms of interaction are combined with content, they can induce pleasure in preschool children. Furthermore, Leech and Rowe (2014) found that picture books can be easily understood by preschool children and can lead to subsequent discussions about this content with their parents, meaning that they also help children's language development. Preschoolers can easily interact with books according to their intentions, which increases their sense of participation and enhances positive emotions.

These positive emotions could be induced by different cognitive mechanisms, and contribute to enhancing their motivation to read (Seo et al., 2010). The positive emotions induced by listening stories are different from those that are induced by a change of the book's method of interaction. For example, when children participate in listening, understanding, and imagining, they experience emotional changes that result from their immersion and the consistency of their expectations about the ending of the story (Mohr, 2006; Wei et al., 2018). However, the book's interaction induces a positive emotion, based on cognitive processes, such as visual cognition, creative thinking, and operational execution. Book interaction is an important means of improving the reading experience of children, as they are likely to feel a positive emotion once their expectations are fulfilled, and will be encouraged to read again in the future.

Reading Interests and Preference

Reading interests and preferences evolve with age. Attracting preschoolers to reading and encouraging them to spontaneously engage in it, is crucial. This study evaluated children's interest in reading by examining reading time. A longer reading time often indicates a greater interest (Hou and Lu, 2018). We also explored the effect of book interaction on reading time and the reading preferences of preschool children. Results showed that book interaction has a significant impact on reading interest, suggesting there are significant differences in the reading time associated with different interactive reading materials. For

preschool children, the most attractive interactive book form was folding interaction, while the overall sensory interaction was higher than behavioral interaction. Preschool children are curious, they read pictures rather than words, and pictures helped them understand the story (Leech and Rowe, 2014; Li and Zhu, 2017), thus interactions that changed the picture into a different story attracted them the most. Behavioral interaction is an important factor in the design of books and could affect how they display illustrations and words. The results of this study show that interaction design is a good way to encourage preschool children to read.

The rating scores attributed by preschool children to book interactions resulted in a higher mean score for tactile and olfactory interactions compared with behavioral interactions. The differences between olfactory interaction, folding interaction, and draw interaction were not significant, indicating that preschool children preferred these designs to pop-up, tactile, and flip interaction. The mean value of olfactory interaction scores was the highest because this type of interaction is rare in everyday books, and reading a book by smell went beyond the expectations of the participants. Folding interaction is related to the presentation of book content, and changes the content of books and enhances the novelty of materials, as the story continued by unfolding the book. The drawing-based interaction is also easy to access, and the content and form are well-matched, and the score was also high. The analysis found that subjective scores positively correlated with reading time ($r = 0.74$, $p = 0.012$). The longer the reading time, the higher the score for the corresponding book interaction style. In summary, the interactive form of books has a significant impact on the reading interest, subjective ratings, and preferences of preschool children. This indicates that a reasonable way to interact with books helps to improve the quality of a child's reading experience.

Gender Effects

Gender differences often affect all aspects of life. When it comes to reading, gender differences weres reflected in the different choices of color, content, and forms of the books chosen by participants (Jadva et al., 2010). This study found that the gender difference in reading time is not significant, and boys and girls spent a similar amount of time reading the same book for each of the different interaction styles. However, the gender difference was significant in terms of participant preferences. This study found that girls prefer pop-up interaction and folding interactions, while boys rated these types of interaction much lower. In other forms of interaction, the ratings of book forms were similar. The participant reading interests were not affected by gender, but subjective ratings of book interactions did have significant differences.

Gender differences were also reflected in the content of the books read, as well as in the participants' selection of particular books, which may already be informed by their reading habits (Fisher, 1988; Boraks et al., 1997). Even though gender differences do exist in society, this factor is not widely considered in the scope of early education. Considering the influence of gender in book interaction design is beneficial to improve the quality of children's reading experience.

Implications and Design Recommendations

Despite the fact that flip interaction is the most frequent interaction in children's books, it was not fascinating for preschool children. Based on the results of this study, suggestions about which book interaction formats might be most effective in designing children's books are summarized in **Table 3**. Firstly, olfactory interaction, tactile interaction, and folding interaction are excellent choices, because these interactions could induce more positive emotional experiences and get higher subjective rating scores in preschool children. Tactile and olfactory interactions are seldom used in children's books. Secondly, it is important to consider gender effect and how it informs children's book selection. According to the results, tactile olfactory interaction should be considered a priority for both boys and girls, but folding interaction and pop-up interaction could potentially incite positive reactions in girls. Teachers should make full use of these interactions as a way of encouraging reading habits in preschool children. This study examined the effects of each interaction on children's emotional experience, reading time, ratings, and preference, to improve the overall reading experience for children and help teachers to design more appropriate activities for preschool children.

Limitations

Because emotional responses are inconsistent and complicated, there are limitations in the accuracy of the Russell's emotional record card, used in this experiment. Although the target population is too young to use biometric measurements, future studies should consider other methods to ensure data is more objective in further studies. The age of participants was between 5 and 6 years old and due to dramatic changes in reading interests and preferences between different age groups, these conclusions are confined to this population. There are also more than 6

TABLE 3 | Summary of early reading recommendations.

Interactions	Recommendations for teachers	Gender priority
olfactory	Use of olfactory interaction in children's books can not only help children understand things, but also improve their reading interests and reading experience.	–
Tactile	Preschool children could know by touching, as it helps improve their reading experience.	–
Draw	Adding animation to a book helps improve the reading experience.	–
Folding	Girls like folding more than boys. Extending or changing stories aimed at girls, could improve the reading experience.	Girls
Pop-up	Girls pop up books more than boys, but their overall average preference was medium.	Girls
Flip	Could be used with other interactions.	–

interaction styles in children's book design, and we hope to analyze more interactions in future studies.

CONCLUSION

Through experimental research methods, this study clarified the effects of book interaction methods and factors such as gender on preschool children's reading interests, including their subjective evaluation, preferences, and emotional responses to reading. These results indicate that preschool children prefer sensory interactive reading materials. In addition, their overall evaluation of folding interaction and drawing-based interaction was also high. Preschool children look forward to having a pleasant emotional experience when reading, which can be satisfied by olfactory, tactile, and folding reading interactions. Gender differences are observed only in the interactive forms, namely folding and pop-up interactions, which were preferred by female children. These conclusions can help teachers better understand the expectations of preschool children, and provide a theoretical reference for early education.

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 Design Lab of Jinan Universtiy. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

MZ wrote the manuscript. GH was in charge of experiment design. Y-CC dealed with data analysis. TZ was in charge of experiment organization. JY was in charge of big data and deep learning. All authors contributed to the article and approved the submitted version.

FUNDING

This project was sponsored by the Natural Science Foundation of Zhejiang Province Grant No. LGF20G010001, Grant No. 2018SJA0810 from Jiangsu University Philosophy and Social Sciences Research Foundation, MOE (Ministry of Education in China) Youth Foundation Project of Humanities and Social Sciences (No: 18YJCZH114), and Science and Technology Program of the Ministry of Housing and Urban-Rural Development (2019-K-001).

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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.

frontiers in Psychology

ORIGINAL RESEARCH
published: 19 November 2020
doi: 10.3389/fpsyg.2020.595374

Measuring and Improving User Experience Through Artificial Intelligence-Aided Design

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This paper aims to propose a methodology for measuring user experience (UX) by using artificial intelligence-aided design (AIAD) technology in mobile application design. Unlike the traditional assistance design tools, AIAD focuses on the rational use of artificial intelligence (AI) technology to measure and improve UX since conventional data collection methods (such as user interview and user observation) for user behavior data are inefficient and time-consuming. We propose to obtain user behavior data from logs of mobile application. In order to protect the privacy of users, only a few dimensions of information is used in the process of browsing and operating mobile application. The goal of the proposed methodology is to make the deep neural network model simulate the user's experience in the process of operating a mobile application as much as possible. We design and use projected pages of application to train neural networks for specific tasks. These projected pages consist of the click information of all users in the process of completing a certain task. Thus, features of user behavior can be aggregated and mapped in the connection layers and the hidden layers. Finally, the optimized design is executed on the social communication application to verify the efficiency of the proposed methodology.

Keywords: user experience, artificial intelligence aided design, human computer interaction, mobile application design, deep neural network, usability evaluation

OPEN ACCESS

Edited by:
Mu-Yen Chen,
National Taichung University of Science and Technology, Taiwan

Reviewed by:
António Fernando Coelho,
University of Porto, Portugal
Laith Abualigah,
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Specialty section:
This article was submitted to Human-Media Interaction, a section of the journal Frontiers in Psychology

Received: *16 August 2020*
Accepted: *12 October 2020*
Published: *19 November 2020*

Citation:
Yang B, Wei L and Pu Z (2020) Measuring and Improving User Experience Through Artificial Intelligence-Aided Design. Front. Psychol. 11:595374. doi: 10.3389/fpsyg.2020.595374

INTRODUCTION

With the development of mobile Internet, more and more users get information and services through mobile devices. Mobile devices represented by touch-screen mobile phones and tablet computers are gaining people's favor with their high-density human–computer interaction (HCI). In these mobile devices, a variety of applications are being introduced into different categories, such as social transport letters, health care, and lifestyle, etc. Currently, there may be dozens or even hundreds of applications on mobile devices. However, mobile applications are becoming more and more homogeneous. How to achieve differentiated competition is a problem faced by many enterprises. At the same time, enterprises are trying to find a breakthrough. More and more enterprises begin to realize that user experience is closely related to user loyalty. Therefore, improving the user experience of products is the best business opportunity for enterprises (Park and Woo, 2006).

The concept of user experience has been widely spread and rapidly accepted in the field of HCI. It is generally believed that the concept of user experience was proposed and promoted by

Norman (2002) in the early 1990s. Its connotation and framework have been expanding, involving more and more fields, such as psychology, HCI, and usability testing, which have been included in the relevant fields of user experience (Hassan Basri et al., 2016). User experience (UX) emphasizes the non-utility aspect of HCI and focuses on the user's emotion, feeling, and the significance and value of such interaction in daily life. As a result, UX is seen as a desirable thing, although what it really means is still open and controversial (Law et al., 2009). Although more and more people accept and recognize the importance of UX, there is no consensus on the definition of user experience. Rajanen et al. (2017) discussed the views of UX professionals on definitions of usability and UX. They compared the research results of different countries and social–cultural groups. There are differences in the definition of user experience among user experience professionals, and there are systematic differences related to social and cultural conditions. UX professionals in Finland and France tend to emphasize the definition of experience qualities, while Turkey and Malaysia tend to reflect the definition of ease of use, utility, attractiveness, and usage. Experience is the user's subjective psychological feeling, but the feeling will leave traces. Researchers can describe and measure them through objective evidence or experiments. The ISO 9241-210 defines UX as:

- "Person's perceptions and responses that result from the use and/or anticipated use of a system, product or service."

User experience focuses on the individual experience in relation to the use of a product.

Rajanen et al. (2017) believed that usability is now an established concept among UX professionals. Kocaballi et al. (2019) reviewed the understanding of UX in conversation interface literature and examines six questionnaires commonly used to evaluate conversation systems, in order to evaluate the potential applicability of these questionnaires in measuring different UX dimensions in this context. On the other hand, with a good usability of the product, users will feel convenient, fast, and comfortable after use and reduce the possibility of user operation error. Obviously, it will arouse users' good emotional experience, make users feel happy, and then achieve the purpose of improving UX. In this work, we follow the definition of UX in ISO 9241-210, and strive to perceive and improve user experience in the process of using mobile applications. To better understand when to use which UX research methods, Christian Rohrer illustrated 20 popular methods in a three-dimensional framework (Rohrer, 2014). The UX research method proposed in this paper can be divided into behavioral and quantitative dimension in Rohrer (2014). Social platforms have gradually shifted to the mobile Internet, and several large and comprehensive social APPs (WeChat, QQ, and Weibo, etc.) have monopolized the market in China. Different APPs were designed to meet different social communication needs. Vertical social APP has the characteristics of strong pertinence and clear service field. People need not only one to two large social APPs, but also some vertical social APPs to meet single-point needs. Therefore, how to grasp the precise vertical users is an important issue. For example, Chinese users tend to focus on one or several applications to complete specific tasks based on mobile terminals. Users will have a strong sense of control over the overall status and distribution of task operations. This mode of application tends to combine multiple tasks into a single task process, thus freeing up some cognitive resources for users to use when they operate other tasks at the same time. If the subtasks in the "big and complete" application are less relevant, and the task process is not cohesive, users will compete for psychological resources, which leads to users wandering and switching between multiple tasks, and the overall efficiency is unpleased. It is a great challenge for a vertical social APP to develop rapidly and enhance its user loyalty under the environment of a large and comprehensive social APP monopoly market. "Waterman" is a vertical social APP belonging to water supply and drainage industry. However, the user experience and user loyalty of this APP is unpleased. We then optimized the application by the proposed methodology. The basic idea of the artificial intelligence-aided design (AIAD) methodology is to make the deep neural network model simulate the user's experience in the process of using some functions. The contribution of our work can be summarized as follows:

- We propose to measure UX from the click behavior of users when they operate the application.
- According to the three levels of human brain activity, the corresponding machine experience model (MEM) is established.
- The neural network model is trained for specific tasks with projected pages. All features of user behavior can be aggregated and mapped in the connection layer and the hidden layer.

RELATED WORK

In order to make the best design of products in the early stage of product development life cycle, many observation methods have been introduced to capture and measure user experience. Battarbee and Koskinen (2005) effectively classify user experience methods into three categories: measurement, emphasis, and pragmatism. Measurement methods focus on all aspects of the user experience, which can be directly measured through physical reactions or subjective reports of the body. The emphasis method is to have a rich understanding of the user's needs, wishes, dreams, and motives in the design stage through various formal methods, including visual and text data, as well as creative tasks. These methods aim to plan the future user experience and motivate designers, rather than evaluating the current user experience of the system. Pragmatic methods provide a holistic view of user experience, focusing on the understanding that the interaction among users, technology, and environment is an integral part of experience. Mctear et al. (2016) defined the interactive interface as the communication between users and machines through a variety of interaction technologies. They believe that with the rapid development of artificial intelligence (AI) technology and the rapid progress of semantic web, a large amount of online knowledge will emerge. Inspired by currently measuring and understanding methods based on AI techniques, we believe that

user experience can be learned by machine. In this section, we briefly introduce the related works from three aspects.

Measuring User Experience

Since the 1930s, traces of behavior have been collected in psychological research (Dumais et al., 2014). In this method, participants were asked to randomly stop, and their experiences were recorded in real time. AttrakDiff (Hassenzahl et al., 2003) is one of the most commonly used standardized questionnaires in HCI to measure hedonic quality. Although it explicitly focuses on hedonic quality, it also measures practical quality and the overall appeal of the product. According to the user experience model of Hassenzahl, (2005), AttrakDiff has a strong theoretical basis. The model considers that a product can have two main qualities: hedonism and practicality. Hedonic quality refers to the ability of product support to achieve the goal, while pragmatic quality refers to the ability of product support to achieve the goal. It consists of 28 items in three categories: pragmatic quality, hedonic quality, and attractiveness. It is worth noting that the theoretical model behind AttrakDiff does not attempt to measure emotions such as pleasure, satisfaction, happiness, or anger because they are considered to be the result of the cognitive assessment process Karapanos et al. (2009) developed a daily reconstruction method (DRM) to investigate the rich quality experience of users, and expound the concept of user experience in some narrative terms. They put forward an in-depth, 5-week ethnographic study that tracked six people during the actual purchase of the apple iPhone. They found that the motivation for long-term use was different qualities rather than providing positive initial experience.

However, traditional methods of user data collection and user feature model extraction are inefficient. With the increase in the amount of user data, the cost of research and development is also greatly increased. Meanwhile, AI technologies such as big data and machine learning had rapidly developed (Abualigah et al., 2018b; Abualigah, 2020b). Using these tools to assist in the design may be an efficient way. Dumais et al. (2014) summarized different types of behavior data for improving a design in **Table 1**. They believe that log files can be used to understand how users experience a product or service. Behavior log is the trace of human behavior seen through the sensor lens that captures and records the user's activity. It ranges from low-level keystrokes to rich audio and video recording. User behavior data collection methods can be roughly divided as lab studies, field studies, and log studies.

Logs also have the advantage of being easy to capture on a large scale. Although laboratory and field studies usually include tens or hundreds of people, journal studies can easily include data of tens or hundreds of millions of people. Such a large sample size means that even small differences between populations can be observed. In particular, large-scale logs provide an unusual but important piece of behavior data that is hard to capture in smaller studies. Log documents classify different types of user behavior data by some genetic algorithms. Genetic algorithms are usually used in information retrieval systems to enhance the information retrieval process Abualigah and Hanandeh (2015) applied genetic algorithms to text information retrieval. After that, a series of text clustering methods (Abualigah and Khader, 2017; Abualigah et al., 2017a,b, 2018a; Abualigah, 2018; Abualigah and Diabat, 2020a,b) were proposed by the author, which enriched and promoted the development of text clustering algorithms. In the next section, several classic click models based on user behavior logs data are introduced.

Click Models

In recent years, more and more researchers are interested in how to use the data in the process of using software to better understand decision making. Click models have been wildly used to explain or predict the click actions of users (Jiang et al., 2020). Most of the click models are based on the most basic research on click models. It is believed that users browse search engines from top to bottom along the search results list. According to this assumption, the browsing order of users is consistent with the location order of search results. Most of the click models are based on location. In addition, the most important information source of click model is user interaction information (mainly click information), so the inference of user behavior and result correlation in the model is from click behavior. Therefore, these click models assume that all the results in the search page are homogeneous (all of them have similar forms, only different in content, corresponding to the model, only different in result relevance). After excluding the effect of result relevance, these results do not affect the user's behavior.

Click logs can provide a valuable source of relevant information. However, the probability of click is affected by the position of the document in the result page, which brings deviation to the establishment of click model. Craswell et al. (2008) proposed a cascade model (CM) to handle such bias. They assume that users scan the search engine results page from top to bottom until they find a relevant document she clicked on. In its canonical form, CM assumes that "the clicked user will never return, and the skipped user will always continue," which limits it to querying sessions with just one click. Different from CM models, Koller and Friedman (2009) developed the probabilistic graphical model (PGM). User behaviors on web search engines are represented as a series of observable and hidden events in PGM framework. It provides a mathematically reliable way to infer a group of events given some information about other

TABLE 1 | Different types of user data for improving design.

Types	Range	Experimental
Lab studies	Controlled interpretation of behavior with detailed instrumentation.	In-lab controlled tasks, comparison of systems
Field studies	In the wild, ability to probe for detail	Clinical trials and field tests
Log studies	In the wild, little explicit feedback but lots of implicit signals	A/B testing of alternative systems or algorithms

events. Most probabilistic models distinguish two events: the user checks the document, and the user is attracted to the document. These events are generally assumed to be independent of each other. In addition, most models assume that a user will only click on a document if he wants to check it or is attracted to it. This problem has been addressed in the User Browsing Model (UBM; Dupret and Piwowarski, 2008). Based on the application of web search, user activity model can be divided into three categories: analysis model, whose purpose is to deeply understand the specific behavior of users and predict the future behavior model of users. UBM focuses the latter, which only uses the source information from web search logs. According to the ranking of documents and the distance from the last clicked documents (by ranking), UBM can estimate the inspection probability of documents. However, this method does not use maximum likelihood estimator and expectation-maximization algorithm to obtain the point estimation of the relevant parameters, but uses Bayesian method to infer their posterior distribution. Inspired by UBM, Liu et al. (2009) proposed a Bayesian browsing model (BBM), which has similar assumptions on user behavior. Two sets of experiments were presented to test model effectiveness and efficiency. The experimental results show that BBM has the ability of precise reasoning and is a single channel and parallelizable method.

Different click models have different models of test probability. The probability of attraction is calculated by different parameters (Koller and Friedman, 2009). However, the structure of the dependencies between events must be set manually. Different click models use different handmade dependency sets. Chen and Fischbacher (2016) discovered that simple information such as response time and click location can provide people's preferred information. These data can be collected almost free of charge. They found that individualistic subjects click more often on their own payoffs than on the others' payoffs. Moreover, the response time information and the click position information are complementary in explaining subjects' preferences. Regular analysis of click locations is often used to optimize web design (Guo et al., 2009).

Previous work on click models has made a great effort in reducing the systematic bias and improving the trueness of relevance estimation by experimenting with different user behavior assumptions and building more sophisticated models. Click models aim to extract accurate relevance feedback from the noisy and biased user clicks. It is also important to test the reliability and accuracy of click model correlation estimation (Wang and Guo, 2017; Shen et al., 2018). A variety of information can be used to build a click model, such as information about the user, her current tasks, result presentation, result content, and other search characteristics. Shen et al. (2012) proposed a novel personalized click model to describe user-oriented click preferences. This model applies and extends matrix/tensor decomposition from the perspective of collaborative filtering, connecting users, queries, and documents together. This model is a general personalization framework, which can be incorporated into the click model. Although search click data is scarce, the model can penetrate query and document through potential eigenvectors, so as to deal with rare or even new query document pairs. Unfortunately, for many areas, even weak surveillance data can be scarce (Yang et al., 2018). The query generation system is trained on general domain data, but it is applied to target domain documents. This makes it possible to create any large, noisy, domain-targeted query document association pairs. Based on this, the zero-shot learning (Fu et al., 2015) technique can be used to synthesize the query-generated retrieval model (Huang et al., 2016). The click position cannot provide enough information for users to complete a task. There is a consistent relationship between response time and strength-of-preference, which arises from optimal solutions to sequential information sampling problems (Konovalov and Krajbich, 2016). Chen and Fischbacher (2016) investigated that the response time correlates with subjects' preferences. The response times and click positions were used to infer people's preferences. Therefore, response time is also used in our proposed framework.

Recently, Jiang et al. (2020) proposed a data-driven agent-based model to analyze the click position and user posting behavior in online review. The model explains how the click position affects the volume of posting main reviews and response reviews. It also analyzes the moderating effect of the number of items per webpage on the relationship between the clicking position and posting behaviors. They divided the clicking position into five modes. Because the posting behavior of the participant is driven by the knowledge and ability related to the reading content, the clicking position will affect the posting behavior of the members. Similar to the webpage on the monitor, clicking position can also be used in modeling user experience in mobile application design (Abualigah, 2020a).

Search engine page analysis through click model is another research direction in these years. A large number of search results including rich text information are introduced into search pages. These search results come from several sub engines with specific search targets, which are usually called vertical search engines. These vertical search results from the vertical search engine (such as the image results obtained by the image search engine) often have different presentation form from the traditional results, so the search results on the current search page are becoming very heterogeneous, which also makes the user's browsing behavior habits and preferences may have great changes. By analyzing the large-scale search logs of a Chinese commercial search engine, Wang et al. (2013) found that more than 80% of the search result pages in the current Chinese search environment contain vertical results, and the vertical results in different forms of presentation have a great impact on the behavior of users, including the vertical results themselves (local impact) and the whole search page (global impact). Therefore, it is important to consider different vertical results. They conducted in-depth analysis on the change in users' browsing behavior and finally summarized four user behavior bias assumptions: (1) attraction bias hypothesis, (2) global influence bias hypothesis, (3) first bias impact hypotheses, and (4) browsing order bias impact hypothesis.

Measuring User Experience From Behavior Data

By assuming how the behavior bias affects the user's click behavior, the click model can estimate the impact of behavior

bias and the correlation between each operation separately. After training the click model of the log, the model can get the correlation estimation with small deviation and use it for the subsequent task prediction. For example, the click-based relevance estimation as ranking features can be used to train a learning-to-ranking model (Chapelle and Zhang, 2009). These features can also be used as weak supervision signals to train and test data-hungry neural ranking models (Li et al., 2019; Yang et al., 2020b).

One of the key problems in information retrieval is the location deviation. There are two problems with conventional methods. First, the information of the selected document is usually ignored when the user clicks on it. Second, they only consider the location deviation and ignore the other problems caused by users' browsing behavior. In order to improve the performance of follow-up tasks, the correlation estimation given by click model should be as accurate as possible. Generally, the accuracy of estimation depends on two factors: authenticity and accuracy. Authenticity is the estimation of system error (i.e., estimation deviation), while accuracy is the estimation of random error (i.e., estimation variance). Mao et al. (2019) suggested to study the reliability of correlation estimates derived from click models. The posteriori distribution of correlation parameters is inferred by the method of variable decibels instead of the point estimation of correlation. Based on the posterior distribution, the reliability measure of point pair correlation estimation is defined.

In recent years, deep learning techniques have been successfully applied to image understanding and information mining tasks (Guo et al., 2015; Liu et al., 2015b; Zou et al., 2018; Cheng et al., 2019; Yang et al., 2020a). By using deep learning framework, deep neural networks (DNN) can mine high-level abstract information and even predict user behavior, such as human action recognition (Guo and Chen, 2015), VISL design (Guo et al., 2014; Huang et al., 2015; Liu et al., 2015a), classification (Luo et al., 2017), and saliency detection (Niu et al., 2018). Nair and Hinton (2010) used the pre-training method to alleviate the problem of local optimal solution and pushed the hidden layer to seven layers, which made the neural network have "depth" in the real sense and thus opened the upsurge of deep learning. In order to overcome the disappearance of gradient, transfer functions such as Relu and Maxout replace sigmoid and form the basic form of DNN (Yang and Ma, 2016). Subsequently, more and more user behavior analysis methods are proposed based on various of neural network models, such as recurrent neural network (RNN; Zhang et al., 2017), convolutional neural networks (CNN; Zhang et al., 2018; Zhu et al., 2018), long short-term memory (LSTM) networks (Borisov et al., 2016), etc.

Based on the idea of distributed representation, Borisov et al. (2016) proposed a neural click model for web search. Vector state is used to represent the information needs and available information of users. Vector state components are used to model user behavior. User behavior is modeled as a sequence of vector states associated with a query session. The query initializes the vector state, which is then updated iteratively based on the information that interacts with the search engine. One of the key problems of location deviation is to deal with implicit but biased user feedback data in information retrieval (Guo et al., 2018). Unbiased sorting usually relies on causal model, while debias obtains user feedback by reverse tendency weighting. Although these methods are practical, there are still two problems. First, when inferring a user's click, the impact of contextual information, such as checked documents, is often ignored. Second, only the location deviation is considered, and other problems caused by users' browsing behavior are ignored. Recently, Jin et al. (2020) adopted RNN to model the contextual information and estimates the conditional likelihood of user feedback at each position. Then, they combine the survival analysis with the probability chain to restore the correct joint probability of user behavior.

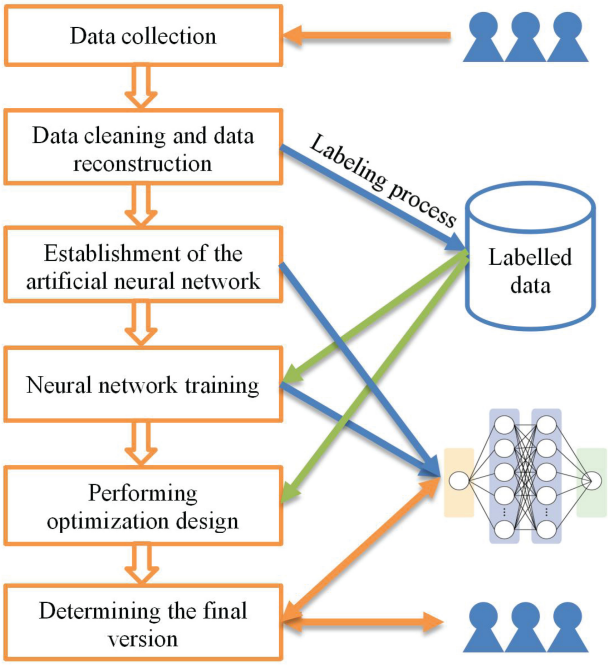

FIGURE 1 | Flowchart of the proposed AIAD framework.

METHODOLOGY

With the rapid development of AI technology, mobile application designs have also ushered in changes and development. As presented in **Figure 1**, several AIAD techniques were used in the optimization scheme. The proposed AIAD scheme is based on the following five steps:

1. First, a data collection function is developed and set into the former version of the software.
2. Second, data cleaning and data reconstruction processes are performed on the collected dataset. Successful operations are marked as positive records, and failed operations are marked as negative records.

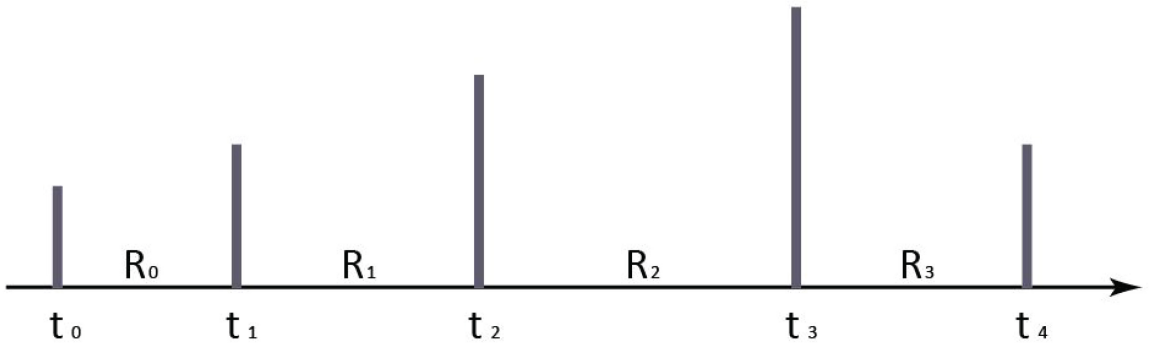

FIGURE 2 | Simplified mental model.

3. Third, an artificial neural network is designed to adapt the specific work. The network structure (such as VGG, and DBN, etc.) can be selected and adjusted according to the task.
4. Fourth, the reconstructed data is input into the neural network model as training data. In this work, the clicks of all users in the process of completing a task are project into the pages needed for the task.
5. The user's operation information mapping heat-map and the original APP interface.
6. Fifth, the optimization design is performed according to the labeled user's data. For example, the designer can find some problems in function logic and interface design by browsing the user operation process of failure records.
7. Finally, the interface according with normal operation data of the optimized APP can be input into the trained neural network model. The neural network will give an evaluation of the optimization effect (e.g., give a score). In this way, the proposed AIAD system is more like a virtual "designer assistant" existing in the data.

User Behavior Data Collection

Data collection is the process of gathering and measuring information on targeted variables in an established application. What types of user data should be collected from mobile applications? Most users may be reluctant to expose too much personal data. Thus, the fewer user data the program collects, the better. In our proposed data collection function, only two kinds of user behavior information were collected based on the theory of spatial consistency of mental model. Spatiality is an important feature of mental model for HCI. Spatiality plays an important role in the correct use of menu interface, search for information in hierarchical file management and navigation interface. Consistency in mental model space is important while designing a mobile application. During the whole process of a task, the logical consistency in mental space is caused by the material representation (icon, text, graphics, and layout mode, etc.) and feedback on different interfaces. This consistency includes size consistency, layout consistency, and texture consistency, etc. **Figure 2** is a simplified mental model with spatial consistency of layout. The spatial consistency of mental model provides a good criterion for evaluating the rationality and performance of mental models. In this model, only several data (page, button, position of the click/drag, and operation time, etc.) are needed.

We can obtain detailed information of user's behavior by projecting the coordinates of each click on the page. Therefore, only page ID, coordinates and retention time in page are collected. **Table 2** presents some user behavior records for a mobile application of "Waterman."

Availability Evaluation for a Task

A task can be divided into several units according to the correlation between its internal components in interactions. To evaluate the availability for a task performed by a user, an availability algorithm of interface interactive is proposed in this paper. We first mark each click event on the timeline for a task. Let R_i denotes the retention time of a page in a specific task. We weight R_i as the value of each click. We then obtain a histogram of timeline for a task. **Figure 3** is a histogram example of **Figure 2**.

After superimposing and normalizing all histograms of the same tasks, we get an overlapping histogram. However, histograms cannot be directly superimposed because different operations have different timelines for a task. All histograms should be scaled into the same length. Therefore, we map all timelines into the same length by scaling projection algorithm. A scaled and superimposed histogram is then obtained and saved as an array data. All arrays are divided into positive and negative categories.

In order to project the clicks of all users in the process of completing a task T_i into the pages, the histogram data needs to be converted into image data. We use a circle with gray value α to represent each click. The gray value α can be roughly calculated by dividing 255 by the dwell time of each page. In practical application, the calculation method of gray value α can be adjusted to adapt to different neural network models.

Optimization by Using Artificial Neural Network

Recurrent artificial neural networks are very helpful to solve dynamical problems. Compared to Shallow Learning, the architecture of artificial neural network contains more hidden

TABLE 2 | User behavior records for searching friends on "Waterman."

Task	Page ID	Coordinate 1	Coordinate 2	Retention time (ms)
Search friends	CD101	605, 1,775	605, 1,775	2,424
Search friends	CD102	988, 143	988, 143	412
Search friends	CD102	1,012, 148	1,012, 148	788
Search friends	CD103	1,175, 1,071	1,175, 1,071	231
Search friends	CD103	1,195, 1,063	1,195, 1,063	147
Search friends	CD103	1,199, 1,074	1,199, 1,074	88
Search friends	CD103	845, 1,442	878, 941	211
Search friends	CD103	812, 1,522	846, 874	189
Search friends	CD103	744, 578	744, 578	411

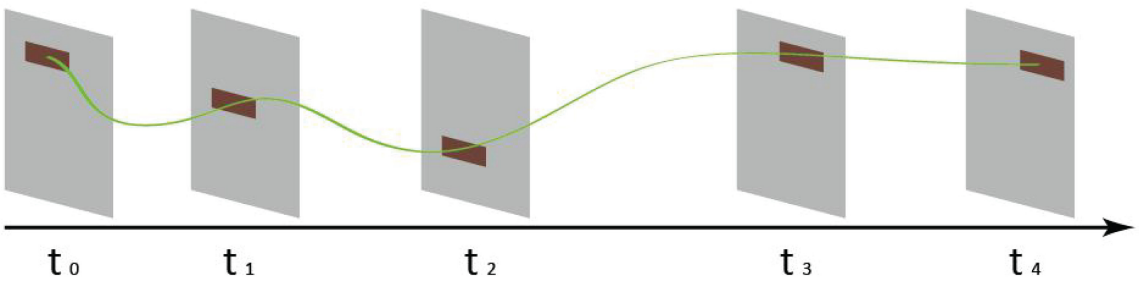

FIGURE 3 | A histogram example of **Figure 2**.

layers. Norman (2002) proposed that human brain activity can be divided into three levels: instinct, behavior, and reflection. Based on these three levels and AIAD technology, we propose to establish a corresponding MEM, as shown in **Figure 4**.

Big data mainly involves data distributed processing, storage, mining, and other technologies, which represent the ability of large-scale data processing and is a good support for deep learning. Deep learning supported by massive and valuable data has become more accurate and intelligent. By analyzing the multilevel mapping and association mechanism of data, neural network, and machine intelligence, the logical relationship among intuition layer, behavior layer, and reflection layer can be mapped. In this work, we use a classic neural network architecture VGG (Simonyan and Zisserman, 2014) as our deep learning model. The reason why we choose VGG is that its structure is very simple, and it is easy to be implemented by non-professionals. The size of convolution kernel (3×3) and the maximum pooling (2×2) layer used in the whole network are the same size. The combination of several small convolution layers is better than that of a large convolution layer. User behavior data from mobile operation is mapped on the corresponding page. A classic VGG with 16 layers is presented in **Figure 5**.

Long short-term memory is used to construct the network model, since the task has great time attribute. LSTM is a kind of special RNN, which is mainly used to solve the problems of gradient vanishing and gradient explosion in the process of long sequence training. RNN is a kind of neural network for processing sequence data. Compared with the general neural network, it can process the data, which change according to the time series. Inspired by the LSTM-CNN Model (Tan et al., 2015), we propose to combine the LSTM model with the VGG network structure. The training process of artificial neural network can be summarized as the following steps.

First, we divide the training data into task groups according to different task T_i (for example, search friends) of an APP. In this way, each group of tasks contains the pages that must appear, which are sorted in the order in which they appear.

Second, we project clicks of all users in the process of completing a task T_i into the page needed for the task, as described in the Availability Evaluation for a Task section. **Figure 6** is an example of the proposed projection method. The projected page groups of successful tasks are marked as positive samples, while failed tasks are marked as negative samples.

Third, we train the neural network model according to the specific task. Each projected page in the task group is used as network input. Thus, all the features will be aggregated and mapped in the connection layer and the hidden layer.

The deep neural network has only one output representing the score of input data. Since the neural network model has been trained on the user behavior data from the previous version of APP, the model can more reflect the user's cognition and behavior habits, and then, the designer finds out the what need to be improved based on the user's click behavior data, and improves the interface and function path accordingly to obtain an optimized version. The interface according with normal operation data of the optimized APP can be input into the trained neural network model. The neural network will give an evaluation of the optimization effect. In this way, the proposed AIAD system is more like a virtual "designer assistant" existing in the data. The

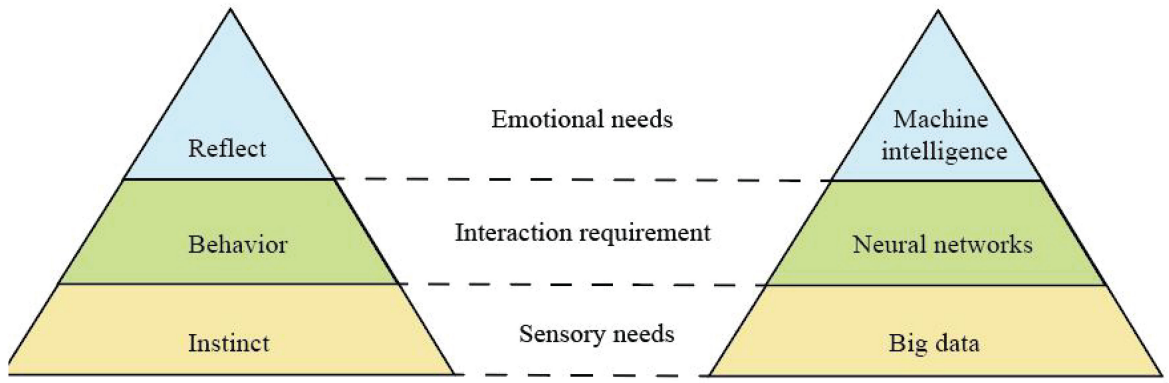

FIGURE 4 | Human behavior model and proposed machine experience model.

speed and efficiency of APP development and improvement will be greatly improved.

DISCUSSION

User experience can be defined as an overall experience, which includes all aspects of user interaction with products or services. All existing theories about user-centered design, availability, impact engineering, and technology acceptance model are applicable to UX (Park et al., 2013). Traditional interaction design process, design principles, design patterns, and other methodologies are applicable to the design of traditional HCI products or services. For the application of intelligence and situational awareness, they are generally applied in a wide range without pertinence.

In order to verify the effectiveness of the proposed methodology, we evaluate a classic experiment to compare the usability of the optimized mobile application. It is suggested that 80% of usability problems could be exposed by five to seven participants in usability testing. Therefore, we invited six users to participate in the evaluation with their own mobile devices.

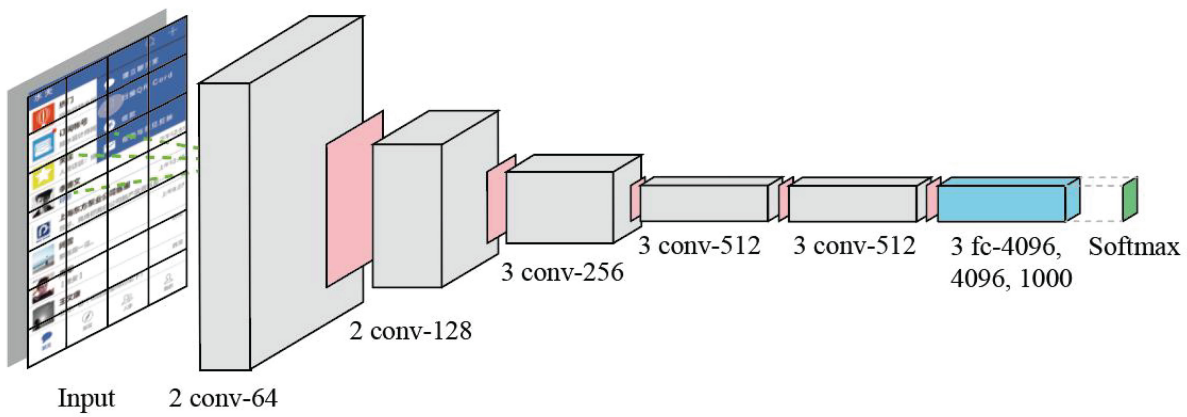

FIGURE 5 | The deep neural network with 16 layers used in our methodology. The parallelogram with pink color is Max-pooling layer.

TABLE 3 | Four tasks designed in the experiment.

Tasks	Operation process
User registration	(1a) Open sub-menu "Mine." (1b) Run application for the first time. (2) Choose "Login or Register." (3) Input telephone NO. (4) Input user information (e.g., username, gender, company, sub-segments). (5) Submit.
Add a new friend	(1) Open sub-menu "Connections." (2a) Choose "New friend." (2b) Click button "+." (3a) Input a friend's account. (3b) Find friends nearby. (4) Browse friends' information (e.g., username, gender, company, sub-segments). (5) Submit add friend request.
Search friends	(1) Open sub-menu "Connections." (2a) Browse the list of friends and select one. (2b) Click "Find" button and input a friend's name. (3) Open the page of the friend you want to find. (4) Call him.
Participate in activities	(1) Open sub-menu "Finds." (2) Browse the list of activities. (2a) Filter some activities. (3) Select an activity and open the detail page. (4) Choose to attend this activity. (5a) Set an alarm.

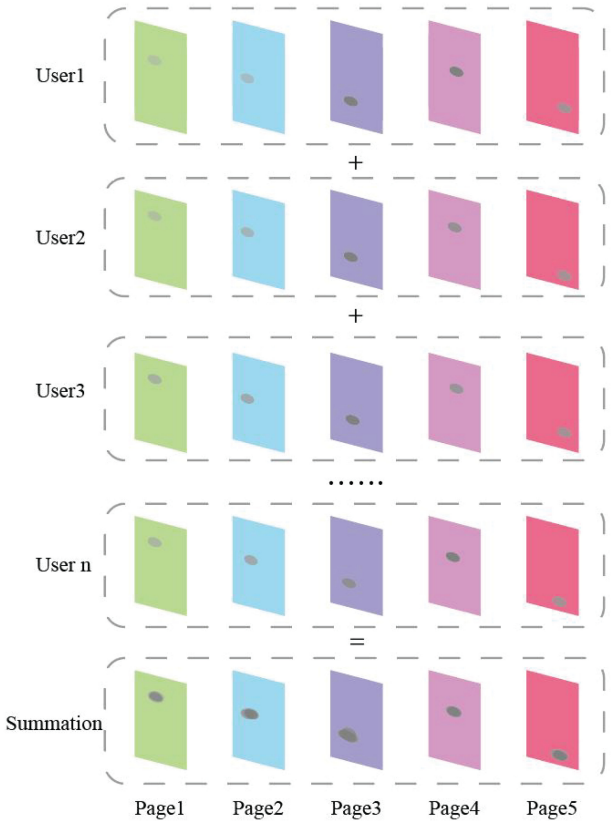

FIGURE 6 | An example of the proposed projection method.

These users are school students who have mobile application experience and use mobile social application services, including three boys and three girls, distributed in different grades and majors. Before the experiment, we explained to each participant the purpose of the experiment and the type of data that will be sent to the mobile phone. The whole experimental study lasted for about 2 months. Users were required to install a "Waterman" application on their mobile phones. User's log data and user evaluation documents were obtained and stored. Because the screen of mobile terminal is small, it can only present content in limited space, so it is important to present users a sense of visual comfort. So, the esthetics of interface should also be included in the evaluation index. Finally, we determined seven indicators to evaluate the usability of "Waterman," namely, learning, effectiveness, efficiency, error, interface esthetics, and satisfaction. As shown in **Table 3**, we designed four experimental tasks as examples.

In the evaluation process, each participant needed to complete all tasks and submit the feedback feeling every 3 days at least. All the user behavior data in the process of application operation were uploaded to the server and stored as log files. The evaluation results are presented in **Table 4**.

As shown in **Table 4**, the optimized mobile application was superior to the former in all indicators. Evaluation results verified the effectiveness of our proposed methodology, especially

TABLE 4 | Evaluation results.

Evaluation indicators	The former version	The optimized version
Learning	2.4	3.0
Effectiveness	3.4	3.5
Efficiency	1.8	3.8
Error	2.3	4.3
Interface esthetics	3.1	3.5
Satisfaction	2.2	4.3

Note. Indicator values range from 1 to 5 (5 for best).

in efficiency, error, and satisfaction. We believe that deep neural network can understand user experience better through behavioral data. With the assist of deep network model trained by user behavior data, the version can be determined efficiently and accurately in A/B test. Specifically, two versions of APP (version A and version B) were used in the experiments of two groups of subjects. The results of the evaluation are then recorded and used to determine which version is better. Experimental results show that the efficiency of optimal design has been greatly improved. The main difference between this algorithm and other algorithms is that we establish the relationship between human brain activity and machine experience model. We propose to measure UX from the click behavior of users by deep neural network model. Thus, all features of user behavior can be aggregated and mapped in hidden layers. The evaluation results verify the effectiveness of the AIAD scheme. However, for some indicators (such as learning, effectiveness), deep neural network is unable to greatly improve the user experience. This means that AI is not omnipotent; it can only be used as an assistant design tool by designers.

CONCLUSION

Designers are lagging behind in taking advantage of this not so new technology. The future of AI mediation seems to be driven by data availability and learners' performance rather than a well-thought out user-centered vision. At present, AI technology has rarely become a standard part of user experience design practice, nor a part of design pattern, prototype tool, or design education. Yang et al. (2016) think that user experience designers still lack the knowledge of deep neural network. In this paper, we present a methodology for understanding and measuring user experience by using AI techniques in mobile interaction. The key of AI technology is using machine learning, more specifically, using deep neural network. The assumption of this paper is that by analyzing the multilevel mapping and association mechanism of data, neural network, and machine intelligence, the logical relationship among intuition layer, behavior layer, and reflection layer can be mapped. Deep neural network model can simulate user experience to a certain extent based on user behavior data. Therefore, we propose to make full use of user's log data to reduce the acquisition cost of user behavior data. The flexibility of this model makes it good assistant design tool, which can be used in future work to understand the user's experience.

For future work, first of all, we hope to extend our method to more user behavior data, such as drag and return. Second, we want to incorporate information about the user, e.g., user profile, location, and time, etc. Third, the deep neural network model for matching user mental model is not limited to VGG; we will try to adjust or improve the network structure.

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. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

BY was in charge of the study design. LW was responsible for the literature review. ZP was in charge of the coding and assessment. All authors contributed to the article and approved the submitted version.

FUNDING

This work is supported by the Humanities and Social Sciences Projects of the Ministry of Education (No. 18YJC760112), the Social Science Fund of Jiangsu Province (No. 18YSD002), and the Zhejiang key R&D plan (No. 2020C02020).

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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.

frontiers in Psychology

ORIGINAL RESEARCH
published: 15 January 2021
doi: 10.3389/fpsyg.2020.614460

Developing an Instrument for Assessing Self-Efficacy in Data Mining and Analysis

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With the continuous progress and penetration of automated data collection technology, enterprises and organizations are facing the problem of information overload. The demand for expertise in data mining and analysis is increasing. Self-efficacy is a pivotal construct that is significantly related to willingness and ability to perform a particular task. Thus, the objective of this study is to develop an instrument for assessing self-efficacy in data mining and analysis. An initial measurement list was developed based on the skills and abilities about executing data mining and analysis, and expert recommendations. A useful sample of 103 university students completed the online survey questionnaire. A 19-item four-factor model was extracted by exploratory factor analysis. Using the partial least squares-structural equation modeling technique (PLS-SEM), the model was cross-examined. The instrument showed satisfactory reliability and validity. The proposed instrument will be of value to researchers and practitioners in evaluating an individual's abilities and readiness in executing data mining and analysis.

Keywords: self-efficacy, data mining, measurement instrument, big data, artificial intelligence

OPEN ACCESS

Edited by:
Mu-Yen Chen,
National Taichung University of Science and Technology, Taiwan

Reviewed by:
Chingmu Chen,
Chung Chou University of Science and Technology, Taiwan
Wen-Tan Chang,
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Specialty section:
This article was submitted to Human-Media Interaction, a section of the journal Frontiers in Psychology

Received: *06 October 2020*
Accepted: *23 December 2020*
Published: *15 January 2021*

Citation:
Wang Y-M, Chiou C-C, Wang W-C and Chen C-J (2021) Developing an Instrument for Assessing Self-Efficacy in Data Mining and Analysis. Front. Psychol. 11:614460. doi: 10.3389/fpsyg.2020.614460

INTRODUCTION

With the penetration and advent of data storage technologies and automatic data collection techniques, the big data age is coming. Although these technologies bring rich and diverse digital data to organizations, they can also cause serious information overload. Organizations of all sizes are under pressure to extract large amounts of data and process it into useful information and knowledge. Therefore, organizations increasingly need professionals to develop and deploy data mining technologies for competitive advantage (Nemati and Barko, 2003).

Data mining is a multi-disciplinary field (Chung and Gray, 1999; Feelders et al., 2000). Successful and effective data mining requires a collaborative effort in a number of areas, including statistics, artificial intelligence, database management, data visualization, subject area expertise, data analysis expertise, and data mining algorithms (Chung and Gray, 1999; Feelders et al., 2000; Nemati and Barko, 2003). However, at present instruments to properly and accurately measure individual abilities in data mining and analysis remain lacking. This study addresses this gap in research and practice.

Self-efficacy is an important construct in social science and information management (Compeau and Higgins, 1995). It has critical influences on task success and performance (Torkzadeh and Van Dyke, 2001). The purpose of this paper is to empirically develop an instrument for assessing an individual's self-efficacy in data mining and analysis. Self-efficacy in data mining and analysis represents an individual's judgment of their capabilities and skills to use data mining techniques

for analysis and discovery in a given domain (Bandura, 1997; Wilson et al., 2007; Wang Y. Y. et al., 2019).

The remainder of this paper is organized as follows. Section "Background and Literature Review" reviews the related literature. Section "Research Methods" describes the research method and section "Results" presents the results of data analysis. Section "Application Analysis" describes the application analysis. Finally, the conclusion, implications, and research limitations are discussed in section "Conclusion and Implications."

BACKGROUND AND LITERATURE REVIEW

Data Mining

In the past, corporate decisions were often made subjectively by decision makers, leading to errors. With the rapid development of science and technology, companies have gradually begun to use objective data to make decisions. In particular, the accumulation of data at large companies has increased rapidly and technology-assisted data analysis (e.g., data mining analysis) has gradually become an important tool for corporate decision-making. Data mining technology is an indispensable technology in the era of big data analysis. Hand et al. (2001) define data mining as the analysis of data sets (usually a large number of data sets) to identify unexpected relationships and summarize the data in novel patterns, and then provide useful information. Jain and Srivastava (2013) observed that data mining algorithms are divided into two functional types, predictive and descriptive, and eight application types, classification, estimation, forecasting, correlation analysis, sequence, time series, description, and visualization (Dunham, 2003).

Data mining technology is not only used in corporate decision-making, but is widely used in various industries. For example, in business management, Alola and Atsa'am (2020) applied data mining technology to measure the psychological capital of employees in the organization, and noted that when measuring the psychological capital of employees in recruitment interviews and promotion evaluations, data mining classification models can be useful as tools for human resource management. Zhen and Yao (2019) analyzed the lean production and technological innovation of the manufacturing industry based on the support vector machine algorithm and data mining technology. Data mining can discover novel, effective, potential, and finally understandable data patterns from a deeper level, and encode the data to predict the development trend of the enterprise. Machine learning support vector machine methods are used to analyze and model the collected data. Ding et al. (2019) indicated that the current cloud computing technology is developing rapidly, gradually integrating into IoT data mining technology and forming a new model. On this basis, the construction of an IoT data mining model based on cloud computing technology was studied. Another example is application in medicine. Zhao et al. (2020) used data mining to study the risk factors that can predict IHD during pheochromocytoma surgery, and observed that data mining techniques are increasingly being used in clinical and medical decision-making to provide continuous support for the diagnosis, treatment, and prevention of disease. Massi et al., 2020 noted that the healthcare industry is an interesting target for fraudsters. The availability of large amounts of data makes it possible to solve this problem through the use of data mining techniques, thereby making the review process more effective. The purpose of this research was to use the hospital discharge chart in the management database to develop a new type of data mining model specifically for fraud detection between hospitals. Qian and Liu (2020) proposed data mining technology that first determined the classification of index parameters. They then used this data mining technology to establish a sports training analysis mechanism to complete the construction of the index analysis model.

Data mining technology has also been widely used in the education field and is now being used more and more widely in teaching activities (Calders and Pechenizkiy, 2012; Maldonado and Seehusen, 2018). Data mining technology can be used to analyze educational data and explore educational research issues (Campagni et al., 2015). It can be used to improve educational practices and learning materials (Romero and Ventura, 2013), and to predict student performance, group students, plan courses, discover bad student behavior, model students, and classify courses based on student preferences (Romero and Ventura, 2010; Goyal and Vohra, 2012; Maldonado and Seehusen, 2018). The main focus of educational data exploration is to help solve problems related to the learning process of students, as well as to help schools conduct adaptive curriculum planning and students conduct adaptive learning (Calders and Pechenizkiy, 2012; Maldonado and Seehusen, 2018).

Self-Efficacy

According to the theory of social cognition, perceptual self-efficacy is the key mechanism for exercising human agency within a causal structure involving the ternary causality of people, environment, and behavior (Bandura, 1986). Self-efficacy belief is an individual's belief in their ability to achieve expected results, overcome obstacles, resist adversity, self-regulate in the face of urgent circumstances, discern many competing choices and negotiate important life changes (Basili et al., 2020). Self-efficacy means an individual's confidence in their own problem solving and task completion ability (Sun and Chen, 2016; Ghazi et al., 2018). İncirkus and Nahcivan (2020) observe that self-efficacy refers to people's belief in their ability to implement an action plan, deal with challenges, and make the judgments that make a particular action successful. Mamaril et al. (2016) and Liu et al. (2020) indicated that self-efficacy is an individual's conjecture and judgment of whether they have the ability to complete a certain behavior, which can reflect the individual's belief in taking appropriate action to address environmental challenges. It contains expectations of results and expectations of effectiveness (Bandura, 1997). The former is the belief that certain actions will ensure certain results, while the latter is the belief that one can complete these actions and obtain results (Sun and Chen, 2016). Bandura and Cervone (1986) and Sullivan et al. (2006) argue that since people who are confident in a task will expect success, concentrate on thinking about how to succeed, persist

in facing difficulties, and avoid low self-efficiency tasks, self-efficacy beliefs are highly positively correlated with work and academic performance. Thus, when self-efficacy beliefs can be improved, performance improvement will occur (Dunlap, 2005; McLaughlin et al., 2008; Kuiper et al., 2010).

Many studies have explored the self-efficacy of students in academic fields and the self-efficacy of employees in practical fields. Research on employees largely explores personal self-efficacy in specific work situations (Bandura, 1986; Judge et al., 1998; Bandura and Locke, 2003). Bandura and Locke (2003) argue that self-efficacy is positively related to individual behavioral processes and results, such as perseverance in adversity, efforts to achieve high achievements, and ultimately high performance in various fields. Chae and Park (2020) indicate that expectations of personal self-efficacy determine how much task-related effort will be expended. Therefore, beliefs related to self-efficacy are the most powerful predictors of individual behavior and persistence in adversity (Bandura, 1986). Bandura (1986) and Bandura and Locke (2003) contend that when individuals have a high sense of self-efficacy, the resources they are willing to invest in tasks will increase, leading to better results. Other studies have explored the relationship between self-efficacy and entrepreneurial enthusiasm and entrepreneurial behavior (Shane et al., 2003; Murnieks et al., 2014). Shane et al. (2003) observed that self-efficacy and enthusiasm are two important factors in maintaining entrepreneurial efforts. Sun (2020) showed that self-efficacy mediates the relationship between entrepreneurial enthusiasm and entrepreneurial behavior. Researchers have also explored general self-efficacy, individuals' perception of their ability to perform in various situations, in the general workplace (Smith, 1989; Scholz et al., 2002; Chen et al., 2004). Results show that general self-efficacy is positively correlated with job performance (Beattie et al., 2016) and knowledge sharing (Srivastava et al., 2006). Chae and Park (2020) explored the relationship between an employee's general self-efficacy and task performance and knowledge-sharing. The results showed that the high general self-efficacy of key employees has a positive impact on task performance but has a negative impact on knowledge sharing.

Most studies of the self-efficacy of students agree that self-efficacy has a positive impact on learners' academic achievement and personal success (Vancouver et al., 2001; Honicke and Broadbent, 2016; Basili et al., 2020). Fernandez-Rio et al. (2017) indicated that academic self-efficacy beliefs affect the perception of ability in the self-regulation process that is beneficial to learning. Cooper (2015) demonstrated that self-efficacy can help students at risk overcome their at-risk conditions and positively impact their academic performance. Schunk (1994) and Carroll et al. (2009) demonstrated that students with higher self-efficacy beliefs can better manage their own learning and are more likely to do better academically. Klassen and Usher (2010) and Talsmaa et al. (2018) all observed that people with high self-efficacy set more difficult goals, put in more effort, persist in challenges for a longer time, and show resilience in adversity, which can improve academic achievement (Bandura, 1997). Klassen and Usher (2010) contended that self-efficacy has a key and powerful influence on academic achievement. Pajares and Kranzler (1995) found that self-efficacy can effectively predict academic achievement. Multon et al. (1991), Richardson et al. (2012), and Honicke and Broadbent (2016) conducted a meta-analysis of self-efficacy, finding that self-efficacy is strongly correlated with academic achievement.

Many researchers have found that self-efficacy plays an important role in the process and results of individual behavior. However, since self-efficacy is a kind of behavioral cognition, a psychological scale to measure personal self-efficacy is needed. A number of different self-efficacy scales have been developed for various fields, such as self-efficacy in the medical field (Lorig et al., 1989; İncirkus and Nahcivan, 2020), general self-efficacy scales in the workplace (Chen et al., 2004), self-efficacy scale for engineering education (Mamaril et al., 2016), multi-dimensional self-efficacy scale for adolescents (Bandura, 1990), teacher research self-efficacy scale (Wester et al., 2019), teacher self-efficacy scale for student-oriented teaching (Kilday et al., 2016), college student self-efficacy scale (Khasawneh et al., 2009), and a mathematical self-efficacy energy scale (Betz and Hackett, 1983). Based on the development of education in the high-tech era, the popularization of technology-assisted teaching has led many researchers to study the role of self-efficacy when the Internet or technology is applied to teaching, and develop numerous Internet and technology-related self-efficacy scales, such as the Internet self-efficacy scale (Hsu and Chiu, 2004; Kao et al., 2011), the computer ethical self-efficacy scale (Kuo and Hsu, 2001), and the Internet ethical self-efficacy scale (Williamson et al., 2011). With the development of Internet and high technology, though big data analysis and artificial intelligence have gradually become common across various industries, data mining and artificial intelligence self-efficacy scales remain lacking. Therefore, the main purpose of this research is to develop a self-efficacy scale for data mining and analysis.

RESEARCH METHODS

Based on the prior measures and definitions of self-efficacy, this study conceptually defines "self-efficacy in data mining and analysis" as an individual's judgment of his or her ability to successfully execute data mining and analysis. The initial instrument, which consisted of 28 items, was developed based on the review of the literature on skills and abilities for executing data mining and analysis (Fayyad et al., 1996; Chung and Gray, 1999; Mitchell, 1999; Chapman et al., 2000; Feelders et al., 2000; Liao, 2008; Han et al., 2011; Tufféry, 2011; McCormick et al., 2013; Singhal and Jena, 2013; Abbott, 2014; Jian and Hsu, 2014; Xue, 2014; Marvin, 2016; Salcedo and McCormick, 2017; Struhl, 2017; Chang and Kung, 2019; Liao and Wen, 2019; Wang, 2019; Wang Y. S. et al., 2019) and expert experience. Three global items for measuring perceived overall self-efficacy were added to serve as a criterion. All items were measured using a seven-point Likert-type scale with anchors of "(1) strongly disagree, (2) disagree, (3) slightly disagree, (4) neutral, (5) slightly agree, (6) agree, and (7) strongly agree." **Table 1** shows all 31 items.

The survey methodology was adopted and empirical data for this study were collected using an Internet questionnaire survey in Taiwan. University students with data mining knowledge or experiences were qualified to participate in the survey, and were asked to fill in the questionnaire based on their experiences and self-perceptions. Every respondent in the survey was given an NT 100-dollar coupon as an incentive. The survey duration was 2 months: from April to May in 2020. This study obtained 103 useful responses. There were more females than males in the sample (51.5 and 48.5%). The proportion of college students in the sample is higher than that of graduate students (85.4 and 14.6%). The respondents had an average age of 21.6 years. On average, they took 4.03 courses and 12.57 credits in data mining.

Data from 103 university students was tested against the proposed 28-item instrument using a two-step assessment approach. In the first stage, the exploratory factor analysis (EFA) and the criterion-related analysis was used to purify the measure, remove noise items, and acquire factor structure. In the second stage, the partial least squares-structural equation modeling (PLS-SEM) was used to assess the hierarchical component model (HCM) based on the EFA result. Internal consistency (reliability), convergent validity, and discriminant validity were checked for the model.

RESULTS

EFA Results

Exploratory factor analysis was used to purify the measurement instrument. Before conducting the EFA, three tests were performed to check the adequacy of the survey data for EFA. First, Cronbach's α coefficient was computed to ensure the internal inconsistency of the measurement items (Churchill, 1979). The results showed that the 28-item instrument had an α coefficient of 0.97, indicating that the measure was unidimensional. Second, Bartlett's test of sphericity was used to assess the overall significance of the correlations among the measurement items (Hair et al., 1998). The results demonstrated a satisfactory suitability of the data for factor analysis ($\chi^2 = 3387.31, p < 0.001$). Third, the Kaiser–Meyer–Olkin statistic was computed for

TABLE 1 | The measurement items.

Items
Q1. I clearly understand the main applications of data mining, e.g., classification, estimation, forecasting, association, and cluster analysis
Q2. I clearly understand the procedure and main steps of data mining
Q3. I am familiar with standards for data mining and modeling
Q4. I have the ability to conduct data mining in a professional field (such as consumer behavior analysis, sales data) to discover useful information or knowledge
Q5. I have the ability to understand and interpret the outputs derived from data mining
Q6. I am familiar with at least one major programming language for data mining, such as R, Python, or Java
Q7. I think I have the programming skills required for data mining
Q8. I know how to use information retrieval methods to find useful information from a large amount of data
Q9. When I search for information, I can use keyword search accurately
Q10. I have the relevant ability of database system
Q11. I have the ability to clean, select, transform, and synthesize data
Q12. I have the ability to execute online analytical processing (OLAP)
Q13. I have the ability to use SQL (Structured Query Language)
Q14. I have the ability to build a data warehouse
Q15. I am familiar with at least one data exploration tool, such as WEKA, RapidMiner, IBM SPSS modeler, and Statistica
Q16. I have the ability to carry out pre-processing of data mining
Q17. I have the ability to execute classification analysis
Q18. I have the ability to execute cluster analysis
Q19. I have the ability to execute the feature selection
Q20. I have the ability to visualize the data
Q21. I have the relevant statistical skills required for data mining
Q22. I have the ability to execute the decision tree analysis
Q23. I have the ability to execute discriminant analysis
Q24. I have the ability to execute association analysis
Q25. I have the ability to execute sequential pattern analysis or causal analysis
Q26. I have the ability to execute time-series analysis
Q27. I have the ability to execute artificial neural networks (ANN) analysis
Q28. I have the ability to use at least one data mining technique for data analysis or discovery
G1. Overall, I think I have professional ability in data mining*
G2. Overall, I think my data mining skills capabilities meet the needs of practitioners*
G3. Overall, I think I have good and complete data mining knowledge*

**Criterion item.*

checking sampling adequacy. The statistical score was 0.91 and greater than 0.50, indicating high shared-variance and relatively low uniqueness (Hair et al., 1998). These test results suggested that EFA was worth pursuing.

The principle-components analysis was used as an extraction technique and varimax method was used to rotate the factor matrix. Referring to Kaiser (1960), Sethi and King (1991), and Hair et al. (1998), four rules were applied in EFA: (1) a factor with an eigenvalue greater than 1.00 was retained; (2) an item with all factor loadings below 0.55 was removed; (3) an item with two or more factor loadings (rounding numbers) above 0.55 was dropped; and (4) an item with two or more correlation coefficients with other items greater than 0.85 was removed. **Table 2** shows the EFA results. The results show that 77.54 percent of variance is explained by four factors and 19 items are left in the instrument. These factors are labeled "Data mining techniques," "Programming and database," "Basic knowledge and procedure of data mining," and "Data retrieval and statistical presentation." The respective Cronbach's α coefficients are 0.94, 0.91, 0.87, and 0.84. All the coefficients exceed the acceptable standard of 0.70.

The criterion-related validity was assessed by the correlation between the sum of scores on all 19 items in the instrument and the validity criterion (sum of three criterion items). The correlation was 0.78, significant at 0.001, representing satisfactory criterion-related validity.

TABLE 2 | EFA results.

Items	Factor 1	Factor 2	Factor 3	Factor 4
Q1			0.56	
Q2			0.83	
Q3			0.61	
Q4			0.78	
Q6		0.86		
Q7		0.85		
Q8				0.59
Q9				0.68
Q10		0.74		
Q12	0.67			
Q13		0.82		
Q15	0.69			
Q16	0.70			
Q20				0.78
Q21				0.69
Q22	0.84			
Q24	0.78			
Q26	0.83			
Q27	0.82			
Eigenvalue	5.40	3.57	2.97	2.79
Variance explained	28.44%	18.80%	15.65%	14.66%
Cumulative variance explained	28.44%	47.23%	62.88%	77.54%
α coefficient	0.94	0.91	0.87	0.84

Factor 1, data mining techniques; Factor 2, programming and database; Factor 3, basic knowledge and procedure of data mining; Factor 4, data retrieval and statistical presentation.

The multitrait-multimethod (MTMM) approach was used for evaluating the convergent and discriminant validity of the instrument. **Table 3** shows the correlation coefficients between items. Convergent validity is acceptable when the correlation coefficients of the same factor are significantly different from zero and large enough for further investigation (Doll and Torkzadeh, 1988). The smallest within-factor correlation coefficients are: Data mining techniques = 0.50, Programming and database = 0.60, Basic knowledge and procedure of data mining = 0.43, Data retrieval and statistical presentation = 0.54. All coefficients are significantly different from 0 ($p < 0.01$) and large enough, demonstrating the convergent validity of the measures.

The discriminant validity for each item was assessed by counting the number of times correlated more closely with items of other factors than items of its own theoretical factor (Wu and Wang, 2006). Such counts should be less than 50 percent of the comparisons. As shown in **Table 3**, there were 45 violations out of 264 comparisons, representing acceptable discriminant validity.

PLS-SEM Results

According to the two-stage HCM method suggested by Hair et al. (2017) and the rationale of EFA results, a reflective-formative measurement model was built. The repeated indicators approach was adopted for analyzing the higher-order measurement model (**Figure 1**). This model hypothesized that the four reflective first-order factors formed one second-order factor. Self-efficacy in data mining and analysis is multi-faceted and the four factors of Data mining techniques, Programming and database, Basic knowledge and procedure of data mining, and Data retrieval and statistical presentation are components of self-efficacy in data mining and analysis. Therefore, the formative type (components second-order construct) is reasonable. The 19 items are reflective indicators of these four first-order factors.

There are two parts in the measurement evaluation. First, internal consistency (rho_A), convergent validity (AVE, outer loading) and discriminant validity (HTMT) were checked for the reflective part of the model, the measurement of the four factors. Second, the convergent validity, collinearity, and significance of the path coefficients were evaluated for the formative part of the model, the four factors forming the higher-order component, self-efficacy.

Table 4 shows the PLS results and relative standards of the reflective part of the measurement model. All rho_A values for the factors exceeded the recommended value of 0.7, supporting internal consistency. The average variance extracted (AVE) values for the four factors are 0.74, 0.80, 0.72, and 0.68. All AVE values are greater than 0.5, justifying the convergent validity. As shown in **Table 4**, the outer loadings of all items are significant and above 0.7, confirming the convergent validity of this measure. Finally, the heterotrait-monotrait (HTMT) was used to assess discriminant validity. As shown in **Table 4**, all HTMT values are below the threshold value of 0.9, confirming discriminant validity (Hair et al., 2017). In sum, the reflective part of the measurement model demonstrates adequate reliability and validity.

Table 5 shows the PLS results and relative standards of the formative part of the measurement model. Three

TABLE 3 | Correlation coefficient between items.

	Q1	Q2	Q3	Q4	Q6	Q7	Q10	Q13	Q8	Q9	Q20	Q21	Q12	Q15	Q16	Q22	Q24	Q26
Q2	**0.66**																	
Q3	**0.63**	**0.72**																
Q4	**0.50**	**0.67**	**0.57**															
Q6	0.41	0.47	0.49	0.46														
Q7	0.30	0.35	0.43	0.41	**0.80**													
Q10	0.35	0.51	0.47	0.50	**0.71**	**0.60**												
Q13	0.43	0.42	0.57	0.35	**0.80**	**0.70**	**0.76**											
Q8	0.60	0.50	0.53	0.48	0.58	0.52	0.50	0.46										
Q9	0.39	0.44	0.34	0.50	0.48	0.36	0.59	0.38	**0.69**									
Q20	0.60	0.39	0.43	0.46	0.42	0.35	0.47	0.46	**0.64**	**0.53**								
Q21	0.48	0.24	0.37	0.21	0.27	0.20	0.32	0.31	0.51	**0.43**	**0.63**							
Q12	0.47	0.65	0.65	0.49	0.53	0.46	0.50	0.52	0.56	0.38	0.36	0.35						
Q15	0.49	0.60	0.69	0.45	0.54	0.44	0.39	0.45	0.50	0.26	0.28	0.35	**0.77**					
Q16	0.58	0.49	0.55	0.32	0.56	0.47	0.36	0.51	0.61	0.36	0.57	0.56	**0.64**	**0.72**				
Q22	0.48	0.53	0.63	0.29	0.38	0.31	0.35	0.46	0.56	0.36	0.41	0.56	**0.68**	**0.60**	**0.65**			
Q24	0.51	0.39	0.58	0.34	0.43	0.37	0.43	0.49	0.58	0.31	0.51	0.68	**0.62**	**0.54**	**0.61**	**0.78**		
Q26	0.49	0.55	0.63	0.37	0.39	0.36	0.39	0.42	0.65	0.42	0.52	0.61	**0.71**	**0.62**	**0.68**	**0.84**	**0.78**	
Q27	0.48	0.47	0.63	0.32	0.43	0.45	0.39	0.46	0.65	0.37	0.45	0.53	**0.71**	**0.66**	**0.67**	**0.75**	**0.72**	**0.84**

The correlation coefficients between items of the same factor will be shown in bold.

analyses were executed. First, convergent validity was evaluated. Convergent validity is the extent to which a measure correlates positively with other measures of the same construct using different indicators (Hair et al., 2017). Therefore, this study used redundancy analysis for assessing convergent validity. The redundancy analysis method is useful for analyzing a directional relationship between two sets of multivariate data (Lambert et al., 1988). We created one exogenous self-efficacy construct that are measured by 19 items and one endogenous self-efficacy construct that are first measured by three global items. Then we examine the path coefficient through which the exogenous construct influences the endogenous construct. The path coefficient is 0.82, above threshold value of 0.8, confirming convergent validity (Wong, 2019). Second, the collinearity issue was assessed. Collinearity should be evaluated in a model with multiple variables as a possible predictor-predictor redundancy phenomenon (Kock and Lynn, 2012). When two or more predictor variables in a multiple regression model are highly correlated, multicollinearity occurs, which will cause the variance inflation and increase the type I error, making some coefficients appear significant when they are not (Lombardi et al., 2017). When the variance inflation factor (VIF) is higher than the threshold value of 5.0, a potential collinearity problem can exist. As shown in **Table 5**, all VIF values are below 5.0, indicating no collinearity problem. Third, the significance of the path coefficients from the four factors to the high-order self-efficacy construct was examined. The path coefficients are 0.51, 0.21, 0.22, and 0.22. All path coefficients are significant.

All indices and statistics in **Tables 4**, **5** have reached relevant assessment standards. The measurement model has satisfactory reliability and validity.

APPLICATION ANALYSIS

Through rigorous empirical analysis, this study has developed a reliable and valid instrument for measuring an individual's self-efficacy in data mining and analysis. This section presents the application analysis of the instrument from three perspectives. First, the correlation between education and self-efficacy in data mining and analysis is assessed. Second, measurement invariance from the gender perspective is evaluated. Finally, the norms of this instrument are developed.

The Correlation Between Education and Self-Efficacy in Data Mining and Analysis

This study found that there is a significant positive correlation between total self-efficacy level and credits taken by university students in data mining and analysis related courses. The correlation coefficient is 0.41, significant at 0.001. This relationship is significant and positive. The regression analysis is also tested. The independent variable is credits taken by university students in data mining and analysis related courses, and the dependent variable is total self-efficacy level. The results are $\beta = 0.41$, $T = 4.57$, and significance level < 0.001. These

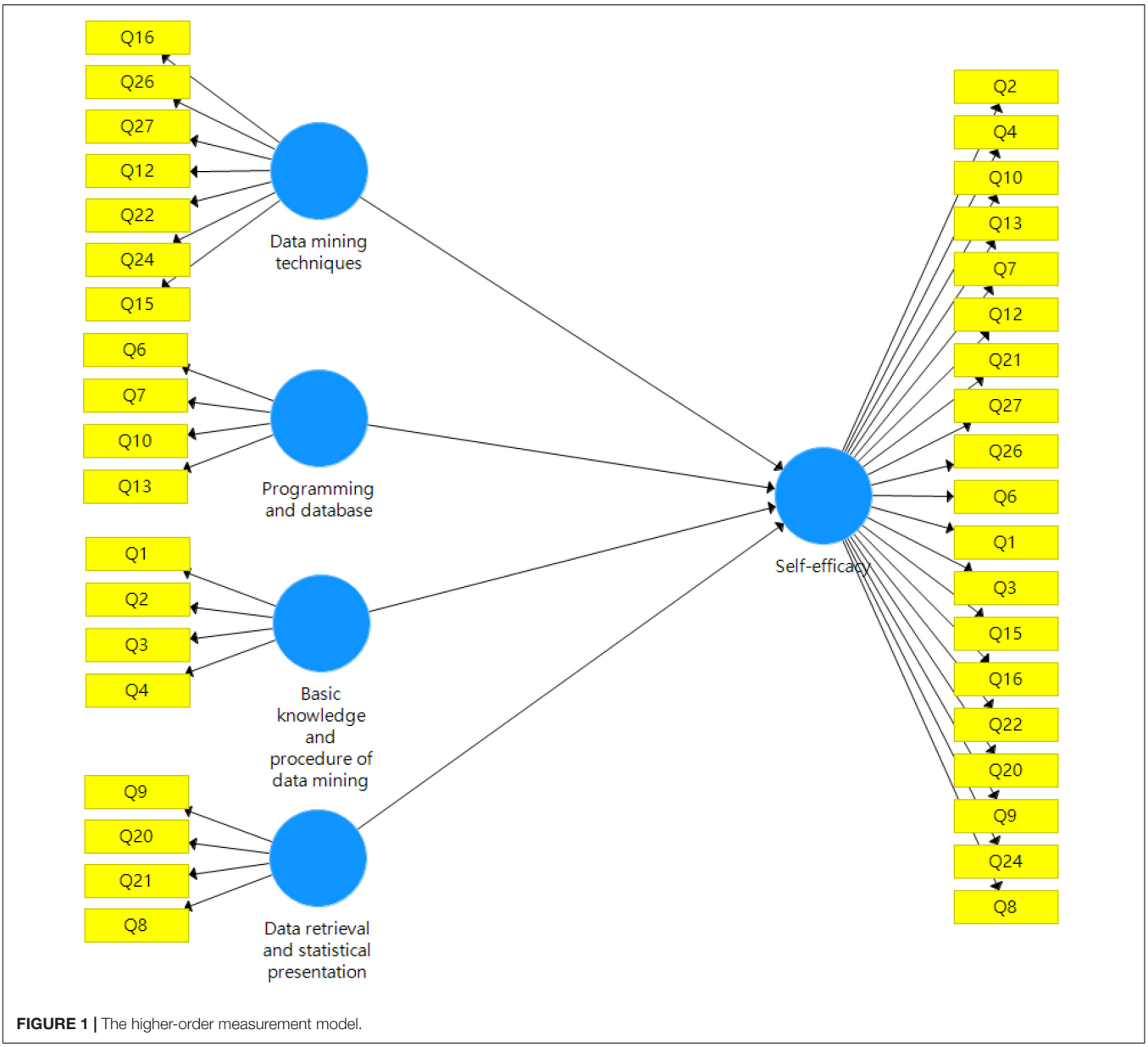

FIGURE 1 | The higher-order measurement model.

findings support the effectiveness of university education in the data mining and analysis domain.

Measurement Invariance

Measure invariance is also called measurement equivalence (Wong, 2019). It refers to the degree of a measure retains the measurement properties across observations and contexts (Mangos and Johnston, 2008). Measure invariance should be checked prior to executing multi-group analysis in the future study. This study assessed the measurement invariance from the gender perspective. Referring to Hair et al. (2017) and Wong (2019), three steps were applied: (1) Configural invariance is developed using the same path model, data treatment, and analysis algorithm. (2) Compositional invariance is evaluated by comparing path coefficients. (3) Composite means and variances are assessed if compositional invariance exists.

For analysis, we split the sample into two groups based on gender. The male group has 53 responses and the female group has 50 responses. First, the same two PLS path models for these two groups were developed. The analysis parameters and algorithm were set the same for configural invariance. Then path coefficients were estimated and compared for examining compositional invariance. The modified two independent-sample *t*-test of Keil et al. (2000) was used to compare whether the path coefficients between male and female samples are significantly different. The results are shown in **Table 6**. One relationship (Data mining techniques → Self-efficacy) was found to have different path coefficients. This implies that males and females have different perceptions about the influence of data mining

techniques on self-efficacy. Compositional variance in measuring data mining techniques may exist across gender.

Norms

The composite scores were computed by summing the 19- item scores. However, a raw composite score on a measurement instrument may be not sufficiently informative (Churchill, 1979). A better way of assessing an individual's self-efficacy is to compare the individual score with norms – the total distribution of the scores achieved by other people. The tentative norm of the self-efficacy instrument was presented in **Table 7**. These statistics offer a frame of reference and comparison for potential instrument users. The instrument users can use the norms as the benchmark for evaluating relative abilities and scores against others.

CONCLUSION AND IMPLICATIONS

Most data-mining studies focus on development of innovative algorithms, comparisons of different algorithms, and application analysis. However, relatively few studies evaluate individuals' capabilities and talents in data mining. This study is a pioneering effort to develop and validate an instrument for assessing an individual's self-efficacy in data mining and analysis. The measure items are developed based on relevant data-mining literature and practical experiences. The instrument is purified and validated empirically. Finally, nineteen items are exclusively used to assess an individual's self-efficacy in data mining and analysis. The results reveal that self-efficacy in data mining and analysis is a higher-order construct composed of four dimensions: Data mining techniques, Programming and database, Basic knowledge and procedure of data mining, and Data retrieval and statistical presentation. The results enhance our understanding of the nature and dimensionality of self-efficacy in data mining and analysis. The research findings have several implications for practitioners and researchers.

First, the instrument developed in this study can be used as an assessment and diagnosis tool. Students and practitioners can use this instrument to assess their abilities in data mining and analysis and take action to address weaknesses. Enterprises can use this instrument to assess employee abilities. When enterprises recruit data-mining professionals, they can design exam questions using the four dimensions. Instructors in universities can refer to the items, dimensions, and relative influences of these dimensions in designing data-mining programs and allocating course credits.

Second, this study finds that "data mining techniques" have the highest influence on self-efficacy (β = 0.51) among the four factors. This implies that "data mining techniques" are the requisite capabilities that individuals need to effectively perform data mining and analysis. When individuals have mastery of

TABLE 4 | PLS results: The reflective part.

Tests	Factor 1	Factor 2	Factor 3	Factor 4
rho_A	0.94	0.92	0.88	0.86
	All coefficients are above the minimum standard of 0.7			
AVE	0.74	0.80	0.72	0.68
	All AVEs are above the minimum standard of 0.5			
Outer loading	0.81–0.92	0.86–0.93	0.79–0.90	0.77–0.88
	All loadings are above the minimum standard of 0.7			
HTMT	0.61–0.76	0.61–0.64	0.64–0.76	0.65–0.75
	All HTMT indexes are below the maximum threshold of 0.9			

Factor 1, data mining techniques; Factor 2, programming and database; Factor 3, basic knowledge and procedure of data mining; Factor 4, data retrieval and statistical presentation.

TABLE 5 | PLS results: The formative part.

Tests	Results
Convergent validity (redundancy analysis)	Path coefficient = 0.82 The path coefficient (HOC → criterion) is above the minimum standard of 0.8
Collinearity	VIF = 2.47, 1.73, 2.25, 2.16 All VIFs are below the maximum threshold of 5.0
Significance of path coefficients	Path coefficients = 0.51, 0.21, 0.22, 0.22 All path coefficients (LOC → HOC) are significant at 0.001 level

TABLE 6 | Comparisons of path coefficients by gender.

Paths	Male		Female		*P*-value
	β	SD	β	SD	
Data mining techniques → Self-efficacy	0.54	0.04	0.43	0.02	0.03
Programming and database → Self-efficacy	0.22	0.04	0.23	0.02	0.86
Basic knowledge and procedure of data mining → Self-efficacy	0.21	0.03	0.25	0.02	0.27
Data retrieval and statistical presentation → Self-efficacy	0.24	0.02	0.21	0.02	0.16

TABLE 7 | Percentile scores for the instrument.

Percentile	Composite score				
	Total	Factor 1	Factor 2	Factor 3	Factor 4
10	45.40	10.80	8.00	9.40	12.00
20	57.00	14.00	11.00	12.00	13.00
30	61.20	18.00	15.00	14.00	15.00
40	68.20	21.00	16.00	15.00	16.00
50	74.00	23.00	19.00	16.00	17.00
60	77.80	27.40	20.00	17.00	19.00
70	87.60	29.00	21.00	19.00	19.00
80	94.00	31.20	23.00	20.00	20.20
90	99.60	35.00	24.00	21.00	22.60

Factor 1, data mining techniques; Factor 2, programming and database; Factor 3, basic knowledge and procedure of data mining; Factor 4, data retrieval and statistical presentation.

data mining techniques, they have the knowledge and abilities to handle decision tree, association, time-series, and artificial neural network analysis, and the pre-processing of data mining. These are indispensable and fundamental capabilities.

Third, this study also finds that the other three factors have significant and similar influences (β coefficients are between 0.21 and 0.22). This finding supports the claim that data mining is a multi-disciplinary field (Chung and Gray, 1999; Feelders et al., 2000). Since executing data mining requires cross-domain knowledge and skills, individuals should possess more than basic data mining techniques. If they want to successfully execute data mining projects and obtain correct outcomes, expertise such as programming and database use, basic knowledge and procedure of data mining, and data retrieval and statistical presentation, should be possessed.

Fourth, this study finds that education and self-efficacy are positively correlated. This implies that the higher the number of credits related to data mining, the higher the self-efficacy. This not only supports the effectiveness of university education, but also encourages students who want to have the abilities in data mining and analysis to take more relevant courses.

Finally, measure variance in the "data mining techniques" dimension may exist across genders. This issue should be re-verified with more samples. If measure variance remains, researchers should address gender difference in the influence of data mining techniques on self-efficacy.

This research has several limitations. First, this research only takes students as the survey object for analysis. However, data mining and analysis are applied in practical domains. It is thus possible that people who work in practical applications of data mining technology will have different self-efficacy. In the future, people working in practical applications of data mining should be surveyed for further analysis. Second, the sample size of the research is not large and the sample does not include students of diverse backgrounds. Future research should expand coverage to students from different backgrounds and compare the differences among them in self-efficacy of data mining and analysis.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because when collecting the survey data, we had a promise to the respondents that the response contents would not be disclosed and be given to the third parties. Requests to access the datasets should be directed to 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 participants was not required to participate in this study in accordance with the National Legislation and the Institutional Requirements. However, consent was implied via completion of the questionnaire.

AUTHOR CONTRIBUTIONS

Y-MW contributed to the research topic, data collection, statistical analysis, developing implications, and writing. C-CC took charge in literature review, writing the manuscript, and responsible for correspondence. W-CW developed the instrument and designed the questionnaire. C-JC contributed to data collection and practical implications. All authors contributed to the article and approved the submitted version.

FUNDING

The authors would like to thank the Ministry of Science and Technology, Taiwan, for financially supporting this research (Grant No. MOST 108-2511-H-001-MY3).

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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.

frontiers in Psychology

BRIEF RESEARCH REPORT
published: 21 January 2021
doi: 10.3389/fpsyg.2020.600814

Can Students' Computer Programming Learning Motivation and Effectiveness Be Enhanced by Learning Python Language? A Multi-Group Analysis

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Python language has become the most popular computer language. Python is widely adopted in computer courses. However, Python language's effects on the college and university students' learning performance, motivations, computer programming self-efficacy, and maladaptive cognition have still not been widely examined. The main objective of this study is to explore the effects of learning Python on students' programming learning. The junior students of two classes in a college are the research participants. One class was taught Java language and the other class was taught Python language. The learning performance, motivations, and maladaptive cognition in the two classes were compared to evaluate the differences. The results showed that the motivations, computer programming self-efficacy, and maladaptive cognition on the learning performance were significant in the Python class. The results and findings of this study can be used in Python course arrangement and development.

Keywords: Python, learning motivation, computer programming self-efficacy, maladaptive cognition, learning performance

OPEN ACCESS

Edited by:
Yenchun Jim Wu, National Taiwan Normal University, Taiwan

Reviewed by:
Shih-Ming Ou, Fujian Jiangxia University, China
Joey Tsai, Binghamton University, United States

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Specialty section:
This article was submitted to Human-Media Interaction, a section of the journal Frontiers in Psychology

Received: *31 August 2020*
Accepted: *09 December 2020*
Published: *21 January 2021*

Citation:
Ling H-C, Hsiao K-L and Hsu W-C (2021) Can Students' Computer Programming Learning Motivation and Effectiveness Be Enhanced by Learning Python Language? A Multi-Group Analysis. Front. Psychol. 11:600814. doi: 10.3389/fpsyg.2020.600814

INTRODUCTION

With the rapid development of artificial intelligence (AI)-related technology, the demand for relevant talents is also increasing (Wu et al., 2020). This has caused a rise in global programming education. More than 25 countries have formulated relevant education policies to cultivate people's programming skills at a young age. Those policies' purpose is to cultivate talents in related industries and improve a country's overall innovation and competitiveness by training people to have better logical and computational thinking. Consequently, programming-related courses have inevitably become essential (Kong et al., 2020).

Although programming is a necessary critical skill for students majoring in information technology-related disciplines, their learning performance of programming might be affected due to the possible maladaptive cognition in the process of their learning programming (Piwek and Savage, 2020). There are many kinds of programming languages; if students cannot master fundamental programming skills, they would have worse learning performance when learning other programming languages in the future.

The debate on determining which programming language a novice chooses has been ongoing (Pears et al., 2007). If a beginner chooses a complex language when he first enters the field, it is easy

to lose interest in the programming field. According to reports from the IEEE (Institute of Electrical and Electronics Engineers), both Java and Python have been in the top-ten-list of programming languages in recent years. For example, the top programming language in 2015 was Java (IEEE Spectrum, 2015), and in the 2018 survey, Python became the top one (IEEE Spectrum, 2018). Khoirom et al. (2020) compared various characteristics and features of Java and Python. However, they did not discuss the differences in learning motivation and learning effects of beginners in learning two languages.

Python is undoubtedly the most popular among the AI-related programming languages because its programming syntax is relatively simple, it has a gentle learning curve, and its applications are diversified and broad (Gorelick and Ozsvald, 2020). Using Python can usually quickly develop simple and practical applications without spending much time, which can improve learners' sense of accomplishment and is suitable for beginners. Nevertheless, few studies explore whether learning Python can better improve learners' learning performance compared with other programming languages. Therefore, this study aims to explore whether, compared with learning Java, students who learn Python are more likely to improve their learning motivation and self-efficacy, reduce their maladaptive cognition, and improve their learning achievement of programming.

Python is one of the most popular languages in teaching introductory programming courses. However, the impact of learning Python on students' learning performance has not been widely studied. In this study, students' learning motivation and self-efficacy are regarded as influencing factors. The purpose is to explore whether the influencing factors would affect their learning achievement and whether maladaptive cognition might occur in the process of their programming learning courses. The research questions are as the following: (1) Will students' learning motivation be higher while learning the Python programming language? (2) Will students' learning performance and self-efficacy be better while learning the Python programming language? (3) Will students' maladaptive cognition be lower while learning the Python programming language?

The main contributions of this paper are listed below:

(1) This study verified that after students learn Python language, their learning motivation and computer program self-efficacy were significantly improved.
(2) This study verified that their maladaptive cognition significantly decreased after learning Python.
(3) The students who learned Python and those who learned Java were compared in the experiments. The results showed that the former group had better learning performance.

It is expected that the results of this study will provide teachers with a reference for teaching programming courses. To cultivate students' programming skills, in addition to strengthening students' logical thinking, different programming languages might be used to enhance students' learning motivation and self-efficacy and to reduce their maladaptive cognition in the process of their programming learning.

LITERATURE REVIEW AND HYPOTHESES

Differences Between Python and Java

A survey report in The State of Developer Ecosystem 2020 pointed out that Java is the most popular primary programming language, although Python has overtaken Java (Jet Brains, 2020). More and more respondents are choosing to use Python to develop programs. The PYPL (PopularitY of Programming Language Index), which is created by analyzing how often language tutorials are searched on Google, found that Python grew the most in the last five years (19.1%) and surpassed Java in 2018. Due to the above facts, the literature was stimulated to explore the differences between Python and Java (Carbonnelle, 2020).

Miller (1956) believes that one of the most significant differences between Python and Java is how variables are handled. Java uses static typing, which forces programmers to define the variable's type when they declare it for the first time. In contrast, Python uses dynamic typing, which allows programmers to change the type of a variable. For novice programmers, dynamic typing is more comfortable to master. However, many developers believe that static typing can reduce the risk of undetected errors that can cause issues for the program (Scanlan, 1989; Prechelt and Unger, 1999).

Ogbuokiri et al. (2016) compared Python and Java to find out which is the most suitable for teaching beginners in computer programming. The research experiment compared the differences between the two languages in terms of runtime or execution time, memory consumption, code size/program length, correctness/robustness, amount of comments, and reliability. Experimental results showed that Python consumes less memory and code size than Java. Moreover, Python executes faster and is more robust than Java. Based on the above results, although the study recommended that Python be used in the first course of computer programming courses for novices, there was no evidence that learning python is better than learning Java in terms of motivation and effectiveness.

Khoirom et al. (2020) analyzed and compared the features, advantages, and disadvantages of Java and Python. It was also mentioned that Python and Java are easy to learn, and there is significant work opportunity for developers in both fields. The study's conclusions include that Java is more complicated in structure than Python, but it is easier for developers to understand memory management. Because Python is written in simple English, the syntax is short and easy to use. It is easier for novices to understand the program. The study focuses on comparing the syntax of the two languages. It is not about the psychological aspects of learners in learning two languages.

Learning Motivation

People's actions, desires, and needs are all derived from motivation to drive people's behaviors or arouse someone's desire to do something (Elliot and Covington, 2001; Vansteenkiste et al., 2020). Learning motivation is the degree of students' willingness to continue to learn hard (Wang et al., 2020). Motivation is one

of the primary factors that drive students to learn. Past studies showed that students' learning motivation impacts teaching results (Law et al., 2019; Sanaie et al., 2019). El-Adl and Alkharusi (2020) also believed that learning motivation is the motivation of achievement for learners to maintain their learning activities in their learning processes. It is one of the critical factors affecting learning performance (Rocha et al., 2019; Gan, 2020).

The ARCS model of motivation proposed by Keller and Reigeluth (1983) is based on the systematic design model of stimulating students' students' motivation to integrate the motivation model derived from motivation theory and the related theories. Proposing the ARCS motivational design model in 1984, Keller believed that four key factors affect learning motivation, namely, attention, relevance, confidence, and satisfaction. The purpose is to help curriculum design or improve teaching, and it was emphasized that these four factors should be utilized to stimulate learners' learners' learning. Keller also believed that the ARCS motivational design model is suitable for learners of all ages.

Python programming language offers simple-to-learn syntax and a large standard library. The advantages can attract beginners to learn and enhance their confidence and satisfaction. Therefore, the following hypothesis is proposed.

H1: Students' learning motivation can be significantly enhanced by learning the Python language.

Maladaptive Cognition

Learning strategy is also known as a cognitive strategy used to explain an individual's control of his/her learning, memory, and thinking behavior (Biwer et al., 2020). In past studies, the adaptive cognitive learning strategy was categorized as deep information processing strategy (organization and elaboration strategies) and self-adjustment strategy (observation, judgment, and response).

Scholars such as Pintrich and DeGroot also categorize cognitive strategy as rehearsal strategy, elaboration strategy, and organization strategy. Rehearsal strategy was considered as a surface cognitive strategy (Anderman and Young, 1994; Bandura, 1997), through which learning content can stay in the short-term memory for a short time. Surface cognitive strategy, also known as surface strategy, is regarded as a passive cognitive strategy (Entwistle and Tait, 1990).

Surface strategy is a strategy in which learners use repetitive rehearsal to keep learning content in their short-term memory and avoid it being forgotten quickly. If learners frequently use this way to learn, they tend to lack in-depth thinking in their learning process, resulting in their inability to organize, integrate, absorb, and internalize the learning content. Consequently, in this study, maladaptive cognition is defined as the degree of using surface strategy to learn.

The syntax of Python language is ease-of-learning, so the learners can keep the syntax in their long-term memory. They also can concentrate their attention on the coding logic, not on the syntax. Therefore, the following hypothesis is proposed.

H2: Students' maladaptive cognition will be lower while learning the Python language.

Self-Efficacy and Learning Achievement of Programming

Self-efficacy refers to one's degree of belief in whether one can use his/her skills to complete a particular behavior (Bandura, 1986). Korkmaz and Altun (2014) used to apply the "Computer Programming Self-Efficacy Scale" to 378 engineering students to test students' self-efficacy levels for learning C++ programming language. The study results showed that the scale has trustworthiness, reliability, and validity, which can be used to quantify the self-efficacy perception of engineering students. It was also found that computer engineering students' self-efficacy is higher than that of electronic engineering students. Many studies in the past have also shown that students' self-efficacy would significantly affect their learning achievement.

Learning achievement is defined hereby as learners' achievement during their programming learning course, and is used to evaluate whether learners' programming skill is improved upon completing their course. In this study, students' final examination results are used as the evaluation index of their programming learning achievement. Learning achievement is a critical index to evaluate students' learning outcomes. Tanah (2009) believed that learning achievement is the degree of learners' mastery of teaching materials, while the factors that affect learning achievement were also explored in past studies.

Python language has user-friendly data structures that can reduce the length of code. Learners can finish their computer programming tasks more quickly and easily. They also can complete their programming tasks through open source code in the Python online communities. Their computer programming self-efficacy and achievement will be enhanced by the advantages of Python language. Hence, the following hypotheses are proposed.

H3: Students' computer programming self-efficacy can be enhanced significantly while learning the Python language.

H4: Students' learning achievement can be enhanced significantly while learning the Python language.

RESEARCH METHOD

The junior students of two classes in a college in central Taiwan are the research participants. The major of the students is information management. In this study, the questionnaire survey method is used. In the first semester, the students of class A were taught with Java. The pre-learning questionnaires for the students were collected at the beginning of the semester, and the post-learning questionnaires for the same students were again collected at the end of the semester after they learned Java. Pearson correlation analysis was further performed against sample data of students' post-learning questionnaires and their final examination results to understand their learning performance in Java. In the second semester, the students of class B were taught with Python. The pre-learning questionnaires for the students were collected at the beginning of the semester, and the post-learning questionnaires for the same students were again collected at the end of the semester after they learned Python.

Sample data of students' pre- and post-learning questionnaires and the two classes' final examination results were analyzed to understand the difference in students' learning performance in Python programming language between the two classes. In addition to the programming language, we try to control the other conditions, such as the same class settings, instructor, and the same test. Before this study, a programming test was used to evaluate students' programming abilities. The test results also showed that there were no significant ability differences in these two classes.

Questionnaire Development

A five-point Likert scale was used for all items, ranging from "strongly disagree" (1) to "strongly agree" (5). The items for learning motivation were adapted from Keller (2009). Items for measuring computer programming self-efficacy were adapted from Ramalingam and Wiedenbeck (1998). Maladaptive cognition was assessed by the items developed based on the operational definition. A pretest was performed with the help of six students with computer programming experience and three experts.

Validity and Reliability

In this study, SmartPLS 2.0, AMOS 22, and SPSS 24.0 were used to analyze the survey data. In the measurement model, confirmatory factor analysis (CFA) and exploratory factor analysis (EFA) were used to examine the reliability and validity of the model. All of the factor loadings in the factor analysis are greater than 0.7. The model fit index of the 3-factor CFA model are above acceptable values (GFI = 0.93, CFI = 0.99, AGFI = 0.85, TLI = 0.98, RMSEA = 0.066). With regard to the reliability, composite reliability (CR) and Cronbach's alpha (CA) are the common criteria. The values of CR and CA ranged from 0.755 to 0.960, which exceed the 0.6 threshold for acceptable reliability (Esbensen, 2009). Analysis of the measurement model indicates the following: all items' indicator factor loadings exceeded the accepted reliability threshold of 0.5, average variance extracted (AVE) values were within the range of acceptability (0.662–0.889), and all values for CR exceeded the accepted threshold. All the figures in the measurement model meet the conditions for convergent validity (Fornell and Larcker, 1981). With regard to discriminant validity, it commonly measures the statistical difference between two factors by comparing each construct's square root of AVE with that construct's correlation coefficients with the remaining constructs. The analysis results show that the correlation coefficients are less than the square root of the AVE. Hence, the results of the discriminant validity are acceptable.

RESULTS

In order to evaluate the learning performance in the two classes, paired sample *t*-tests were conducted to compare the students' perceptions of the pretest with the perceptions of the post-test. In class B (**Table 1**), the perceptions of learning motivation and computer programming self-efficacy were enhanced significantly after learning Python ($p < 0.05$). The students' maladaptive cognition was lower and improved significantly ($p < 0.01$). In class A (**Table 2**), students' perceptions of learning motivation were not enhanced after learning the Java language. Surprisingly, their computer programming self-efficacy and maladaptive cognition were not significantly improved either ($p > 0.05$).

In order to compare the differences in the learning performance in the two classes, a two-sample *t*-test is used to test the differences. The students' learning performance was measured by a final programming exam, which contains six coding tests. According to the results in **Table 3**, there were no significant differences in learning motivation, computer programming self-efficacy, and maladaptive cognition between the two classes before this experiment. As expected, after this experiment, the students' learning performances in the Python class is significantly better than the performances in theJava class. Therefore, H1-H4 were supported.

The results in the correlation test show that students' scores in the Python class were positively related to the other three factors (**Table 4**). However, students' scores in the Java class had no significant relationship with the three factors. The possible reasons may be the scores in Java were relatively low, and Java language is relatively hard to learn; students need more time to develop better learning performance.

DISCUSSION

According to the data analysis results of this study, whether students learn Java or Python, there is a significant positive correlation between students' learning motivation and self-efficacy of programming, which is also justified by a past

TABLE 1 | Paired *t*-test in Python language course (*N* = 35).

Construct		Mean	SD	*t*	*df*	*p*
LM	Pretest	3.50	0.79	−1.795	34	**0.082**
	Post-test	3.70	0.74			
MC	Pretest	2.71	0.99	3.024	34	**0.005**
	Post-test	2.29	1.04			
CPSE	Pretest	3.20	0.92	−2.517	34	**0.017**
	Post-test	3.55	0.78			

LM, learning motivation; MC, maladaptive cognition; CPSE, computer programming self-efficacy. Bold values indicate the probabilities of observing the test results under the null hypotheses.

TABLE 2 | Paired *t*-test in Java language course (*N* = 34).

Construct		Mean	SD	*t*	*df*	*p*
LM	Pretest	3.28	0.80	2.910	33	0.006
	Post-test	2.91	0.81			
MC	Pretest	3.13	0.84	0.671	33	0.507
	Post-test	3.05	0.85			
CPSE	Pretest	3.09	0.75	−1.339	33	0.190
	Post-test	3.25	0.91			

LM, learning motivation; MC, maladaptive cognition; CPSE, computer programming self-efficacy.

TABLE 3 | Independent *t*-test of the two courses.

	Mean (SD)		*t*-value	*p*-value	Hypothesis testing
	Python (*N* = 35)	Java (*N* = 34)			
LM	3.50 (0.79)	3.28 (0.80)	1.149	0.255	
MC	2.71 (0.99)	3.12 (0.84)	−1.861	0.067	
CPSE	3.20 (0.92)	3.09 (0.75)	0.550	0.584	
LM (post)	3.81 (0.89)	2.91 (0.81)	4.379	**0.000**	Supported
MC (post)	2.31 (0.93)	3.05 (0.85)	−3.412	**0.001**	Supported
CPSE (post)	3.71 (0.90)	3.25 (0.91)	2.111	**0.038**	Supported
LP (post)	91.43 (14.38)	73.53 (25.57)	3.570	**0.001**	Supported

LM, learning motivation; MC, maladaptive cognition; CPSE, computer programming self-efficacy; LP, learning performance. Bold values indicate the probabilities of observing the test results under the null hypotheses.

TABLE 4 | Correlation analysis.

Python	**1**	**2**	**3**
1. LM	–	–	–
2. MC	−0.605**	–	–
3. CPSE	0.680**	−0.687**	–
4. LP	0.501**	−0.818**	0.541**
Java	**1**	**2**	**3**
1. LM	–	–	–
2. MC	−0.333*	–	–
3. CPSE	0.748**	−0.374*	–
4. LP	0.287	0.029	0.121

**p < 0.05, **p < 0.01.*
LM, learning motivation; MC, maladaptive cognition; CPSE, computer programming self-efficacy; LP, learning performance.

study that stated that learning motivation would affect self-efficacy (Wang et al., 2008). In addition, learning motivation and maladaptive cognitions are shown to be significantly negatively correlated for students' learning of Java and Python, which indicates that, with better learning motivation, students would obtain a sense of achievement from learning the programming language, and are willing to continue to participate in their learning; they would also have better self-efficacy perception of programming, increase their own level of confidence, lower the degree of their maladaptive cognition, and become more willing to learn the programming language through understanding rather than memorizing by rote.

The data analysis results show a significant positive correlation between students' maladaptive cognition and self-efficacy of programming, whether students learn Java or Python. It indicates that having completed homework or tests by rote memorization, students' confidence in coding a complete program to achieve a particular goal would become lower, and their self-efficacy worse.

In terms of different programming language courses, this study's research results show that students would reduce their maladaptive cognition by learning Python. In other words, students in the Python class would improve and complete the course objectives not by rote memorization and instead would gradually learn and complete the course objectives with the intent of mastering the course in a comprehensive manner. However, after that, students in the Java class seem to not have a significant improvement in their maladaptive cognition. In other words, compared with the Java course, students tend to reduce their maladaptive cognition more by learning Python.

Past studies used to point out that there is a correlation between learners' self-efficacy perception and their learning achievements. A good learning experience can improve one's own self-efficacy and bring better learning achievement. According to the data analysis results of this study, there is a significant positive correlation between self-efficacy of programming and learning achievement of programming in the process of learning Python, although the foregoing significant correlation is not seen in the process of learning Java. It can be concluded that the higher the student's self-efficacy perception of programming during students' Python learning, the higher their confidence in their skill to code is, and thereby the better their learning achievements would be.

In terms of different programming language courses, the research results of this study show that students learning Python would increase their confidence in coding a program to achieve their task goals when learning Python, but students learning Java would not significantly improve their self-efficacy when learning Java, which indicates that for students, learning Python would improve their self-efficacy more against that achieved through learning Java.

According to the analysis results of the Pearson correlation test, students' learning motivation, maladaptive cognitions, self-efficacy of programming, and learning achievement of programming all show a significant correlation to one another for the students leaning Python, while the foregoing significant correlation is not seen for the students learning Java. According to the results of the t-test analysis, the learning achievement of the students learning Python is significantly higher than that of the students learning Java, which indicates that for students, learning Python has better learning motivation and self-efficacy perception, and reduces their maladaptive cognition to obtain better learning achievement.

CONCLUSION

This study used an experimental design to compare students' learning performance and effectiveness in Python and Java programming courses. The experimental results showed that students' learning effectiveness, learning motivation, computer programming self-efficacy, and maladaptive cognitions could be significantly improved in the Python programming class. Possible reasons are that Python is simpler in data and prograaming structure and its syntax is shorter (Khoirom et al., 2020). The results of the research can be a reference for programming teaching/learning. However, this study still has some limitations. First of all, the experiment is conducted alongside the courses' teaching, the courses given in this study take a longer time, and the number of classes is fewer, resulting in insufficient samples. In the future, more questionnaires are expected to be collected from students of more classes of the foregoing two

programming languages to increase the number of subjects under test for further exploration and study. Secondly, in the future, more diversified programming language courses are expected to be studied at the same time to understand the impacts of different programming languages on students' learning performance, to find out the programming languages more suitable for students to learn. This study also explores the factors that affect the learning performance of different programming languages based on students' learning motivation, self-efficacy, and the negative factor, maladaptive cognitions. In terms of the exploration of the factors affecting the learning performance of different programming languages, it is recommended to explore the impact of students' satisfaction with the content of the programming language course on their learning performance and to examine whether students' experience about the content of different programming language courses may affect their learning performance.

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 Teaching Practice Research Program, Ministry of Education, Republic of China (Taiwan). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

H-CL contributed to the research topic and the methodology. K-LH contributed to the research model and the experimental design and results. W-CH contributed to the statistical analysis and the discussion. All authors contributed to the article and approved the submitted version.

ACKNOWLEDGMENTS

The authors would like to thank the Ministry of Education of the Republic of China for supporting this study financially (Contract No. PBM1080094).

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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.

frontiers in Psychology

ORIGINAL RESEARCH
published: 22 January 2021
doi: 10.3389/fpsyg.2020.611383

A Meaning-Aware Cultural Tourism Intelligent Navigation System Based on Anticipatory Calculation

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To improve the personalized service of cultural tourism, anticipatory calculation has become an essential technology in the content design of intelligence navigation system. Culture tourism, as a form of leisure activity, is being favored by an increasing number of people, which calls for further improvements in the cultural consumption experience. An important component of cultural tourism is for tourists to experience intangible cultural heritage projects with local characteristics. However, from the perspective of user needs and the content adaptive system, there are few suitable intelligent navigation and user demand anticipatory systems for intangible cultural heritage content. Purple clay culture is one of the first batches of national intangible cultural heritage protection projects in China. Therefore, taking purple clay culture exhibition as an example, this paper attempts to analyze the personalized information demand of tourism consumption experience in intangible cultural heritage communication activities with affective computing and meaning-driven innovative design method, by taking the content design in the navigation system as the research object. This paper uses the theory of planned behavior to calculate the relationship between tourists' attitude, experience behavior, and display information demand. The findings indicate two issues. First, tourists' demand for the entertainment and leisure attributes of intangible cultural heritage is greater than the demand for educational function attributes. Second, the meaning elements of information can change tourists' beliefs in intangible cultural heritage and affect their attitude and behavior toward such heritage. According to the research results, strengthening the meaning elements of specific group information can improve people's cultural identity and tourism satisfaction. The research results provide the basis for the content design direction of future museum intelligent navigation systems.

Keywords: meaning innovation, theory of planned behavior, affective computing, artificial intelligence, navigation system, intangible cultural heritage exhibition, content design

OPEN ACCESS

Edited by:
Mu-Yen Chen,
National Taichung University of Science and Technology, Taiwan

Reviewed by:
Long-Sheng Chen,
Chaoyang University of Technology, Taiwan
Mary Gladence L.,
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Specialty section:
This article was submitted to Human-Media Interaction, a section of the journal Frontiers in Psychology

Received: *28 September 2020*
Accepted: *30 November 2020*
Published: *22 January 2021*

Citation:
Meng L and Liu Y (2021) A Meaning-Aware Cultural Tourism Intelligent Navigation System Based on Anticipatory Calculation. Front. Psychol. 11:611383. doi: 10.3389/fpsyg.2020.611383

INTRODUCTION

According to the report of the nineteenth National Congress of the Communist Party of China, the main contradiction of China's society has been transformed into "the contradiction between the growing needs of the people's life and the development of imbalanced development" (Jinping, 2017). People's life needs have also developed from tangible "material" needs to intangible and living "process" experience (Chiara, 2007). Pursuing the enrichment of material life and spiritual life in

one's own culture along with life satisfaction has become the norm. Cultural tourism has become a popular cultural leisure activity (Blazquez-Resino et al., 2020). In addition, the intangible cultural heritage experience tourism projects provided by tourist attractions and travel agencies have helped in enhancing the ability to promote the cross-border integration of intangible cultural heritage in recent years (Su et al., 2020). The original purpose of UNESCO's intangible cultural heritage protection convention is to protect and promote cultural diversity and alleviate the alienation of human beings caused by industrial society and global commercialization (Saito, 2005; UNESCO, 2005). The intangible cultural heritage inherited by one generation from another is constantly recreated by different communities and groups in the process of adapting to the surrounding environment and nature and interacting with their history. This provides them with a continuous sense of identity and enhances respect for cultural diversity and human creativity (UNESCO, 2003). This sense of identity can generate community cohesion and improve quality of life. The core of protecting intangible cultural heritage is to enhance its vitality and sustainability (Lenzerini, 2011). The protection and dissemination of intangible cultural heritage is significant for the promotion of cultural belonging and the generation of self-confidence and happiness. Intangible cultural heritage exhibitions not only play an important role in improving personal well-being, emotional belonging, psychological identity, self-confidence, and relieving pressure but are also significant in promoting social inclusiveness. Therefore, it is necessary to pay attention to the research and design of the intelligent navigation systems' content to improve the dissemination efficiency and user experience of intangible cultural heritage display information by affective computing and meaning innovation. Since 2005, the protection of intangible cultural heritage has been greatly promoted across all government departments in China. From 2005 to 2019, local governments have built many cultural infrastructures, such as high-quality exhibition space and supporting facilities, to meet the needs of people's tourism and leisure experience and for intangible cultural heritage protection (Maags, 2019; Luo, 2020). The establishment of the Ministry of Culture and Tourism is an important measure to promote the integration of culture and tourism (2018). Such an integration attests to the government's proactive promotion in the protection, inheritance, and effective utilization of intangible cultural heritage. Contrarily, when intangible cultural heritage (ICH) protection is combined with tourism, a new phenomenon of ICH protection is created: intangible cultural heritage living performance for cultural tourism (Zandieh and Seifpour, 2020).

The national intangible cultural heritage project "Qinhuai Lantern Festival," for example, includes tourism elements, such as "eating, living, traveling, shopping and entertainment" which are deeply combined to create a representative cultural tourism brand in Nanjing, Qinhuai District. In 2018, during the festival, the number of tourists exceeded 10 million in Nanjing, and the total tourism revenue exceeded 10 billion yuan (Le, 2019). Whether ICH living performance or exhibition is of a nostalgic, an appreciative, or an interactive type, it has already attracted specific groups of people. As tourists' target needs to change from material to experience, appropriate regional cultural experience will induce a positive effect on their sense of experience and well-being.

Past studies on the communication activities of intangible cultural heritage mostly focused on inheritors teaching the next generation about traditional skills, program performance and recording, and cultural tourism activities publicity (An et al., 2015). A few studies focused on the exploratory issue of the design of cultural and creative products (Boix and Lazzeretti, 2012; Boccella and Salerno, 2016; Thorne et al., 2017). In addition, Wang (2018) investigated the effect of the productive protection of intangible cultural heritage on the inheritors of intangible cultural heritage. However, from the perspective of cultural tourism integration, there is a big gap between the demand for intangible cultural heritage exhibitions for leisure and entertainment and the original utilitarian communication demand. Stephenson (1967) believes that communication can be divided into working communication and game communication. The result of game communication is the pleasure of communication; work communication entails communication of others' behavior, such as command, help-seeking, persuasion, and request. The Play Theory of Communication is applicable to the mode of intangible cultural heritage communication from the perspective of cultural tourism. Schramm and Porter (2019) believe that communication is closely related to the formation of cultural communities. Without communication, there will be no community; conversely, without community, there will be no communication (Lo and Janta, 2020). Therefore, targeted information delivery and community formation can help enhance the motivation and behavior of tourists for active dissemination of information. Nevertheless, in the intangible cultural heritage exhibition activities, there are few studies on the behavior and motivation of tourists' voluntary and active information dissemination activities.

With the increasing popularity of intangible cultural heritage exhibition activities after the integration of culture and tourism, the research attention and depth has also increased in the field of intangible cultural heritage display. Some scholars (Huang et al., 2019; Kim et al., 2019; Tan et al., 2020) believe that previous research on the design content of intangible cultural heritage exhibitions primarily focused on the "how" of the design, and not on the "why" (Verganti, 2016).

Focusing on the scenario of cultural tourism, this study analyzes the interaction between people and objects and information related to intangible cultural heritage exhibition. In addition, the study points out that the significant factors of exhibition content are influencing tourists' emotional experience and cultural consumption and innovation of the meaning of content, which is an important way to improve the protection and communication efficiency of intangible cultural heritage. The study considers tourists as the research object, and calculates the tourists' attention variations on the functional level and significance level of information while contacting intangible cultural heritage. It also explores the design framework of adaptive content in intelligent navigation systems to meet the user's demand perception through the relationship among

tourists' attributes, attitudes, and behaviors. Through an empirical analysis, this study can provide relevant suggestions for the content designers of museum navigation system, intangible cultural heritage protection practitioners, and cultural tourism management departments.

The structure of this paper is as follows: Literature review introduces the Museum digital navigation system, cultural tourism, intangible cultural heritage, and theory of planned behavior. The research methodology provides the research hypothesis and framework, measurement, sampling method, and respondents' profile of this research. Results include reliability and validity, hypothesis testing, and so on. Discussion and Conclusions present the discussion, conclusions, theoretical contributions, and suggestions for future research in this study.

LITERATURE REVIEW

Intelligent Navigation System for Exhibition in Museums

Over the past few years, the prevalence of smart mobile devices has also increased the popularity of personalized content navigation services in the field of cultural heritage display and communication. In addition, the exponential rise of location-based services (LBSs) (Wu et al., 2017) has made indoor positioning, navigation (La Delfa et al., 2016), and content context aware adaptive system into research hotspots (Wei et al., 2018). For museums, the ICH exhibition hall, and other public buildings, the development of mobile positioning and navigation-related intelligent navigation systems (Wang, 2019) helps improve the visitors' user experience in exhibition venues and their quality of life (La Delfa et al., 2016). Research on intelligent navigation systems in the field of culture and museums mainly focuses on the following aspects:

First, research on positioning technology and methods needed for indoor navigation. Smartphones have become indispensable in most people's lives. Given the various kinds of sensors built into smartphones, resolving indoor navigation problems using these phones has become the key solution (Gareev et al., 2019; Xia et al., 2019). Specifically, smart phones combined with widely deployed unlimited LANs provide technical solutions for indoor navigation (Carboni et al., 2015). To cope with the limitations and complexity of indoor environments, indoor positioning solutions based on UWB, WiFi, and Bluetooth have also been proposed (Wang et al., 2015; Yang and Shao, 2015). In addition, a smartphone camera can be used to locate users by detecting common static objects, such as doors and windows in indoor space as a reference, and then calculate the location of smart phones (Xiao et al., 2018). Based on the functions of modern smart phones, low-cost indoor navigation systems without any physical infrastructure or reliance on any wearable devices have also been studied (Carboni et al., 2015). Under this research topic, there is scope of finding a solution for achieving a low-cost and accurate positioning system.

Second, research on auxiliary equipment or systems related to mobile navigation. Research on auxiliary equipment primarily focuses on helping people with special needs, for example, Blind Museum Tourer, a system for indoor interactive autonomous navigation for blind and visually impaired persons and groups (such as primary school students), which has primarily addressed blind or visually impaired (BVI) accessibility and self-guided tours in museums (Meliones and Sampson, 2018). In the navigation process of blind tourists, effective walking can be achieved through the integration of multi-sensor integrated audio tactile signal and motion feedback (Gori et al., 2017). In addition, due to the high performance of smartphone cameras, marker-less and maker-based computer vision approaches have been investigated. For example, a technique for indoor localization and navigation using Bluetooth low energy (BLE) and a two-dimensional visual marker system (La Delfa et al., 2016) were deployed on the floor. A reliable and high-precision indoor positioning system can also be designed and implemented by combining wireless local area networks (WLANs) with surface-mounted auxiliary tactile path indication, BLE beacon, and inertial dead reckoning (Meliones and Sampson, 2018).

Third, digital content development and interactive experience research of cultural heritage. Digital content recommendation services in display and communication include a mobile audio guide to enhance tourists' experience (Ambard et al., 2015), AR and VR solutions for digital image superimposing real scenes of cultural heritage, etc. (Wang, 2019). In the past, augmented reality (AR) projects have made it possible to provide enhanced visual and acoustic stimulation through the application of smartphones (Gimeno et al., 2017; Wang, 2019). DinofelisAR, for example, uses mobile AR technology to give users a panoramic view of a grand reconstruction forum in the Roman era from its existing ruins. As a result, users can continue to perceive the current surroundings of a Roman city in ruins, while exploring matching virtual models (Marto and Goncalves, 2019).

In the field of cultural relics and museums, intelligent navigation includes relatively in-depth research on equipment development, positioning technology, digital content (Huang et al., 2019; Kim et al., 2019), and user experience (Wang, 2019). However, from the perspective of meaning innovation, the function and efficiency of displaying communication content in the navigation system are still insufficient. Through the analysis of tourists' interests and attributes, this study provides a design idea of meaning-driven navigation personalized content. It is no longer a simple discussion on how to design and implement technology, but to explore its "why" and explain the value of intelligent navigation systems. This integrated system design brings together human, technology, content, and other factors.

Cultural Tourism and Intangible Cultural Heritage

Culture is one of the driving forces behind the growth of tourism (Pololikashvili, 2018). According to the United Nations World Tourism Organization (UNWTO), cultural tourism is "movements of persons for essentially cultural motivations such as study tours, performing arts and cultural

tours, travel to festivals and other cultural events, visits to sites and monuments, travel to study nature, folklore or art, and pilgrimages." Cultural tourism includes travel, the purpose of which is to visit scenic spots and participate in activities of cultural and historical value. Cultural tourism is a type of tourism activity in which the visitor's essential motivation is to learn, discover, experience, and consume tangible and intangible cultural attractions or products in a tourism destination. These attractions/products relate to a set of distinctive material, intellectual, spiritual, and emotional features of a society (UNWTO, 2017). Exploring the global wealth of traditions is a principal motivation for travel, with tourists seeking to engage with new cultures and experience the global variety of performing arts, handicrafts, rituals, and cuisines. The cultural interaction spurred by such encounters prompts dialogue, builds understanding, and fosters tolerance and peace. Tourism offers a powerful incentive for preserving and enhancing intangible cultural heritage because its revenue can be channeled back into initiatives to aid its long-term survival. Therefore, tourism activities and intangible cultural heritage protection are inseparable.

The general conference of the United Nations Education Scientific and Cultural Organization (UNESCO) issued the Convention on the safeguard of intangible cultural heritage in 2003. It defines "intangible cultural heritage" as follows: "The intangible cultural heritage means the practices, representations, expressions, knowledge, skills—as well as the instruments, objects, artifacts and cultural spaces associated therewith—that communities, groups and, in some cases, individuals recognize as part of their cultural heritage. This intangible cultural heritage, transmitted from generation to generation, is constantly recreated by communities and groups in response to their environment, their interaction with nature and their history, and provides them with a sense of identity and continuity, thus promoting respect for cultural diversity and human creativity." Intangible cultural heritage protection is an important way to maintain cultural diversity, cope with globalization, and provide sustainable cultural development. It also guarantees to improve the quality of life. Cultural diversity is a source of communication, innovation, and creation, and is as essential to human beings as it is to maintain biological balance (UNESCO, 2001). With the change of transportation and information dissemination, people frequently visit places outside their normal living environment for a certain purpose. Therefore, tourism has become a social, cultural, and economic phenomenon (World Tourism Organization [UNWTO], 2008b). The growing interest of tourists in cultural experiences brings along many opportunities and complex challenges for tourism. Only by truly understanding the wishes and values of all parties can a true partnership be established between the community and the tourism and heritage sector; this can ensure the sector's survival and prosperity. Novelty is the foundation of tourism (Mitas and Bastiaansen, 2018). Excellent exhibitions can meet the needs of tourists who are looking for novelty. Tourism novelty is associated with nostalgia (Skavronskaya et al., 2020). Intangible cultural heritage display in cultural tourism is an important channel to provide novelty and nostalgia. Common types of cultural tourism related to ICH mostly include digital tourism of legends and folklore (Vassiliadi et al., 2018) and community-based cultural ecotourism (Lo and Janta, 2020). Digital tourism carries out cultural experiences through digital narrative. For example, through the digital narration of the volcanic eruption scene of Pompeii ancient city by MR technology, we can get a higher sense of experience (Vassiliadi et al., 2018). In terms of community tourism (Lo and Janta, 2020), it is important to empower communities, involve local residents, cultivate cultural resources, and ultimately maintain the sustainability of the overall tourism resources.

Exhibition is a typical communication activity. Communication is closely related to the formation of a cultural community. Without communication, there will be no community; conversely, without community, there will be no communication (Zeng et al., 2017). As the stakeholders, tourists, and local residents are becoming increasingly important in tourism destinations (Shen et al., 2019), their support is seen as an important prerequisite for the sustainability of tourism in destinations (Sinclair-Maragh and Gursoy, 2016; Ribeiro et al., 2017). In this study, the experience of an intangible cultural heritage exhibition is a participatory narrative experience based on community cultural ecology. Tourists are the protagonists of experience activities.

According to Mckercher and Tolkach (2020), the "depth of experience" pursued by tourists is different. According to the depth of experience, cultural tourists are divided into sightseeing, serendipitous, casual cultural tourism, and so on. In the process of cultural communication, tourists are not only audiences but also participants and disseminators of community culture (Ezio, 2014). Most of the research on tourism culture experience has mainly focused on tourists. For tourists, the essential motivation is to learn, discover, experience, and consult through tourism. Indeed, this kind of research focuses on the purpose and sightseeing cultural tourism. This study focuses on tourists and local community residents who have been identified as inhibitors of intangible cultural heritage. Their motivations for participating in cultural tourism exhibition activities are likely to be different from the motivations and cognitions of the other types of tourists.

The Theory of Planning Behaviors (TPB)

The applicability of information in the intelligent navigation system is determined by the emotional experience of each tourist. Emotional experience is closely related to behavior and attitude in intangible cultural heritage exhibition activities. TPB is based on the theory of rational action proposed by Fishbein and Ajzen (1975). According to the TPB, behavior intention is one of the best variables for behavior prediction (Ajzen, 1985). Intention is influenced by attitude, subjective norms, and perceived behavioral control. Behavioral intention is the closest predictor of behavior, reflecting the level of motivation for executive behavior (Jekaus et al., 2015). The premise of the theoretical hypothesis is that "behavior is based on rational reasoning, which believes that individuals can properly control their own behavior through personal will" but in fact, individual behavior and personal will

are not consistent. Behavior is also affected by the external objective environment or resource constraints. For example, the expensive price and complicated production process of purple clay pots will determine the degree of personal preference for purple clay culture. These factors make the Theory of Reasoned Action (TRA) inapplicable in explaining tourists' behavior of participating in intangible cultural heritage exhibition activities. For this reason, Ajzen (1985) adds the "perceived behavioral control" into the TRA model. Among the three core variables of TPB, "attitude" is a personal positive or negative view and belief about a specific behavior. The social pressure that individual feels to his/her behavior is called "subjective norm." The level of individual control over a particular behavior is called "perceived behavioral control," which means that individuals predict the possible difficulties in performing the behavior according to his/her past experience. This study investigates whether tourists think that the dissemination of intangible cultural heritage–related information can gain the admiration and respect of their relatives and friends and that it is a beneficial behavior for their own cognition and knowledge. Accordingly, their attitude toward active communication and tourism consumption behavior will also tend to be positive. In this process, the "attitude" and "subjective norm" variables in TPB will be enhanced. If tourists release relevant information through social media, few people agree with it, or friends do not support participating in intangible cultural heritage exhibition activities, or they do not have time or money for tourism consumption, they will regard "lack of resources" as an obstacle to behavior, which will ultimately affect their behavioral intention to actively participate in the dissemination. Hsu (2006) points out that the limitations of TPB itself are obvious. Although TPB can predict the relationship between intention and behavior, there are inconsistencies in age group, education level, and income level. In addition, the influence of consumption habits and social customs on behavioral intention has also been verified (Lin et al., 2020). Due to the influence of subjective factors, different groups have different demands on the same exhibits. Different demands also mean that different meanings and connotations need to be considered in the design of the display content. Therefore, this paper will explore the relationship between content meaning and behavioral intention.

In cultural tourism, the active participation of tourists determines the effectiveness of information exchange and the quality of tourism experience. Different groups of people have different beliefs about actively participating in exhibition activities (Bastiaansen et al., 2019). For example, young people will pay attention to personality and fashion elements in intangible cultural heritage; local people and foreigners also have different needs for the same cultural information. This finding comes from field investigation and literature review, which constitutes the motivation of the current study. Therefore, this study will take tourists and community personnel as the research subjects. Further, it will expand the TPB by adding a factor of meaning cognition to investigate their behavioral intention of showing communication participation in cultural tourism, investigate the relationship between content meaning and their behavioral beliefs or behavioral intention, realize the clustering of communication groups on this basis, and finally, realize the accuracy of information dissemination.

The Purple Clay of ICH Theme Cultural Tourism in Yixing

Purple clay ceramic is the local cultural characteristic of Yixing, which is well regarded worldwide. Purple clay ceramic–themed cultural tourism is an important tourism resource and cultural brand in Yixing City. The local cultural and Tourism Bureau actively promotes cultural tourism with a purple clay theme, and develops the whole regional tourism brand with multiple themes. For example, "Tea Zen culture tour to Yixing in April" is a tourism season from March to June each year, highlighting theme activities, such as new tea picking and selection, vegetarian culture expansion, rural homestay experience, and pottery handicraft tours. The theme tour of ceramic culture has a positive impact on people's lives based on its profound historical accumulation, rich ceramic cultural resources, and tea Zen culture. According to the master plan for the development of the tourism industry in Yixing City, Jiangsu Province (2013), Yixing City is positioned as the "ceramic capital of China," creating a "ceramic" lifestyle Builder (see **Figure 1**), which introduces the tourism image slogan of "China's ceramic capital, intoxicated China" (This is a homonym in Chinese, which is easy to remember). The tourism industry has been welcomed by tourists through a clear cultural theme. According to the data of the national economic and social development statistical bulletin of Yixing City in 2019, Yixing received 29.511 million domestic tourists and 98,000 foreign tourists in 2019, and the total tourism income reached 29.144 billion yuan (Yixing Bureau of Statistics, 2020). Yixing's purple clay ceramic theme cultural tour is among the favorite tourist destinations for domestic and foreign tourists alike. It not only meets the needs of tourists for local cultural experience but also becomes a powerful working mode of intangible cultural heritage theme and cultural ecological protection zone. Therefore, taking Yixing purple clay ceramic culture tourism as a case study, exploring the relationship between the significance of intangible cultural heritage display content and tourists' demand becomes an important topic of this paper.

RESEARCH METHODOLOGY

Research Framework and Hypotheses

According to results of research by Pierre Bourdieu (1984), the relationship between "taste" and "class" means that there are significant differences in the artistic and life "taste" of people from different classes. This paper uses these results to define the difference between the needs and responses of visitors to the exhibition. In recent discussions on Museum Visitor Studies, visitors have changed from "the undifferentiated mass public" to "active meaning-makers" in complex cultural sites (Hooper-Greenhill, 2006; Recupero et al., 2019). For the evaluation of exhibitions, the shift from "effects" to "affect" also describes the idea of tourists as "active meaning-makers" (MacDonald, 2007). According

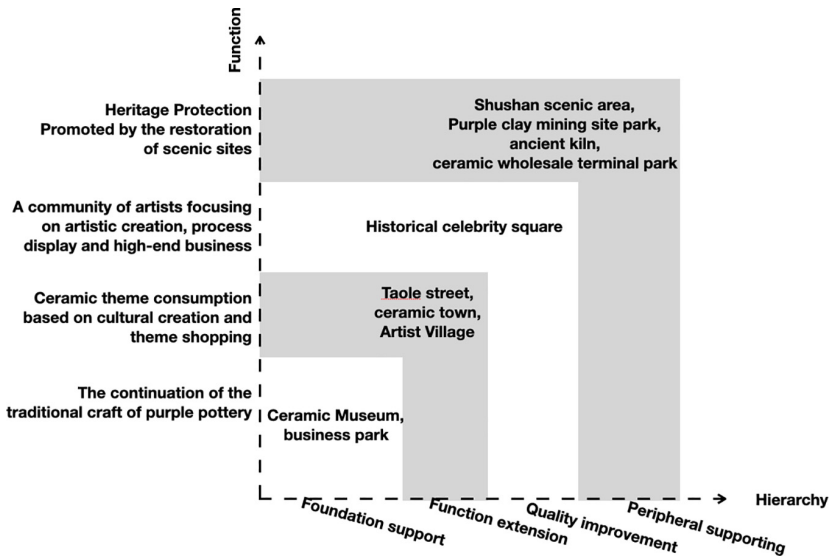

FIGURE 1 | Yixing purple clay ceramic themed cultural tourism development planning framework. Source: Yixing Municipal People's Government, The People's China (2013).

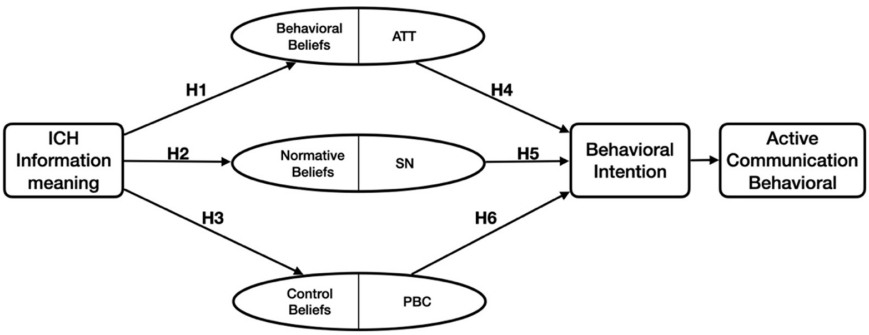

FIGURE 2 | Research framework.

to Krukar and Dalton (2020) and Kirchberg and Tröndle (2012), exhibition information affects visitors' cognition and experience. Roberto Verganti (2016) considers that "meaning" focuses on the cause of things; the attribute of meaning is determined by people's individual interpretations and judgments. Therefore, there is a close correlation between meaning and cognitive behavior (Martela and Pessi, 2018; Wei et al., 2020). Based on the aforementioned theoretical research results, and according to the literature review regarding cultural tourism, intangible cultural heritage exhibition, intelligent navigation system, TPB, exhibition meaning innovation, and the research framework, the following hypotheses are proposed:

H1: Meaning has a positive impact on tourists' attitudes toward intangible cultural heritage exhibitions by influencing beliefs.

H2: Meaning has a positive impact on the subjective norms of tourists' participation and dissemination of information through influencing beliefs.

H3: Meaning has a positive impact on tourists' perception behavior control of intangible cultural heritage tourism through influencing belief.

H4: Attitude has a positive impact on a tourist's communication behavioral intention toward intangible cultural heritage tourism consumption.

H5: Subjective norm has a positive impact on a tourist's behavioral intention toward intangible cultural heritage tourism consumption.

H6: Perceived behavior control has a positive impact on a tourist's communication behavioral intention toward intangible cultural heritage tourism consumption.

Based on the TPB and principles, and the relationship between the hypotheses, a research framework was developed, as shown in **Figure 2**.

Measurement

Drawing on previous studies and the exhibition case of this research, we construct the behavioral tendency scale. Cultural tourism is a type of cultural consumption behavior. Therefore, our questionnaire survey is not only based on the meaning and function of intangible cultural heritage communication (UNESCO, 2003) and the TPB (Ajzen, 1991; Han and Kim, 2010) but also on social identity related to symbolic consumption behavior (Hogg and Turner, 1987; Jetten et al., 2012). The contents of the questionnaire of "ICH theme cultural tourism habits scale" included 35 questions. It is divided into three parts: demographic information, the relationship between meaning and social identity, and behavior tendency information. The behavioral tendency scale has 20 questions, categorized into five parts: attitude, subject norm, perceived behavior control, behavior intention, and the meaning of exhibition. All the questions about TPB are assessed by Likert scale with 7 points. The scores were 1, 2, 3, 4, 5, 6, and 7, respectively (**Table 1**). The sociodemographic features of the participants are shown in **Table 2**. **Table 3** shows the tourists' cognitive needs differences in the meaning and function of the purple clay tea set. The mean and SD of behavior and attitudinal measurement problems are shown in **Table 1**. Informed consent was obtained from each subject after providing an explanation of the study.

Sampling Method

Purple clay culture is representative of Chinese ceramic culture. The traditional handicraft artistry of purple clay utensils has been listed in the national intangible cultural heritage protection list of China. In this study, Yixing's purple clay cultural ecological zone in traditional street shops and the purple clay Museum of tourists' behaviors are taken as the research objects. A questionnaire survey was conducted in China Yixing ceramics museum, Huishan ancient town, and Shushan old street. The survey was conducted by convenient sampling among the tourists from the three previously mentioned places. The specific sampling methods are as follows: first, the questionnaire is generated into two-dimensional code through the questionnaire star platform; second, the two-dimensional code is printed on the paper card, and the sampling population is randomly selected at the sampling location. After scanning the QR code through WeChat, the sample population can complete the questionnaire through the digital platform. All participants received a brief training, and 116 samples were generated by a convenient sampling method, of which 105 were valid questionnaires, with a 90.5% effective questionnaires rate.

RESULTS

Respondent Profiles

Among the 105 valid samples, 46 were male and 59 were female, accounting for 43.81 and 56.19% of the samples, respectively. In terms of age distribution, 20–25 age group is 57.78%, 26–30 age group is 14.29%, 30–40 age group is 16.19%, and 40–60 age group is 11.42%. Most of the people who participated in the survey were young, with college students and newly employed people as the key group (affected by the COVID-19, tour groups for the middle-aged and the elderly have been canceled; in addition, most of the "free travel" tourists are young people, which is the main reason for this age distribution). In terms of education level, 84.76% of the population had a college degree or above. With respect to the income level, 63.81% of the effective samples failed to reach the local average income level of 7,000 yuan, and only about one-third of the people reached or exceeded the local average income level. The urban population exceeded the sub-urban samples, accounting for 93.33%. In the research on the purpose of tourists' contact with purple clay culture, 60.58% of them are leisure for better health, and 21.15% are collection and investment. Only 3.85% showed off their tastes and socialized. According to the data, most tourists' interest in purple clay display information focuses on the meaning aspects of production artisanship, shape implications, and creation reasons.

Examination of the Offending Estimate

According to the two conditions of offering estimate examination criteria proposed by Hair et al. (2016), one is whether the negative error variance exists; the second is whether the standardized expression coefficients are higher than or close to 1.0. In this study, the sampling results were sorted. From **Table 4**, the error variances are non-negative, ranging from 0.020 to 0.038, and the standardized regression coefficients are between 0.614 and 0.981. The results show that the entire model can be tested.

Reliability and Validity

Measurement Model Analysis

Before testing the proposed hypotheses, this study used the SPSS analysis function provided by the SPSSAU platform to evaluate the measurement model. Specifically, we employed the online SPSS analysis software in the online data analysis platform "Questionnaire Star" to analyze the individual reliability, reliability, convergence validity, and discriminant validity of each item and conducted relevant tests combined with convergence validity and discriminant validity.

Composite Reliability and Convergent Validity

In this study, the standardized path coefficient, average coefficient of variation, and comprehensive reliability were used to examine the convergent validity of the measurement model. According to Fornell and Larcker (1981), the comprehensive reliability should be greater than 0.60 and the average value should be greater than 0.50.

The standardized parameter estimates used in confirmatory factor analysis related to behavioral propensity are shown in **Table 5**: the factor loading ranges of the attitude dimension are from 0.775 to 0.882; the subjective norm dimension is from 0.815 to 0.952; the perceived behavior control dimension is from 0.839 to 0.922; in the behavior intention dimension, the range is between 0.614 and 0.798; and the

TABLE 1 | Means and standard deviations of all questions of the measurement.

Questions	For all		Male	Females
	Mean	SD.	Mean	Mean
Attitude toward cultural tourism (ATT)				
A1. Participating as an exhibition information co-creator in ICH tourism is good for me	5.55	1.69	5.28	5.76
A2. Participating as an exhibition information co-creator in ICH tourism is pleasurable for me	5.21	1.75	5.17	5.24
A3. Participating as an exhibition information co-creator in ICH tourism is enjoyable for me	4.1	1.72	4.59.	3.71
A4. Participating as an exhibition information co-creator in ICH tourism is fun for me	5.1	1.77	5.26.	4.98
Subjective norm (SN)				
B1. My family thinks I should visit the ICH (purple clay) culture.	4.78	1.69	4.74	4.81
B2. My friends think I should visit the ICH (purple clay) culture	4.67	1.67	4.61	4.71
B3. People around me agree with my behavior of visiting ICH (purple clay)	4.86	1.60	4.74	4.95
B4. The tourist attractions have actively guided me to carry out active communication	4.54	1.64	4.61	4.49
Perceived Behavioral Control (PBC)				
C1. I have enough financial capacity to purchase or access to purple clay information	3.47	1.92	3.76	3.24
C2. I have enough time to contact or purchase the purple clay products	3.34	1.98	3.98	2.85
C3. I have enough information to contact or purchase the purple clay products	3.64	2.07	4.26.	3.15
C4. I have a strong desire and energy to actively participate in purple clay activities	3.9	1.94	4.13	3.71
Behavioral intention (BI)				
D1. In the future, I may continue to participate in purple clay activities	4.25	2.01	4.39	4.14
D2. In the future, I want to continue to consume purple clay knowledge and products	4.05	2.08	4.43	3.75
D3. In the future, I intend to persuade relatives and friends to purchase purple clay	3.39	1.79	3.63	3.2
D4. In the future, I plan to participate in purple clay exhibition activities	4.33	1.95	4.43	4.25
The request for meaning				
E1. My primary purpose of visiting exhibitions is to enjoy the cultural atmosphere	4.67	1.83	4.93	4.34
E2. I want to know more about the meaning and reason of purple clay works	3.38	2.14	4.67	3.12
E3. I feel happy when I disseminate the purple clay culture information	4.73	1.81	4.46	4.83
E4. I would like to share my story about purple clay tea set with others	5.21	1.62	5.41	5.02

TABLE 2 | Participant's sociodemographic features [sample demographics (N = 105)].

Background	Category	Frequency	Percentage (%)
Gender	Male	46	43.81
	Female	59	56.19
Age	20–25	60	57.78
	26–30	15	14.29
	30–40	18	16.19
	>40	12	11.42
Education	High School or below	16	15.24
	College or above	89	84.76
Income	<7,000	67	63.81
	≥7,000	38	36.19
Region	Urban	98	93.33
	Sub-urban	7	6.67

factor load range of the meaning demand dimension is from 0.831 to 0.918. For the five potential variables of attitude, subjective norm, perceived behavior control, behavior intention, and meaning demand, the prediction results of the compound variables were as follows: the composite reliabilities were 0.827, 0.930, 0.909, 0.905, and 0.923, and the average values were 0.715, 0.831, 0.832, 0.839, and 0.812, respectively.

The results show that the comprehensive reliability of each dimension is >0.60; the average value is >0.50, indicating that the internal quality of the model is good, with the required composite reliability and convergent effectiveness.

Discriminant Validity

In this study, we examined whether the correlation coefficient between the two dimensions was 1.0 (Torkzadeh et al., 2003) to verify if there was a statistical difference between the two dimensions. As shown in **Table 6**, discriminant validity exists among the dimensions.

Hypotheses Testing

In this study, the values of structural equation modeling are consistent with the criteria of model fitness. The analysis values are shown in **Table 6** and **Figure 3**. The results show that the hypothesis causality proposed in this study has statistical significance at different levels of probability (Gladence et al., 2015). Hypothesis 1—the meaning has a significant and positive impact on attitude ($\beta = 0.452$, $p < 0.001$); Hypothesis 2—meaning to subjective norm ($\beta = 0.671$, $p < 0.001$); Hypothesis 3—meaning to perceptual behavior control ($\beta = 0.568$, $p < 0.001$); Hypothesis 4—attitude to behavioral intention ($\beta = 0.146$, $p < 0.001$); hypothesis 5—subjective norm to behavioral intention ($\beta = 0.247$, $p < 0.001$); and Hypothesis 6—perceived

TABLE 3 | Cognitive needs and cognitive level of the purple clay pot.

	Category	Frequency	Percentage (%)
Function and meaning	Leisure for better health	63	60.58
	Collection and investment	22	21.15
	Drinking tea to quench thirst	15	14.42
	Show off your taste and socialize	4	3.85
Information demand (Random sorting)	Favorite crowd	15	14.42
	Craftsmanship	82	78.85
	Production location	7	6.73
	Manufacturing materials and tools	54	51.92
	Friend attitude	5	4.81
	Modeling implication	72	69.23
	Creator information	22	21.15
	The reason for creating	50	48.08
	Usage method	43	41.35
	Other	3	2.88

TABLE 4 | Test results of offending estimate.

Questions	Standardized coefficient	Standard error
1. Attitude —— > A1	0.797	0.026
2. Attitude —— > A2	0.882	0.028
3. Attitude —— > A3	0.790	0.022
4. Attitude —— > A4	0.775	0.022
5. Subjective norm —— > B1	0.934	0.033
6. Subjective norm —— > B2	0.952	0.038
7. Subjective norm —— > B3	0.936	0.032
8. Subjective norm —— > B4	0.815	0.020
9. Perceived Behavioral Control —— > C1	0.895	0.028
10. Perceived behavioral control —— > C2	0.922	0.029
11. Perceived behavioral control —— > C3	0.888	0.024
12. Perceived behavioral control —— > C4	0.839	0.022
13. Behavioral intention —— > D1	0.698	0.028
14. Behavioral intention —— > D2	0.733	0.031
15. Behavioral intention —— > D3	0.798	0.034
16. Behavioral intention —— > D4	0.614	0.025
17. The request for meaning —— > E1	0.880	0.033
18. The request for meaning —— > E2	0.981	0.026
19. The request for meaning —— > E3	0.905	0.027
20. The request for meaning —— > E4	0.831	0.031

behavior control over behavioral intention ($\beta = 0.588$, $p < 0.001$). The results show that all of them have positive effects. Therefore, the hypotheses are supported.

The results of the data analysis show that the meaning demand of exhibition content is a strong predictor of attitude, subjective norms, and perceived behavior control. The values of the three paths were as follows: in the case of subjective norms, the β value was 0.671, the R^2 value was 0.354; in the case of subjective behavior control, the β value is 0.568, the R^2 value is 0.544; these two situations are significantly higher than the values of attitude ($\beta = 0.452$, $R^2 = 0.253$). In the traditional TPB model, the three antecedent beta value coefficients of behavioral intention are 0.146, 0.247, and 0.588, respectively. The three antecedents explained 0.721 of the variances of behavioral intention. According to Han and Kim (2010), an R^2 of about 0.7 indicates a high predictability of behavioral intention.

The results show that the demand sensitivity of subjective norms and perceived behavior control to the meaning of exhibition content is higher than the structural sensitivity to attitude. This may indicate that the demand dimension of content meaning has a relatively important relationship with group cognition, social identity, and ability improvement. It also indicates that strengthening the meaning of exhibition content may become an important way to enhance the protection and dissemination of ICH under the background of cultural and tourism integration. It is also important to realize tourists' social and self-identity and enhance their cultural confidence by experiencing the ICH-themed tourism activities section.

DISCUSSION AND CONCLUSION, CONTRIBUTIONS, AND SUGGESTIONS

Discussion and Conclusion

In the first part of this paper, we addressed the cultural tourism as an important form for tourists to experience culture. One of the core demands of tourists to experience local culture is to experience the intangible cultural heritage of local communities. From the perspective of tourists' demand and content adaptive systems, tourists need intelligent navigation to guide their visiting behavior and cognitive demand prediction system suitable for intangible cultural heritage content. Although there are rich research results on the application of digital technology in navigation system, such as indoor positioning (Carboni et al., 2015; Wang et al., 2015; Yang and Shao, 2015; Wu et al., 2017), auxiliary equipment (La Delfa et al., 2016; Meliones and Sampson, 2018), and AR and VR navigation solutions (Marto and Goncalves, 2019; Wang, 2019), the researches on the satisfaction mechanism of tourists' personalized needs are

TABLE 5 | Composite reliability and convergent validity.

Latent variable extracted	Factor composite		Average reliability variance	
	variable	loading		
Attitude	A1	0.797	0.827	0.715
	A2	0.882		
	A3	0.790		
	A4	0.775		
Subjective norm	B1	0.934	0.930	0.831
	B2	0.952		
	B3	0.936		
	B4	0.815		
Perceived behavioral control,	C1	0.895	0.909	0.832
	C2	0.922		
	C3	0.888		
	C4	0.839		
Behavioral intention:	D1	0.698	0.905	0.839
	D2	0.733		
	D3	0.798		
	D4	0.614		
The request for meaning	EI	0.880	0.923	0.812
	E2	0.918		
	E3	0.905		
	E4	0.831		

TABLE 6 | Empirical results of hypotheses.

Hypothesis	Path relation	Path value	Tenable?
1	Meaning → Attitude	0.452	Yes
2	Meaning — > Subjective norm	0.671	Yes
3	Meaning → Perceived behavior control	0.568	Yes
4	Attitude → Behavioral intention	0.146	Yes
5	Subjective norm → Behavioral intention	0.247	Yes
6	Perceived Behavior Control — > Behavioral Intention	0.588	Yes

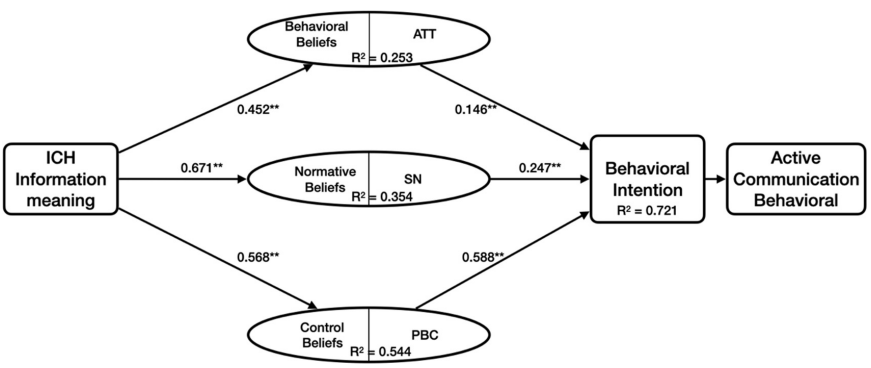

FIGURE 3 | Model design for this research.

relatively insufficient. As for the meaning construction of the content of the guide system in the process of intangible cultural heritage communication to tourists, researchers believe that there is no design paradigm that can meet the content framework design of dynamic complex navigation system in the context of cultural tourism.

The purpose of this study is to use the theory of planned behavior to calculate the relationship among tourists' attitude,

experience behavior, and the need to show the meaning of information. Through the verification of the relationship between the meaning information of intangible cultural heritage and tourists' cognition, attitude, and behavior, this paper puts forward the view that the content design framework of intangible cultural heritage display intelligent navigation system should pay attention to meaning. The results of this paper provide a direction for the design framework of the next generation intelligent navigation system. By analyzing the interaction between tourists and tour guide system in the process of cultural tourism, the guide system can identify the personalized content needs of tourists. Under the content framework to meet the needs of tourists, the diversified combination of meaning information and functional information in the content of navigation system is realized through meaning innovation design, so as to achieve the goal of intelligent navigation system and personalized content presentation.

Through a questionnaire survey and empirical data analysis, with the help of planned behavior theory, this paper verifies that the "significance" of intangible cultural heritage dissemination content is an important factor affecting tourists' attitude and behavior. The research data verify that the innovative design of displaying the meaning of information is the key to providing tourists with experience satisfaction. Meaning innovation can give different explanations and reasons for why intangible cultural heritage "why spread" (Verganti, 2016) combined with tourism context. Tourists can get the explanation and reason for the different "tastes" embodied in the same intangible cultural heritage display content by means of interactive behavior, enhancing their satisfaction and sense of identity. The deficiency of this study is that the TPB model is based on rational reasoning (Fishbein and Ajzen, 1975; Ajzen, 1985; Hsu, 2006), while the cognitive needs and emotional experience of tourists in cultural tourism are not only rational but also perceptual to a large extent (Lin et al., 2020). Therefore, emotional computing will become an important method to further improve the follow-up research in this paper.

This study's hypotheses are supported by its findings. The meaning of the navigation system's content is closely related to the attitude and behavior of tourists toward the dissemination and experience of intangible cultural heritage. There is a positive correlation between tourists' perceived demand for the meaning of exhibition content and tourists' participation. Through the demand degree of content meaning elements, tourists' attitudes, subjective norms, and perceived behavior control can be predicted. The results show that mining the meaning of the display content for crowd attributes has a clear causal relationship with subjective norms and perceived behavior control. Perceived behavioral control also has a significant effect on behavioral intention. It is noteworthy that the influence of attitude antecedents on behavioral intention is relatively weak. This also shows that when the TPB is applied to different research fields, it cannot capture every decision-making behavior, which also supports the views (Han and Kim, 2010; Chang et al., 2014) that TPB needs to be modified and perfected when studying specific empirical phenomena.

For the comparative study of the content design function factors and meaning elements of the display guide system, the sample size of the model proposed in this study is relatively small, with a sample size of 105. Although the small sample size can also meet the model validation requirements of a small number of elements to a certain extent (Hair et al., 2016), because of objective factors, such as the time and place of the survey, it is difficult to determine qualified and sufficient visitors to participate in the survey. Therefore, the small sample size is a limitation of this study. For example, more than 70% of the sample size is under 30 years old, and nearly 85% of the tourists have received university or higher education. These limitations may affect the results of this study and should be considered.

Theoretical Contributions

As previously mentioned, this study expands the TPB model by adding a variable of information meaning. In the context of cultural tourism, this study reconsiders the influence of meaning as a variable on attitude, social norms, and perceived behavior control related to belief and behavior. Taking tourists' cultural experience behavior as the research object, this study investigates people's experience and communication behavior intention of intangible cultural heritage theme cultural tourism, and makes contributions to the meaning innovation design, along with the literature and theory of cultural tourism and intangible cultural heritage display and dissemination. This study emphasizes the meaning of the exhibition content for tourists. It not only conforms to Bourdieu's (1984) theory that "taste" is affected by the social class but also meets the development needs of museums from "information provider centered" to "information receiver centered" (Hooper-Greenhill, 2006; Recupero et al., 2019). These findings provide a theoretical basis for the study. In contact with the meaning of information rather than function, tourists are highly satisfied with the information experience, which also meets the greatest demand for leisure and entertainment in cultural tourism. For tourists, the motivation to arouse cultural consumption is to a large extent the meaning attribute of tourism products, rather than their functional attributes. For example, the attraction of purple clay tea sets comes from the content of "who made it," "why do it," and "the reason for creation and the implication of modeling," rather than the functional information, such as capacity and usage. Among the various factors of displaying intangible cultural heritage projects, meaning is the main motivation to actively participate in and spread culture to meet the emotional experience and knowledge demands of tourists. Meaning can also satisfy tourists and help realize their personal identity and social communication through tourism consumption. Cultural tourism needs sharing, co-creation, and empathy to realize deep experience and social innovation. As emphasized by Ezio (2014) and Verganti (2016), meaningful innovation and joint participation contribute to the design of the system. The healthy and sustainable development of cultural tourism requires special emphasis on the active participation of tourists and the meaning of innovative design. The theoretical value of this study lies in inheriting the aforementioned

academic viewpoints, which is different from the previous research on intelligent navigation system focusing on technology exploration, but develops the personalized and emotional research on the content of intelligent navigation system through meaning innovation.

Empirical Suggestions

The purpose of this study is to explore the relationship between the meaning elements of intangible cultural heritage exhibition related to content design and tourists' experience, attitude, and behavior. Through the analysis of tourists' behavioral intention, this paper further discusses the influencing factors of tourists' behavioral intention from the subjective and objective dimensions. According to the results of the empirical analysis, this paper provides constructive suggestions for intangible cultural heritage protection and communication departments. Two suggestions are put forward to provide some enlightenment for future research on the intangible cultural heritage theme cultural tourism. Based on the research results, the following suggestions are proposed for reference.

First, for cultural tourism tourists, hypotheses 1 and 2 of this study imply that if they have an understanding of the use value and internal significance of intangible cultural heritage product information in cultural tourism, they are more likely to choose and participate in the dissemination and secondary creation of intangible cultural heritage information. Therefore, it is suggested that the departments of intangible cultural heritage protection and communication should not only present the functional elements but also highlight the emotional, psychological, and social significance of information content. The meaning of information has a positive effect on the satisfaction of tourists. As early as 1959, Sidney levy put forward that "consumers not only pay attention to function, but also value the content and meaning of products." Professor Clayton M. Christensen, a scholar in the field of innovation management, believes that it is very important to accurately locate the intrinsic meaning of products and understand the real motivation of consumers to buy products. According to the aforementioned research results, Roberto Verganti (2016) clearly proposed that products have dual attributes: one is the functional attribute, which primarily involves the function and performance of the product; the other is the internal meaning, which is related to the symbolic meaning, internal characteristics, and emotional factors of the product. In cultural tourism, there are two kinds of information dimensions to attract tourists. First is the use value of the product, which is its functional side. The most intuitive response is product performance, which mainly depends on the development and progress of technology. Second is the intrinsic meaning of the product, which refers to the reason why tourists consume a certain product, that is, the deep psychological and cultural factors that motivate consumers to choose the product. This dimension can be divided into individual motivation and social motivation. Personal motivation is related to the psychological and emotional factors of consumers. For example, the reason someone bought a purple clay tea set is that it can reflect the traditional cultural atmosphere, so that one can get a real-life feel. Social motivation is related to the symbolic meaning and cultural significance of the product, that is, social norms, or how other people evaluate the consumers and products of cultural products. For example, a person's consumption of purple clay tea sets is to show others their unique taste, life attitude, strong economic strength, or a lot of leisure time. It should be noted that the two dimensions of a product that attracts consumers are not clearly distinguished; sometimes, they overlap and relate to each other. As "function follows inner meaning," the results show that the design of the information content framework in navigation systems needs to present good cognitive experience to consumers through innovative design of meaning.

Second, for the design of the intelligent navigation system model, the core is the organization and design of the content in the model. Based on the research results, the intensity of demand for meaning cognition can affect perceived behavior control and perceptual behavior control, and subjective norms of tourists have a significant influence on behavior intensity. Therefore, to enhance the positive attitude of tourists, it is suggested that the information design of intangible cultural heritage display content should reflect the entertainment and leisure value pursued by cultural tourism, rather than functional preaching. According to the game theory of information communication (Stephenson, 1967 esp., chs. 4 and 11), one characteristic of mass communication is "no intention of accomplishing anything, only seeking satisfaction and happiness." Tourism is not to cope with reality and make a living, nor is it for production. On the contrary, tourism is mostly for self-satisfaction. Therefore, the principle of content design is to ensure that tourists can realize communication pleasure through the navigation system. In addition, the intelligent navigation system needs to establish the interaction between tourists and information to realize the intrinsic meaning of intangible cultural heritage projects. The meaning of information is not an inherent part of the product, nor can it be determined by the design process. The framework of the model should reconstruct the content through the attributes of tourists, which is similar to the "montage" method, to create a possibility. Then, the tourists can interpret the internal meaning of the intangible cultural heritage project through interaction with the information. This is the most popular type of experience.

Suggestions for Future Research

In reviewing the literature, it is found that previous research on intangible cultural heritage theme tourism mainly focuses on the related knowledge, inheritors, and development context of intangible cultural heritage projects, and most of these studies are based on the relevant theories and methods of sociology. Theories and methods of psychology such as TPB are rare in the field of intangible cultural heritage communication. The theoretical contribution of this study lies in the use of interdisciplinary research methods, such as design, psychology, and communication, and it proposes a reference design strategy for display content elements in the field of intangible cultural heritage protection and communication.

Regarding future research, it is worth noting that the influence of the intrinsic meaning of display information on tourists' emotional attitude and behavioral intention does not show a significant difference in motivation of consumption significance after being included in the TPB model. This result might imply that the factors influencing tourists' participation in cultural

tourism are more extensive. Therefore, it is suggested that further investigation should be carried out, particularly the modernity aspects involved in intangible cultural heritage theme tourism projects. Intangible cultural heritage is a representative of traditional culture deeply recognized by a place. Cultural tourism's appeal for leisure and entertainment and emotional pleasure needs to explore the contemporary value of traditional culture, explore the strategy of meaning innovation and communication experience path, and realize the new strategy of intangible cultural heritage display and communication from the perspective of cultural tourism.

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.

ETHICS STATEMENT

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

AUTHOR CONTRIBUTIONS

LM conceived the idea, participated in all steps of the research process, and wrote the first setup and draft of the article. YL made a substantial, direct, and intellectual contribution to this work, edited the article, participated in the interpretation of the results, participated in the compilation of supplementary material, and approved it for publication. Both authors approved the article and agreed to be accountable for all aspects of the work.

FUNDING

This research was supported by the Postgraduate Research & Practice Innovation Program of Jiangsu Province (Grant No. KYCX20_1887), Jiangsu Provincial Cultural Research Fund Project (Grant No. 19YB48), the key research topics of Jiangnan culture and Grand Canal cultural belt construction (Grant No. JUSRP12089), Wuxi Social Science Research Fund Project (Grant No. WXSK20-B-30), and the project of philosophy and Social Sciences in Jiangsu Province (Grant No. 2020-SJZDA-138).

ACKNOWLEDGMENTS

The authors would like to thank Professor Ruimin Lv for excellent technical support and for critically reviewing 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.

frontiers in Psychology

ORIGINAL RESEARCH
published: 02 February 2021
doi: 10.3389/fpsyg.2021.600218

The Talent Training Mode of International Service Design Using a Human–Computer Interaction Intelligent Service Robot From the Perspective of Cognitive Psychology

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To effectively improve the efficiency of international service design talent training and make it more in line with society's needs, we analyze the current status of international service design talent training and its professional training focus. Based on the above problems, from the perspective of cognitive psychology, artificial intelligence and human–computer interaction (HCI) technology are used to construct the international service design talent training mode of the HCI intelligent service robot. This mode can be used to solve the existing teaching problems by using novel means to ensure the quality of teaching. Finally, through the actual analysis of teaching cases, the effectiveness of the proposed talent training mode is verified. The HCI system is based on knowledge of cognitive psychology. According to the characteristics and functions of an educational robot, the robot is combined with traditional teaching activities, and the robot-assisted talent training mode is designed. Robot-assisted talent training is a feasible training method that can improve the efficiency of talent training. Students have confidence in their learning skills before the course, and the confidence is further strengthened after the end of the course. After the course, the students have a stronger sense of cooperation. This study can provide theoretical ideas for the research of international service talent training mode.

Keywords: artificial intelligence, robot, talent training mode, cognitive psychology, talent training

OPEN ACCESS

Edited by:
Mu-Yen Chen,
National Taichung University of Science and Technology, Taiwan

Reviewed by:
Long-Sheng Chen,
Chaoyang University of Technology, Taiwan
Patrick Hung,
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Specialty section:
This article was submitted to Human-Media Interaction, a section of the journal Frontiers in Psychology

Received: *29 August 2020*
Accepted: *05 January 2021*
Published: *02 February 2021*

Citation:
Yang Y (2021) The Talent Training Mode of International Service Design Using a Human–Computer Interaction Intelligent Service Robot From the Perspective of Cognitive Psychology. Front. Psychol. 12:600218. doi: 10.3389/fpsyg.2021.600218

INTRODUCTION

The deep integration of information technology and the manufacturing industry will inevitably give birth to a group technological revolution with intelligent manufacturing as the core and new energy and new materials infiltrating each other. A new production mode, industrial form, and business model will also form (Wang and Han, 2020). The rapid implementation of digitization, networking, intelligence, and service will certainly improve the product design ability and quality and promote the rapid transformation of production mode and industrial form in various fields (Qi and Tao, 2018). Developed countries have carried out rapid planning and distribution in industries that are conducive to their own development to adapt to leading a new era of scientific, technological, and industrial revolution (Sani et al., 2020). In particular, for the development of science, technology, the economy, and higher education institutions of talent training, a new professional talent training

mode is proposed (Xu et al., 2019). Therefore, the study of the talent training model is of great significance to ensure the sustainable development of the economy and society.

International service design majors should pay attention to stakeholders, products, and services from the perspective of service to meet the needs of all stakeholders and achieve a good state of sustainable development (Pacheco et al., 2019). International service design has gradually become the focus of academic and industrial circles (Talevski et al., 2018). However, at present, the knowledge system and ability system of the specialty and talent training need to be adjusted and updated. In terms of talent training objectives, talent training programs, curriculums, and teaching evaluations, it is not only necessary to emphasize the basic, personalized, practical, integrated, and service-oriented cultivation but also to strengthen the guidance of students' innovation consciousness, social responsibility, industry-university-research and multi-dimensional professional evaluation (Grenha Teixeira et al., 2017), which can better cope with the new needs of international service design talent.

With the advent of the information age, the application of information technology in the field of education has gradually penetrated various disciplines. The combination of artificial intelligence (AI) and robot technology will bring breakthroughs to the robot industry (Bin and Mandal, 2019). Kuo et al. (2017) used AI robots in hotel services and found that hotel industry in Taiwan has good potential to implement service robots. A robot service can help hotels deal with seasonal employment and labor utilization (Kuo et al., 2017). Luo et al. (2018) analyzed the influence of AI on the accounting industry's development and put forward relevant suggestions for the problems existing in AI (Luo et al., 2018). Yu et al. (2019) proposed active design research based on an AI technology development platform. The platform can help students to develop learning plans and register for required courses (Yu et al., 2019). Liu and Wang (2020) established an AI education informatization teaching model, read and collated a large number of literature, such as big data and ice snow talent training, constructed a visual analysis framework of AI teaching data, and discussed the realization process and mechanism of data visualization of ice and snow mixed talent training from two dimensions (timeliness and media form) (Liu and Wang, 2020). Pillai and Sivathanu (2020) proposed a model to explore the use of Adobe Illustrator technology for talent training. Research shows that the use of AI technology in talent training has a positive impact, which can effectively reduce costs and effectively improve teaching efficiency (Pillai and Sivathanu, 2020). It shows that AI technology has been applied to talent training in many studies, and good experimental results have been achieved.

Therefore, in order to change the existing teaching methods of international service design talents and effectively improve the efficiency of teaching and talent training, the relevant theories are analyzed on the basis of previous studies, and the feasibility of the application of AI and robots to the international service design talents training mode is explained from the perspective of cognitive psychology. The questionnaire is used to verify the application effect of robots in the international service design talent training mode. This study can provide a theoretical basis for international service design talent training.

METHOD

Current Situation of International Service Design Talent Training

The international service design talent training mode in domestic colleges and universities is still in the pipeline. University education is a highly specialized semi-closed teaching method. On the one hand, teaching is open to factories and enterprises, emphasizing practical teaching and teaching practice. On the other hand, the self-closing and automation mode of different discipline systems in schools begins to emphasize general education on the basis of professional education. The university's teaching of different departments and disciplines begins to move toward limited opening, forming a new era of semi-open talent training (Yu and Sangiorgi, 2018). With the development and change of economy, the content of service design is also different. The development of a service-oriented economy has experienced the following stages, as shown in **Figure 1**.

The core of service design is to provide value for users, and products and interaction are essential ways to realize service value (Touloum et al., 2017). Service design can be divided into three core values: caring for people, responding to unforeseen needs, and providing access rights for people. The three core values of service have the characteristics of overlapping and mutual influence, and the process of service design is nonlinear and iterative (Iriarte et al., 2018). Generally speaking, professional service design includes the scenario study stage, service innovation stage, and organization implementation stage. These three stages are crucial, each with their own workload and expertise. Among them, interdisciplinary collaboration runs through the whole service process.

The teaching of international service design courses and teachers' knowledge structure in domestic colleges and universities are seriously lagging. At present, many international service design teachers adopt the traditional teaching model, so teachers themselves have the ideology and tendency of emphasizing external form and neglecting internal ideological root (Kohlbry, 2016). This requires that, in the formulation and design of professional talent training objectives, curriculum, classroom teaching management, and guidance, teachers have a wide range of knowledge, rich information content, and an improved knowledge structure rather than being limited to the scope of their professional research. Teachers lack integration with related disciplines and also inevitably lack the spirit of innovation (Chydenius, 2020). It is very difficult for backward teachers to cultivate compound talents with high professional quality and strong adaptability; adapting to the industrial era will inevitably bring great resistance to the development of the major and the cultivation of talents, affecting the teaching of professional courses and the employment of students.

Analysis of Cognitive Psychology

Cognitive psychology is a psychological science that studies the mental processing behind cognition and behavior (including thinking, decision, reasoning, and the degree of motivation

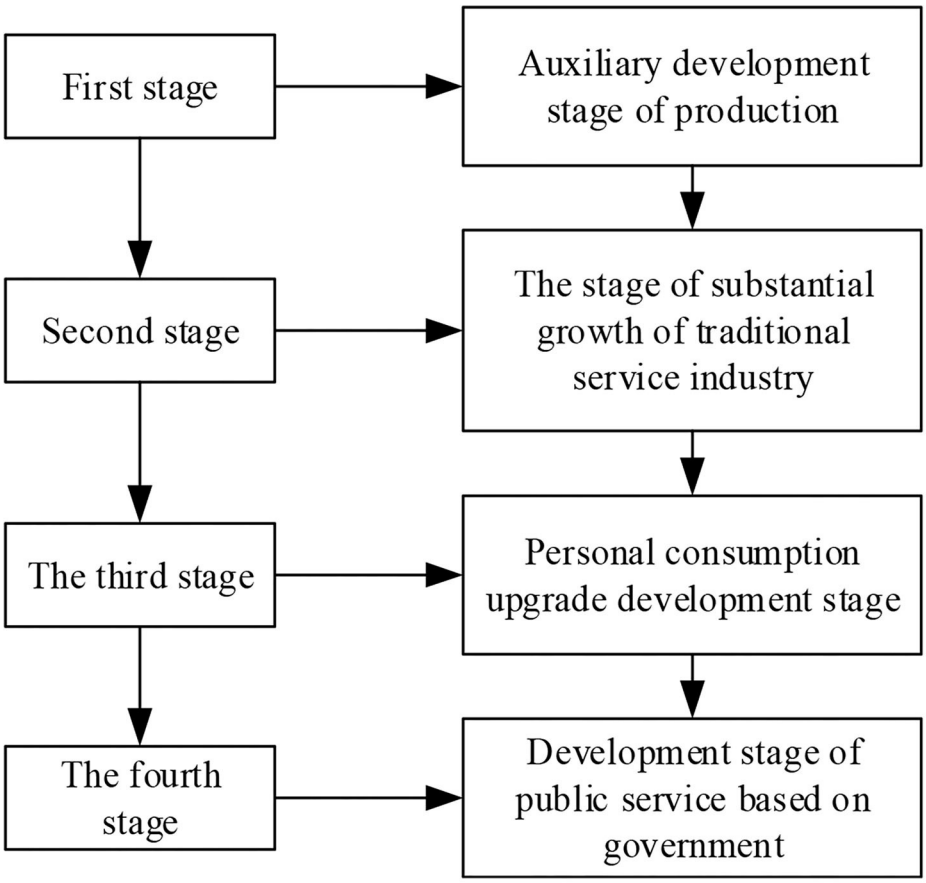

FIGURE 1 | Four stages of service-oriented economy development.

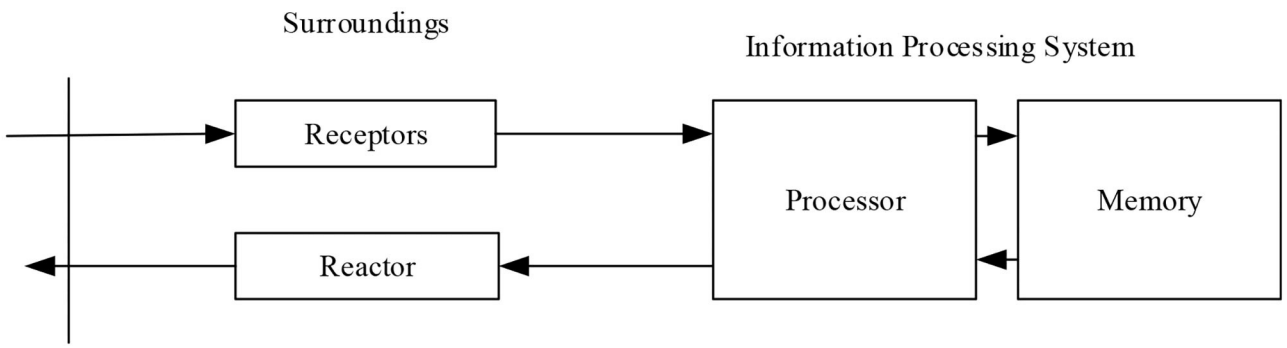

FIGURE 2 | Structural model of cognitive psychology.

and emotion). This science covers a wide range of research fields, aiming to study the operation of memory, attention, perception, knowledge representation, reasoning, creativity, and problem-solving (Ritter et al., 2017). According to the theory, the information-processing system of the human brain is composed of four parts: receptor, effector, memory, and processor (or control system). First, the environment inputs information into the receptor, and the receptor converts the information. Before entering the long-term memory, the converted information needs to be symbol reconstructed, identified, and compared by the control system. The memory system then stores the symbol structure that can be extracted. Finally, the effector reacts to the outside world (Zwaan et al., 2018) it was shown in **Figure 2**.

The field of education uses service design. The receivers of teaching services are students, and they are thus the main target users of service design. The purpose is to tap students'

potential needs to improve the existing teaching experience and quality and meet the teaching requirements. This exploration focuses on the design of a student-centered teaching service. The characteristic of student-centered teaching service design is to let students directly participate in the design. The student-centered teaching design method aims to integrate the needs of students into the development process of teaching service design, which is a supplement to the existing teaching plans and means. In the theory of service design, service-oriented technologies, such as Internet grid technology, service technology, and cloud computing, are in the process of development and change. However, the whole design process should closely focus on users and attach importance to the user experience to improve user satisfaction and increase the popularity of service design (Greenberg et al., 2017). Cheng et al. (2019) designed a talent training model for cross-border e-commerce by combining problem-based learning and the social media cognitive process. They developed a procedure to evaluate the effectiveness of the model. The actual verification proves that, in the service design, the cognitive psychology of users can be used to effectively improve students' perception and attention (Cheng et al., 2019).

In service design, students' cognitive psychology can be used to transform students' perception, attention, memory, reaction, and other requirements into design points, which can be introduced into the process of service design. It can enhance students' learning ability, improve service level, and facilitate product updates and iteration. The design of the human–computer interface will affect the user's sense of use and satisfaction in the operation process. In the process of human cognition, the stimulus information transmitted by the interface is received through a variety of sensory channels. Then, through the attention mechanism, the received information is effectively selected, and the conversion from instantaneous storage to long-term storage is completed. Finally, the information is encoded and stored by the storage system (Van Doorn et al., 2017).

AI Analysis

AI includes psychology, philosophy, neurophysiology, computer technology, and many other areas of knowledge. An AI device simulates human perception, learning, reasoning, communication, and other complex activities (Luo et al., 2019). The difference between AI and natural human intelligence is that an AI can save a lot of organic activities. An intelligent machine developed by AI technology can simulate the function of human organs and can replace simple, repetitive, and even complex work that is difficult to complete in daily life, thus changing people's social needs (Deng, 2018).

AI education is the product of the deep integration of AI and education. In educational activities, people use intelligent technology to improve teaching quality, accelerate the development of education and teaching, create a new teaching environment, provide personalized teaching services for schools, and achieve the purpose of education by realizing the student-centered teaching concept (Makridakis, 2017). The current intelligent classroom is the product of AI. In the intelligent classroom, the Internet of Things architecture, network control mode, touch control terminal, and convenient and efficient Internet technology are used to realize the interconnection between teachers' computers and students' terminals, and real-time interactive teaching is carried out.

This mode has a flexible multi-screen interaction and video display switching mechanism, which can flexibly realize the purpose of multi-device display switching and complete teaching tasks through a variety of teaching methods (Bruya and Ardelt, 2018). AI technology provides support for teaching, provides a good platform for learners, improves the teaching effect, realizes the evaluation of teachers' information resources and students' learning status, and puts forward corresponding learning suggestions for each student (Bajaj and Sharma, 2018). From the perspective of technology development, the development of AI can be divided into three stages: computational intelligence, perceptual intelligence, and cognitive intelligence. Among them, computational intelligence is the initial form of AI, and it is also the basis for its continuous development. Perceptual intelligence is the stage in which the development of AI is concentrated in China and foreign countries. Cognitive intelligence is the advanced form of AI, which is the breakthrough of future development of AI.

In the teacher's console, the advanced network system control architecture is adopted; it can realize the remote control of various equipment and allow teachers to control unexpected situations in the classroom and adjust accordingly. At present, AI technology has been widely used in teaching activities. The educational robot is one of the products of AI technology and human–computer interaction (HCI) technology that can improve the efficiency of talent training.

Analysis of HCI

In the HCI system, people and machines perform their respective duties and use their respective processing systems to process information. The first is the perception interface. The human perception system will receive visual, tactile, or auditory stimuli presented by the machine interface, select and process the stimuli presented by the machine interface, and transmit them to the cerebral cortex for memory. The second is the storage system. Through the human storage system, the information obtained is stored, processed and extracted, and transmitted to the human response system. Finally, HCI is implemented. Through the HCI system, the machine interface can be operated accordingly, and the received stimulus can be fed back to the human perception system (Kuo et al., 2019). **Figure 3** shows the workflow of the HCI system.

HCI is characterized by repeatability, flexibility, digitization, humanoid appearance, body movement, interaction, and personification. When HCI is used in personnel training, it can carry out simple and repeated operations to help the talents get familiar with and master the knowledge of service design. It can make use of flexibility to help teachers adjust and design teaching activities according to relevant teaching requirements so that teachers and students are no longer restricted by learning content and teaching materials. In terms of digitization, it can use the sharing and preservation characteristics of digital data to record teachers' teaching experience so as to serve personnel training (Khan, 2016) better. A humanoid appearance is more attractive, which can stimulate students' curiosity and fantasy

and improve their initiative; body movement can guide learning content through action; and HCI can interact with students to improve their initiative and practicability. The personification of HCI can also to an extent avoid student embarrassment during the learning process (Urquiza-Fuentes and Paredes-Velasco, 2017).

STEM Education

STEM is the abbreviation of science, technology, engineering, and mathematics. Among them, science involves understanding the world and explaining the objective laws of nature; technology and engineering are made to transform the world, realize the control and utilization of nature, and solve the problems encountered in the process of social development on the basis of respecting the natural laws; and mathematics is the basic tool of technology and engineering. A STEM curriculum focuses on strengthening the education of students in four aspects. The first is scientific literacy, that is, the use of scientific knowledge (such as physics, chemistry, biological science, and geospatial science) to understand nature and participate in the process of influencing nature. The second is technical literacy, that is, the ability to use, manage, understand and evaluate technology. The third is engineering literacy, which is the understanding of the process of technical engineering design and development. The fourth is mathematical literacy, which is students' ability to discover, express, explain, and solve mathematical problems in a variety of situations. Among science, technology, engineering, and mathematics, there is a relationship of mutual support, supplement, and development. To understand them—especially the relationship between them—they cannot be separated. Only in their interaction and mutual collision can deep learning and understanding be realized and cultivated.

The STEM teaching method also attempts to change the typical teacher-centered classroom model and encourage the

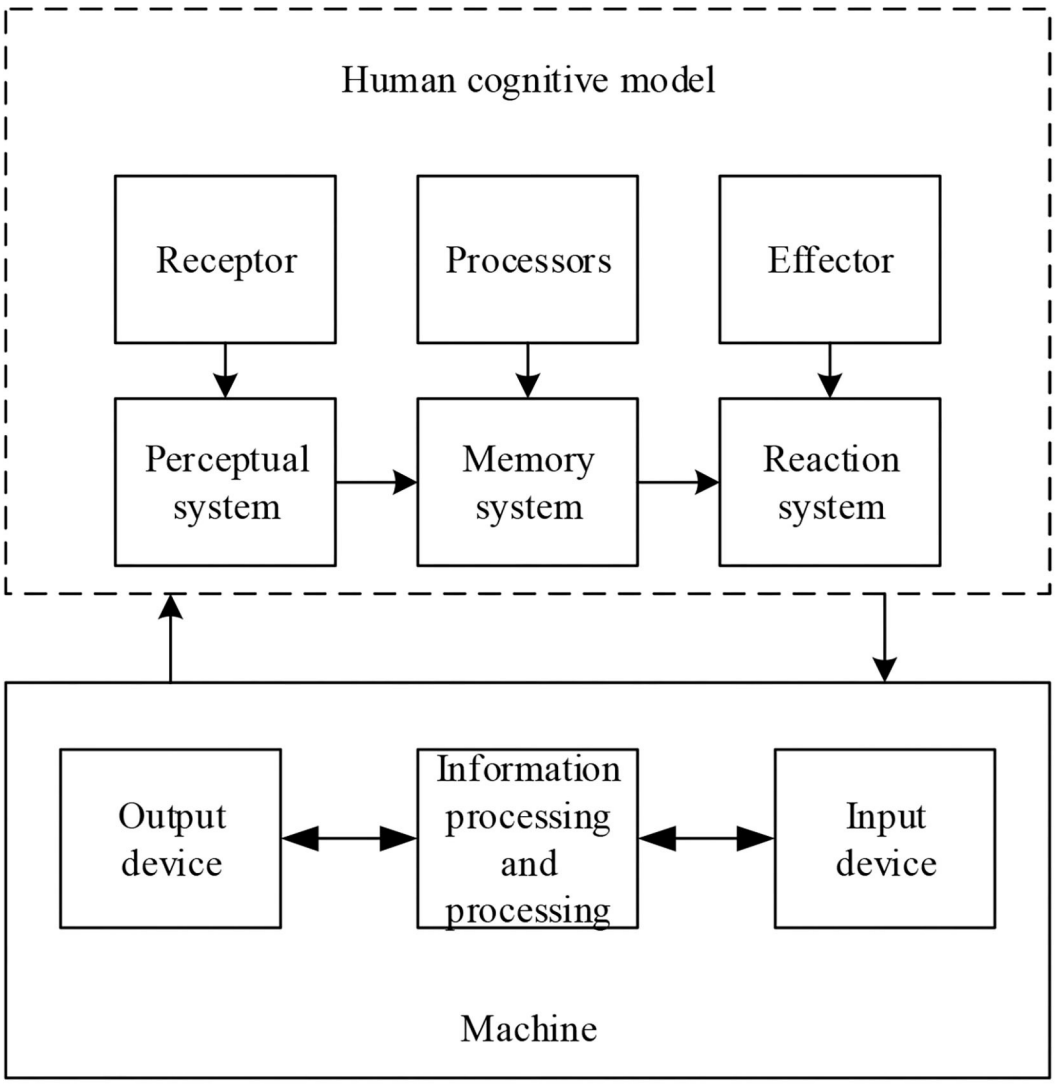

FIGURE 3 | Workflow chart of HCI system.

development of a problem-solving, exploration and discovery learning curriculum model. This model requires students to actively seek solutions to problems. In recent years, the number of college students majoring in science and technology and related fields has decreased significantly. On the one hand, it is due to the lack of warm-up in the high school classroom. On the

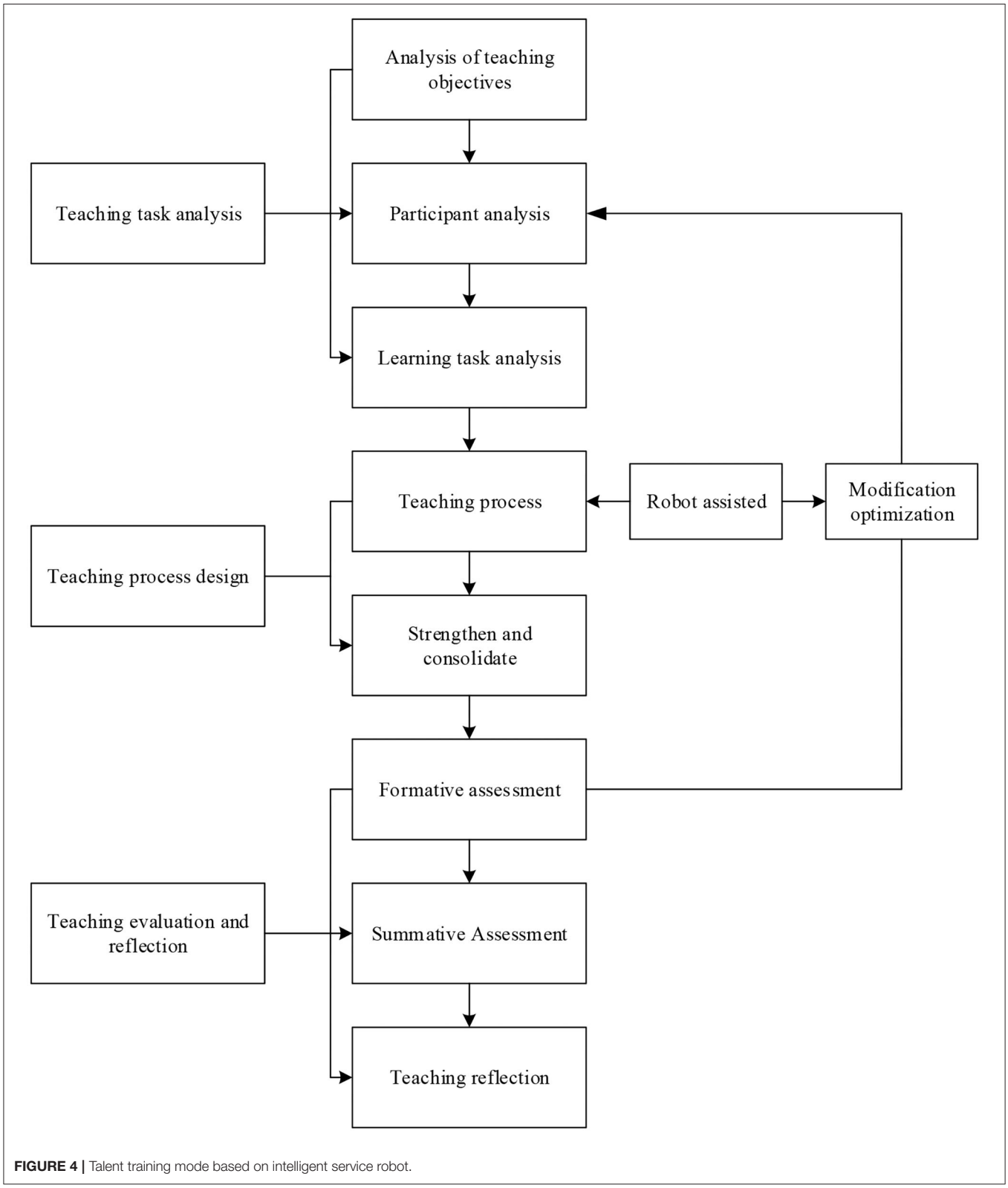

FIGURE 4 | Talent training mode based on intelligent service robot.

other hand, in addition to classroom teaching, these majors also require the completion of high-intensity experimental courses. Due to inadequate preparation in all aspects, the students give up the major they want and invest in the courses and majors with a relatively low difficulty coefficient. In the long run, there will be a labor shortage in the field of engineering science. The four parts of STEM have been in the mode of separate teaching and are, in most cases, independent of each other. However, the STEM teaching method breaks the disciplinary boundaries of science, technology, engineering, and mathematics so that they complement each other and complete the whole teaching together. Science, engineering, and mathematics are perfect because of technology. At the same time, the technology discipline also provides an innovative way to solve problems.

Training Mode of International Service Design Talents Based on HCI

The HCI-based international service design talent training process is divided into three parts: teaching task analysis, teaching process design, and teaching evaluation and reflection. Among them, teaching tasks analysis is the basis of the whole teaching design. The teaching tasks analysis includes the analysis of teaching objectives, the analysis of participants, and the analysis of learning tasks. The teaching process design is to improve the use of the technical advantages of robots to create a real learning situation, formulate appropriate learning strategies, and help talents to carry out independent inquiry learning by using learning resources and tools. Teaching evaluation and reflection is used to evaluate the learning effect of students and the overall situation of teaching to optimize the teaching design scheme, which is an essential link in teaching design. **Figure 4** shows the talent training mode based on an intelligent service robot.

Among them, teaching task analysis includes teaching objective analysis, learning task analysis, and participant analysis. Teaching process design includes learning situation design, teaching resource design, and learning strategy design. Teaching evaluation is divided into formative evaluation and summative evaluation. Teaching reflection refers to the last step in the design of teachers' teaching activities, which is also an indispensable step.

Teaching Case Verification

(1) Curriculum design: A total of 16 robot experiments are carried out for 36 class hours. The research is mainly based on the theme project of international service design. Due to the limitation of teaching space and experimental equipment and the large number of students (41 in total) selecting this course, the course is taught in batches; 41 students are divided into groups according to the diversified and voluntary combination rules. There are 10 groups with 3–4 people in each group and 3–4 groups in each batch with 3 batches. The teaching activities of the teaching project are designed and implemented according to the three parts of the robot teaching activity design model. The teaching site is in the teacher's laboratory, which can only accommodate 10 people each time for teaching. The experimental site and experimental equipment are limited so students are required to carry personal notebook computers, which not only solves the problem of insufficient resources but also facilitates students' learning after class. The software and equipment related to the experiment are provided or prepared by the teaching assistant after class.

(2) Data source: in this survey, students from two schools in city C are selected as the research objects. Among them, the questionnaire survey is for all students, and the semi-structured interview is to select the excellent and backward students of each grade from the two schools for interview. The two selected schools are school A and school B. **Table 1** shows the basic distribution of students participating in the questionnaire survey in the two schools.

In this exploration, 2,810 questionnaires are distributed, and 2,658 valid questionnaires and 152 invalid questionnaires are collected. In the process of answering questions, if there is an obvious careless phenomenon, it will be regarded as an invalid questionnaire. In school A, of the 12 freshmen classes enrolled in autumn, 2 classes are randomly selected as experimental classes with 55 and 56 students, and the remaining classes are the control class. In school B, among the nine freshmen classes enrolled in the autumn, two classes are randomly selected as experimental classes with 55 students in each class. The other classes are the control class.

TABLE 1 | Basic distribution of students participating in the questionnaire survey in two schools.

School	Level 1	Level 2	Level 3	Total
School A	Male 272	Male 258	Male 171	Male 701
	Female 205	Female 198	Female 206	Female 609
	Gender not written 10	Gender not written 9	Gender not written 10	Gender not written 29
Total	487	465	387	1339
Invalid questionnaire	14	21	62	97
School B	Male 73	Male 79	Male 131	Male 283
	Female 130	Female 91	Female 183	Female 404
	Gender not written 333	Gender not written 269	Gender not written 30	Gender not written 632
Total	536	439	344	1319
Invalid questionnaire	10	17	28	55
Total valid questionnaire	1,023 + 24 (Invalid questionnaire)	904 + 38 (Invalid questionnaire)	731 + 90 (Invalid questionnaire)	2658 + 152 (Invalid questionnaire)

(3) Survey method: through the open-ended interview method, the students with different academic achievements (excellent, medium, and backward) are interviewed. First, the concept of learning strategy is put forward to the students so that they can think about which behaviors are helpful to improve learning efficiency and which behaviors affect learning. Then, each student is asked to write at least five related items. Six forums are held in six schools, with about 30 participants in each forum. The students participating in the forum represent different grades of academic achievement, from excellent to backward, with about 10 students in each grade. Through interviews, 86 effective learning behaviors and 64 unfavorable learning behaviors are obtained.

TABLE 2 | Reliability statistics of the questionnaire.

	Number of items	Sample size	Questionnaire response rate
Q	19	41	100%
H	19	41	100%
A	24	39	95.12%
L	24	40	97.56%
P	24	41	100%

TABLE 3 | KMO and Bartlett's test.

	Sig	df	Approximate chi-square	Measure
Comparison questionnaire	0.00	0.171	334.067	0.695
Teaching Satisfaction Questionnaire	0.00	0.276	693.217	0.701

These items are sorted out into a learning strategy questionnaire. The process of sorting out is to retain the projects with high recognition, eliminate the projects with low recognition (fewer than five people), and then carry out the single dimension treatment of the items, that is, an item can only represent one event content. Thus, 98 descriptive sentences about learning strategies are obtained as the measurement items of the questionnaire. The questionnaire mainly observes the difference in learners' comprehensive quality from five dimensions: learning interest, learning skills, classroom participation, cooperation consciousness, and reflection. The questionnaire dimension setting and topic determination are mainly based on "Learning and Study Strategies Inventory (LASSI)" and "College and University Classroom Environment Inventory (CUCEI)" (Opperman and Mason, 2020).

Then, the next step is to distribute the questionnaire, the students answer the questionnaire, and the head teacher cooperates to collect the questionnaire in a certain order. The questionnaire is classified and coded according to the students' academic performance. The head teacher takes the questionnaire and classifies the students into three categories: excellent, medium, and backward according to their academic achievements. The classification criterion is to divide the students' scores in the recent big exams into three categories: excellent, medium, and backward, and then code them. Excellent is 1, medium is 2, and backward is 3.

Likert's 5-point scoring method is used in the questionnaire, and the options are "very agree," "agree," "general," "disagree," and "very disagree," which are set as 1, 2, 3, 4, and 5, respectively (Shin et al., 2018). For the teaching satisfaction questionnaire, in this exploration, the "robot experiment teaching satisfaction questionnaire" is designed and compiled from the five dimensions of learning resources, learning activities, communication and communication methods, learning results, and recognition of STEAM teaching. **Table 2** shows some data results.

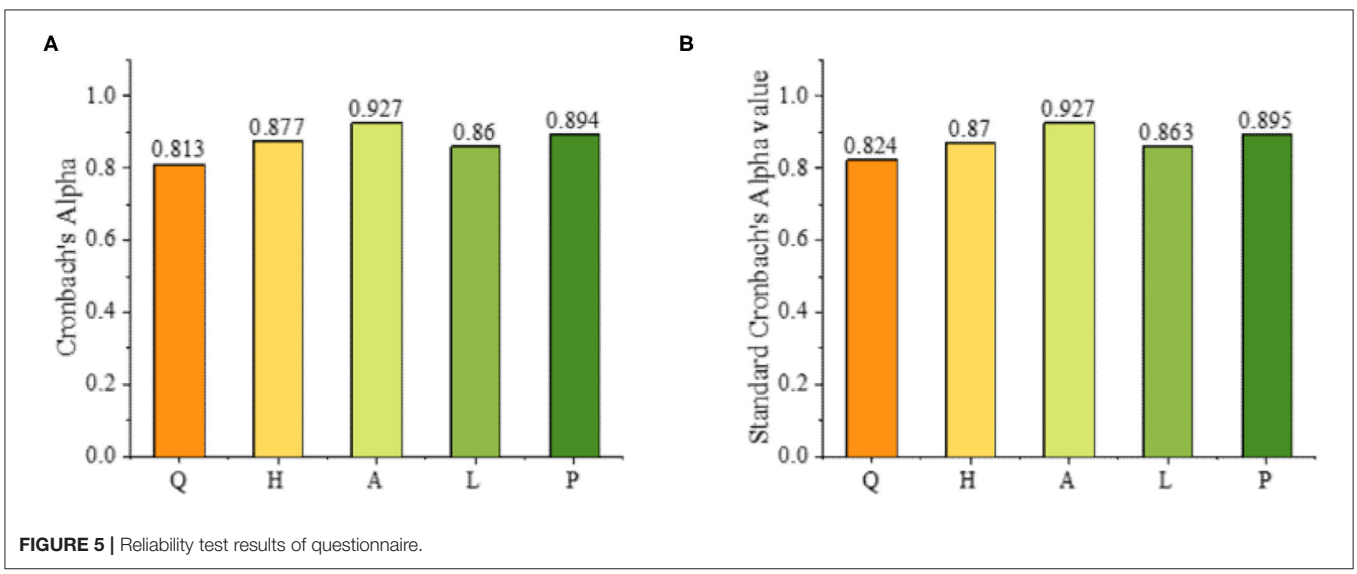

FIGURE 5 | Reliability test results of questionnaire.

RESULTS AND ANALYSIS

Questionnaire Test

In order to ensure the reliability and validity of the "comparison questionnaire" and "teaching satisfaction questionnaire," two questionnaires are distributed to 41 students before formal teaching. In order to test the construct validity of the scale, factor analysis is needed. The purpose of factor analysis is to find out the potential structure of the scale, reduce the number of questions, and turn it into a group of fewer variables with greater correlation. As shown in **Table 3**, the Kaiser-Meyer-Olkin (KMO) index values of the "comparison questionnaire" and "teaching satisfaction questionnaire" are 0.695 and 0.701, respectively. According to Kaiser's point of view, when the KMO index value is above 0.6, factor analysis can be carried out; the Bartlett's test chi square value of the two questionnaires reaches a 0.05 level of significance, which proves that the research content is suitable for factor analysis. The above two aspects indicate that the data measured by the "comparative questionnaire" and "teaching satisfaction questionnaire" are suitable for factor analysis.

Two questionnaires were compiled based on the study of much relevant literature, combined with actual research needs, teaching conditions, and other related content. After the completion of the initial questionnaire, the content validity of the two questionnaires is ensured by appropriate modification through the analysis of pre-survey items. The construct validity of the two questionnaires is discussed by the exploratory factor analysis method. Finally, it is concluded that the two questionnaires are suitable for factor analysis, and five factors are extracted from each questionnaire so that the excellent construct validity of the two questionnaires can be ensured.

After the validity of the questionnaire is ensured, it is also necessary to test the reliability of the questionnaire. Cronbach's Alpha is used to test the internal consistency reliability of the scale. **Figures 5A,B** shows that the results of the questionnaires used have high stability and consistency.

TABLE 4 | Analysis of the differences before and after teaching.

	Before teaching	After teaching	*T*	*P*
Q	8.1951	10.3659	−5.653	0.00
H	8.2683	10.7073	−3.172	0.00
A	4.8293	6.9656	−6.354	0.00
L	5.1463	5.7805	−2.685	0.011
P	4.8049	6.6341	−7.649	0.00

Comprehensive Quality Comparison Results

According to **Table 4**, from the overall perspective of pre-test and post-test, students have greater confidence in their own learning skills before the course (X = 8.2683) and after (X = 10.7073), followed by a strong interest in learning.

Teaching Satisfaction Results

The results in **Figures 6A,B** show that the students have a strong interest in learning the course before and after the course, and the learning interest is further strengthened after the course learning. There is a significant difference in the learning interest of the students in the robot experiment course ($P = 0.000 < 0.05$), and the learning interest after the course is higher than that before the course ($T = 5.653 > 0$). The results show that the learning interest of the students after the course is higher than that before the course and is more obvious. The students have a certain confidence in their own learning skills before the course, and the confidence is further strengthened after the end of the course; there are significant differences in the learning skills of the students before and after the course learning ($P = 0.000 < 0.05$), and the learning skills after the course are significantly improved compared with those before the course ($T = 6.172 > 0$). The results show that the students have mastered the

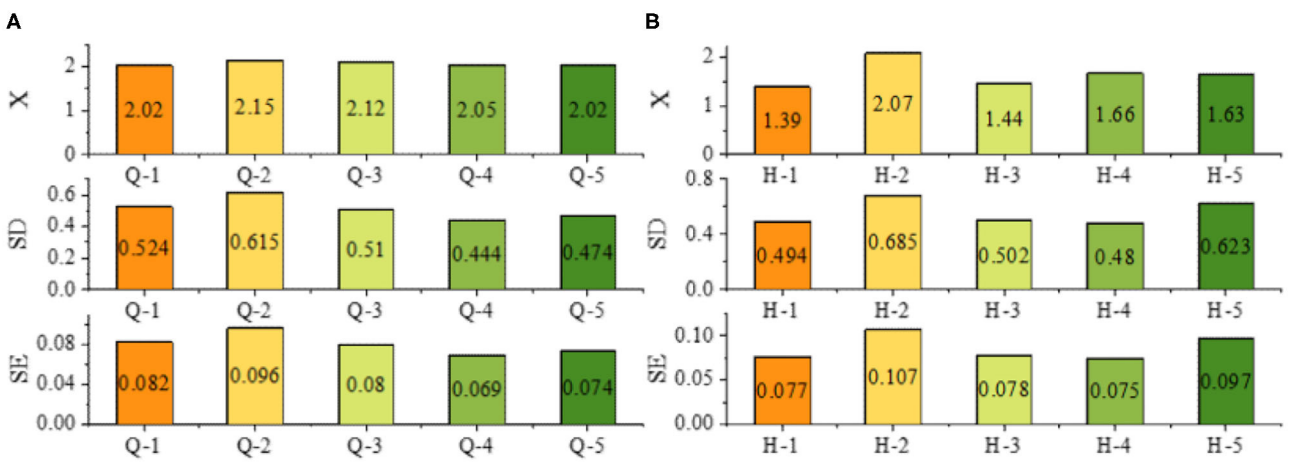

FIGURE 6 | Learning interest and learning skill satisfaction.

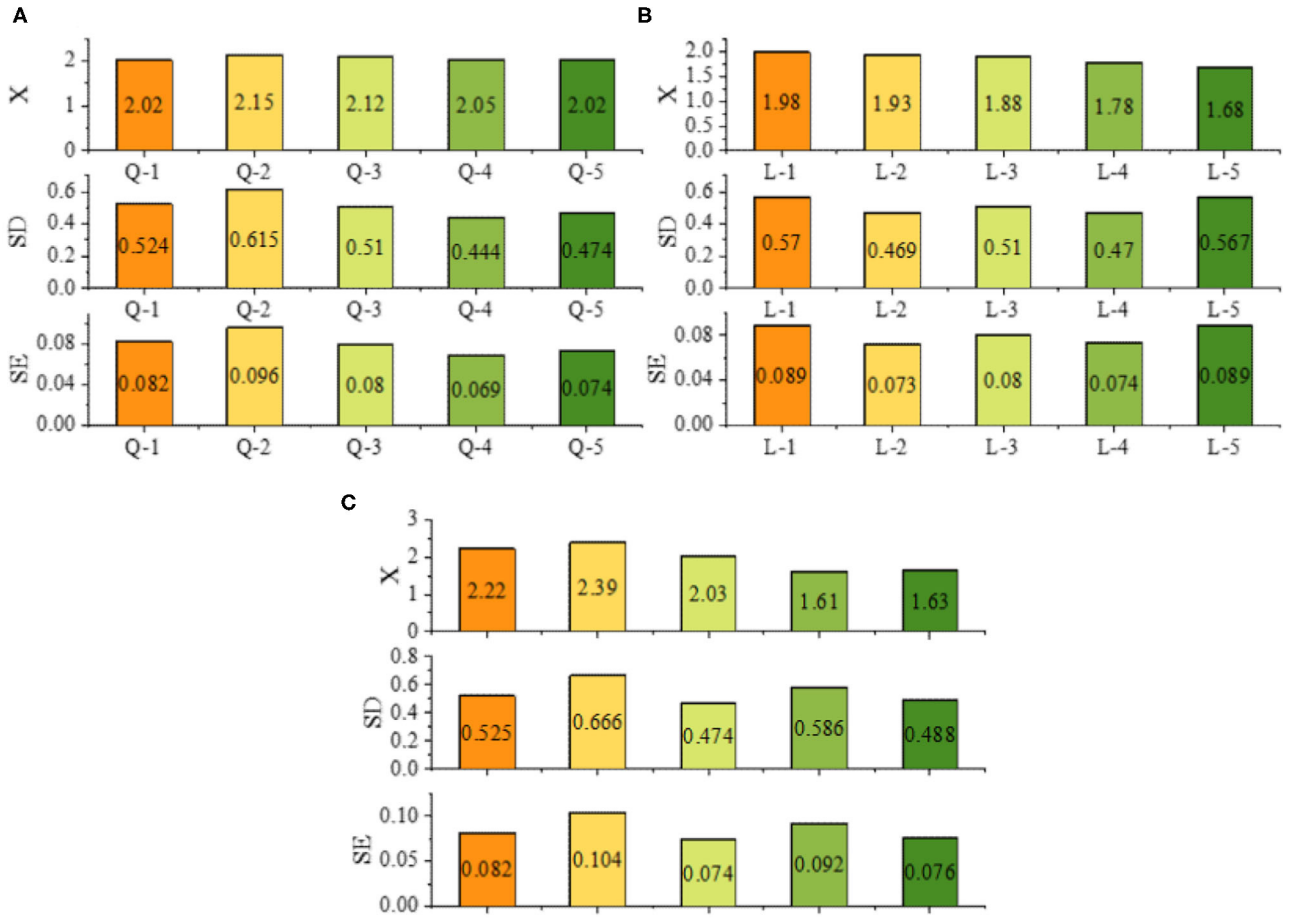

FIGURE 7 | The results of cooperation consciousness, classroom participation, and satisfaction of after class style.

TABLE 5 | Difference test results of the examination results in experimental class and the control class before and after the optimization of learning strategies.

Teaching methods	Class type	*N*	Mean	*t*	df	*P*
Before the optimization of learning strategies	Experimental class	54	619.110	0.420	536	0.675
	Control class	484	615.580			
After the optimization of learning strategies	Experimental class	54	594.780	2.243*	537	0.025
	Control class	485	574.230			

*$p < 0.05$.

corresponding learning skills in the learning process of the robot experiment course.

Figures 7A–C shows that most of the students are full of expectations for the teaching activities arranged by the teachers before the course. They think that they will actively participate in classroom activities. Moreover, the statistical results of the post-test data further prove this result: the average value of the post-test is lower than the corresponding average value before teaching, indicating that students are actively involved in the teaching and learning activities arranged for them by the teaching team. Most of the students have a strong sense of cooperation before the course; after learning the course, they have a stronger sense of cooperation. There is a significant difference in the awareness of cooperation before and after the course, and the awareness of cooperation has improved after the course. The results show that the cooperative consciousness of the students is improved by the learning robot experiment, but the range is small. When they encounter difficulties, problems and so on, they usually review, summarize, and reflect. These abilities gradually improve in the process of their course learning and group learning, and the growth rate rises.

Analysis Results of Teaching Achievements

Table 5 shows that after the optimization of learning strategies, the learning performance of the experimental class is better than

TABLE 6 | Examination results of experimental class and control class before and after learning strategy optimization.

Class type		Before the optimization of learning strategies	After the optimization of learning strategies
Experimental class	Mean	619.11	594.78
	N	54	54
	SD	73.71	74.66
Control class 1	Mean	608.65	581.17
	N	54	54
	SD	41.72	47.85
Control class 2	Mean	627.91	589.07
	N	54	54
	SD	46.48	49.46
Control class 3	Mean	626.48	575
	N	54	54
	SD	55.98	62.89
Control class 4	Mean	621.98	574.54
	N	54	54
	SD	49.60	58.38
Control class 5	Mean	622.85	571.06
	N	53	54
	SD	45.37	63.97
Control class 6	Mean	628.17	583.83
	N	54	54
	SD	40.79	49.36
Control class 7	Mean	614.62	577.49
	N	53	53
	SD	37.49	36.53
Control class 8	Mean	588.85	553.52
	N	54	54
	SD	98.70	105.01
Control class 9	Mean	600.87	562.46
	N	54	54
	SD	58.29	61.75
Total	Mean	615.94	576.29
	N	538	539
	SD	58.50	64.10

that of the control class, and the difference reaches a significant level ($t = 2.243$, $df = 537$, $p < 0.05$).

Table 6 shows that, through the optimization of learning strategies, the learning performance of the experimental class has been significantly improved, with the average score rising to the first of 10 parallel classes.

Table 7 shows the experimental class's population distribution structure and the control class at these three grades. According to the above chart, the number of excellent students decreases, and the number of backward students increases in the control class; the number of excellent students increases while the number of backward students decreases in the experimental class. It shows that after the optimization of learning strategies, the overall academic achievement of the experimental class students has improved. This shows that the training mode of international service design talents based on an HCI intelligent robot from the perspective of cognitive psychology is more successful.

TABLE 7 | Grade distribution of students' academic achievement in experimental class.

Grade	Before the optimization of learning strategies		After the optimization of learning strategies	
	Students number	Proportion (%)	Students number	Proportion (%)
Excellent	14	25.9	18	33.3
Medium	27	50.0	27	50.0
Backward	13	24.1	9	16.7

DISCUSSION

Through the suggestions and problems put forward by the research objects, it is found that the lack of teaching resources, the shortage of teachers, and the inadequate consideration of the details in teaching design and teaching methods will create certain losses in terms of the learning experience, learning process, and even learning results. Therefore, the teaching team must pay enough attention to this point and fully grasp all aspects of teaching design in future teaching and learning activities. Of course, the existence of problems is the best motivation for self-improvement, and the suggestions put forward by students are the most valuable wealth for the improvement of teaching. While the learners are required to grow up, educators also need to continually develop to ultimately achieve the common growth of both teachers and students. The expectation expressed by the learners is the greatest affirmation to the teaching team. They have learned something during the experimental course and expect to have more opportunities to learn in the future. This shows that the teaching team's contribution is valuable, and the teaching team is also full of a sense of achievement so that the teaching team has a greater passion for continuing to improve the teaching design and students can acquire more knowledge and skills.

The four aspects can be summarized as three points. First, the research objects give a positive evaluation of the whole teaching and learning activities. In the reflection diary, learners clearly describe the teaching content and experimental tasks, actively participate in teaching and learning activities, and recognize the teaching design and teaching implementation of the teaching team. Second, the object of study has gained and learned something. During the course, learners not only enrich the knowledge system and cognitive structure but also get inspiration from daily life and cultivate their own innovative thinking. At the same time, it has cultivated the creative consciousness, improved practical ability, and enhanced the sense of teamwork. Third, in view of the shortcomings in the teaching process, some constructive suggestions are put forward. These suggestions can urge the teaching team to design teaching more carefully, provide high-quality teaching resources, and constantly optimize

teaching and learning methods so as to promote meaningful learning of learners.

CONCLUSION

The talent training mode of international service design has been studied. The background of the development of educational information technology in China has been understood. Through the study of relevant policy documents, major events, and documents, the revolutionary impact of information technology on educational reform has been analyzed. It is found that, although the use of the domestic educational robot starts relatively early, most educators are more focused on teaching the course than using the robot. Relatively speaking, there have been few studies made on creating a language learning environment and assisting language teaching by using robots, which, to a certain extent, lacks theoretical guidance and empirical research. Therefore, the robot-aided design talent training mode is taken as the research object, trying to bring a new scheme with research data support for the studies into robot-aided teaching, which is also the innovation point of this study. First, the research background and significance are described, and the current development of robot education and service design is introduced. Then, the related concepts, such as AI, robot, talent training mode, and cognitive psychology, are analyzed, and the application of AI, the robot, and cognitive psychology in talent training is analyzed theoretically. Finally, the talent training mode of international service design by AI technology and robot is studied, and the talent training mode of service design with the robot as auxiliary education way is established. Through the survey, the application of a robot in the talent training mode of international service design is analyzed. The results show that robot-assisted talent training is a feasible way to improve the efficiency of talent training.

Due to the limited knowledge level, there is a lack of comprehensiveness and depth in the research process. The focus is to analyze the application of cognitive psychology, AI, and other related theories and technologies in talent training, which lack specific research on AI technology and human–computer interaction technology. It is hoped that in the follow-up research, the AI technology and human–computer interaction technology can be specifically analyzed so as to improve the current technology deficiencies. This study lacks practical application of a human–computer interaction-based intelligent service robot in the process of talent training, and it is more inclined to theoretical analysis. It is hoped that, in the follow-up research process, the talent training mode can be applied in practice to observe the specific application effect of the designed talent training mode and improve the deficiencies of this study.

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 Taiyuan University of Technology Ethics Committee. The patients/participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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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.

frontiers in Psychology

ORIGINAL RESEARCH
published: 09 February 2021
doi: 10.3389/fpsyg.2020.582480

Apriori Algorithm for the Data Mining of Global Cyberspace Security Issues for Human Participatory Based on Association Rules

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This study explored the global cyberspace security issues, with the purpose of breaking the stereotype of people's cognition of cyberspace problems, which reflects the relationship between interdependence and association. Based on the Apriori algorithm in association rules, a total of 181 strong rules were mined from 40 target websites and 56,096 web pages were associated with global cyberspace security. Moreover, this study analyzed support, confidence, promotion, leverage, and reliability to achieve comprehensive coverage of data. A total of 15,661 sites mentioned cyberspace security-related words from the total sample of 22,493 professional websites, accounting for 69.6%, while only 735 sites mentioned cyberspace security-related words from the total sample of 33,603 non-professional sites, accounting for 2%. Due to restrictions of language, the number of samples of target professional websites and non-target websites is limited. Meanwhile, the number of selections of strong rules is not satisfactory. Nowadays, the cores of global cyberspace security issues include internet sovereignty, cyberspace security, cyber attack, cyber crime, data leakage, and data protection.

Keywords: association rules, data mining, network sovereignty, cyberspace security, Apriori algorithm

OPEN ACCESS

Edited by:
Yenchun Jim Wu, National Taiwan Normal University, Taiwan

Reviewed by:
Mary Gladence L., Sathyabama Institute of Science and Technology, India
Ruey-Shun Chen, National Chiao Tung University, Taiwan

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Specialty section:
This article was submitted to Human-Media Interaction, a section of the journal Frontiers in Psychology

Received: *12 July 2020*
Accepted: *14 September 2020*
Published: *09 February 2021*

Citation:
Li Z, Li X, Tang R and Zhang L (2021) Apriori Algorithm for the Data Mining of Global Cyberspace Security Issues for Human Participatory Based on Association Rules. Front. Psychol. 11:582480. doi: 10.3389/fpsyg.2020.582480

INTRODUCTION

Association rules, reflecting the interdependence and correlation between one thing and others, are one of the critical research methods in the data mining of graphic patterns (Epifania et al., 2020). In other words, an association rule is a practical and straightforward knowledge model implied in the data through quantified numbers, which mines the correlation relationship among valuable data items from massive data (Smink et al., 2019). At present, the data mining technology of association rules is mostly based on the Apriori algorithm, of which the core optimization lies in finding all the frequent item-sets in the transaction database (Shashi et al., 2020). Data mining is an essential branch of artificial intelligence. Celik (2019) expounded another view of the Apriori algorithm for data mining of association rules, finding hidden information processes through an algorithm in massive data information (Celik, 2019).

Regarding the mining issues of association rules, Agrawal and Elabbadi (1994) first proposed the Apriori algorithm, and discovered the potential association relationship among different items in a customer transaction database in 1995 (Li et al., 2005). Most algorithms are association rules discovered based on the massive data. The Apriori algorithm is mainly divided into two steps. The first step is to use the zhega universal transaction database to find all item-sets that satisfy the minimum confidence threshold. The second step is to find all the item-sets whose support degree are greater than the threshold value and to find the strong association rules with the confidence greater than the threshold (Hiba et al., 2020). However, in the process of the Apriori algorithm, this study used the inverse monotonicity of support and confidence of item-sets. In other words, the support and confidence of replaced item-sets are not higher than that of the original. This characteristic of the Apriori algorithm can be used to remove frequent item-sets, thus reducing computational load. There is a fatal flaw in the Apriori algorithm. During mining association rules, the transaction database should be traversed repeatedly to mine the time-consuming growth index with the increasing data volume (Yan et al., 2019). After development, the Apriori algorithm has established a closed item-set theory, widely used in medicine, finance, Internet, and other fields.

Psychology was used to confirm the five personality traits, meta traits, and the hypothetical relationship between self-esteem and the legal network terminology network (Rogoza et al., 2018). Although the social information processing theory integrates the literature on humility and resilience, it fails to explore its contextual triggers (Zhu et al., 2019). In terms of social exchange theory, the study focuses on the role of social interaction, mining samples to test hypothetical models on data (Qian et al., 2018). Besides, the social business model illustrates that information and communication technology can be integrated with transportation service providers and government resources (Wu et al., 2020). As a popular means of obtaining information, social media can mine bilingual texts, and promote the exploration of topics and market trends, gaining essential insights from crowd intelligence (Shen et al., 2019).

Association-rule mining includes mining frequent item-sets and discovering strong association rules (Jongseong et al., 2020). Mining frequent item-sets is an important step, and the Apriori class proposes many algorithms for mining frequent item-sets (Mary et al., 2016). The so-called frequent item-set mining is one of the steps of association rule mining, and the association rule is a close association between the item-sets that frequently appear on a given training item-set and the others (Sharmila and Vijayarani, 2020). In the process of scanning the data set, the Apriori algorithm uses an automatic recursive connection to mine the candidate item-sets (Hossain et al., 2020). Then pruning is used to mine frequent item-sets. The Apriori algorithm can mine all item-sets of large data sets (Huang, 2012). However, the data set is scanned repeatedly in order to ensure accuracy, resulting in a large number of candidate item-sets.

When association rules are mined from frequent item-sets, the method of using the "support-confidence" model has been recognized by most researchers. In recent years, Hazarika and Rahman (2014) found that mining association rules with the "support-confidence" model make it easy to produce the significance of the research conclusion. Meanwhile, the procedure is convenient to operate (Hazarika and Rahman, 2014). Brin et al. (1997) and his group first proposed the concept of interest and used the lift metric and chi-square test to mine relevant rules, which overcomes the shortcomings of "support-confidence" model (Brin et al., 1997).

Based on the association rules of the Apriori algorithm in data mining, global cyberspace security was studied, to seek the focus of current cyberspace issues and to provide a path reference for future cyberspace governance (Johns, 2019). The process can be divided into three stages. The first stage determines the relevant cyberspace security lexicon and selects target websites on the global Internet (Lintern, 2018). In the second stage, Python is used as a crawler tool to obtain the news hyperlink of target websites, and then the news page is segmented according to the lexicon mentioned in the first stage. Based on the word segmentation results in the second stage, the Apriori algorithm for data mining of association rules is analyzed in the third stage.

LEXICON SELECTION OF TARGET WEBSITES IN GLOBAL CYBERSPACE SECURITY

It is essential to select appropriate target websites, thus ensuring the validity of the keywords database. Meanwhile, this study focused on target websites of global cyberspace security, which were divided into two types, professional and non-professional, to consider the comprehensiveness of data coverage.

Professional websites include internet sovereignty, data breach, cyber attacks, and rogue software, involving multiple aspects of cyberspace security. However, non-professional websites are based on the information content published by mainstream news media. Although the content is relatively small compared to professional websites, it involves rich information about global cyberspace security.

In the implementation of the first stage, professional websites and non-professional news websites were selected explicitly in global cyberspace security as the databases for lexicon selection. The ratio of the selected lexicon is generally maintained in a range of 1:1. A total of 15 target professional websites (See **Table 1**) and 25 non-professional target news websites were selected (See **Table 2**). The two types of target websites covered China, the United States, the United Kingdom, Germany, France, India, and other Internet developed and developing countries.

The process of the first stage requires collecting lexicons to determine the necessary ones for the second stage of Python in the above website data crawler. As the basis for word segmentation, if the lexicons are not correctly selected, it is easy to miss critical data mining in the later analysis. This study selected 89 lexicons related to cyberspace security to cover all aspects of global cyberspace security, thus providing high-quality data for later association rules mining. The selected lexicons are listed as follows:

TABLE 1 | Target professional websites.

No.	Name of institution	Website address
1	Info Security Magazine	http://www.infosecurity-magazine.com
2	The First Stop For Security News	https://threatpost.com/
3	The Hacker News	https://thehackernews.com/
4	National Security Agency	https://www.nsa.gov/
5	European Cyber And Information Security Agency	https://www.enisa.europa.eu/
6	Internet Governance Forum	http://www.intgovforum.org/multilingual/
7	European Telecommunications Standards Institute	https://www.etsi.org/
8	International Organization For Standardization	https://www.iso.org/conformity-assessment.html
9	International Telecommunication Union	https://www.itu.int/zh/itu-t/about/groups/pages/sg13.aspx
10	National Cyber Security Center (United Kingdom)	https://www.ncsc.gov.uk/
11	Australia Cyber Security Center	https://www.cyber.gov.au/
12	Airbus Cyber	https://airbus-cyber-security.com/
13	World Internet Conference	https://www.wicwuzhen.cn/
14	Cyberspace Administration Of China	http://www.cac.gov.cn/
15	Global Cyberspace Governance	https://www.pishu.com.cn/skwx_ps/sublibrary/14/10755.html

TABLE 2 | Non-professional news target websites.

No.	Country	Media name	Website address
1	The US	The Huffington Post	http://www.huffingtonpost.com/
2		CNN	https://edition.cnn.com/
3		New York Times	https://www.nytimes.com/
4		Buzzfeed	https://www.buzzfeed.com/
5		Aol	https://www.aol.com/
6	The UK	BBC	http://www.bbc.co.uk/
7		Daily Mail	http://www.dailymail.co.uk/
8		The Guardian	https://www.theguardian.com.au/
9	France	Le Figaro	https://www.lefigaro.fr/
10		Le Parisien	http://www.leparisien.fr/
11		Reuters	http://reuters.com/
12		Agence France-Presse	https://www.afp.com/
13	Germany	Daily Mirror	https://www.tagesspiegel.de/
14		Le Monde	https://www.welt.de/
15	Russia	Rt Web Team	https://www.rt.com
16		ITAR-TASS	https://tass.ru/
17	Spain	Elmundo Es	https://www.elmundo.es/
18		Eleconomista Es	https://www.eleconomista.es/
19	China	CCTV	http://www.cctv.com/
20	Canada	The Globe And Mail	http://www.theglobeandmail.com/
21	Japan	Asahi Shimbun	http://www.asahi.com/ajw/?iref=comtop_usnavi
22	Singapore	zaobao	http://www.zaobao.com/
23		The New Pape	http://www.tnp.sg/
24	India	the Daily Telegraph	http://www.telegraph.co.uk/

Cyberspace governance, cyberspace security, system security, information dissemination security, information content safety, internet ecosystem, cyber infrastructure security, application security (application system security), Internet security, Internet of things security, transaction security, database security, mobile security, risk management, risk assessment, information disclosure, communication technology, cyber technology, cyber protocol security, cyber running security, local area cyber (cyber security inspection), computer viruses, information alterations (loss), media security, and environmental security, equipment security, cyber security inspection, communication cyber, global governance, artificial intelligence, security strategy, cyber attacks, cyber security vulnerability, cyber law, information security, cyber threat, strategic proposition, cyber supervision, coordination mechanism, emergency management, social cyber, monitoring and early warning, cyber risk, cyber crime, security specification, security prevention, data protection, business secret, cosmopolitan web, data service, security framework, data breach, security event, security threat, cyber intrusion, and cyber security crisis, international cooperation, security system, information technology, encryption technology, cyber pattern, ICANN, cyber competitiveness, cyber deterrence theory, cyber self-management, Internet governance, cyberspace sovereignty, national safety, information infrastructure, cyber-culture, cyber terror, cyber governance, fundamentals of cyber security, cyberspace protection, international cyber cooperation, personal information protection, critical information infrastructure, multi-stakeholders, digital economic cooperation, personal privacy protection, digital divide and poverty, international internet system, cyber ecological governance, internet governance, cyber rules, cyber laws, cyber sovereignty, and cyber monitoring.

DATA MINING AND APRIORI ALGORITHM FOR ASSOCIATION RULE ANALYSIS

Association rules are similar to the implication expression of $X \Longrightarrow Y$, where X and Y are disjoint subsets, that is, $X \cap Y = \emptyset$ (Guo et al., 2017). The strength of the expression can be measured with support and confidence. Support is to determine how often association rules can be used for a given dataset, while confidence determines how often Y occurs in the transactions that contain X. Strong rules satisfy both the minimum support threshold (Minsup) and minimum confidence threshold (Minconf) rules (Watkins et al., 2020). Moreover, support is an important measure (Johnston and Baker, 2020). Since the rule with low support may emerge by chance, it rarely occurs in the entire dataset. Therefore, support is usually used to delete meaningless rules. Besides, it has the desired nature to discover association rules (Tightiz et al., 2020). However, confidence is inferred through association rules.

For a given $X \Longrightarrow Y$, the higher the confidence, the greater the probability that Y is included in the transaction of X. Certainly, confidence can also estimate the conditional probability of Y at a given X (Sharadqah and Mojirsheibani, 2020). For example, cyber attacks $\Longrightarrow$ data breach, the higher the support, the higher the frequency of data breach and cyber attacks occur in a given dataset. Meanwhile, the higher the confidence, the higher the probability of data breach after cyber attacks.

Apriori algorithm of a mining association rule is based on two core theories: the subsets of frequent item-sets are frequent item-sets, and the supersets of infrequent item-sets are infrequent item-sets (Goldhammer et al., 2020). Frequent item-set refers

to the set with several items that often appear, the support of which is greater than the minimum threshold (Minsup); non-frequent item-set refers to the item-set with a support lower than the threshold (Nguyen et al., 2017). If {cyber attacks, data breach} is a frequent item-set, {cyber attacks} and {data breach} must be frequent item-sets. If {cyber attacks, data breach} is an infrequent item-set, {cyber attacks, data breach, and artificial intelligence}, {cyber attacks, data breach, and cyber crime}, or {cyber attacks, data breach, cybercrime, and artificial intelligence}, and other supersets are infrequent item-sets.

However, the Apriori algorithm uses an Iterative Method (Shashi et al., 2020). First, the candidate 1-item-set and the corresponding support are searched to obtain the frequent 1-item-set by pruning out the 1-item-set with lower support. Then the remaining frequent 1-item-set is connected to get the candidate frequent 2-item-set. Meanwhile, the real frequent 2-item-set is obtained through filtering out the candidate frequent 2-item-set with lower support. Using this iterative method to operate until the frequent k + 1 item-set cannot be found, the corresponding frequent k-item-set is the output of the algorithm (Surender and Hegde, 2020). For example, the data set D in this study has four records, namely, (1) cyber attack, data protection, and cybercrime; (2) data breach, data protection, and artificial intelligence; (3) cyber attack, data breach, data protection, and artificial intelligence; and (4) data breach and artificial intelligence.

The Apriori algorithm is used to find frequent k-item-sets, setting the minimum support to 50%. First, a candidate frequent 1-item-set is generated, including all five data and calculating the corresponding support. Secondly, pruning is performed after the calculation. Since the support of {cyber crime} 1-item-set is only 25%, it has to be cut off. Therefore, the final frequent 1-item-set, {cyber attacks, data breach, data protection, and artificial intelligence}, is linked to generate the candidate frequent 2-item-set, {cyber attacks, data breach), {cyber attacks, data protection}, {cyber attacks, artificial intelligence}, {data breach, data protection}, {data breach, artificial intelligence}, and {data protection, artificial intelligence}, with a total of six groups. The first round of iteration ends at this point.

In the second round of iteration, the scanned data set is used to calculate the support of the candidate frequent 2-item-set, and then the item-sets are removed (Shariq, 2020). The support of {cyber attacks, data breach} and {cyber attacks, artificial intelligence} is only 25%, thus the frequent 1-item set is screened out to generate the real frequent 2-item set, {cyber attacks, data protection}, {data breach, data protection}, {data breach, artificial intelligence}, and {data protection, artificial intelligence}. Next, the four groups of frequent 2-item-sets are linked to generate a candidate frequent 3-item-set, {cyber attack, data breach, and data protection}, {cyber attacks, data protection, and artificial intelligence}, and {data breach, data protection, and artificial intelligence}. Through the calculation of the support of the candidate frequent 3-item-set, the support of {cyber attacks, data breach, data protection} and {cyber attacks, data protection, artificial intelligence} are both 25%. Therefore, the data needs to be pruned again to obtain the real frequent 3-item-set {data breach, data protection, and artificial intelligence}. Because there is only one frequent item-set remaining, no more data is linking at this stage. The candidate frequent 4-item-set is obtained, the final result of which is the frequent 3-item-set {data breach, data protection, and artificial intelligence}.

For the frequent item-set of {data breach, data protection, and artificial intelligence}, the subsets are {data breach}, {data protection}, {artificial intelligence}, {data breach, data protection}, {data breach, artificial intelligence}, and {data protection, artificial intelligence}. The rules are as follows:

Data Breach $\Longrightarrow$ Artificial Intelligence^Data Protection.
Data Protection $\Longrightarrow$ Data Breach^Artificial Intelligence.
Artificial Intelligence $\Longrightarrow$ Data Breach^Data Protection.
Data Breach^Data Protection $\Longrightarrow$ Artificial Intelligence.
Data Breach^Artificial Intelligence $\Longrightarrow$ Data Protection.
Data Protection^Artificial Intelligence $\Longrightarrow$ Data Breach.

Therefore, based on the data mining of global professional and non-professional target websites, the Apriori algorithm is used to analyze association rules. Combining this association rule with a series of attributes can present the specific information content of cyberspace security on global professional and non-professional target websites, which marks the completion of mining association rules for transaction databases at the third stage.

SPECIFIC PRESENTATION OF GLOBAL CYBERSPACE SECURITY ISSUES

The specific presentation of global cyberspace security issues is based on the association rule of the Apriori algorithm. The confidence formula of conf (I1->I3^I2) = support (I1, I2, I3)/ support (I1) is used to calculate the confidence of each rule. Then the minimum confidence and minimum support are compared to mine the strong rules corresponding to the data (Ahmed and Tien, 2016).

However, the value of the corresponding rule can be analyzed through a series of attributes of association rules. (1) Support representing the support of the union of the former and the latter items (Joki et al., 2020); (2) Confidence involves the rules to identify the rule support/rule leader (Lin and James, 2020); (3) Lift refers to the ratio of the probability of containing an left-hand side (LHS) and an right-hand side (RHS) to the probability of containing RHS (Musab et al., 2019). It reflects the correlation between the LHS and the RHS in association rules. When the lift is larger than one, the higher it is, the higher the positive correlation is; when the lift is lower than one, the lower it is, the higher the negative correlation is. Meanwhile, there is no correlation when the lift is equal to one. (4) Leverage indicates the number of times that the LHS and RHS appear together when they are independently distributed. When the leverage is equal to zero, the LHS and RHS are independent (Kaveh et al., 2020). The larger the leverage is, the closer the relationship between the LHS and RHS. (5) Conviction is used to measure the independence of the LHS and RHS. Similar to the lift, the greater the value of confidence is the greater, the correlation is the greater (Unvan, 2020).

After the statistic of word segmentation and word frequencies of professional and non-professional target websites involved in global cyberspace issues, the Apriori algorithm is used to mine association rules and set threshold based on word frequency results. As a result, a series of association rules greater than the minimum support, and minimum confidence is obtained. Meanwhile, the patterns of LHS and RHS of association rules show the relationship among different word frequencies (Dario and Solange, 2019). The rule of "data breach to cyber-attack" reveals the connection between the data breach and cyber attacks. In terms of probability theory, when a data breach occurs, there will be cyber attacks with the probability depending on the size of confidence. The greater confidence of rules means that there are more sufficient reasons to trust the rule (Komiya et al., 2020).

Meanwhile, the rule has an essential attribute of support, which indicates the frequency of rules occurring in this data set. The larger the threshold is, the more frequently the rule occurs (Reigal et al., 2020). If both the two thresholds are relatively large, the data breach is often accompanied by cyber attack. **Table 3** shows the details.

Table 3 shows that 181 strong rules are mined in 22,493 web pages of 15 global professional target websites, of which 32 strong rules are analyzed. Each row lists a strong rule and the corresponding support, confidence, lift, leverage, and conviction, which are arranged from largest to smallest according to confidence. From a whole perspective to study the 32 strong rules, it has little impact on judging confidence because of the vast amount of data and small support, and the threshold is still credible. However, the overall small support indicates that the words related to cyberspace security are comprehensive in global professional target websites. Moreover, the information discussing cyberspace security is relatively comprehensive and detailed. However, the threshold of confidence means that when some or a specific cyberspace security term in global target professional websites is mentioned, another term related to cyberspace security will be mentioned with a higher probability. The strong rule with the highest confidence is "Cyberspace Security, Cyberspace Governance ⟹ Cyber Sovereignty," with the confidence of about 96.2%, showing that after referring to cyber sovereignty, there is a higher possibility of mentioning cyberspace security.

Meanwhile, the lifts of LHS and RHS of 32 strong rules higher than the threshold are both greater than one, indicating the positive correlation of word frequency between the two items.

TABLE 3 | Strong rules above the threshold of global professional target websites.

No.	LHS	RHS	Support	Confidence	Lift	Leverage	Conviction
1	Cyberspace security, Cyberspace governance⟹	Cyber sovereignty	0.12732	0.96239	6.61387	0.10807	22.71992
2	Cyber sovereignty⟹	Cyberspace security	0.13512	0.92857	5.30847	0.10966	11.55108
3	Cyberspace governance⟹	Cyber sovereignty	0.13252	0.92763	6.37500	0.11173	11.80749
4	Information technology, Cyberspace governance⟹	Cyber sovereignty	0.04417	0.89675	6.16274	0.03701	8.27554
5	Cyber crimes, International cooperation⟹	Internet governance	0.01537	0.87147	7.36255	0.01328	6.85954
6	Artificial intelligence, Cyber sovereignty⟹	Cyberspace security	0.05197	0.86957	4.97114	0.04151	6.32559
7	Cyberspace security, Information technology⟹	Information security	0.04821	0.86251	2.75249	0.03069	4.99422
8	National security, Cyberspace governance⟹	Information security	0.03030	0.85358	2.72399	0.01917	4.68963
9	Personal information protection⟹	Information security	0.02178	0.85281	2.72154	0.01378	4.66513
10	Security threats, Cyber attacks⟹	Information security	0.02488	0.84428	2.69430	0.01564	4.40941
11	Cyber crime, Cyberspace security⟹	Information security	0.02659	0.83944	2.67887	0.01667	4.27659
12	National security, Information technology⟹	Cyberspace security	0.02565	0.83906	4.79675	0.02030	5.12660
13	Artificial intelligence, Cyberspace governance⟹	Information security	0.04683	0.83366	2.66042	0.02923	4.12798
14	Cyber governance⟹	Cyberspace governance	0.02416	0.81835	5.72846	0.01994	4.71870
15	International rulemaking⟹	Information technology	0.01128	0.80952	8.55296	0.00996	4.75310
16	International cooperation, Cyber attack⟹	Information technology	0.01056	0.80591	8.51475	0.00932	4.66453
17	Intent governance⟹	Cyberspace security	0.03096	0.80344	4.59314	0.02422	4.19766
18	Cyber governance⟹	Information security	0.02366	0.80150	2.55778	0.01441	3.45913
19	Information technology Cyberspace governance⟹	Information security	0.03909	0.79349	2.53223	0.02365	3.32499
20	Infrastructure security⟹	Information technology	0.02460	0.75042	2.39478	0.01433	2.75121
21	National security, Information technology⟹	Information security	0.02272	0.74322	2.37180	0.01314	2.67404
22	Cyberspace security, Internet governance⟹	Information technology	0.02836	0.70564	2.25187	0.01577	2.33266
23	Artificial intelligence, Information technology⟹	Cyberspace security	0.02764	0.69638	3.98107	0.02070	2.71746
24	Information infrastructure⟹	Cyberspace security	0.03179	0.67807	3.87638	0.02359	2.56288
25	Artificial intelligence, Information technology⟹	Cyberspace governance	0.02676	0.67409	4.71866	0.02109	2.63004
26	Information infrastructure⟹	Information security	0.03068	0.65448	2.08861	0.01599	1.98728
27	International cooperation⟹	Cyberspace security	0.03345	0.64845	3.70704	0.02442	2.34694
28	Artificial intelligence, Information technology⟹	Information security	0.02527	0.63649	2.03120	0.01283	1.88893
29	Artificial intelligence⟹	Cyberspace security	0.06026	0.62500	3.57301	0.04340	2.20021
30	Artificial intelligence⟹	Cyber sovereignty	0.05976	0.61984	4.25975	0.04573	2.24771
31	International cooperation⟹	Cyberspace governance	0.03146	0.60986	5.15234	0.02535	2.25979
32	Information technology⟹	Cyber sovereignty	0.05457	0.57652	3.96203	0.04079	2.01777

Thresholds set by Python have the minimum support of 0.01 and minimum confidence of 0.3. According to this threshold, 6,876,606 strong rules are mined to facilitate data observation following the rules with equal support, remaining 181 rules. Table 3 lists 32 strong rules, while the remaining 149 rules are not analyzed because of low importance and little research value.

"International rule-making ⟹ information technology" and "international cooperation and cyber attacks ⟹ Information technology" have the highest lifts, which are 8.55296 and 8.51475, respectively. Information technology is mentioned most frequently by international rule-making, international cooperation, and cyber attacks in the field of global cyberspace security. Moreover, the leverages of LHS and RHS of the 32 strong rules are both more than zero, showing that the word frequency cohesion between the two items is higher than expected. The strong rules with the closest relationship are "cyberspace governance ⟹ cyber sovereignty," "cyber sovereignty ⟹ cyberspace security" and "cyberspace security and cyberspace governance ⟹ cyber sovereignty," the values of which are 0.11173, 0.10966, and 0.10807, respectively. Results show that cyberspace governance, cyber sovereignty, and cyberspace security in global cyberspace security have been mentioned and concerned frequently. However, "cyberspace security and security governance ⟹ cyber sovereignty" has the highest conviction among the 32 strong rules, which is 22.71992, the same as the maximum value of lift. The independence of "cyberspace security and security governance" and "cyber sovereignty" is strong and closely related, which are mentioned almost simultaneously.

Table 4 shows that the TOP 10 rules with the highest support and the corresponding confidence can be mined through 32 strong rules in global professional websites. First, the word frequency of cyber sovereignty is accompanied by the frequency of cyberspace security, cyberspace governance, artificial intelligence, and information technology. Then, the word frequency of artificial intelligence appears, followed by cyberspace security, cyber sovereignty, information security, and cyberspace governance. Besides, the word frequency of information technology is mentioned in the wake of cyber sovereignty, cyberspace security, information security, and cyberspace governance. Finally, analyzing from the rule with the highest support, "cyber sovereignty ⟹ cyberspace security," cyberspace security appears in the confidence possibility of 92.8% after cyber sovereignty occurs. Moreover, analyzing from the top 10 rules, Cyber sovereignty has become the most frequent item in global target professional websites.

Table 5 shows that the Top 10 strong rules with the highest confidence and the corresponding support can be mined through the 32 strong rules above the threshold. Then, the conclusions can be drawn as follows. Firstly, "cyberspace security and cyberspace governance ⟹ cyber sovereignty" has the highest confidence among the global target professional websites. The word frequency of "cyber sovereignty" appears after "cyberspace security and cyberspace governance," which has higher support among all strong rules. Also, cyber sovereignty appears frequently and has higher support, whether as LHS, "cyber sovereignty ⟹ cyberspace security," or as RHS, "cyberspace security and cyberspace governance ⟹ cyber sovereignty," "cyberspace governance ⟹ cyber sovereignty," and "information technology and cyberspace governance ⟹ cyber sovereignty."

When any word frequency of "cyber sovereignty" or "artificial intelligence and cyber sovereignty" appears, cyberspace security has a high probability of appearing. When the word frequencies of "cyberspace security and information technology," "national security and cyberspace governance," "personal information protection," and "security threats and cyber attacks" appear as LHS, "information security" frequently appears as RHS. After the appearance of "cyberspace security and information technology," "national security and cyberspace governance," "personal information protection," or "security threats and cyber attacks," "information security" occurs, with the probabilities of 86.2, 85.3, 85.2, and 84.4%, respectively.

TABLE 4 | Top 10 rules with the highest support for global professional target websites.

Top	LHS	RHS	Support	Confidence
1	Cyber sovereignty⟹	Cyberspace security	0.13512	0.92857
2	Cyberspace governance	Cyber sovereignty	0.13252	0.92763
3	Cyberspace security, Cyberspace governance⟹	Cyber sovereignty	0.12732	0.96239
4	Artificial intelligence⟹	Cyberspace security	0.06026	0.62500
5	Artificial intelligence⟹	Cyber sovereignty	0.05976	0.61984
6	Information technology⟹	Cyber sovereignty	0.05457	0.57652
7	Artificial intelligence, Cyber sovereignty⟹	Cyberspace security	0.05197	0.86957
8	Cyberspace security, Information technology⟹	Information security	0.04821	0.86251
9	Artificial intelligence, Cyberspace governance⟹	Information security	0.04683	0.83366
10	Information technology, Cyberspace governance⟹	Cyber sovereignty	0.04417	0.89675

TABLE 5 | Top 10 rules with the highest confidence for global target professional websites.

Top	LHS	RHS	Confidence	Support
1	Cyberspace security, Cyberspace governance⟹	Cyber sovereignty	0.96239	0.12732
2	Cyber sovereignty⟹	Cyberspace security	0.92857	0.13512
3	Cyberspace governance⟹	Cyber sovereignty	0.92763	0.13252
4	Information technology, Cyberspace governance⟹	Cyber sovereignty	0.89675	0.04417
5	Cyber crime, International cooperation⟹	Internet governance	0.87147	0.01537
6	Artificial intelligence, Cyber sovereignty⟹	Cyberspace security	0.86957	0.05197
7	Cyberspace security, Information technology⟹	Information security	0.86251	0.04821
8	National security, Cyberspace governance⟹	Information security	0.85358	0.03030
9	Individual information protection⟹	Information security	0.85281	0.02178
10	Security threats, Cyber attacks⟹	Information security	0.84428	0.02488

Therefore, after comparing the Top 10 rules with the highest confidence and Top 10 rules with the highest support of global target professional websites, this study can obtain the following conclusions.

Firstly, although "cybercrime and international cooperation ⟹ Internet governance" does not appear in the Top 10 rules of support, it has the fifth-highest confidence. As long as cybercrime and international cooperation are mentioned in global professional target websites, there is a high probability of "Internet governance" appearing. Moreover, "cyber sovereignty ⟹ cyberspace security" rank high in both the Top 10 support rules and the Top 10 confidence rules, which mean cyber sovereignty and cyberspace security are often mentioned by the international community in global professional target websites. Meanwhile, cyberspace sovereignty is mentioned as information about cyberspace security.

Table 6 shows that a total of 181 strong rules are mined in 33,603 web pages of 25 global non-professional target websites, of which 27 strong rules are analyzed. Each row lists a strong rule and corresponding support, confidence, lift, leverage, and conviction, which are arranged from largest to smallest according to support. Though the study of 27 strong rules is from a whole perspective, the volume of useful information about cyberspace security mentioned in non-professional websites is less than that of professional websites. However, the overall support is slightly higher than that of professional websites. Meanwhile, the support of some strong rules is relatively high, indicating that the words related to cyberspace security are relatively simple when used in global non-professional websites, and the information on cyberspace security is monotonous. For example, the strong rule with the highest support is "cyber attacks ⟹ artificial intelligence," with the support of about 33.7%, showing that cyber attacks and artificial intelligence are discussed more frequently in non-professional websites. Moreover, the rule with the highest confidence is "cyber sovereignty ⟹ Internet governance" in non-professional websites, with the confidence of about 92.8% and support of about 13.6%, showing that cyber sovereignty and Internet governance are discussed frequently in non-professional websites. Meanwhile, cyber sovereignty and Internet governance are mentioned with a high probability.

The lifts of LHS and RHS of 27 strong rules higher than the threshold are both greater than 1, indicating the negative correlation of word frequency between the two items, and the relationship of mutual promotion is not significant. Moreover, the leverages of LHS and RHS of the 27 strong rules are both more than zero, showing that the word frequency cohesion between the two items is higher than expected. The strong rules with the closest relationship are "Cyber sovereignty ⟹ Internet governance," "Cyber attacks ⟹ Artificial intelligence," and "Cyber attacks ⟹ Cyber crime," the values of which are 0.11166, 0.09816, and 0.07866, respectively. Results show that the international community generally pays attention to artificial intelligence, cyber sovereignty, cyber attacks, cyber crime, and

TABLE 6 | Strong rules for global non-professional target websites above the threshold.

No.	LHS	RHS	Support	Confidence	Lift	Leverage	Conviction
1	Cyber attacks⟹	Artificial intelligence	0.33704	0.47867	1.41091	0.09816	1.26741
2	Cyber attacks⟹	Cyber crime	0.26585	0.37757	1.42022	0.07866	1.17948
3	Cyber crime⟹	Cyber crime, Artificial intelligence	0.14905	0.56067	1.66350	0.05945	1.50902
4	Cyber attacks, Artificial intelligence⟹	Cyber crime	0.14905	0.44224	1.66350	0.05945	1.31626
5	Cyber crime⟹	Artificial intelligence	0.14905	0.56067	1.65260	0.05886	1.50396
6	Cyber attacks, Cyber crime⟹	Artificial intelligence	0.14905	0.56067	1.65260	0.05886	1.50396
7	Artificial intelligence⟹	Cyber crime	0.14905	0.43934	1.65260	0.05886	1.30945
8	Artificial intelligence⟹	Cyber attacks, Cyber crime	0.14905	0.43934	1.65260	0.05886	1.30945
9	Cyber attacks⟹	Cyber crime, Artificial intelligence	0.14905	0.21169	1.42022	0.04410	1.07946
10	Cyber sovereignty⟹	Internet governance	0.13682	0.75000	5.43750	0.11166	3.44828
11	Cyber attacks⟹	Data breach	0.10790	0.15324	1.21913	0.01939	1.03253
12	Cyber attacks, Data breach⟹	Artificial intelligence	0.07453	0.69072	2.03593	0.03792	2.13637
13	Artificial intelligence⟹	Cyber attacks, Data breach	0.07453	0.21967	2.03593	0.03792	1.14324
14	Data breach⟹	Cyber attacks, Artificial intelligence	0.07453	0.59292	1.75919	0.03216	1.62857
15	Cyber attacks, Artificial intelligence⟹	Data breach	0.07453	0.22112	1.75919	0.03216	1.12252
16	Data breach⟹	Artificial intelligence	0.07453	0.59292	1.74766	0.03188	1.62311
17	Artificial intelligence⟹	Data breach	0.07453	0.21967	1.74766	0.03188	1.12043
18	Cyber attacks⟹	Data breach, Artificial intelligence	0.07453	0.10585	1.42022	0.02205	1.03503
19	Cyber attacks, Data breach⟹	Cyber crime	0.04894	0.45361	1.70625	0.02026	1.34363
20	Cyber crime⟹	Cyber attacks, Data breach	0.04894	0.18410	1.70625	0.02026	1.09340
21	Data breach⟹	Cyber crime	0.04894	0.38938	1.46466	0.01553	1.20230
22	Data breach⟹	Cyber attacks, Cyber crime	0.04894	0.38938	1.46466	0.01553	1.20230
23	Cyber attacks, Cyber crime⟹	Data breach	0.04894	0.18410	1.46466	0.01553	1.07158
24	Cyber crime⟹	Data breach	0.04894	0.18410	1.46466	0.01553	1.07158
25	Cyber attacks⟹	Data breach, Cyber crime	0.04894	0.06951	1.42022	0.01448	1.02210
26	Cyber attacks⟹	Data breach	0.04561	0.06477	1.38641	0.01271	1.01930
27	Cyber attacks⟹	Data breach, Cyber threat	0.03893	0.05529	1.42022	0.01152	1.01732

Thresholds set by Python have the minimum support of 0.01 and the minimum confidence of 0.05. According to this threshold, 181 strong rules are mined. Table 6 lists 27 strong rules, while the remaining 154 rules are not analyzed because of low importance and little research value.

Internet governance in the non-professional websites of global cyberspace security issues. "Cyber sovereignty ⟹ Internet governance" has the highest conviction among the 27 strong rules, which is 3.44828, while the maximum lift is the same as the maximum value of confidence. The independence of cyber sovereignty and Internet governance is strong and closely related, which are mentioned almost simultaneously.

Therefore, this study compared the strong rules of professional and non-professional websites as a whole. Firstly, cyber sovereignty is widely concerned by people. Among professional websites, the strong rule of "cyber sovereignty ⟹ cyberspace security" has the highest support, with the support of about 13.5%. In non-professional websites, "Internet sovereignty ⟹ Internet governance" is the tenth rule order by support, with the support of about 13.6%. Secondly, from the perspective of confidence, the word frequency of cyber sovereignty is usually accompanied by cyberspace security, cyberspace governance, artificial intelligence, and information technology in professional websites. Finally, based on confidence, the word frequency of cyber sovereignty is only accompanied by Internet governance in non-professional websites. For the same LHS, there are more diverse RHS in professional websites, but it is single in non-professional websites, showing that cyber sovereignty has been studied more comprehensively in professional websites.

Through analyzing the data mining accuracy in global professional and non-professional target websites, namely, the ratio of the number of websites with cyberspace security to the total number of websites, the following can be found.

1. **Figure 1** shows that the number of websites containing cyberspace security in global professional target websites accounts for 69.6%, while that of websites without cyberspace security for 30.4%;
2. **Figure 2** shows that the number of websites containing cyberspace security in global non-professional target websites accounts for 2%, while that of websites without cyberspace security for 97.8%. After further interpreting, 15,661 websites refer to cyberspace security from the total sample of 22,493 professional websites, accounting for 69.6%; meanwhile, 735 non-professional websites mentioned cyberspace security among the entire 33,603 sites, accounting for 2%. Therefore, there is a large gap in the proportion of valuable data between global professional and non-professional target websites. Meanwhile, the probability of cyberspace security appearing in professional target websites is far higher than that of non-professional websites, and the non-professional target websites pay far less attention to cyberspace security than professional websites.

According to the statistics of word segmentation on the data mining of global target websites, the word frequency results can be generated into the word cloud of professional and non-professional target websites. If the word cloud appears more frequently in cyberspace, the larger the font size of the word, the more pronounced the problem will be. **Figures 3, 4** show that the word cloud of professional target websites is richer than that of non-professional websites, and the information describing cyberspace security is comprehensive. Word frequencies of the data breach and cyber sovereignty in target

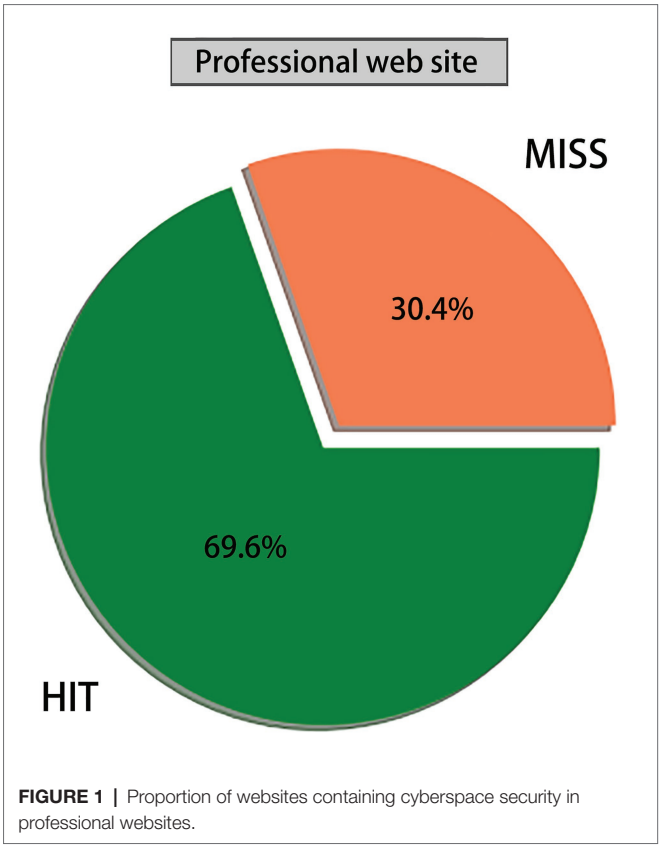

FIGURE 1 | Proportion of websites containing cyberspace security in professional websites.

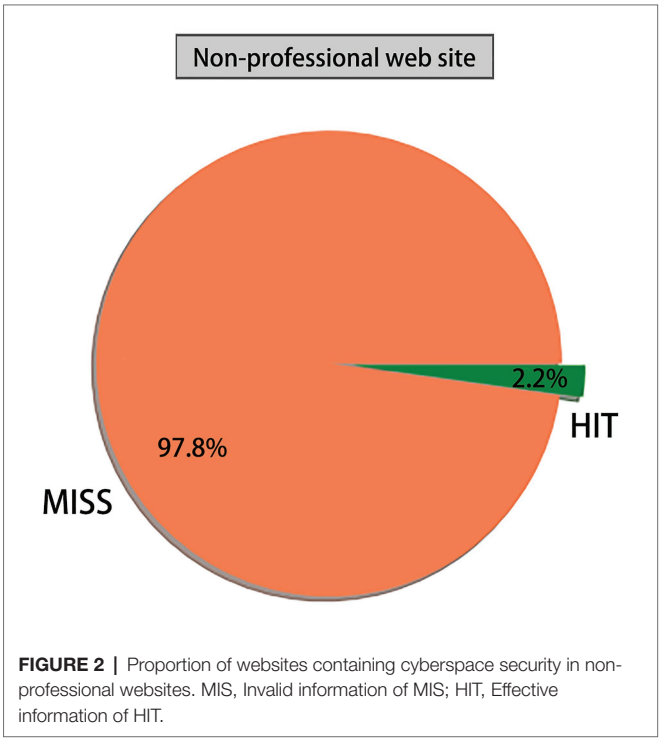

FIGURE 2 | Proportion of websites containing cyberspace security in non-professional websites. MIS, Invalid information of MIS; HIT, Effective information of HIT.

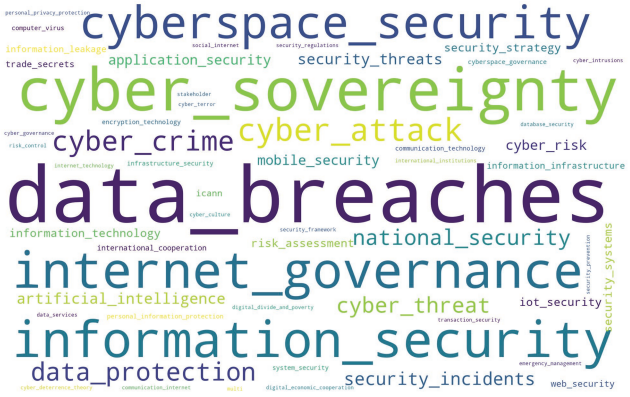

FIGURE 3 | Word clouds of professional websites.

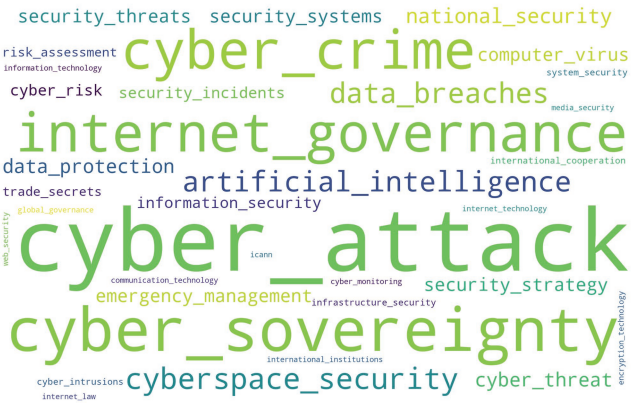

FIGURE 4 | Word clouds of non-professional websites.

professional websites, and cyber attacks and cyber sovereignty in non-professional websites are prominent, indicating that cyber security issues have been widely valued by the international professional field and mainstream news media.

Data breach, cyber sovereignty, Internet governance, information security, cyberspace security, national security, data protection, and cybercrime repeatedly appear in target professional websites, showing that the word frequencies involved in cyberspace security issues are professional and in-depth. However, the word frequencies of cyber sovereignty, cyber attacks, cybercrime, internet governance, security threat, computer virus, cyberspace security, cyber threat, artificial intelligence, and emergency management appear frequently in target non-professional websites. It shows that the mainstream news sites of the international community have only reported extensively on cyber security issues, lacking detailed and in-depth understanding.

Through comparing the word frequencies that often appear in target professional and non-professional websites, although the perspective of cyberspace security issues is different, the two types of websites focus on cyber sovereignty, cyber attacks, cyberspace security, Internet governance, national security, data breaches, and cyber threat.

Through sorting the word frequencies of global professional and non-professional target websites, the Top 10 strong rules of cyberspace security words with high frequency were obtained. If the proportion of word frequencies of the first 10 words is larger, the higher the ranking of the word is, the more frequently it is presented in global target websites, and the more it will be valued and recognized.

Figures 5, 6 show that the high word frequencies of Top 10 strong rules in professional websites are as follows: the word frequency of data leakage is 14%; that of cyber sovereignty 13.9%; that of information security 13.7%; that of Internet governance 12%; that of cyberspace security 10.8%; that of cyber attacks 10.6%; that of cyber crime 7.8%; that of data protection 7.4%; that of national security 5.6%; and that of the word cyber threat 4.2%. The high word frequencies of the Top 10 strong rules in non-professional websites are as follows: the word frequency of cyber attacks is 39%; that of cyber sovereignty 26%; that of Internet governance 8.1%; that of cyber crime 7.8%; that of cyberspace security 6.8%; that of artificial intelligence 4.6%; that of data leakage 3.3%; that of national security 2.5%; that of data protection 1.1%; and that of cyber threat 0.7%.

The frequent words of the Top 10 strong rules of global professional and non-professional target websites are compared to find that the frequent words of professional target websites are more evenly distributed. In contrast, those of the non-professional websites are unevenly distributed with cyber attacks in a dominant position.

Moreover, the word frequencies of global non-professional target websites are relatively broad, which are not as specific and accurate as that of professional websites. When presenting news related to cyberspace security, non-professional websites tend to use a single word frequency of cyber attacks. Conversely, professional websites use more specific and comprehensive words, adopting data breach, cyber sovereignty, information security, Internet governance, cyberspace security, and cyber attacks.

DISCUSSION

There are differences in cultural traditions and ideologies in different countries on the global Internet, which have pervaded the whole cyberspace. Moreover, cyberspace security issues have attracted worldwide attention. This study analyzed association rules based on the Apriori algorithm. Besides, the association rules were studied by selecting 15 professional target websites and 22,493 web pages, of which 15,661 websites are related to cyberspace security, accounting for 69.6% of the total target professional websites. A total of 25 non-professional target websites and 33,603 web pages are selected. Among them, 735 websites mention cyberspace security, accounting for 2% of the total number of non-professional websites. According to the threshold set by Python, the minimum support is 0.01, and the minimum confidence 0.05, with a total of 181 strong rules mined.

The 32 strong rules for the professional target website and 27 strong rules for the non-professional website are listed above. Moreover, the other strong rules are not analyzed due to their

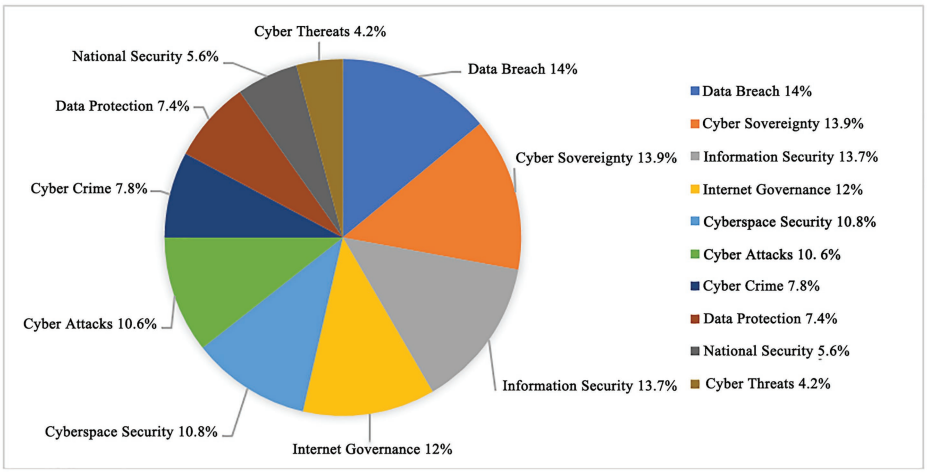

FIGURE 5 | Proportion of Top 10 word frequencies of professional websites.

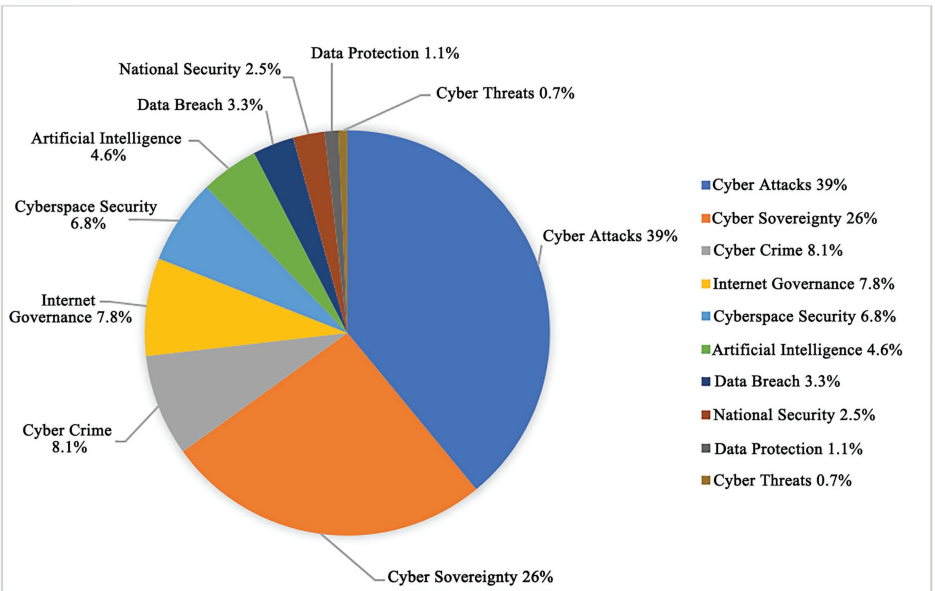

FIGURE 6 | Proportion of Top 10 word frequencies of non-professional websites.

low importance and low research value. The two types of target websites cover China, America, Britain, Germany, France, India, and other developed and developing countries on the Internet. The results reflected the interdependence and correlation among global cyberspace security issues.

After the word clouds of global professional and non-professional target websites are compared, professional websites focus on the Top 10 high-frequency words containing a data breach, cyber sovereignty, information security, Internet governance, cyberspace security, cyber-attacks, cybercrime, data protection, national security, and cyber threat. Global non-professional websites, namely the mainstream news website of the international community, focus on the Top 10 high-frequency words of cyber attacks, cyber sovereignty, Internet governance, cybercrime, cyberspace security, artificial intelligence, data breach, national security, data protection, and cyber threats.

The limitation of the work lies in the limited number of data mining samples due to different language restrictions for global professional and non-target websites, which leads to an insufficient selection of strong rules. In future research, the following aspects will be completed: breaking through the language bottleneck, highlighting the number of selected data with strong rules, and taking mainstream countries as the target samples. A single country will be taken as a sample to

analyze professional and non-professional websites involving cyber security issues. After concluding, the focus on cyber security issues between countries will be compared.

CONCLUSION

Through comparing the word frequencies, the professional and non-professional target websites focused on cyber sovereignty, cyber attack, cyberspace security, Internet governance, national security, data leakage, and cyber threats. After sorting the word frequencies of global target professional websites and non-professional websites separately, the high word frequencies of the Top 10 strong rules of professional websites were data breach, cyber sovereignty, information security, Internet governance, cyberspace security, cyber attacks, cyber crime, data protection, national security, and cyber threats. Meanwhile, the high word frequencies of the Top 10 strong rules of non-professional websites were cyber attacks, cyber sovereignty, Internet governance, cyber crime, cyberspace security, artificial intelligence, data breach, national security, data protection, and cyber threats. Therefore, the focuses of current global cyberspace security issues were cyber sovereignty, Internet governance, cyberspace security, cyber attacks, cyber crime, national security, cyber threat, and data protection.

From an industry perspective, the first level of focus referred to data breach and cyber sovereignty. The second was Internet governance, information security, cyberspace security, architectural security, data protection, cyber crime, and cyber attacks. The third referred to cyber threat, artificial intelligence, application security, security threat, physical cyber security, and cyber risk. The fourth refers to security strategy, information technology, multi-stakeholder, Internet security, risk assessment, infrastructure security, and international cooperation.

In terms of the international community, the first level included cyber sovereignty and cyber attacks. The second included Internet governance, cybercrime, data protection, security threats, data breach, cyberspace security, emergency management, national security, security strategy, and security system. The third includes computer viruses, cyber risks, artificial intelligence, information security, international cooperation, ICANN, risk assessment, security incidents, trade secrets, and infrastructure security. The fourth includes Internet security, global governance, cyber monitoring, communication technology, cyber law, cyber technology, and system security.

Based on this level analysis, this study sorted out the security issues in global cyberspace, and summarized the specific security problems in cyberspace. It showed that the global cyberspace security issues were different from the identification of the international community. For the global governance of cyberspace security, effective and targeted governance solutions can be proposed according to this study, which is conducive to building a community with a shared future in cyberspace and constructing an Internet governance system.

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 Zhejiang University and Dalian University of Foreign Languages Ethics Committees. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

ZL designed the study, conceived the analysis question and conducted the analysis; XL and LZ conducted the analysis also and critically revised the manuscript content; and RT is the organizer of the project and responsible for sorting out the contact data and connecting with other researchers.

FUNDING

This work was supported by the National Social Science Fund of China of the Youth Project "A Comparative Study on the Laws of Global Cyberspace Security Governance and Its Enlightenment to China" (Grant No. 19CXW039).

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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.

frontiers in Psychology

ORIGINAL RESEARCH
published: 15 February 2021
doi: 10.3389/fpsyg.2021.594031

Early Warning Method for Public Health Emergency Under Artificial Neural Network in the Context of Deep Learning

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The purpose is to minimize the substantial losses caused by public health emergencies to people's health and daily life and the national economy. The tuberculosis data from June 2017 to 2019 in a city are collected. The Structural Equation Model (SEM) is constructed to determine the relationship between hidden and explicit variables by determining the relevant indicators and parameter estimation. The prediction model based on Artificial Neural Network (ANN) and Convolutional Neural Network (CNN) is constructed. The method's effectiveness is verified by comparing the prediction model's loss value and accuracy in training and testing. Meanwhile, 50 pieces of actual cases are tested, and the warning level is determined according to the *T*-value. The results show that comparing and analyzing ANN, CNN, and the hybrid network of ANN and CNN, the hybrid network's accuracy (95.1%) is higher than the other two algorithms, 89.1 and 90.1%. Also, the hybrid network has sound prediction effects and accuracy when predicting actual cases. Therefore, the early warning method based on ANN in deep learning has better performance in public health emergencies' early warning, which is significant for improving early warning capabilities.

Keywords: public health emergencies, artificial neural network, convolutional neural network, structural equation model, early warning

OPEN ACCESS

Edited by:
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National Taichung University of Science and Technology, Taiwan

Reviewed by:
Ruey-Shun Chen,
National Chiao Tung University, Taiwan
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Specialty section:
This article was submitted to Human-Media Interaction, a section of the journal Frontiers in Psychology

Received: *12 August 2020*
Accepted: *18 January 2021*
Published: *15 February 2021*

Citation:
Zheng S and Hu X (2021) Early Warning Method for Public Health Emergency Under Artificial Neural Network in the Context of Deep Learning. Front. Psychol. 12:594031. doi: 10.3389/fpsyg.2021.594031

INTRODUCTION

With the continuous development of the economy, culture, and technology of all countries globally, people's life quality is gradually improving. However, due to society's rapid development, the ecological environment has brought more uncertainty to human beings' survival status. Emergencies have also become a norm for various countries. Many countries can actively respond to unexpected economic and technological situations through improvement and innovation. However, health emergencies may cause substantial losses worldwide (Xu et al., 2017; Carleton et al., 2019). For example, the white anthrax powder incident in the United States has brought the international community into an emergency state in response to public health incidents. Subsequent Severe Acute Respiratory Syndrome (SARS) incident, highly pathogenic avian influenza, Streptococcus suis infection, hand-foot-mouth disease outbreaks, Ebola, and Corona Virus Disease 2019 (COVID-19) pandemic at the end of 2019 have all sounded alarm bells one after another for the global public health safety issues (Carleton et al., 2018; Stroeymeyt et al., 2018).

After the infectious diseases in the past were detected, various countries have actively taken countermeasures to control them well. The SARS incident in 2003 also started the emergency management of major public safety incidents in China. China continually reflects on the management of public crisis events. While governments at all levels continue to strengthen economic regulation and market supervision, they should value the social management and social public service functions so that they can respond quickly and effectively to emergencies and risks (He et al., 2020; Zhou et al., 2020). Simultaneously, after the SARS incident, China also wrote an "emergency" to the Constitution. Afterward, the social early warning system and emergency response mechanism are gradually established and improved as much as possible to improve the ability to handle emergencies and protect people's lives and property safety. The COVID-19 has also spread throughout the world. This major pandemic has also caused severe threats to human health and impacts people's daily lives, social development, the market economy, and national security (Piciullo et al., 2018; Shenfield et al., 2018; Syafrudin et al., 2019).

The deep learning technology's continuous development provides possibilities for many fields. Deep learning can solve classification problems. Neural networks and Long Short-Term Memory (LSTM) networks can solve text recognition problems. Especially, there are numerous information sources in the big data context. How to transform public information data into adequate support to improve information and countermeasure management has become an essential problem to be solved by information technology (Carleo and Troyer, 2017; Annarumma et al., 2019).

In summary, public health emergencies' early warning is significant for people all over the world. Therefore, in deep learning, the Artificial Neural Network (ANN) constructs an early warning system for public health emergencies. The relevant news and other information data are intelligently extracted and analyzed to predict the early warning level of events, assisting relevant departments to improve the emergency detection efficiency. It guarantees the follow-up management and coordination work, thereby reducing all kinds of losses caused by public health emergencies to society.

LITERATURE REVIEW

In recent years, there have been more or less public health incidents in countries around the world. Experts and scholars are actively exploring early warning systems to reduce the losses in various aspects as much as possible when public health events occurred, thereby reducing public health events' impact on people. Huang and Xiang (2018) proposed a deep belief network method based on the Softmax classifier and Dropout mechanism to reduce rainfall-induced landslide disasters. Its powerful non-linear mapping ability was used to extract the landslide factors' inherent characteristics. The algorithm's advantages in accuracy and technology were verified by practical cases (Huang and Xiang, 2018). Yang et al. (2020) predicted high-risk students using the Convolutional Neural Network (CNN)'s learning image recognition function. The results showed that the two proposed methods could perform better than algorithms such as support vector machines, random forests, and deep neural networks. Its average recall rate reached 77.26%, indicating this method's effectiveness (Yang et al., 2020).

To detect blood infections early, identify the type of pathogens, and treat them in time, Van Steenkiste et al. (2018) applied long-term memory networks to predict the results of blood culture experiments. The prediction results were also relatively accurate (Van Steenkiste et al., 2018). Jang et al. (2020) used ANNs to develop and test their classifiers. The test results were used to predict cardiac arrest in the emergency department. Also, the dangerous patients of cardiac arrest were predicted by training multi-layer perceptron, long-term memory, and mixed memory. The results indicated that the dangerous patient would have a cardiac arrest 24 h after the prediction, showing the prediction model's excellent performances (Jang et al., 2020). Guo et al. (2020) established an early warning model using ANNs to accurately grasp disease prevention and treatment timing. By analyzing concentrated infectious diseases in China, the epidemic intensity and the need to issue early warning signals were comprehensively determined. The experimental results also validated the method's effectiveness in determining epidemic conditions (Guo et al., 2020).

Most of the past investigations detect and predict public emergencies through the current data situation and purpose. For some public health emergencies, data collection and analysis are significant. Emergency management efficiency is currently low. ANN builds an early warning model with significant influences using deep learning to warn people by analyzing intelligence data due to public health emergencies.

MATERIALS AND METHODS

Artificial Neural Network

ANN is a simulated human nervous system, and information is output and transmitted through countless neurons. The human brain can process complex information. The reason is the countless neurons in the human nervous system, and they are non-linear in processing the input information. Therefore, the computer can imitate the human brain's thinking process to help solve practical problems (Li H. et al., 2017; Mocanu et al., 2018; Zador, 2019).

The most widely used ANN is the three-layer neural network structure. The structure includes an input layer, a hidden layer, and an output layer. The input layer accepts data. The hidden layer processes and converts input signal data and determines the output signal. The output layer transfers the network's processing results. The input layer determines input nodes based on the number of input variables. According to different processing software and processing strategies, the output layer corresponds to different output nodes (Tealab, 2018; Jia et al., 2019). The ANN structure is shown in **Figure 1**.

Through continuous sample data training, the network weights are continuously adjusted to minimize the prediction error. When the error after each learning is considerable, it is

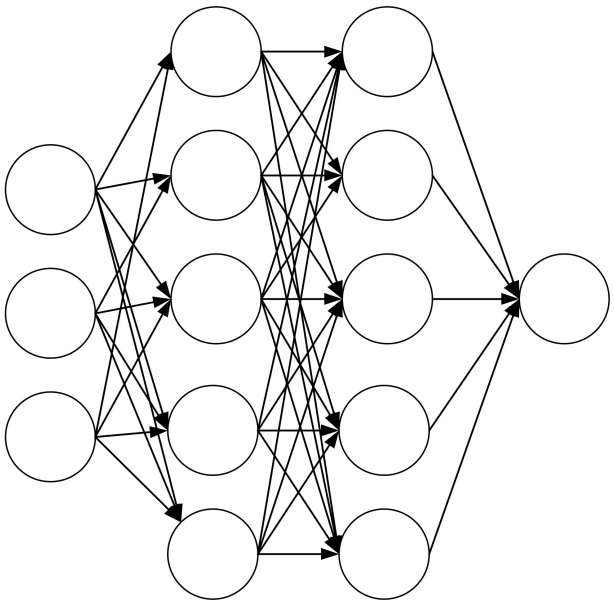

FIGURE 1 | The structure diagram of ANN.

necessary to continue learning and iterate continuously until the termination condition is satisfied. The input node has no upper node connected to it, and other nodes need to use the output of the upper node as the input value to complete the training further. It needs to go through the adder and activation function to complete the node work for each node. When X represents the input node's value, and y represents the output node's output signal, the node j's accelerator can be defined as Eq. 1.

$$U_f = \sum_{i=1}^{n} w_{ij} x_i + \theta_j \tag{1}$$

where w_{ij} represents the weight between the upper layer's node i and this layer's node j in the two adjacent network layers, θ represents the node deviation, regarded as a constant term, n denotes the number of nodes in the upper layer, and x_i denotes the output of the node i.

Besides, in the network, the activation function is also relatively important. It is assumed that the activation function of the node j can be expressed by Eq. 2.

$$y_j = f\left(U_j\right) \tag{2}$$

where y_j represents the activation function value, i.e., the node's output value, and U_f in the adder refers to the input value in the activation function.

The Sigmoid function is the most commonly used activation function in ANN (Zhou et al., 2018; Ayzel et al., 2019), described by Eq. 3.

$$f\left(U_j\right) = \frac{1}{1 + e^{-U_j}} \tag{3}$$

CNN

CNN is a significant and widely used network model in deep learning technology. It is a supervised learning model. The network connection method is also changed from full connection to partial connection, which reduces the parameter number in the network and the training process complexity and effectively improves the analysis efficiency (Guo et al., 2018; Hussain et al., 2018; Kriegerowski et al., 2019). CNN has good performance in image recognition and processing. It can complete feature extraction through image segmentation, convolution, pooling, and other operations. Its structure is shown in **Figure 2**.

CNN's structure includes an input layer, a convolutional layer (C1, C3), a pooling layer (S2, S4), a connection layer, and an output layer. Among them, the convolutional layer and the pooling layer constitute the hidden layer. Convolution and pooling operations are performed by extracting the input value's features, and the local features are integrated into all features for output (Montoro et al., 2018; Tommasetti et al., 2018).

Structural Equation Model

The Structural Equation Model (SEM) is a multivariate statistical technique that combines factor analysis and path analysis. It makes up for traditional statistical methods' shortcomings and becomes an essential tool for multivariate data analysis. SEM includes the measurement model and the structural model. The structural model is the internal model, mainly representing hidden variables, that is, the causal relationship between unobservable variables. The measurement model represents the external model, representing the explicit variables: the relationship between the observable variable and the hidden variable (Jiang et al., 2018; Jia et al., 2019).

In the structural model, ellipses represent hidden variables. The causal relationship between hidden variables is realized by the arrow pointing from cause to effect. "Cause" can also be called an endogenous hidden variable, and "effect" is called an independent variable. There may be multiple dependent variables in the structural model. A dependent variable may correspond to multiple hidden variables. The complicated causal relationship between hidden variables can be expressed by Eq. 4.

$$\eta = B\eta + \Gamma\xi + \zeta \tag{4}$$

where η represents the endogenous hidden variable, B and $\tilde{A}$ represent the coefficient matrix, ξ stands for the exogenous hidden variable, and ζ stands for the error term of the structural equation.

In the measurement model, the explicit variables are represented by rectangles. The obtained weight coefficient expresses the relationship between the explicit and hidden variables. The hidden variables' number determines the number of measurement models, which can be achieved by Eqs 5 and 6).

$$y = \Lambda_y \eta + \varepsilon \tag{5}$$

$$x = \Lambda_y \xi + \delta \tag{6}$$

Equation (5) describes the endogenous hidden variable, where y represents the explicit endogenous variable, η represents the

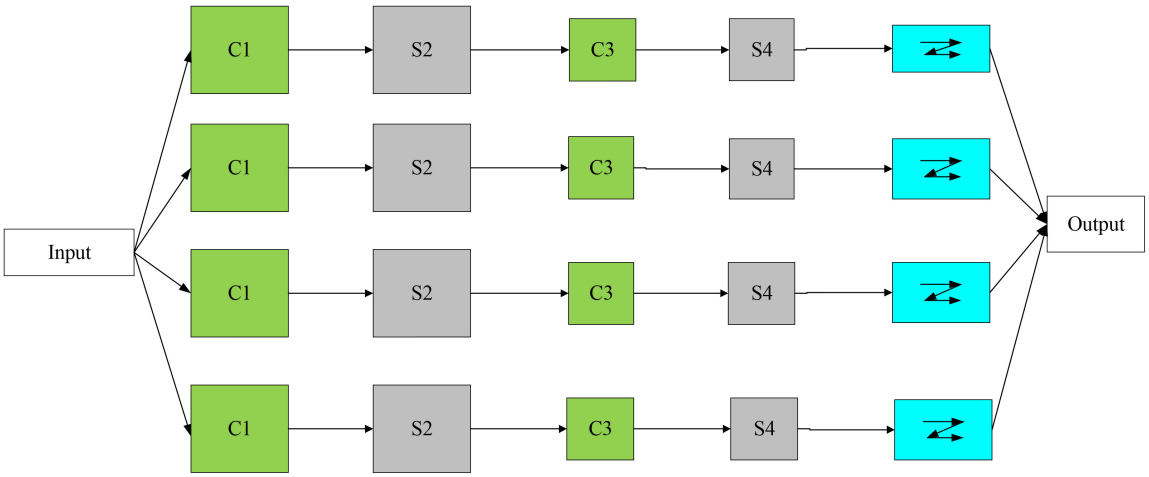

FIGURE 2 | CNN structure.

endogenous hidden variable, and ε represents the measurement error term of y. Equation (3) describes the exogenous hidden variable, where x represents the explicit exogenous variable, ξ represents the exogenous hidden variable, and δ represents the measurement error term of x. The error terms involved in the above equations must meet the following conditions: (1) the mean is 0, and the variance is constant; (2) there is no correlation sequence; (3) the error term is not related to exogenous and endogenous hidden variables; that is, ζ is not related to δ and ε.

The following steps must be followed to establish SEM (Li C. et al., 2017; Cella et al., 2019).

Step 1: The event's relevant background is explored. The logical relationship between explicit variables is analyzed according to the event's relevant background. The explicit variable corresponding to each hidden variable is determined through reasoning and assumptions. Then, the model structure of the variable is obtained.

Step 2: The hidden variables and explicit variables are defined. Hidden variables are unobservable variables, and explicit variables are observable variables. The relationship between them can be understood as: the hidden variable is a high-level summary of the explicit variable, and the explicit variable is the indicator representation of the hidden variable.

Step 3: SEM's path diagram. The model structure is set to visually show the relationship between them through graphics through the definition of variables.

Step 4: Parameter estimation. The Partial Least Squares (PLS) method estimates the SEM's parameters. This method does not require assumptions about the data when predicting events. It has a fast convergence speed and high computing power.

Therefore, the path diagram of SEM based on the above steps is shown in **Figure 3**. In the figure, *X1*, *X2*, *X3*, and *X4* represent hidden variables, and *X11*, *X12*, *X13*, *X21*, *X22*, *X31*, *X32*, *X33*, *X41*, and *X42* represent explicit variables.

The ANN model can express the non-linear relationship between the variables, and it also has self-learning ability. It can automatically adjust the connection weights between network nodes to fit the relationship between variables. However, its topological structure is determined by experience. Neurons are often fully connected, and the model lacks explanations for influence paths between input and output variables and the neurons. If SEM and ANN are combined, SEM can determine the causal relationship between perceptions and convert it to the ANN model's topology. The ANN model's non-linear mapping ability and self-learning ability can fit the causality between multiple perceptions. This method solves SEM's linearity and difficult parameter estimation problem and establishes the well-founded ANN model topology structure. The structural Equation model can express the causal relationship between various elements and concisely show each element's influence on the result. There are two methods for SEM: PLS and Maximum Likelihood (ML), and PLS is used adopted for structural Equation model analysis.

Therefore, a perceptual modeling method combining SEM and ANN is proposed herein. The SEM-ANN model is a structured neural network model. It can explain network nodes' causal relationship and influence degree and improve the perceptual model's goodness by the neural network's non-linear fitting ability to express the relationship between perceptions accurately and quantitatively and the factors that affect perceptions. SEM can determine hidden variables and explicit variables, infer hidden variables by the explicit variables' measurement, and test the correctness of model assumptions.

The topological structure of the SEM-ANN model is determined by the results of the SEM causal analysis. The SEM-ANN model can analyze the influence path and degree of the input variables on the output variables. The number of external measurement variables determines the number of input nodes. Assuming that there are I external measurement variables, then x_i represents the external measurement variables' input. The numbers of hidden layers and hidden layer neurons are determined by the number of exogenous latent variables and endogenous latent variables. Assuming that there are B exogenous latent variables and N endogenous latent variables,

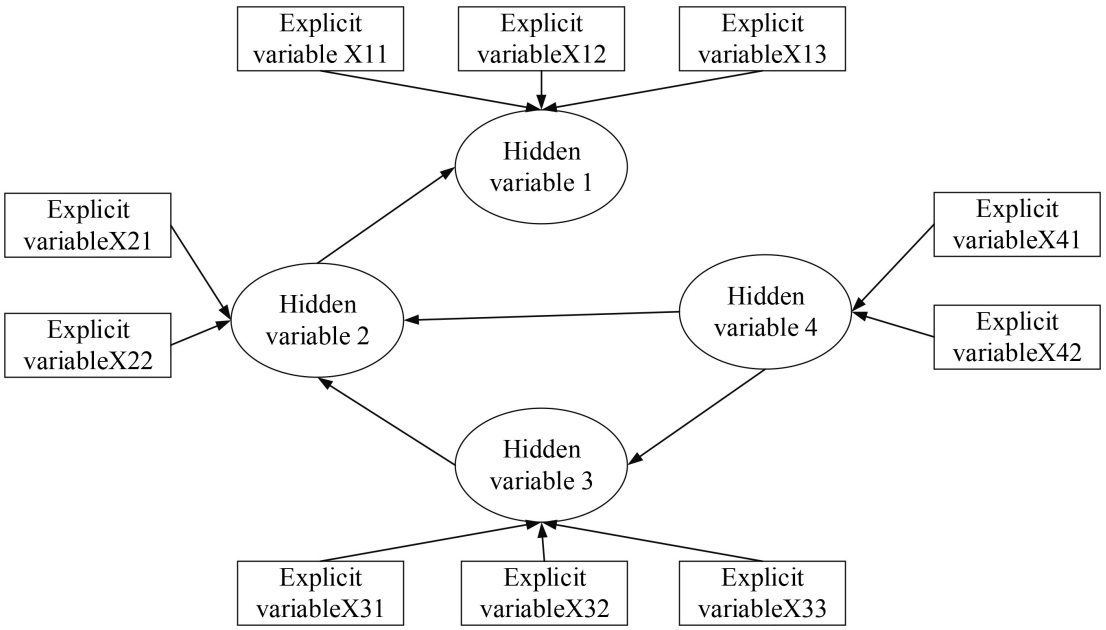

FIGURE 3 | SEM path.

represented by $\xi_b(b = 1, 2, \ldots, B)$ and $\eta_n(n = 1, 2, \ldots, N)$, respectively. The number of endogenous measurement variables determines the number of output neurons. Assuming that there are O endogenous measurement variables, the γ_O denotes the output of endogenous measurement variables. According to the neural network model's topology structure, the connection weight between the input layer network node and the hidden layer neuron node is determined as a $B \times I$ dimensional vector. The connection weight between hidden layer neuron nodes is an $N \times (B+N)$ dimensional vector. The connection weight between hidden layer neuron nodes and output layer neuron nodes is an $O \times N$ dimensional vector. Each neuron in the neural network contains a non-linear activation function. Here, the activation function of all neurons is assumed to be the Sigmoid function.

Data Sources and Processing

In the big data era, the information source scope continues to expand, and the information data amount has also increased explosively. Current information sources have also grown more based on traditional information sources. Traditional information sources are mainly divided into three categories. The first is the text category, such as books, magazines, government reports, brochures, and newspapers. The second is the human resources category, mainly public character interviews and related event introductions. The third is the media category, which mainly includes radio and television programs. With the continuous development of information technology and network, new information sources appear in front of the public and are divided into five categories. The first is online media, including news websites and WeChat public accounts. The second is social networks, such as WeChat, Weibo, and Dingding. The third is related literature, such as academic institutions, corporate reports, and related research papers. The fourth is the Internet of Things information, including the number of vehicles and people in public places. The fifth type of information data includes various statistical data, document databases, and archive databases. The increase in information sources brings more information data. Therefore, more sample data can be provided in the subsequent data processing to ensure that the event can be truly reflected.

In the investigation, a city's disease control center and tuberculosis hospital are visited from June 2017 to 2019, and relevant data are grabbed from multiple information sources. A cluster of patients diagnosed with active tuberculosis was selected and reported to the China Disease Prevention and Control Information System case report card. The relevant information was derived from the China Disease Prevention and Control Information System. The tuberculosis data in all schools (high school to university) of the city from 2017 to 2019 are obtained. Cases found in physical examinations with comparatively short exposure time and complicated transmission channels are excluded; cases of school-leavers and adult education students who cannot be screened for close contacts are deleted. The comparison of many scholars' research results shows that disease outbreaks in school three have primary causes. The first is the delay in doctors' diagnosis. Then, there is much personnel in schools, providing conditions for disease transmission. Finally, the school dormitory's hygienic condition is low, which cannot be ventilated and disinfected in time, providing a hotbed for diseases. Therefore, through visit surveys and data collection, ten indicators that affect the disease spread are determined, namely the patient age (PA), the students' number in the school (SN), the school

doctor ratio (SDR), the infectious exposure time (IET), the school level (SL), bacteria status case sputum (DSBS), strong positive rate of the tuberculin pure protein derivative (PPD-SPR), consecutive case number (CN), number of patients with pleurisy (NPP) in all cases, dormitory staff setting (DSS), displacement ventilation (DV), and disinfection (D-D). The units of exposure time, sputum bacteria status, dormitory staffing, students' number, and ventilation and dormitory disinfection are not uniform. Therefore, the processing is needed to obtain the data in **Table 1**.

On this basis, the indicators are statistically described, and the results in **Table 2** are obtained.

The SEM of tuberculosis early warning includes five hidden variables, infection status, natural status, school status, disease status, and prevention status based on the consult to tuberculosis experts and previous scholars' research. The infectious disease situation has two explicit variables, the natural state one, the school state three. The disease situation has three latent variables, and the prevention state has two explicit variables.

Variable Definition and Parameter Estimates

According to the classification level of public health emergencies in China, Level I (especially serious-red), Level II (severe-orange), Level III (heavier-yellow), and Level IV (general-blue), Equation 7 is used for calculation in early warning.

$$T = 0.9a + 0.6b + 0.3c + 0d \tag{7}$$

Where: a, b, c, d represent the event numbers of the four corresponding levels, and the corresponding coefficients are the weights given to the level events. The threat degree and early warning value range are shown in **Table 3**.

Therefore, based on the existing literature, the infection speed (IS), natural state (NS), school state (SS), patient situation (PS), and prevention (P) are used as hidden variables. There are two explicit variables in infection speed, namely CN and NPP. There is an explicit variable in the natural state, namely PA. There are three explicit variables in the school state, namely SDR, SL, and NS1. The patient situation includes two explicit variables, namely IET and PPD-SPR. The prevention includes three explicit variables, namely DSS, DV, and D-D. According to the above variable relationship, the SEM path diagram can be obtained, as shown in **Figure 4**.

Prediction Model Based on ANN and CNN

When using ANN and CNN to build a prediction model based on the SEM, two stages are involved: training learning and recognition. In the training learning stage, CNN performs supervised learning training on the sample data obtained. The input neuron's activation value reaches the output layer via the hidden layer, and the output layer neurons respond to the network according to the input pattern. When the prediction

TABLE 1 | Case data processing.

Variable	Description processing
SL	• University level is 1
	• Junior level is 2
	• Technical secondary level is 3
	• High school level is 4
NS	• The level under 5,000 people is 1
	• The level of 5,000–10,000 people (including 5,000 people) is 2
	• The level of 10,000–15,000 people (including 10,000 people) is 3
	• The level above 15,000 people is 4
SDR	Number of school doctors per 100 students
IET	• The level of cough for more than 28 days (including 28 days) is 1
	• The level of cough for 15–28 days (including 15 days) is 2
	• The level of cough for 2–14 days (including two days) is 3
	• The level of cough for less than one day (including one day) is 4
DSBS	• The negative level is 1
	• The positive level is 2
DSS	• The level for eight people is 1
	• The level for six people is 2
	• The level for four people is 3
	• The level for two people is 4
DV	• From November to January of the following year, the level is 1
	• From February to April, the level is 2
	• From May to August, the level is 3
	• From September to October, the level is 4
D-D	• Less than once a month, the level is 1
	• 1–2 times a month, the level is 2
	• 3–4 times a month, the level is 3
	• More than four times a month, the level is 4

TABLE 2 | Descriptive statistics.

Indicator	Number of samples	Maximum value	Minimum value	Average	Median
PA	410	30.00	10.00	18.653	21.000
NS	410	4.00	1.00	2.594	2.000
SDR	410	1.00	0.29	5.58E-01	5.789E-02
IET	410	4.00	1.00	2.4319	3.000
SL	410	4.00	1.00	1.5142	1.000
DSBS	410	3.00	1.00	1.8896	2.000
PPD-SPR	410	4.00	0.00	0.1805	0.1500
CN	410	4.00	1.00	3.0081	1.4087
NPP	410	4.00	1.00	0.1671	0.0000
DSS	410	4.00	1.00	2.9757	3.0000
DV	410	4.00	1.00	2.1197	2.0001
D-D	410	4.00	1.00	2.3157	2.0000

TABLE 3 | Threat degree and early warning value range.

Security level	Weights	Early warning value range
I	0.9	$21.3 < T$
II	0.6	$16.6 < T \leq 21.3$
III	0.3	$11.7 < T < 16.5$
IV	0.0	$T \leq 11.7$

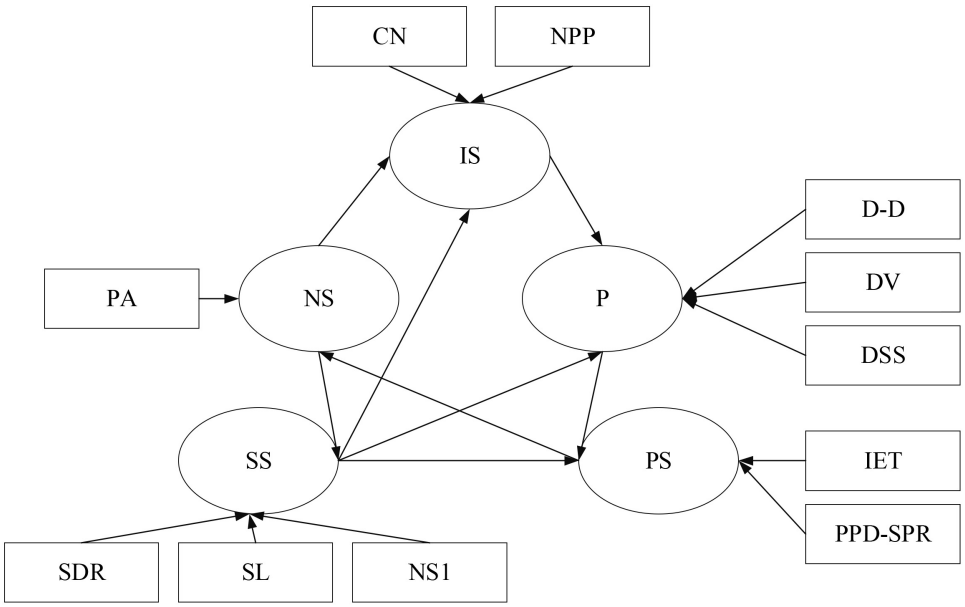

FIGURE 4 | Variable path diagram.

error is large, the learning training is repeated until the termination condition is met, and the output value at this time is accurate. Then comes the recognition stage. At this stage, ANN mainly classifies and decides the information input later based on the trained network model. In this case, binary is used for output.

The neuron number in the hidden layer can be obtained by Eq. (8).

$$n = 2x_n + 1 \tag{8}$$

where n represents the neuron number in the hidden layer, and x_n represents the input layer's neuron number.

The experiment evaluates the prediction model's performances in precision, recall, and FScore. The precision, recall, and FScore are expressed by Eqs (9)–(11).

$$P = \frac{p_{Ture}(m_i)}{p_{Ture}(m_i) + p_{False}(m_i)} \tag{9}$$

$$R = \frac{p_{Ture}(m_i)}{A(m_i)} \tag{10}$$

$$F = \frac{2PR}{P + R} \tag{11}$$

where P, R, and F represent the precision, recall, and F-Score, respectively, $p_{Ture}(m_i)$ denotes the true prediction number as m_i, $p_{False}(m_i)$ refers to the false prediction number as m_i, and $A(m_i)$ indicates the actual m_i number.

The model's accuracy reflects the model's fitting ability, while recall is an evaluation indicator for the original sample. There are sometimes contradictions between P and R indicators. At this time, comprehensive consideration is required. The most common method is the F-Score. The F value is an evaluation indicator that integrates the P and R and can comprehensively reveal the whole.

Experimental Setup

This experiment uses the Scrapy crawler framework to capture relevant data about tuberculosis. Also, the word segmentation and cleaning are performed. It is tested on Lenovo Intel(R) Core(TM) i5-7400CPU, 8GB running memory, windows10 operating system. The initial weight is set to a random number between (0,1) to ensure the anisotropy of subsequent weight adjustment. The learning rate is 0.001, and the iteration number is 5,000. The captured data samples are 410 samples, with 330 training samples, 30 verification samples, and 50 test samples.

RESULTS

The loss value and accuracy of the ANN, CNN, and hybrid network of ANN and CNN during model training are analyzed and compared, obtaining the results of **Figures 5**, **6**.

Figures 5, **6** show that as the iteration number increases, the three network models' loss values during training parameters are gradually decreasing. The hybrid network's loss value based on ANN and CNN gradually approaches 0.15, and its accuracy approaches 96%. The loss value and accuracy during the test are shown in **Figures 7**, **8**.

The above two figures indicate that when the iteration number reaches 3000, its accuracy reaches more than 85%. The reason is that the data obtained through the crawler may cause deviation in the processing process, which, in turn, impacts accuracy. Overall, the test results have almost met expectations.

Hence, the results of the precision, recall, and F-Score of these three methods are obtained, as shown in **Table 4**.

The above results show that the ANN-SEM hybrid algorithm's information classification performance is better than that of the

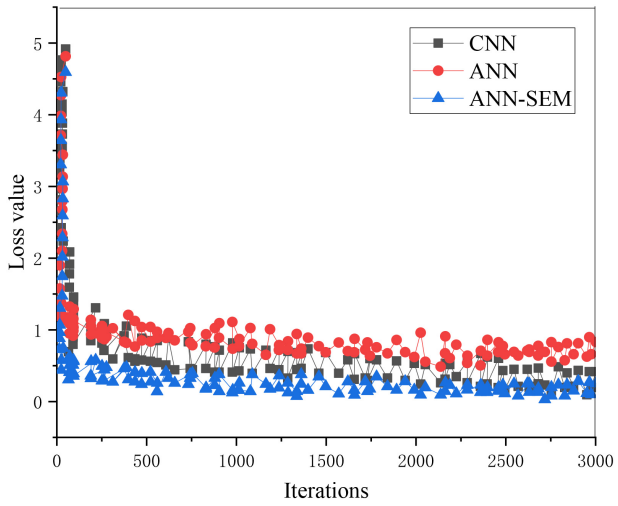

FIGURE 5 | Trend graph of parameter loss values in the training set.

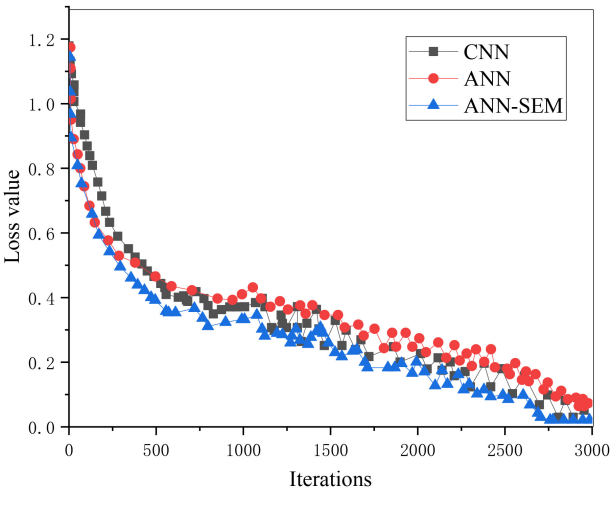

FIGURE 7 | Trend graph of parameter loss values in the test set.

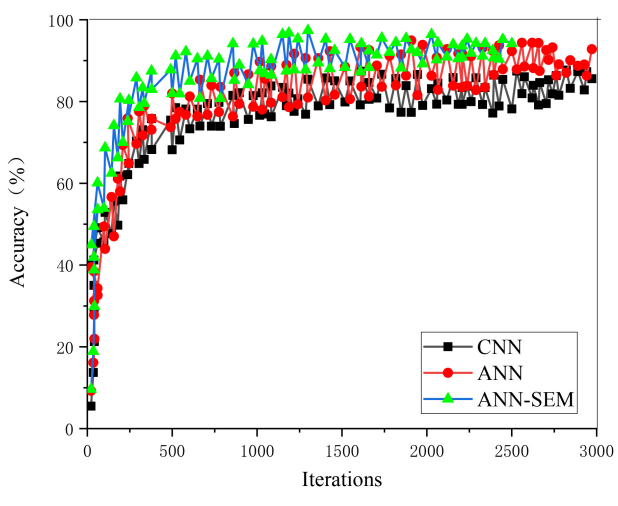

FIGURE 6 | Trend graph of parameter accuracy in the training set.

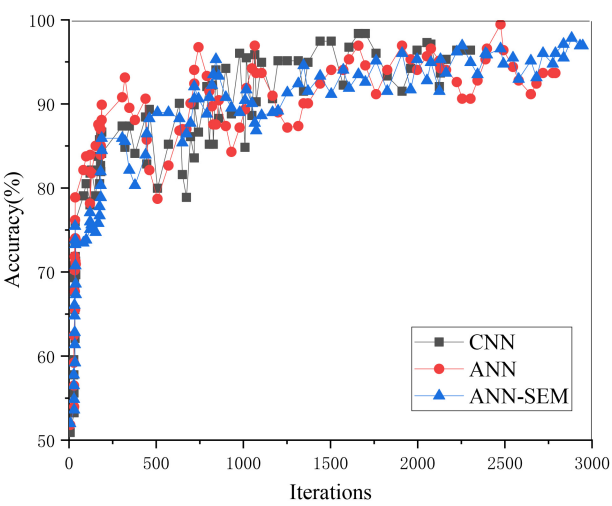

FIGURE 8 | Trend graph of parameter accuracy in the test set.

pure neural network, and its accuracy is improved by 6 and 5%, respectively.

When training the model, its iteration number and accuracy are shown in **Figure 8**.

Figure 9 shows that the hybrid network's accuracy tends to be stable when iterating about 3,000 times, and the corresponding accuracy is higher than that of the pure neural network.

TABLE 4 | Model evaluation results.

Model	*P*-value	*R*-value	*F*-value
CNN	89.1	87.2	88.7
ANN	90.1	88.5	90.3
ANN-SEM	95.1	94.7	94.8

The output results of the SEM's path coefficients are shown in **Figure 10**.

The above figure indicates that the path coefficient between the prevention and the patient situation is -0.015, showing that the relationship between the two is not apparent, and the indirect positive effect is significant. The path coefficient between the school state and the patient situation is 0.8999, showing that the natural state has a more significant impact on the school situation.

The measurement model's load and weight results are shown in **Figure 11**.

Figure 11 shows that consecutive case number affects the infection degree to a greater extent. The lower the school level, the greater the impact on the school state. The fewer the school's student number, the safer the school is, and the school's better. The higher the strong positive rate, the greater the impact on the

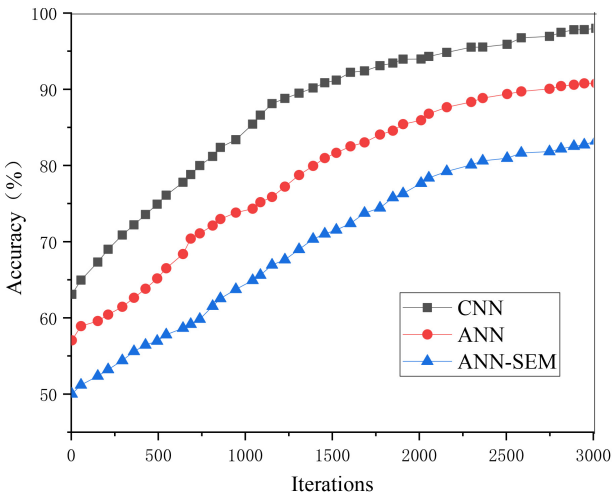

FIGURE 9 | Iterative results of the prediction model.

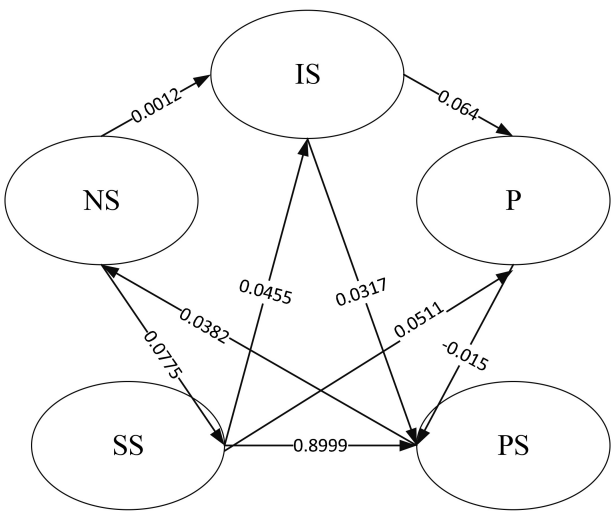

FIGURE 10 | Path coefficient output results.

disease state. The longer the exposure time of the infection source also affects the disease state to a certain extent. In schools, the dormitory staffing situation has a more significant impact on the prevention status. Although ventilation and disinfection have an impact, the overall impact is relatively low.

After classifying the 50 pieces of information data from June 2017 to 2019, the time in each level is selected for analysis

TABLE 5 | Model classification results.

Prediction model	Level I threat	Level II threat	Level III threat	Level IV threat	Accuracy
ANN	11	9	13	8	89.1%
CNN	10	9	15	6	90.1%
ANN-SEM	12	10	10	5	95.1%

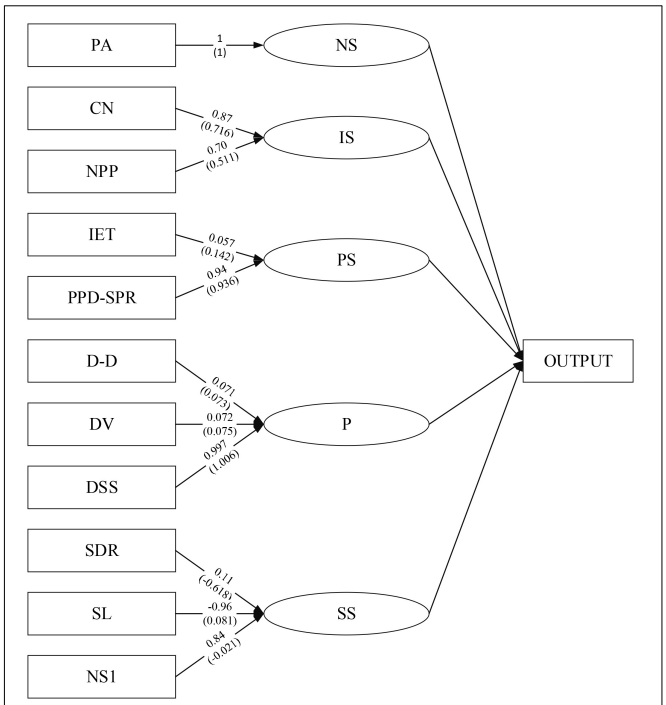

FIGURE 11 | Measurement model.

and processing. Also, errors are analyzed. The accuracy reaches 95.1%, which shows some errors in the prediction process, but the overall classification is useful. The three models' classification is shown in **Table 5**.

Among the 50 pieces of information data, there are 13 pieces of early warning data, including three pieces of Level I, four pieces of Level II, four pieces of Level 3, and 2 pieces of Level IV. This result is substituted into the numerical Equation for the warning level, and the *T*-value can be obtained, which is 6.3. *T*'s value range determines that the event is a Level IV response.

DISCUSSION

In deep learning technology, the ANNs' application to construct early warning methods for public health emergencies can accurately predict public health emergencies. CNN and ANN train the model due to CNN's advantages in image and speech recognition, thereby obtaining the loss value and prediction accuracy. The results also show that the hybrid ANN-SEM training's loss value approaches 0.15, and its corresponding accuracy reaches 96%. In the test, the loss value decreases, and the accuracy increases. However, because crawlers realize the information data, there may be some deviations in the data processing process, impacting the accuracy. As the iteration number continues to increase, the parameter accuracy tends to be stable, and the results have almost reached expectations.

The precision, recall, and F-Score of the ANN-SEM network, CNN, and ANN are analyzed. ANN-SEM's information classification performance is better than the other two networks,

and its precision is also improved by more than 5%. The result shows that the hybrid network proposed has better classification performance.

Then, the SEM analyzes the pathological data and indicators to obtain SEM's path coefficient. The results show that the path coefficient between the prevention and the patient situation is negative. The relationship between the two is not apparent, but there is an indirect positive effect. When there is no good prevention, although the patient situation is not directly affected, it will impact the patient situation if it affects the environment and surrounding conditions. The path coefficient between the school state and the patient situation reaches 0.8999, which shows that the influence significantly impacts the patient situation, which needs to be focused on in the subsequent prediction process. The SEM measurement model shows that the lower the school level, the fewer the school's student number, and the better the school state. The higher the strong positive rate, the more significant the patient situation's impact, and the longer the exposure time of the infection source will increase the patient situation. The dormitory staff setting, ventilation, and disinfection frequency will also impact the patient situation, but overall, the impact is relatively small. By controlling the student number and the strong positive rate, the patient situation can be reduced.

Finally, after classifying and analyzing the collected information data, the hybrid network's effectiveness is further verified by comparing the three networks' classification and accuracy. Meanwhile, among the existing information data, 13 pieces of early warning data can be accurately classified. When using these data to calculate the warning level, the final T-value also indicates that the event belongs to the Level IV response, and the prediction method is effective.

The information data collected from June 2017 to June 2019 is processed to meet the prediction expectations of public health emergencies so that the constructed prediction model faces fewer interference factors. It may also affect the experimental results.

When using the ANN-SEM network to classify the collected information data and analyze the loss value and accuracy of training and testing, the hybrid network can obtain higher accuracy. It provides a more reliable prediction method for SEM and can accurately determine the early warning level corresponding to the event when predicting public health events. The hybrid method based on ANN-SEM is effective in event prediction, which provides an early warning basis for the health department and provides prediction ideas for other emergencies.

CONCLUSION

The deep learning technology and ANN are combined based on the SEM's application to determine hidden and explicit variables. CNN processes and analyzes the information data obtained by the crawler. Also, ANN classifies the data, and the early warning method's effectiveness is verified by comparing the loss value and accuracy. However, the investigation of the model's optimized content is less in the process. Then, the model optimization will be deeply explored to improve the early warning model's accuracy. With the information data's continuous increase, the processing of information data becomes particularly significant. The advantages of deep learning technology and other neural network methods in image recognition and data processing provide more possibilities for related fields. Therefore, against the deep learning background, the investigation of public health emergencies' early warning methods based on ANN is incredibly significant for judging and predicting the disease development trend. Moreover, it has a particular reference value for the investigations of other emergencies' early warning methods.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the NingboTech University Ethics Committee. The patients/participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

SZ conceived the analysis question, conducted the analysis also and critically revised the manuscript content. XH was the organizer of the project and responsible for sorting out the contact data and connecting with researchers.

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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.

frontiers in Psychology

ORIGINAL RESEARCH
published: 16 February 2021
doi: 10.3389/fpsyg.2021.592925

Exploration of Social Benefits for Tourism Performing Arts Industrialization in Culture–Tourism Integration Based on Deep Learning and Artificial Intelligence Technology

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As a product of the tourism performing arts industry in culture–tourism integration development, to develop a featured culture–tourism town is a new trend for tourism development in the new era. To analyze the social benefit of the culture–tourism industry, in this study, an artificial intelligence model for social benefit evaluation is constructed based on backpropagation (BP) neural network and fuzzy comprehensive analysis, with Yiyang Town taken as an example. The criterion layer in the model includes three indexes (life benefit G1, environmental benefit G2, and economic benefit G3), and the index layer contains 11 indexes (H1–H11). The weight values of cultural inheritance and protection, ecological environment improvement, and commercial economy development to the social benefit of the town are 0.522, 0.570, and 0.424, respectively. For G1, 41.20% is excellent; for G2, 39.5% is excellent; and for G3, 40.5% is good. In general, 30.76% of the total social benefit is excellent, with 37.69% being good, 21.48% being qualified, and 10.07% being unqualified. It is inferred that the total social benefit level of Yiyang Town is good according to the constructed model. Therefore, the culture inheritance and protection, the ecological environment improvement, and the commercial economy development are the key evaluation factors of social benefit.

Keywords: social benefit, BP neural network, towns with cultural and tourism characteristics, fuzzy comprehensive analysis method, cultural inheritance and protection

OPEN ACCESS

Edited by:
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Reviewed by:
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Zhaoyi Xu,
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Specialty section:
This article was submitted to Human-Media Interaction, a section of the journal Frontiers in Psychology

Received: *08 August 2020*
Accepted: *05 January 2021*
Published: *16 February 2021*

Citation:
Zhang R (2021) Exploration of Social Benefits for Tourism Performing Arts Industrialization in Culture–Tourism Integration Based on Deep Learning and Artificial Intelligence Technology. Front. Psychol. 12:592925. doi: 10.3389/fpsyg.2021.592925

INTRODUCTION

As time goes by, Chinese tourists can no longer be attracted by purely scenic spots. Industry integration, as a more advanced mode for the vigorous development of the industry, has become an inevitable trend (Kim et al., 2019; Urien-Lefranc, 2020; Yang and Wang, 2020). Tourism performing arts is one of the typical forms in culture–tourism integration development in recent years. Being an important carrier of cultural heritage, it carries forward Chinese culture during tourism (Samora-Arvela et al., 2020). In recent years, the tourism performing arts is increasingly energetic. According to relevant data from 2013 to 2017, the domestic number of channels for the tourism performing arts program increased from 187 to 268, up by 43%. The number of tourism performing arts programs increased from 53,336 to 85,753, with an increase of 61%. Audience of tourism performing arts increased from 27.89 million to 68.21 million, up by 145%. The

box-office revenue of tourism performing arts increased from 2.26 billion yuan to 5.15 billion yuan, with an increase of 128% (Ranasinghe and Cheng, 2018). Especially in the past 2 years, with the market being more mature, tourism performing arts projects have seen faster development. The culture–tourism town is a new tourism product with the integration of cultural and performing industries (Zhang et al., 2020). As one of the culture–tourism towns in Hunan Province, the transportation infrastructure in Yiyang has experienced vigorous progression in recent years, which further highlights its regional advantages. In addition, many culture–tourism projects of Yiyang characteristics have been constructed, such as Tianyi Muguo (a resort characterized by the things made of wood), tea-horse ancient road, tea-scented flower sea (a place characterized by all kinds of flowers), and Anhua Meishan Cultural Ecological Park, which makes Yiyang more popular in tourists (Wu and Wu, 2017; Drius et al., 2019). Therefore, the Yiyang Town in Yiyang region is taken as an example in the study.

Fuzzy comprehensive evaluation based on fuzzy mathematics is a comprehensive evaluation method which adopts fuzzy relation synthesis to quantify some factors with unclear boundaries (Wu and Wu, 2017; Chen, 2019; Yuan and Wu, 2020). This method is mainly applicable to evaluation objectives with multiple variables and fuzziness. Through the construction of a reasonable evaluation system, the evaluation factor is assigned a certain value according to the score given by the expert, and then reliable results are obtained through analysis (Su et al., 2016; Obschonka et al., 2018). Traditional artificial intelligence mainly contains pattern analysis, machine learning, and data mining. As a hot topic in the field of artificial intelligence, deep learning has made breakthroughs in such fields as large-scale speech recognition and large-scale image retrieval (Li and Cao, 2018). The BP neural network is one of the most effective multilayer deep learning methods among them, which has complex pattern classification capability and excellent multidimensional function mapping capability, and can solve different problems that simple perceptron cannot solve. Further, it can also continuously adjust the network weight value to make the final output of the network as close as possible to the expected output (Rogoza et al., 2018; Li et al., 2019). From the perspective of inbound tourism demand, Shi (2020) used deep learning BP neural network to extract 7 influence factors to construct the eigenvector and predicted the number of inbound tourists in Yangjiang in 2018–2019. The results showed that the mean square error and R2 coefficient were 0.011695 and 0.94744, respectively, which were acceptable. Based on the deep learning BP neural network, Li (2020) constructed an artificial intelligence prediction model for the temporal and spatial distribution of tourists and collected the spatial and temporal distribution data from five aspects: the probability distribution of tourists' destinations, the transfer probability between tourist attractions, the scenic spot time distribution, the moving time between scenic spots, and the scenic spot area. It is found that this artificial intelligence model had high prediction accuracy and is suggested in the temporal and spatial distribution prediction of tourists. Therefore, in the study, deep learning BP is combined with the fuzzy comprehensive evaluation method to design an artificial intelligence model for social benefit evaluation.

MATERIALS AND METHODS

The Selection of the Research Subject

In this study, the Yiyang culture–tourism town in Yiyang region is selected as the research subject. The function zones of this town include health and health community (F1), agricultural sightseeing and leisure zone (F2), outdoor ecological experience zone (F3), waterfront leisure zone (F4), and folk performing arts culture experience zone (F5). As shown in **Figure 1**, the healthcare community covers a floor space of 789,167m^2 and a building area of 453,717m^2, respectively; the agricultural sightseeing and leisure zone covers a floor space of 568,807m^2 and a building area of 334,107m^2, respectively; the outdoor ecological experience zone covers a floor space of 227,362 square meters and a building area of 43,189m^2, respectively; the waterfront leisure area covers a floor space of 164,911m^2 and a building area of 105,726m^2, respectively; and the folk performing arts cultural experience covers a floor space and a building area of 257,737 and 86,081m^2, respectively.

Definition of Relevant Concepts

The Culture-Tourism Town

A culture-tourism town refers to a town with clear industrial orientation, cultural characteristics, tourism characteristics, and certain community functions, which is different from an administrative town. It can turn the idle resources of rural areas, such as green mountains and clear waters, pastoral lifestyle, and traditional culture, into economic advantages. Besides, it can also drive the flow of urban capital to the countryside, thus improving rural infrastructure, public services, and environmental health. Furthermore, it also creates new jobs for farmers (Yi et al., 2019). In general, the culture–tourism town is a town involving culture inheritance in tourism development, which combines various elements such as food, clothing, housing, and transportation. Nowadays, there has been a preliminary industrial chain for culture–tourism town development, as shown in **Figure 2**, including three stages which are upstream development and investment, midstream planning and operation, and downstream product distribution. The upstream development investment includes investors and developers, the midstream planning and operation includes service providers and operators, and the downstream product distribution includes product distributors and distribution channels, and at the end are the users.

Social Benefit of Small Towns With Culture–Tourism Characteristics

Social benefit refers to the maximum use of limited resources, which aims to satisfy growing material and cultural needs of people in society. To be specific, it is the total contributions of a certain project to employment, living standard, and social welfare. The construction of the culture–tourism town improves local employment, living standard, and regulation system (Kim et al., 2020). What is more, the coordination and cooperation

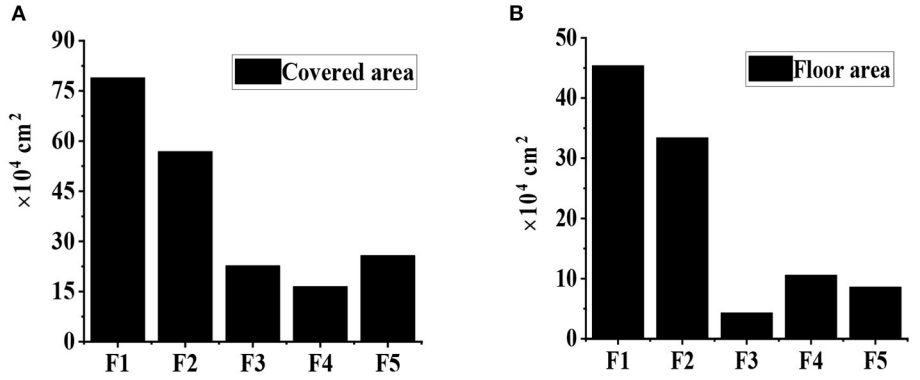

FIGURE 1 | The floor space and building area of function zones in Yiyang culture–tourism town. **(A)** The floor space; **(B)** is the building area.

TABLE 1 | Evaluation index of social benefit of small towns with culture–tourism characteristics.

	Number	Social benefit evaluation index	Definition
G1	H1	Cultural inheritance and protection	Whether the construction can coordinate the relationship between local cultural resources and town development
	H2	Employment rate increase	Whether a large number of jobs are created for local people
	H3	The life quality improvement	Whether the local economy is growing faster, residents' living quality is improving, and the income is rising
	H4	Infrastructure improvement	Whether infrastructure such as transportation, water supply, heating, and wireless networks has been improved
Environment benefit	H5	Ecological environment improvement	Whether local water, air, noise pollution, and other environmental problems have been properly dealt with
	H6	Green vegetation protection	Whether the economic value of the local green vegetation is exploited and well-preserved
	H7	Raised environmental protection awareness	Whether local residents feel the benefit brought by the beautiful environment and can be more active in protecting the local ecological environment
G3	H8	Commercial economy development	Whether it can attract a large number of foreign tourists to promote the local and surrounding accommodation, catering, and other related industries
	H9	Return on equity (R0E)	R0E = project net profit/net assets × 100%, which can reflect the profitability of the project
	H10	Ratio of profits to cost and expense (RPCE)	RPCE = total profit/total cost × 100%, which can reflect the profit brought by operating costs
	H11	Return on capital (ROC)	ROC = net profit/average capital × 100%, which can reflect the ability to use capital to bring income

between government supervision and market economy is realized during the process.

Evaluation Indexes of Social Benefit of the Culture–Tourism Town

At present, although there are an increasing number of scholars analyzing the benefit of the culture–tourism town, with some relevant index systems established, there are few studies on the social benefit of the culture–tourism town. Most of the literature focuses on the economic benefit (Ramsey and Malcolm, 2018; Yousif, 2018). Therefore, with China's national conditions and policy development taken into account, the social benefit evaluation indexes are selected by referring to previous literature. The results are shown in **Table 1**. According to these indexes, the social benefit evaluation index system of the culture–tourism town is constructed, as shown in **Figure 3**.

Artificial Intelligence Evaluation Model Based on BP-Fuzzy Comprehensive Analysis

Many evaluation indexes are selected in this study, all of which are qualitative factors with fuzziness. In addition, there are differences in the influence degree of each index on the social benefit of the culture–tourism town. Therefore, the fuzzy processing on each index is carried out. Then, the fuzzy factors are quantitatively analyzed to determine the expected output value of the deep learning BP neural network (Wu et al., 2020). Finally, the model is constructed through sample training and learning. The specific process is as follows.

First, the fuzzy comprehensive evaluation method is used to deal with the evaluation indexes.

Step 1: Establishment of a set of evaluation indexes. After the evaluation indexes are selected, they are all put into a factor set U,

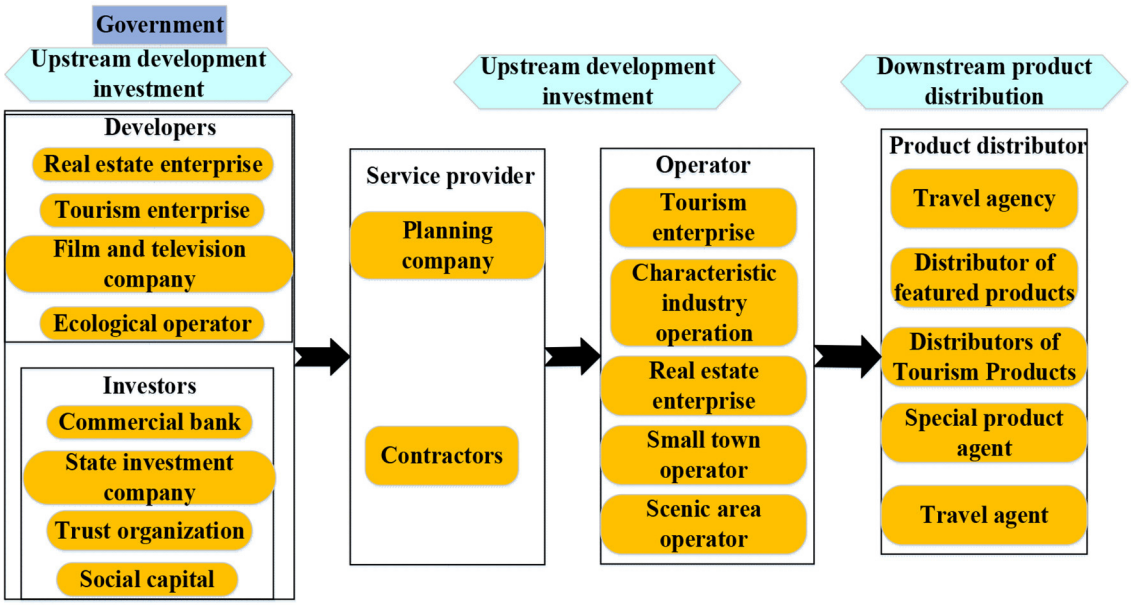

FIGURE 2 | The industry chain of the culture–tourism town.

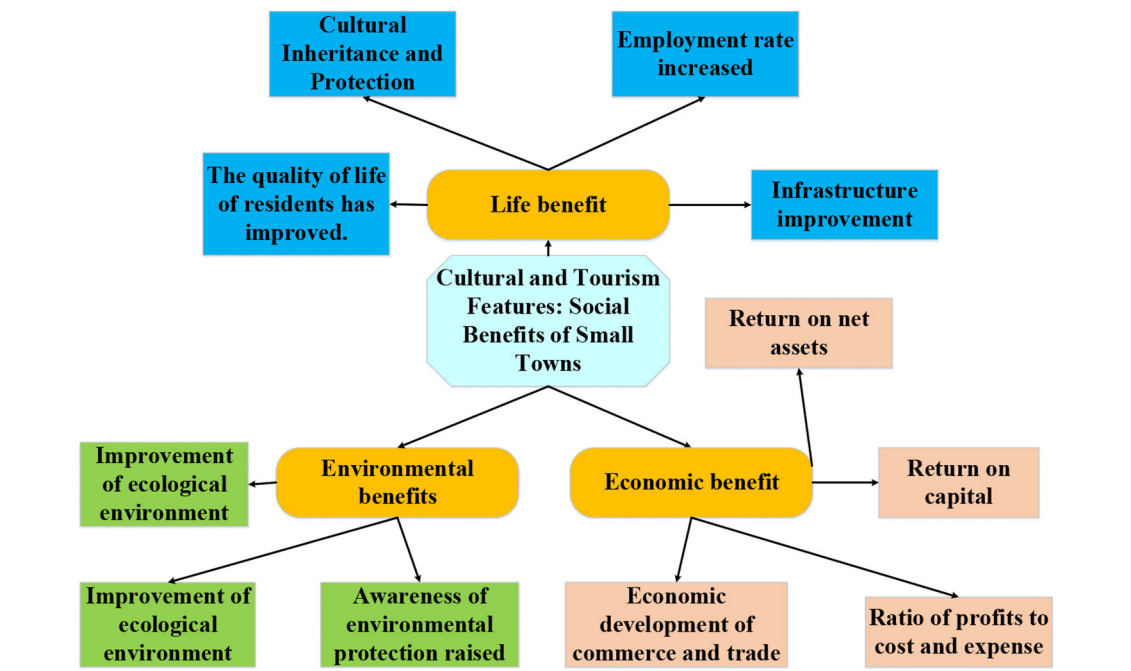

FIGURE 3 | The evaluation indexes of social benefit of the culture–tourism town.

which can be expressed as follows.

$$U = \{u_1, u_2, u_3, \cdots, u_n\} \quad (1)$$

where $u_i (i = 1, 2, 3, \cdots, n)$ is the evaluation index factor and n represents the number of evaluation factors at the same level.

Step 2: Establishment of a comment set. According to the evaluation results of the evaluation system, the evaluation set V can be expressed as follows.

$$V = \{v_1, v_2, v_3, \cdots, v_m\} \quad (2)$$

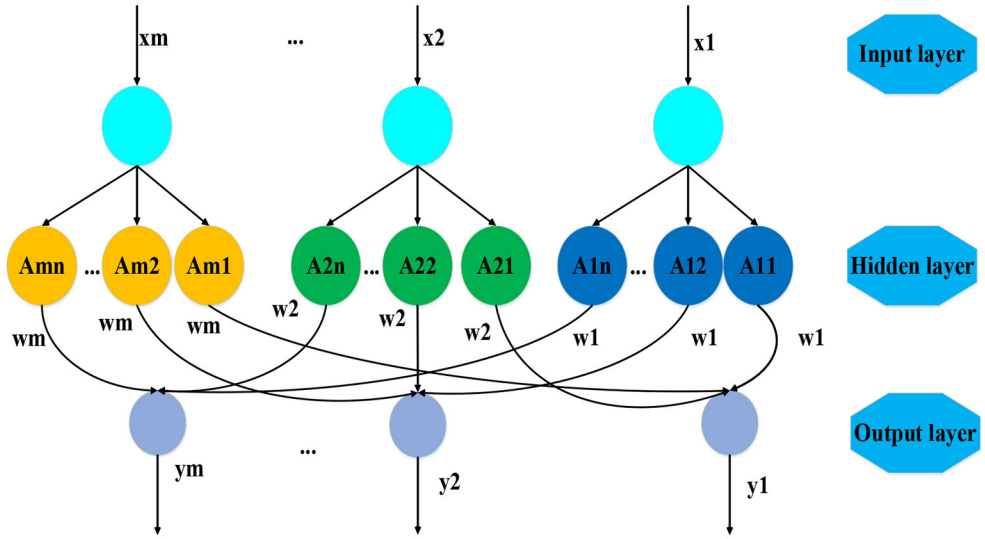

FIGURE 4 | The three-layer BP neural network structure.

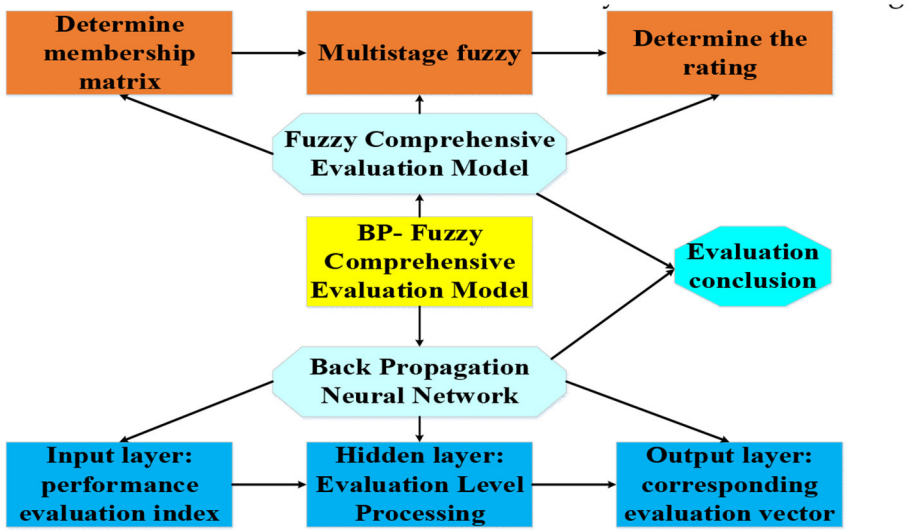

FIGURE 5 | The construction of BP-fuzzy comprehensive model for social benefit evaluation of the culture–tourism town.

where $v_j(j = 1, 2, 3, \cdots, m)$ represents the evaluation result of the jth type and m represents the number of evaluation grades.

Step 3: Establishment of the weight coefficient of the evaluation index. The analytic hierarchy process is used to classify the evaluation indexes. The first layer is the evaluation target layer, and the second layer is the criterion layer, which can be expressed as follows.

$$U = \{u_1, u_2, u_3, \cdots, v_k\} \tag{3}$$

The third layer is the quantification of evaluation indexes.

$$U_i = \{u_1, u_2, u_3, \cdots, v_k\}, (i = 1, 2, 3 \cdots, n) \tag{4}$$

Then, the index weight of each layer is obtained by building a judgment matrix and normalization. In this study, the weight of the second layer is set as G, which can be expressed as follows.

$$G = \{g_1, g_2, g_3, \cdots, g_k\} \tag{5}$$

The weight of the index of the third layer is set as follows.

$$G_i = \{g_{i1}, g_{i2}, g_{i3}, \cdots, g_{in}\} \tag{6}$$

where $G_i \geq 0$, $G_{ij} \leq 1$, and $G_i + G_{ij} = 1$.

Step 4: First-level fuzzy comprehensive evaluation. In this study, the single-level evaluation method (Wang, 2020) is used

to obtain the membership matrix of each evaluation index, which can be as follows.

$$R_i = \begin{bmatrix} r_{i11} & r_{i12} & \cdots & r_{i1q} \\ r_{i21} & r_{i22} & \cdots & r_{i2q} \\ r_{i31} & r_{i32} & \cdots & r_{i3q} \\ r_{in1} & r_{in2} & \cdots & r_{inq} \end{bmatrix} \quad (7)$$

where $i = 1, 2, \cdots, k$, q represents the number of evaluation criteria, and n represents the number of evaluation factors. Through the combination of the weight coefficient of each evaluation index with the membership degree matrix, the evaluation result vector of the index factor can be expressed as follows.

$$B_i = gi \times R_i = \left\{g_{i1}, g_{i2}, g_{i3}, \cdots, g_{in}\right\} \times \begin{bmatrix} r_{i11} & r_{i12} & \cdots & r_{i1q} \\ r_{i21} & r_{i22} & \cdots & r_{i2q} \\ r_{i31} & r_{i32} & \cdots & r_{i3q} \\ r_{in1} & r_{in2} & \cdots & r_{inq} \end{bmatrix} = (b_1, b_2, b_3, \cdots, b_{iq}) \quad (8)$$

Step 5: Second-level fuzzy comprehensive evaluation. Based on the first-level fuzzy comprehensive evaluation results, there is also a corresponding relationship between each evaluation index, so the evaluation results of each index are integrated using fuzzy mathematics calculation. Then, the final evaluation result vector obtained is as follows.

$$B = G \times \{B_1, B_2, B_3, \cdots, B_K\}^T = (g_1, g_2, g_3, \cdots, g_k) \times (B_1, B_2, B_3, \cdots, B_K)^T \quad (9)$$

According to the above steps, the weight value of each index has a great impact on the final evaluation result. Therefore, the BP neural network is used in this study to determine the weight value of the comprehensive evaluation index. First, the structure of the neural network used to determine the weight is constructed, as shown in **Figure 4**, which is divided into the input layer, the hidden layer, and the output layer.

Step 6: The input layer. The input element is the value of each evaluation index. The dimensionality of each index is different, so the values of each index are converted into non-dimensional standard values first. There are m neurons in the input layer, and the input and output of the neurons can be expressed as follows.

$$I_i^1 = x_i \quad (10)$$

$$O_{ij}^1 = x_i \quad (11)$$

where $i = 1, 2, \cdots, m$, $j = 1, 2, \cdots, n$, I_i^1 represents the input, and O_{ij}^1 is the output.

TABLE 2 | Calculation of the weight value of the W-G judgment matrix.

W	G1	G2	G3
G1	1	1/2	7
G2	2	1	3
G3	1/7	1/3	1

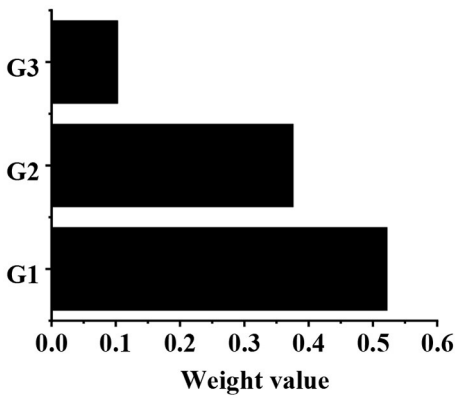

FIGURE 6 | The weight values of G1, G2, and G3 relative to the target layer W.

Step 7: The hidden layer. The hidden layer differentiates the input of the input layer and obtains the membership value of each input level according to the membership function. In the constructed BP network, there are n comment levels and a total of $m \times n$ neurons. In this study, trigonometric functions (Zhang et al., 2019) are introduced to express membership functions, which can be as $\{A_{ij}\} = \{NB, NS, N, PS\} = \{\text{excellent, good, qualified, unqualified}\}$. Therefore, $n = 4$, then the evaluation index membership function is calculated as follows.

When $j = 1$, the corresponding membership function parameters are a_1 and a_2.

$$\mu_1 x = \begin{cases} 1 & x \le a_1 \\ {}^{a_2 - x}/_{a_2 - a_1} & a_1 \le x \le a_2 \\ 0 & x \ge a_2 \end{cases} \quad (12)$$

where $\mu_1 x$ represents a membership function. When $j = n$, the corresponding membership function parameters are a_n and a_{n-1}.

$$\mu_n x = \begin{cases} 0 & x \le a_{n-1} \\ {}^{x - a_n}/_{a_n - a_{n-1}} & a_{n-1} \le x \le a_n \\ 1 & x \ge a_n \end{cases} \quad (13)$$

When $1 < j < n$, the corresponding membership function parameters are a_j, a_{j-1}, and a_{j+1}.

$$\mu_j x = \begin{cases} 0 & x \le a_{j-1} \text{or } x \ge a_{j+1} \\ {}^{x - a_{j-1}}/_{a_j - a_{j-1}} & a_{j-1} \le x \le a_j \\ {}^{a_{j+1} - x}/_{a_{j+1} - a_j} & a_j \le x \le a_{j+1} \end{cases} \quad (14)$$

TABLE 3 | Calculation of weight value of the G1–H judgment matrix.

G1	H1	H2	H3	H4
H1	1	7	3	5
H2	1/7	1	1/5	1/3
H3	1/3	5	1	3
H4	1/5	3	1/3	1

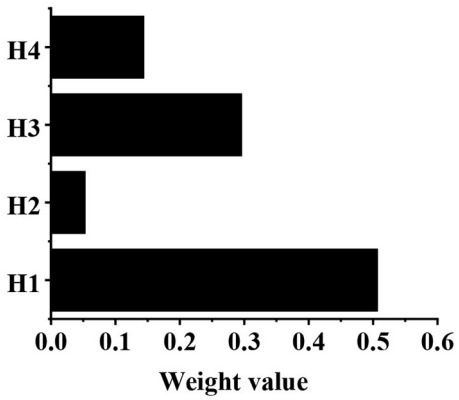

FIGURE 7 | The weight values of H1, H2, H3, and H4 relative to G1.

TABLE 4 | Calculation of weight value of the G2–H judgment matrix.

G2	H5	H6	H7
H5	1	5	3
H6	1/5	1	1/4
H7	1/3	4	1

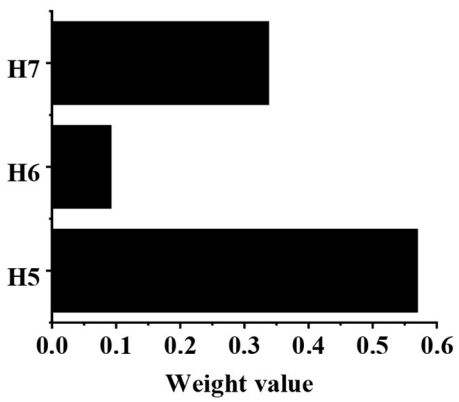

FIGURE 8 | The weight values of H5, H6, and H7 relative to G2.

According to the above calculation method, the output of the hidden layer can be obtained as follows.

$$O_{ij}^{2} = A_{ij}(x_i) \tag{15}$$

TABLE 5 | Calculation of weight value of the G3–H judgment matrix.

G3	H8	H9	H10	H11
H8	1	5	3	2
H9	1/5	1	1/4	3
H10	1/3	4	1	1/3
H11	1/2	1/3	3	1

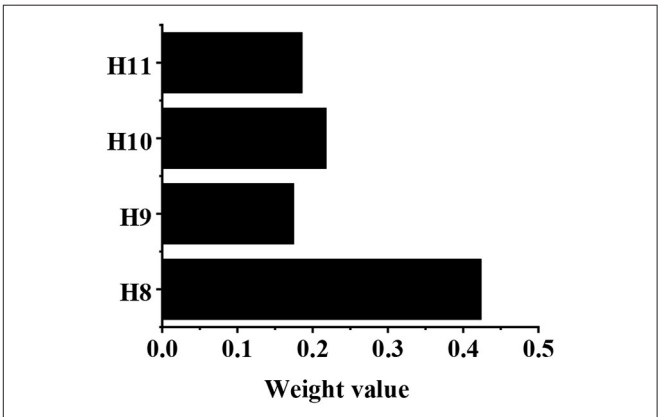

FIGURE 9 | The weight values of H8, H9, H10, and H11 relative to the G3.

where $A_{ij}(x_i)$ represents the numerical membership function of the jth comment level and O_i^2 represents the membership value of each level.

Step 8: The output layer. The output layer mainly evaluates each input vector and obtains the corresponding evaluation vector according to the value of the evaluation level. Then, the output can be expressed as follows.

$$O_i^3 = \sum_{j=1}^{m} w_j I_{ij}^3 \tag{16}$$

where $i = 1, 2, 3, \cdots, m, j = 1, 2, 3, \cdots, n$.

To sum up, the structure of the BP-fuzzy comprehensive evaluation model for social benefit of small towns with culture–tourism characteristics in this study are shown in **Figure 5**.

RESULTS

Calculation of Each Index Weight

Calculation of the Weight Value of the W–G Judgment Matrix

According to the model constructed in this study, the index system is firstly divided into three layers. The first level is the target layer: social benefit of the culture–tourism town, recorded as W. The second level is the criterion layer: G1, G2, G3. The third level is the index layer which contains indexes of the cultural inheritance and protection H1, the employment rate increase H2, the quality-of-life promotion H3, infrastructure improvement H4, the ecological environment improvement H5, green vegetation protection H6, the environmental awareness

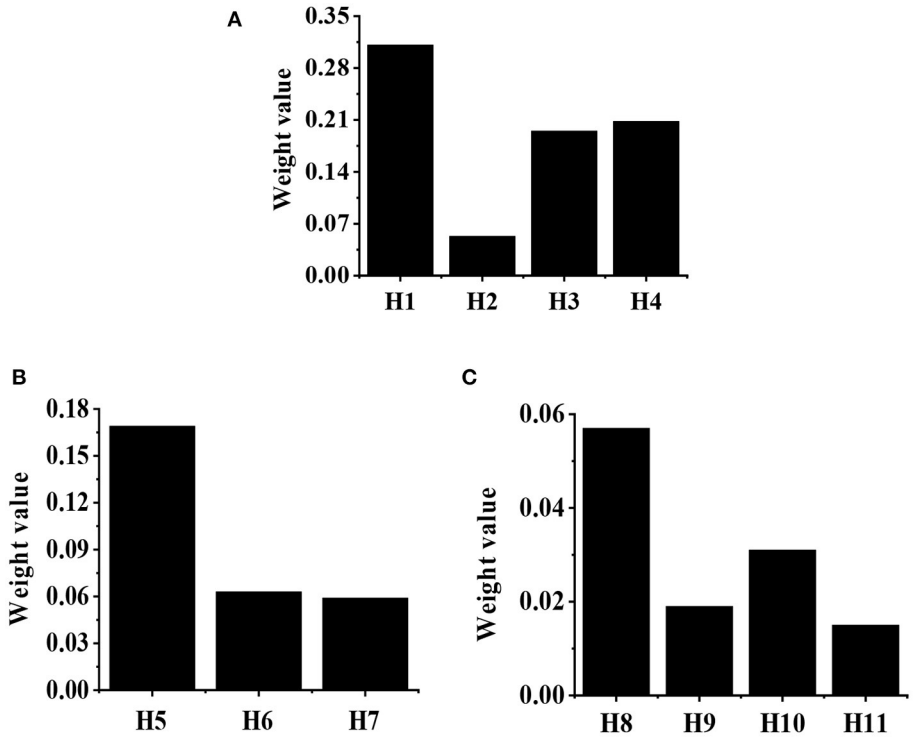

FIGURE 10 | The weight value of each index in the index layer to the target layer W. **(A)** The index of G1; **(B)** the index of G2; **(C)** the G3 index.

improvement H7, the commercial economy development H8, ROE H9, RPCE H10, and ROC H11.

The calculation of the weight value of the W–G judgment matrix is shown in **Table 2**. After calculation, g1 = 8.333, g2 = 6, and g3 = 1.643. After normalization, the eigenvector can be obtained as follows: $\overrightarrow{g} = (0.522, 0.376, 0.103)^T$. According to the consistency test, CI = 0.074, and CR = 0.052, which are both <0.1. The weight values of G1, G2, and G3 relative to the target layer W are 0.522, 0.376, and 0.103, respectively, as shown in **Figure 6**.

The Calculation of Weight Value in the G–H Judgment Matrix

The calculation of weight value in the G1–H judgment matrix is shown in **Table 3**. After calculation, g4 = 16, g5 = 1.676, g6 = 9.333, and g7 = 4.533. After normalization, the eigenvector can be obtained as follows: $\overrightarrow{g} = (0.507, 0.053, 0.296, 0.144)^T$. According to the consistency test, CI = 0.050, and CR = 0.039, which are both <0.1. Then, the weight values of H1, H2, H3, and H4 relative to G1 are shown in **Figure 7**, which are 0.507, 0.053, 0.296, and 0.144, respectively. The calculation of weight value in G2-H judgment matrix is shown in **Table 4**. After calculation, g8 = 9, g9 = 1.450, g10 = 5.333. After normalization, the eigenvector can be obtained as follows. According to the consistency test, CI = 0.047, and CR = 0.062, which are both less than 0.1. Then, the weight values of H5, H6, and H7 relative to G2 are shown in **Figure 8**, which are 0.570, 0.092 and 0.338, respectively.

The calculation of weight value in the G3–H judgment matrix is shown in **Table 5**. After calculation, g11 = 11, g12 = 4.45, g13 = 5.666, and g14 = 4.833. After normalization, the eigenvector can be obtained as follows: $\overrightarrow{g} = (0.424, 0.175, 0.218, 0.186)^T$. According to the consistency test, CI = 0.081, and CR = 0.056, which are both <0.1. Then, the weight values of H8, H9, H10, and H11 relative to the G3 are shown in **Figure 9**, which are 0.424, 0.175, 0.218, and 0.186, respectively.

The Weight Value of the W–H Index

According to weight values of the W–G and G–H judgment matrices obtained in 3.1.1 and 3.1.2, the weight value of each index in the index layer relative to the target layer W is calculated, as shown in **Figure 10**. In terms of G1, the weight value of H1 relative to target layer W is the largest (0.311), followed by the H4 index (0.208). In terms of G2, the weight value of the H5 index relative to target layer W is the largest (0.169). In terms of G3, the weight value of the H8 index relative to target layer W is the largest (0.057), followed by the H10 index (0.031).

The Membership Degree of Each Index

The Membership Matrix of Each Index of G1

As shown in **Table 6**, the membership degree of H1 of G1 to the comment set is [0.481, 0.362, 0.157, 0], with 48.1% being excellent, 36.2% being good, and 15.7% being qualified. The membership degree of H2 to the comment set is [0.274, 0.405, 0.321, 0], with 27.4% being excellent, 40.5% being good, and 32.1% being qualified. The membership degree of H3 to the comment set is [0.288, 0.526, 0.186, 0], with

TABLE 6 | The membership matrix of each index of G1.

Index		H1	H2	H3	H4
Membership matrix	Excellent	0.481	0.274	0.288	0.433
	Good	0.362	0.405	0.526	0.371
	Qualified	0.157	0.321	0.186	0.196
	Unqualified	0	0	0	0

TABLE 7 | Membership matrix of each index of G2.

Index		H5	H6	H7
Membership matrix	Excellent	0.247	0.318	0.497
	Good	0.431	0.377	0.311
	Qualified	0.240	0.305	0.176
	Unqualified	0.082	0	0.016

TABLE 8 | Membership matrix of each index of G3.

Index		H8	H9	H10	H11
Membership matrix	Excellent	0.266	0.195	0.053	0.038
	Good	0.608	0.677	0.811	0.793
	Qualified	0.126	0.128	0.136	0.169
	Unqualified	0	0	0	0

28.8% being excellent, 52.6% being good, and 18.6% being qualified. The membership degree of H4 to comment set is [0.433, 0.371, 0.196, 0], with 43.3% being excellent, 37.1% being good, and 19.6% being qualified.

Membership Matrix of Each Index of G2

As shown in **Table 7**, the membership degree of H5 in G1 to the comment set is [0.247, 0.431, 0.240, 0.082], with 24.7% being excellent, 43.1% being good, 24% being qualified, and 8.2% being unqualified. The membership degree of H6 to comment set is [0.318, 0.377, 0.305, 0], with 31.8% being excellent, 37.7% being good, and 30.5% being qualified. The membership degree of H7 to comment set is [0.497, 0.311, 0.176, 0.016], with 49.7% being excellent, 31.1% being good, 17.6% being qualified, and 1.6% being unqualified.

Membership Matrix of Each Index of G3

As shown in **Table 8**, the membership degree of H8 of G3 to the comment set is [0.266, 0.608, 0.126, 0], with 26.6% being excellent, 60.8% being good, and 12.6% being qualified. The membership degree of H9 to the comment set is [0.198, 0.677, 0.128, 0], with 19.8% being excellent, 67.7% being good, and 12.8% being qualified. The membership degree of H10 to the comment set is [0.053, 0.811, 0.136, 0], with 5.3% being excellent, 81.1% being good, and 13.6% being qualified. Furthermore, the membership degree of H10 to the comment set is [0.038, 0.793, 0.169, 0], with 3.8% being excellent, 79.3% being good, and 16.9% being qualified.

TABLE 9 | Calculation of weight value of the G3–H judgment matrix.

Index		G1	G2	G3
Membership matrix	Excellent	0.412	0.395	0.227
	Good	0.358	0.347	0.405
	Qualified	0.230	0.151	0.355
	Unqualified	0	0.107	0

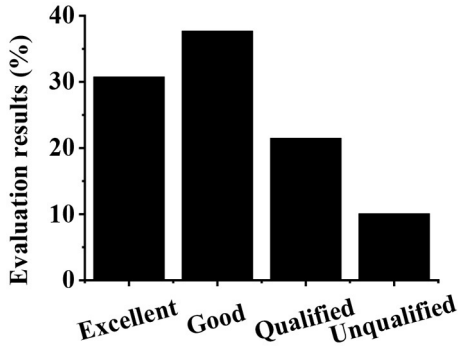

FIGURE 11 | The results of the second-level fuzzy comprehensive evaluation.

Multilevel Fuzzy Comprehensive Evaluation Results

The Results of the First-Level Fuzzy Comprehensive Evaluation

As shown in **Table 9**, according to the first-level fuzzy equation, 41.20% of G1 is excellent, 35.80% is good, and 23% is qualified. For the G2, 39.5% is excellent, 34.7% is good, 15.1% is qualified, and 10.7% is unqualified. For G3, 22.7% is excellent, 40.5% is good, and 35.5% is qualified.

The Results of the Second-Level Fuzzy Comprehensive Evaluation

As shown in **Figure 11**, according to the relative weight value of each index of the criterion layer to the target layer, the social benefit evaluation of the culture–tourism town is obtained through fuzzy calculation. Specifically, 30.76% of the social benefit of the culture–tourism town is excellent, 37.69% is good, 21.48% is qualified, and 10.07% is unqualified.

DISCUSSION

In recent years, the traditional sightseeing tourism, characterized by natural resources, is far from meeting people's growing demands on tourism. As the product of the tourism performing arts industry in the current culture–tourism integration, the culture–tourism town development is a new trend in tourism development (Law et al., 2019; Li et al., 2019). Based on deep learning BP neural network and fuzzy comprehensive analysis method, an artificial intelligence model for the culture–tourism town social benefit evaluation is constructed in the study. The weight values of G1, G2, and G3 relative to the target layer W are 0.522, 0.376, and 0.103, respectively, which is different from the research results of Saeidi et al. (2017). The development

and construction of the culture–tourism town are found to have greatly improved the living standards of local residents, indicating that the weight value of life benefit is the largest, and it is an important factor in the evaluation of social benefit. The weight values of H1, H2, H3, and H4 relative to G1 are 0.507, 0.053, 0.296, and 0.144, respectively, indicating that the cultural inheritance and protection have the greatest influence on the evaluation results of G1 (Kulshrestha et al., 2020). The weight values of H5, H6, and H7 relative to G2 are 0.570, 0.092, and 0.338, respectively, which is consistent with the research results of Lv et al. (2018), indicating that the ecological environment improvement has the greatest influence on the evaluation results of G2. The weight values of H8, H9, H10, and H11 relative to the G3 are 0.424, 0.175, 0.218, and 0.186, respectively, indicating that the commercial economy development has the greatest influence on the evaluation results of G3 (Ma et al., 2018). According to the above analysis, the culture inheritance and protection, the ecological environment improvement, and the commercial economy development are the key factors to evaluate the social benefit of the culture–tourism town.

In addition, according to the first-level fuzzy comprehensive evaluation, for G1, 41.20% is excellent and 35.80% is good. For G2, 39.5% is excellent and 34.7% is good. For G3, 22.7% is excellent and 40.5% is good, which is different from the result obtained by Al Shehhi and Karathanasopoulos (2020). This may be due to the differences in the development priorities of towns with different culture–tourism characteristics. It is evident that G1 and G2 are excellent, while G3 is good. The culture inheritance and protection index has the highest weight value to the social benefit of the target layer, indicating that the construction of the culture–tourism town is conducive to carrying forward the traditional culture and the harmonious development of the society (Hossain and Muhammad, 2019; Wang, 2020). A fine ecological environment is a necessary condition for a culture–tourism town to satisfy tourists' viewing and behavioral psychological demands. G2 is found to be excellent for the subject town, indicating that the construction of a culture–tourism town causes little damage to the local environment (Farmaki, 2018). According to the second-level fuzzy evaluation results, 30.76% of the total social benefit of the culture–tourism town is excellent, 37.69% is good, 21.48% is qualified, and 10.07% is unqualified, which is similar to the research results of Cheng et al. (2017). The total social benefit is good, indicating that the development and construction of the culture–tourism town is of great significance.

CONCLUSIONS

Based on deep learning BP neural network and fuzzy comprehensive analysis method, an artificial intelligence model is constructed for social benefit evaluation, with Yiyang town taken as the research subject. It is found that the life benefit and environmental benefit in the Yiyang culture–tourism town is excellent, with the economic benefit and the total social benefit being good. The culture inheritance and protection, the ecological environment improvement, and the commercial economy development are found to be the key factors to evaluate the social benefit of the culture–tourism town. However, some shortcomings are noted in this study. There are few previous references cited in this study, and the selection of social benefit factors of the culture–tourism town is subjective to some extent, which may reduce the power and increase the error margin of the results. More objective research is necessary in future. In conclusion, the study provides a theoretical basis for applying deep learning in social benefit evaluation of the culture–tourism integration industry.

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 Hunan City University Ethics Committee. The patients/participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

FUNDING

Teaching Reform Research Project of Hunan Ordinary Universities: Innovation Research on Training Mode of Excellent Dance Talents in Application-oriented Universities under the Background of Professional Certification (Grant No. Hnjg-2020-0789). The key project of Hunan Social Science Achievements Review Committee, Research on the Industrialization of Hunan Tourism Performing Arts in tourism Integration below (Grant No. XSP20ZDI016); Key project of Yiyang Social Science and Technology Federation Research on Nanxian Dihua-Gu Dance from the Perspective of Semiotics. It was also supported by the positioning of "The Belt and Area Initiative" is the research on Hunan tourism industrialization in tourism integration.

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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.

frontiers in Psychology

ORIGINAL RESEARCH
published: 19 February 2021
doi: 10.3389/fpsyg.2021.640110

Exploring the Influential Factors on Readers' Continuance Intentions of E-Book APPs: Personalization, Usefulness, Playfulness, and Satisfaction

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With the rapid development of mobile devices, users can now read on the screen. Electronic reading (e-reading) has become a common reading style with the growth in online learning or electronic learning (e-learning). E-book applications (APPs) are widely developed and applied for reading on a screen. However, it is difficult for readers to change their reading habits or preference from paper-printed books to digital devices. The study of readers' continuance intention to use e-book APPs is the first step to improving e-reading. This study focuses on the influential factors on undergraduates' continuance intention of e-book APPs, which analyzed and summarized the literature related to the electronic book (e-book) applications (APPs) and undergraduates' continuous intention, combined with the characteristics of the e-book APPs, introduced relevant theories and variables, and established the factors that influence undergraduates' continuous intention of using e-book APPs. On this basis, the paper analyzed the relationship between various influencing factors and their influence on continuous intention. A model composed of five hypotheses was constructed to test the factors influencing undergraduates' continuous intention in e-book APPs. The results indicated that of all research variables, satisfaction is the most important factor that affects continuous intention; Perceived usefulness and perceived playfulness have an indirect effect on continuous intention through satisfaction; personalization has direct effects on perceived usefulness and perceived playfulness, so it also has an indirect effect on continuous intention. The findings of the study will be helpful for designers and developers of e-book APPs and provide e-book APP suggestions for readers as well.

Keywords: influential factors, undergraduates, continuance intention, e-book APPs, electronic book applications

OPEN ACCESS

Edited by:
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Specialty section:
This article was submitted to Human-Media Interaction, a section of the journal Frontiers in Psychology

Received: *10 December 2020*
Accepted: *20 January 2021*
Published: *19 February 2021*

Citation:
Liu H, Shao M, Liu X and Zhao L (2021) Exploring the Influential Factors on Readers' Continuance Intentions of E-Book APPs: Personalization, Usefulness, Playfulness, and Satisfaction. Front. Psychol. 12:640110. doi: 10.3389/fpsyg.2021.640110

INTRODUCTION

The practice of reading is moving rapidly from print to screen (Miller and Warschauer, 2014). Recently, the emergence of social networks has enhanced the interaction between people and electronic devices (Su et al., 2019; Su and Chen, 2020). New media technologies are emerging one after the another. Reading texts is an unavoidable part of everyday life. Various electronic reading devices, such as Kindle, Sony Reader

and electronic book (e-book) applications (APPs) such as iReader, are continuously emerging (Rainie et al., 2012). Compared with paper reading, the search ability and 24-h availability of electronic reading (e-reading) are popular among undergraduates (Jeong, 2012). More and more undergraduates choose this new way of reading (Coyle, 2008). Existing studies have shown that there is no difference in students' ability to understand what they read electronically or in print (Muter et al., 1982). Lim et al. (2020) also proposed that results from a middle school student reading comprehension test showed no statistical differences between the e-book reading group and the paper-based reading group. Although acceptance of e-reading is an important first step to success, actual success requires continued use. The concept of continuance intentions originates from the intention to act, which refers to an individual's subjective judgment on the possibility of a particular behavior in the future. It originates from the field of psychology. Researchers believe that consumers' will determine their behavior, thus introducing the concept of continuance intention (Bhattacherjee, 2001a). In summary, it is vital to investigate the factors on the undergraduates' willingness to continue using e-book APPs. It has great significance in satisfying demand and developing products for e-book APPs.

Early scholars used terms like "implement or execute" and "routine use" instead of the concept of "continuance intention." Bhattacherjee (2001a) constructed the model of continuous use of information systems on the study of e-banking systems and proposed the term "continuance intention" for the first time, which he defined as the subjective tendency of users to continuously use e-banking. Thus, this study defined users' continuance intention of e-book APPs as: the likelihood or willingness of users of e-book APPs to continue using the APPs in the future.

In addition, a large number of scholars have conducted in-depth discussions on the users' continuance intentions in the field of information systems. Based on a model of technological acceptance, Venkatesh and Davis (2000) predicted user acceptance of computers by measuring their intentions. Perceived usefulness and perceived ease of use are considered to be key factors affecting the continuance intentions (Davis et al., 1989). Based on the study of online banking users' continuance intentions to use the information system, Bhattacherjee (2001a) proposed that the user's continuance intentions to use the information system depends on the satisfaction and perceived usefulness, and the degree of expected confirmation determines the satisfaction and perceived usefulness of users. Regardless, scholars have a lot of research on the continuance intentions in information systems, but there is little research on the continuance intentions in e-book APPs. In addition, existing studies have paid less attention to the role of personalization in the intention to continue using the product. Thus, this paper conducts a study on undergraduates' continuance intentions in e-book APPs. It also explores the correlation among personalization, perceived usefulness, perceived playfulness, satisfaction, and continuance intentions, and proposes suggestions for the improvement of e-book APPs.

LITERATURE REVIEW

E-books and E-reading Applications

With the increase of e-books, more and more people choose this new way of reading (Rainie et al., 2012). Since April 2011, there are 105 e-books for every 100 traditional paper books on Amazon. The authors detailed that print book sales would account for <25% of total sales (Miller and Bosman, 2011). With the text structured in a digital format (Muter et al., 1982), e-books are designed and built into an e-reading device or APP, such as Mobipocket, Microsoft Reader, or iReader. E-books have the same chapters and page numbers as paper books, however, readers can more easily navigate to any page or text and font type and size can also be modified according to the reader's preference. E-books have gained wider interest thanks to the introduction of portable e-readers and software-based readers, which provide a more authentic reading experience for users (Shiratuddin and Hassan, 2020). In recent years, Kindle, and Sony reader, set off a huge wave of e-reading. Today, e-reading devices have been replaced by e-reading APPs such iReader.

As for studies on e-book APPs, most scholars focus on the analysis of the relationship between traditional paper book reading and e-reading. A large number of scholars have proved that the effect of e-reading is no different or better than that of paper reading. In terms of reading comprehension, Muter et al. (1982) divided subjects into an e-reading group and a paper reading group and found that there was no difference in the understanding of the reading content between the two groups (Muter et al., 1982). Additionally, Kerr and Symons (2006) concluded that e-reading can recall more information freely through the comparison experiment of repetition between e-reading and paper reading (Kerr and Symons, 2006). Burghardt et al. (2009) investigated the differences between different reading carriers, such as paper and electronic devices, and concluded that the reading speed was related to individual factors, but not significantly to reading carriers (Burghardt et al., 2009). Recently, researchers have paid more attention to user experience, so the focus of research on e-reading has gradually shifted to practical research on e-reading and the design and development of related hardware and software technologies of e-reading equipment. A few studies have focused on undergraduates' continuance intentions of e-book APPs.

Technology Acceptance Model

Davis (1989) first proposed the technology acceptance model. The TAM examines users' perceptions of usage, usefulness, and ease of use (Davis, 1989). According to this model, perceived usefulness and perceived ease of use can also directly or indirectly affect the user's behavior. Perceived usefulness refers to the actual utility of a new technology that users perceive to bring to their own lives, while perceived ease of use refers to the degree of difficulty users perceive when actually using this technology in operation.

Since then, more and more scholars have conducted research to explore people's acceptance of the product. Venkatesh et al. (2003) studied the theory of the technology acceptance model of development (TAM2), explaining perceived usefulness

and the usage intentions in terms of social influence and cognitive instrumental processes (Venkatesh et al., 2003). He further designed a model which combined the technology acceptance model, the theory of planned behavior, the model of PC utilization, the innovation diffusion theory, and the social cognitive theory, called the unified theory of acceptance and use of technology (UTAUT). Dillon and Morris (2005) introduced the psychological factor, based on the user's acceptance of new information technology-theories (Dillon and Morris, 2005). Based on the TAM model, Fishbein and Ajzen (1977) increased four dimensions: social influence, facilitating conditions, playfulness, and trust (Fishbein and Ajzen, 1977). Ajwang et al. (2021) integrated three models of Innovation Diffuse (DOL), Technology Acceptance Model (TAM), and Technology Readiness Index (TRI) to enhance the understanding of factors that may affect the acceptance and use of smart waste management systems in smart cities. Wang et al. (2020) added personal innovation ability, environmental awareness, and perceived risk into the technology acceptance model to explore users' willingness to use ride-sharing services. Kong et al. (2020) also introduced the content of actual usage behavior into the technology acceptance model. Studies have shown that perceived usefulness, perceived ease of use, and trust factors of social media users will have a positive impact. Today, the technology acceptance model is widely used in research on mobile libraries and online learning.

Bhattacherjee (2000) follow-up studies show that user experience is more important after the initial use over time, and perceived usefulness has less of an impact. Thus, this study not only refers to the variables of perceived usefulness in the model, but also refers to the variables of perceived playfulness (Bhattacherjee, 2000).

Theories About Perceived Playfulness

The theory of perceived playfulness was first proposed by Lieberman (1977), who believed that users would have feel entertained in the process of interacting with computers. Barnett (1991) defined perceived playfulness from the perspective of perceived playfulness characteristics and stated: (1) users' self-generated entertainment psychology is not affected by external factors; (2) an emotional state is induced by external factors (Barnett, 1991), respectively.

Moon and Kim (2001) first introduced the three variables of concentration, curiosity, and enjoyment to measure perceived playfulness while studying the extended technology acceptance model (Moon and Kim, 2001). Wherein, concentration refers to the user's interest during the process of using an information system, and other influences of the spirit of the time in the environment will be filtered. Curiosity means that the interest in the system is doubled in the interaction. The curiosity of the user is aroused and further exploration is promoted. Enjoyment refers to the user in the information system under the condition of interest, in the process of interaction with the information system rather than another external environment. Since it was first introduced, scholars continue to use perceived playfulness in relevant studies, and its influence has been tested in a large number of empirical studies. The research shows that perceived playfulness has a significant impact on both self-efficacy and subjective well-being (Román-Oyola et al., 2018; Demir, 2019).

Literature Summary and Research Limitations

In general, at present, research on the technology acceptance model has matured, and many experts and scholars have expanded its application scope and variables when exploring the technology acceptance model. Most existing research however has applied it in the field of information systems, and not enough attention has been paid to new media. In addition, too much attention is paid to the influence of satisfaction on the continuous intention, and less to the personalized service of the product itself. Thus, based on the technology acceptance model, this current study took perceived usefulness and perceived playfulness as mediating variables to detect the correlation between personalization, satisfaction, and continuous intention to help improve the user's experience of e-reading.

Research Model and Hypotheses

Based on related studies and theoretical discussions, the theory of expectation-confirmation (ECM) is taken as the theoretical basis in this study, and the study combined the technology acceptance model (TAM) and perceived playfulness theory. At the same time, according to characteristics of e-book APPs, five research variables were identified, including satisfaction (SAT), continuance intentions (CON), perceived usefulness (USE), perceived playfulness (PLA), and personalization (PER). A research model of undergraduates' continuance intention of using the e-book APP was constructed, as shown in **Figure 1**.

Dunne et al. (2010) used personalization as measurement variables to explore the reasons why young people use and participate in social networks. The study found that personalization can improve young people's satisfaction with social networks (Dunne et al., 2010). Liang et al. (2012) did a study on customer service provided by e-tailers. He found that personalization influences perceived usefulness through economic and emotional factors (Liang et al., 2012). Tan and Chou (2007) also explored factors on users' perceived playfulness toward mobile services of mobile service quality and its compatibility to mobile technology (Tan and Chou, 2007). They proposed that perceived playfulness was influenced by three most important service quality aspects, perceived usefulness, ease of use, and personalization. Al-Shboul et al. (2020) also proved that network personalization in product innovation has a positive impact on perceived usefulness and perceived ease of use. Therefore, this paper introduced related variables and designed H1 and H2.

H1: The personalized reading service of e-reading has a positive effect on undergraduates' perceived usefulness of the application.

H2: The personalized reading service of e-reading has a positive effect on undergraduates' perceived playfulness of the application.

The variable of perceived usefulness comes from the technical acceptance model proposed by Davis (1989). In the research on the continuous intention model of information systems, it

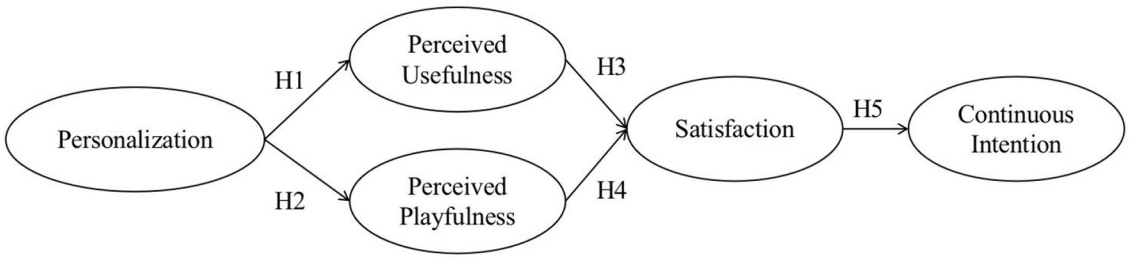

FIGURE 1 | Model of undergraduates' continuance intention of using the e-book APP.

is also proved that perceived usefulness is a key factor that directly affects user satisfaction and also has a direct impact on a user's willingness to continue using the product. Daud et al. (2018) also showed the impact of perceived usefulness on customer satisfaction in their use of IPTV. Thus, the variable of perceived usefulness was introduced to measure undergraduates' satisfaction with the e-book APP and their continuance intentions. H3 was proposed.

H3: undergraduate's perceived usefulness of using e-book APPs has a positive effect on their satisfaction with the APPs.

Lieberman (1977) first proposed the theory of perceived playfulness. Wang et al. (2009) introduced perceived playfulness into the research field of information systems. Users could improve their satisfaction because they feel happy in the process of using the information system, thus affecting their continuous intention. Tania and Marisol (2018) linked perceived entertainment and satisfaction through their research on art courses. Thus, in the study, H4 was proposed.

H4: undergraduates' perceived playfulness of e-book APPs has a positive effect on their satisfaction with the APPs.

Barnes and Böhringer (2011) explored users' continuance intention in microblogging services and found that perceived usefulness, satisfaction, and habit were the key factors (Barnes and Böhringer, 2011). Stone and Baker-Eveleth (2013) found that satisfaction and perceived usefulness influenced users' electronic textbook continuance usage intention (Stone and Baker-Eveleth, 2013). Satisfaction and continuance intention are also important variables in the expectation confirmation model (Amin et al., 2020). H5 was therefore proposed.

H5: undergraduates' satisfaction with e-book APPs has a positive effect on their continuance intentions of using the APPs.

METHODS

The research data collection used a questionnaire. The questionnaire consisted of four parts. The first part was the explanatory information of the questionnaire. The second part was a survey on the participants' basic information (three items). The third part was the participants' experience with e-book APPs (three items). The fourth part was the investigation on the factors influencing undergraduates' continuous intention of e-book APPs, which was the main part of the questionnaire and was designed in the form of a 5-level Likert scale. The options of each question included five levels, indicating the respondents' recognition of the question, so as to explore the factors affecting undergraduates' continuous intention in e-book APPs. The original questionnaire has 5 latent variables, perceived usefulness (4 items), perceived playfulness (5 items), personalization (5 items), satisfaction (4 items) and continuance intentions (5 items), a total of 23 items.

The survey was distributed in two stages. In the first stage, based on the existing research, to test the reliability and validity of the questionnaire, a survey among students from two classes in the fourth grade of an Education Technology major in a Chinese university was conducted. SPSS 24.0 statistical software showed that the reliability and validity of the questionnaire were good. Combined with the test results, two questions were deleted. The questionnaire was modified as 21 items.

In the second stage, the survey was distributed in a large scale and was divided into online and offline parts. The online part was distributed with the tool called *Questionnaire Stars*, and the offline part was distributed and recovered in public places such as libraries and study rooms of three universities in Nanjing, China. In the explanatory part of the questionnaire, the subjects were given a questionnaire "if you have ever used or are currently using e-book APPs, please continue reading and finish the questionnaire, but if you have never used any e-book APPs, please stop answering." This declaration filters out undergraduates who are not currently using e-book APPs. In this survey, 133 online questionnaires and 286 paper questionnaires were recovered, totaling 429. After sorting out the online questionnaires and paper questionnaires, 421 valid questionnaires were obtained, and the effective recovery rate reached 98%.

DATA ANALYSIS AND RESULTS

In this study, SPSS 24.0 was used for descriptive statistics and correlation analysis of population information. Male undergraduates accounted for 33.7% of the participants and female undergraduates accounted for 66.3% of the participants. 44.3% were majoring in liberal arts, 53.6% were majoring in science, and only 2.1% were studying arts. The participants included 13.8% freshmen, 24.4% sophomores, 49.2% juniors, and 12.6% seniors.

The questionnaire listed the top eight popular e-book APPs as options, such as QQ reading, book reading novels, palm reading

iReader, baidu reading, Migu reading, WeChat reading, netease cloud reading, and douban reading. The "other" option was also designed for users. The data showed that some users used other APPs as well. Most of them used Kindle. A small number of the group used starting point reading, ibooks, super star readers, and other APPs.

In addition, the duration and frequency of undergraduates' use of e-book APPs were also investigated and counted. According to the survey, there were 115 users and 112 users who used e-book APPs for 21–40 min and more than 1 h, respectively, accounting for 27.3 and 26.6% of the sample data, while the users who used for 41–60 min were the least, with only 23 users, accounting for 5.5% of the sample. The reading frequency of users showed that the number of users reading once a week or less and every 2 or 3 days was large—a total of 290 people—accounting for 56.5% of the total sample.

Reliability and Validity of the Instrument

The data analysis of this study is divided into three stages. The first stage is first-order CFA to determine the structure and internal reliability of the tool. The second stage is confirmatory factor analysis (CFA) to further confirm the convergence and discriminability of the construction. In the third stage, the structural equation modeling (SEM) is used to evaluate the hypothetical structural model. AMOS (24.0 edition) was used in this study to conduct CFA and path analysis on the structural model of questionnaire data.

In this study, a first order confirmatory factor analysis was used to remove the problems with low reliability and dimensional confusion, so as to facilitate the fitting degree of the model in the later period, if the standardized load of the measurement is <0.5, the measurement should be deleted (Hair et al., 2014). Absolute fitting index and relative fitting index are used to evaluate the fitting degree of the model. After removing some of the questions, in this model, the chi-square is 116/501, the degree of freedom is 109, and the chi-square/df is 1.069. The value of the root mean square error of approximation (RMSEA) of this study was 0.013 (RMSEA <0.08) (Anderson and Gerbing, 1988). The value of goodness-of-fit index (GFI) and the adjust fitness index (AGFI) was 0.970 and 0.958 ($0.9<$ GFI <0.1, $0.9<$AGFI<0.1) (Foster et al., 2006). The value of normed fit index (NFI), comparative fit index (CFI), and the relative fitness index (RFI) was 0.981, 0.999, and 0.976 ($0.9<$ NFI <0.1, $0.9<$ CFI <0.1, $0.9<$ RFI <0.1) (Hair et al., 1995).

From the perspective of model indexes, the chi-square/df, RMSEA, GFI, AGFI, NFI, CFI, and IFI are all within the acceptable range. Hence, 17 remaining items were kept for further analysis, including perceived usefulness (4 items), perceived playfulness (3 items), personalization (3 items), satisfaction (4 items) and continuous use intention (3 items) (see **Appendix 1**).

Dimension Reliability and Validity Analysis

To ensure the reliability and validity of the scale, we used Cronbach's alpha to test its reliability, CR value to test its validity, and the AVE value to test its convergence. According to the Cronbach's alpha reliability standard, when Cronbach's alpha was bigger than 0.7, the questionnaire was credible (Bagozzi and Yi, 1988). In this model, the value of Cronbach's alpha this are all more than 0.8. For a more accurate measurement, the composite reliability (CR) is the reliability of all measurement items, and it is generally suggested that a good value should be >0.7 (Hair et al., 2014). In this study, CR values ranged from 0.862 to 0.947. To ensure the validity of the measurement model and at the same time, when the AVE (Average Variance Extracted. AVE) value exceeds 0.5, it indicates that the dimension has the effect of convergence (Fornell and Larcker, 1981), which means that the load of all standardized factors in the dimension is squared, aggregated, and finally averaged. If the calculated value meets this standard, the convergence validity of each dimension is significant enough. Thus, as **Table 1** shows, the model of this study was constructed reasonably, and the questionnaire had a high validity.

After checking the convergence degree of the scale, we should check the discriminant validity of the model to ensure that the questions in each dimension are independent of those in other dimensions. In terms of construct discriminant validity analysis (see **Table 2**). Normally, the square root of AVE of each dimension must be obtained first, which must be greater than the absolute value of Pearson correlation coefficient between the two dimensions before each dimension can be expressed as discriminant validity (Schumacker and Lomax, 2016). In this study, the square root of the AVE value of all variables is greater than the absolute value of correlation coefficient between variables, which proves that the measurement model has good discriminative validity (Schumacker and Lomax, 2016).

Hypotheses Testing

In this study, absolute fitting index and relative fitting index are used to evaluate the fitting degree of the model. The goodness-of-fit index (GFI) should be more than the suggested value of 0.9 and <1.0 (Foster et al., 2006). The value of GFI was 0.952. The normed fit index (NFI) and comparative fit index (CFI) should all be >0.9 (Hair et al., 1995). The value of NFI was 0.969 and CFI was 0.987. The root mean square error of approximate (RMSEA) should be <0.08 (Dillon et al., 1988), and the value of this study model is 0.039. From the perspective of model indexes, as shown in **Table 3**, the chi-square value and degree of freedom ratio, the approximate error mean square value, the goodness of fit index (GFI), the model comparative fitness index (CFI), the non-normal fit index (NFI), and the incremental fitness index (IFI) were all within the acceptable range. Therefore, the model used for this study fits well.

Through the path analysis of the relationship between variables, this study tested the hypothesis of the research model. The analysis results of path coefficient are shown in **Table 4**. It can be seen that the significance of the five hypotheses proposed in this study has been verified. The p-value was <0.01.

In order to improve the fitting degree of the model, the following adjustments were made, as shown in **Figure 2**.

The determination coefficient R^2 quantifies the variance ratio interpreted by the statistical model and is an important summary statistic of biological benefits (Nakagawa et al., 2017). R^2 represents the degree of interpretation between paths. We

TABLE 1 | Results of confirmatory factor analysis.

Latent variable	Measure item	Average	Standard deviation	Standardized factor loading	CR	AVE	Cronbach's alpha
Critical value				>0.5	>0.7	>0.5	>0.7
Perceived usefulness (USE)	USE1	3.42	0.866	0.868	0.9231	0.7502	0.923
	USE2	3.58	0.817	0.880			
	USE3	3.54	0.879	0.823			
	USE4	3.65	0.810	0.892			
Perceived playfulness (PLA)	PLA1	3.15	1.082	0.789	0.8624	0.6765	0.861
	PLA2	3.10	1.001	0.860			
	PLA3	3.24	0.982	0.817			
Personalization (PER)	PER1	3.01	0.984	0.818	0.9136	0.7794	0.912
	PER2	3.28	0.934	0.904			
	PER3	3.29	0.933	0.923			
Satisfaction (SAT)	SAT1	3.43	1.158	0.917	0.947	0.8171	0.949
	SAT2	3.41	1.211	0.921			
	SAT3	3.41	1.201	0.922			
	SAT4	3.43	1.195	0.854			
Continuous use intention (CON)	CON1	3.54	0.969	0.889	0.880	0.7103	0.882
	CON2	3.23	0.963	0.853			
	CON3	3.20	0.932	0.783			

CR, composite reliability; AVE, average variance extracted.

TABLE 2 | Correlation coefficient matrix and square roots of AVE.

Construct	USE	PLA	PER	SAT	CON
USE	0.866				
PLA	0.307**	0.822			
PER	0.404**	0.256**	0.883		
SAT	0.606**	0.421**	0.473**	0.904	
CON	0.598**	0.326**	0.422**	0.743**	0.843

***p < 0.01.*

consider that R^2 values 0.3–0.6 is medium, and <0.3 is low (Sanchez and Golding, 2013). In addition, effect size of the model (f^2) was proposed by Cohen (1988). This allows researchers to move from a simple recognition of statistical significance to a more general quantifiable description of the size of the effect (Fritz et al., 2012). f^2 >0.8 can be considered large. When it is between 0.2 and 0.8, it can be considered medium, and when it is <0.2, it can be considered small. In this study, the explanatory power of PER on USE is 20% ($R^2 = 0.20, f^2 = 0.25$), and PLA is 10% ($R^2 = 0.10, f^2 = 0.11$). The explanatory variance of USE and PLA on SAT is 49.0% ($R^2 = 0.49, f^2 = 0.96$). The explanatory variance of SAT on CON is 65.0% ($R^2 = 0.65, f^2 = 1.86$). Hence, the six variables in this study have good predictive power (Hair et al., 2014). To improve the fitting degree of the model, the following adjustments were made, as shown in **Figure 2**.

In this study, the direct and indirect influences of each factor on the intention of continuous use were calculated according to the path coefficient, and their influence coefficients were combined to obtain the influence, so as to observe the effect of each research variable on the intention of continuous use of undergraduates' e-book APPs.

Table 5 shows the degree of each variable of influencing factors of undergraduates' intention to continue using e-book APPs investigated in this research model, as personalization (0.289), perceived usefulness (0.485), perceived playfulness (0.230), and satisfaction (0.808).

Moderated Mediating Effect Analysis

First, Model 4 of the SPSS macro compiled by Hayes (2012) (Model 4 is a simple mediation model) was used to test the mediating effect of satisfaction in the relationship between perceived usefulness, perceived playfulness, and continuous intention. As **Table 6** shows, the results showed that perceived usefulness had a significant predictive effect on continuous

TABLE 3 | Model fitting analysis results.

Type	Fitting index	Evaluation standard	The fitting results of this model	Results
Absolute fit index	Chi-square/df	<3	1.650	Supported
	RMSEA	<0.08	0.039	Supported
	Goodness-of-fit index (GFI)	>0.9	0.952	Supported
	Adjust goodness fitness index (AGFI)	>0.9	0.936	Supported
Relative fit index	Normed fitness index (NFI)	>0.9	0.969	Supported
	Non-normalized fitness index (NNTI/TFI)	>0.9	0.985	Supported
	Comparative fitness index (CFI)	>0.9	0.987	Supported
	Incremental fitness index (IFI)	>0.9	0.988	Supported
	Relative fitness index (RFI)	>0.9	0.963	Supported
Parsimonious fit index	Parsimonious normed fitness index (PNFI)	>0.5	0.812	Supported
	Parsimonious goodness fitness index (PGFI)	>0.5	0.710	Supported

TABLE 4 | Path coefficient analysis results.

Hypothesis	Causal factors	Estimate	S.E.	C.R.	*p*
H1	USE⟵ PER	0.375	0.042	5.884	***
H2	PLA⟵ PER	0.294	0.050	8.972	***
H3	SAT⟵ USE	0.832	0.063	13.236	***
H4	SAT⟵ PLA	0.355	0.054	6.615	***
H5	CON⟵ SAT	0.686	0.039	17.703	***

****p < 0.001.*

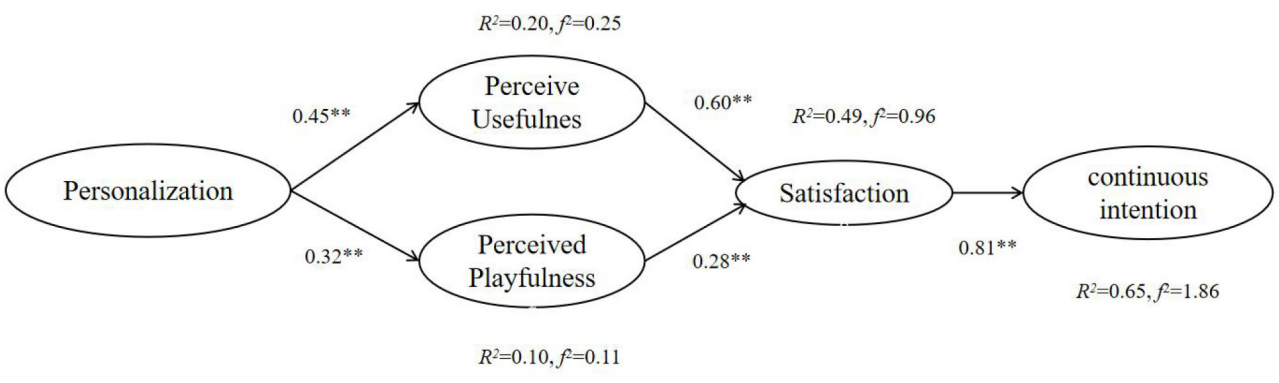

FIGURE 2 | The final structural model with standardized coefficients. ***p* < 0.01.

intention (β =0.0335, t = 5.8913, p < 0.01), and the direct predictive effect was still significant when the mediator variable was included (β = 0.0229, t =15.2495, p < 0.01). At the same time, the mediating effect of satisfaction between perceived entertainment and intention to use continuously is not significant (β = 0.0341, t = 0.6582, p >0.01).

In addition, as **Table 7** shows, the upper and lower limits of the Bootstrap 95% confidence interval of the direct effect of perceived usefulness on continuous intention and the mediating effect of satisfaction do not contain 0, indicating that perceived usefulness can not only directly predict continuous intention, but can also predict continuous intention through the mediating effect of satisfaction. The direct effect (0.197) and the mediating effect (0.309) accounted for 38.86 and 60.95% of the total effect (0.507), respectively.

DISCUSSION AND CONCLUSION

Based on the continuance intentions model, this study introduced relevant theoretical variables and constructed the users' continuance intention model of undergraduates' e-book

APPs. According to the model hypotheses, the questionnaire was designed, distributed, and recovered. After statistical analysis and obtaining effective data, the rationality of the research model was verified. Furthermore, the influence of various research variables on undergraduates' continuance intentions for using e-book APPs was analyzed.

This study proposed five factors; personalization, perceived usefulness, perceived playfulness, and satisfaction will have a direct or indirect influence on undergraduates' continuance intentions in e-book APPs. The empirical hypothesis test confirmed that the five factors had a significant impact.

The satisfaction has a positive direct impact on users' continuance intentions, and its direct impact load was 0.860, the most important of all the variables in this study. H5 was proved. Chiu et al. (2007) and Amin et al. (2020) also proved the point in their studies. Perceived usefulness and perceived playfulness could have a positive indirect effect on the satisfaction of undergraduates' continuance intentions of using e-book APPs by 0.485 and 0.230. The total effect of 0.485 and 0.230 ranked the second and fourth among all variables in this study. So H3 and H4 were proved. Which were the same as the studies by Daud et al. (2018) and Tania and Marisol (2018). However, the conclusion was different from Almaghrabi's study (Almaghrabi and Dennis, 2012).

In addition, the variable of personalization also had a direct effect on perceived usefulness and perceived playfulness reaching 0.447 and 0.316. At the same time, personalization had an indirect effect on undergraduates' continuance intentions reaching 0.289. The total effect of 0.289 ranked the third among all variables in this study. So H1 and H2 were proved. Liang et al. (2012) and Tan and Chou (2007) reached the same conclusion (Lee and Kim, 2005; Moller, 2015). So as the study of Al-Shboul et al. (2020).

This study shows that the most important factor influencing undergraduates' willingness to continue using e-book APPs is satisfaction, followed by perceived usefulness, personalization, and perceived playfulness. The research results show that e-book APPs should satisfy users' perceived usefulness first. Secondly, personalization is particularly important, which is also a common problem of e-book APPs in the market. It is necessary to understand the personalized needs of users from the sense of the user experience, such as the different functional requirements and appearance requirements of users' different professions, and then it is necessary to realize these in terms of technology and involvement. In addition, the perception and entertainment of products should not be ignored. Attention should also be paid to the smooth use and beautiful interface for the e-book APPs.

In addition, the majority of undergraduates' continuance intentions of using e-book APPs depended on the fact that

TABLE 5 | Analysis on the effect of each variable.

Variable	Directly influence	Indirectly influence	Totally influence	comprehensive sequencing
Personalization (PER)		0.289	0.289	3
Perceived usefulness (USE)		0.485	0.485	2
Perceived playfulness (PLA)		0.230	0.230	4
Satisfaction (SAT)	0.808		0.808	1

TABLE 7 | Total effect, direct effect, and mediating effect.

	Effect	Boot SE	BootLLCI	BootULCI	*t*
Total effect	0.5067	0.0332	0.4414	0.5720	15.201**
Direct effect	0.1973	0.0335	0.1315	0.2631	5.8913**
Mediating effect of SAT	0.3094	0.0273	0.2571	0.3664	

$^{**}p < 0.001$.

TABLE 6 | The mediation model testing of satisfaction.

Outcome variable	Predictor variable	Fitting index			Coefficient significance		
		R	R^2	$F_{(df)}$	Coeff	se	*t*
SAT		0.6058	0.3669	242.8736			
	USE				0.8849	0.0568	15.5844**
CON		0.7662	0.5870	27.0522			
	USE				0.1973	0.0335	5.8913**
	SAT				0.3496	0.0229	15.2495**
SAT		0.4188	0.1696	85.5582			
	PLA				0.6739	0.0729	9.2498**
CON		0.7438	0.5532	258.7389			
	PLA				0.0224	0.0341	0.6582
	SAT				0.4258	0.0208	20.4502**

$^{**}p < 0.001$.

e-book APPs could make them feel satisfied with the process and experience, then the user was likely to choose to continue to use the application. The e-book APPs could make the user feel expected and confirmed. If users' experience of using e-book APPs met the expected value or even exceeds it, they would have the willingness to continue using the APP. Moreover, if the e-book APP could increase the user's reading volume, improve the reading efficiency, and reasonably allocate the time, the user would also have the intention to continue to use the e-book APP.

The opinions and feelings of people and comments from the outside media would affect users' continuance intentions of using a product. How to improve users' subjective standards is therefore also a problem that should be considered in e-book APPs.

LIMITATION AND FUTURE STUDY

The samples collected in this study have a limited coverage and are concentrated in different regions. Therefore, they cannot fully represent all undergraduates' continuance intention of using e-book APPs. Future research can hopefully appropriately increase the number of samples, expand the sample range, and carry out more accurate and comprehensive research.

Users' continuous intention of using a product is a dynamic and continuous process. Deep learning and mining of data is especially necessary (Su et al., 2020, 2021; Su and Wu, 2021). There will hopefully be an opportunity to conduct a more long-term dynamic study in the future, which will continue to optimize and improve the model based on more data.

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

All authors contributed equally to the conception of the idea, implementing and analyzing the experimental results, writing the manuscript, and read and approved the final manuscript.

FUNDING

This research was funded by the National Social Science Foundation of China (Grant No. BCA200093), and the Priority Academic Program Development of Jiangsu Higher Education Institutions.

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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.

APPENDIX 1

TABLE A1 | Questionnaire of variables.

Construct	Items	References
Perceived usefulness (USE)	USE1: Using e-book APPs has increased the amount of my reading and improved my reading efficiency. USE2: Using e-book APPs broadened my reading range. USE3: Using e-book APPs allows me to spend my time more efficiently and read more freely. USE4: In general, using e-book APPs is useful for me.	Davis et al., 1989
Perceived playfulness (PLA)	ENT1: Reading with an e-book APP makes me happy. ENT2: When I use an e-book APP for reading, I feel time flies. ENT3: The use of e-book APPs for reading has increased my interest in reading, which is an enjoyable thing for me.	Barnett, 1991; Moller, 2015
Personalization (PER)	IND1: The personalized recommendation content and frequency of e-book APPs are what I need. IND2: The e-book APPs personalized Settings meet my personalized needs. IND3: In a word, the e-book APPs meet my personal reading needs.	Lee and Kim, 2005
Satisfaction (SAT)	SAT1: I enjoy and satisfying with using e-book APPs. SAT2: I am satisfied with the process and experience of using e-book APPs. SAT3: For me, using e-book APPs is a smart choice. SAT4: Overall, I'm happy with the e-book APPs.	Bhattacherjee, 2000; Bhattacherjee and Premkumar, 2004; Hong et al., 2006
Continuous use intention (CON)	CON1: I will continue to use the e-book APPs. CON2: I intend to continue to use e-book APPs rather than related alternative businesses or services. CON3: I will recommend e-book APPs to my friends and family	Bhattacherjee, 2001a,b

frontiers in Psychology

BRIEF RESEARCH REPORT
published: 23 February 2021
doi: 10.3389/fpsyg.2021.640115

Exploring Computational Thinking Skills Training Through Augmented Reality and AIoT Learning

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Given the widespread acceptance of computational thinking (CT) in educational systems around the world, primary and higher education has begun thinking about how to cultivate students' CT competences. The artificial intelligence of things (AIoT) combines artificial intelligence (AI) and the Internet of things (IoT) and involves integrating sensing technologies at the lowest level with relevant algorithms in order to solve real-world problems. Thus, it has now become a popular technological application for CT training. In this study, a novel AIoT learning with Augmented Reality (AR) technology was proposed and explored the effect of CT skills. The students used AR applications to understand AIoT applications in practice, attempted the placement of different AR sensors in actual scenarios, and further generalized and designed algorithms. Based on the results of the experimental course, we explored the influence of prior knowledge and usage intention on students' CT competence training. The results show that proposed AIoT learning can increase students' learning intention and that they had a positive impact on problem solving and comprehension with AR technology, as well as application planning and design.

Keywords: computational thinking, augmented reality, artificial intelligent of thing, problem solving skills, problem reasoning

OPEN ACCESS

Edited by:
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National Taichung University of Science and Technology, Taiwan

Reviewed by:
He-Hai Liu,
Anhui Normal University, China
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Specialty section:
This article was submitted to Human-Media Interaction, a section of the journal Frontiers in Psychology

Received: *10 December 2020*
Accepted: *25 January 2021*
Published: *23 February 2021*

Citation:
Lin Y-S, Chen S-Y, Tsai C-W and Lai Y-H (2021) Exploring Computational Thinking Skills Training Through Augmented Reality and AIoT Learning. Front. Psychol. 12:640115. doi: 10.3389/fpsyg.2021.640115

INTRODUCTION

As science and technology continue to advance, their overall impact on everyday life is no longer limited to basic necessities like food, clothing, housing, and transportation; science and technology are also related to the scope of national education. With Alpha Go defeating humans in chess, artificial intelligence (AI) has quickly attracted global attention. Not only have many studies begun using AI to attempt to solve previously complex and difficult problems, AI education and programming skills have also gradually transitioned from information expertise in universities to an emerging general knowledge requirement for all citizens. For instance, former US President Barack Obama promulgated the Every Student Succeeds Act, which considers computer science to be a key academic field and general ability and encourages schools to incorporate data science into the basic curriculum. Programming education is no longer relegated to information science professionals; it is now a necessary basic skill that all citizens should possess in preparation for the near future. In addition to programming skills training, computational thinking (CT) involves the effective analysis and deconstruction of complex issues and their translation into computer programming languages, so that people can understand human problems from a

computer programming perspective and implement solutions using computers (Wing, 2006, 2011; Grover and Pea, 2013). Integrating CT and programming training immerses students in science education from an early age, which will, to a certain extent, strengthen their ability to apply information science. Furthermore, it shifts the focus of traditional learning from "reading, writing, and arithmetic" skills to the cultivation of academic literacy through "doing, using, and thinking" (Yadav et al., 2017). The International Society for Technology in Education (ISTE) has also defined the standards for CT competences based on students' information age development needs—algorithmic thinking, creativity, logical thinking, and problem-solving skills—demonstrating that CT focuses not only on basic programming skills training but also on fostering students' competences in problem comprehension and solving, and system design. Therefore, CT is suitable for basic literacy and modes of thinking at different stages and in different fields, the integration of interdisciplinary applications, and various fields' teaching curricula (Qualls and Sherrell, 2010; Barr and Stephenson, 2011).

The popular AIoT technology combines the IoT with AI technology to create numerous smart applications, such as smart homes, smart enterprises, and even smart cities (Gubbi et al., 2013; Lee and Lee, 2015; Lai et al., 2021). The diverse sensing technologies of AIoT and AI programming learning are also compatible with various educational strategies in engineering education, maker learning, project-based learning, and problem-oriented learning (Navghane et al., 2016; Lensing and Friedhoff, 2018), thus enabling students to integrate sensor applications with AI algorithms in order to create different smart applications and solve practical problems. Through the learning process, students can not only practice using sensing technology and AI algorithms but also cultivate their competences in thinking about problems and teamwork (Hundhausen et al., 2013). The interdisciplinary integration of sensing technology and problem-solving goals also makes AIoT courses an educational environment capable of cultivating and improving students' CT competences. However, due to its diverse applications and complex environments, AIoT often results in students' lack of familiarity with the application fields, or it involves a flat design, which leads students to explore problems at insufficient depths and/or choose to ignore certain parts of the problem. For example, in smart agriculture, different environments and crops should be taken into account when considering deployment and the choice of sensors; failure to do so can lead to poor overall learning outcomes (Lai et al., 2019; Chen et al., 2020).

In view of the above, this study mainly discusses the impact of this kind of AR AIoT learning on CT skills training and introduces AIoT teaching methods with AR technology in order to explore their effects on the learning outcomes of AIoT courses and CT competency performance. Through the concept of AR space design, we aim to cultivate an understanding of programming structure and expand scientific education field data, thereby laying the foundation for students' basic science knowledge and understanding of the structure of different programming components. Students used the AR application in different fields to place the IoT sensing modules within the actual application field, which enabled them to think about and plan a suitable project design for the specific fields. This study gradually introduced the relevant AR module design, incorporated CT teaching methods into the AIoT course, and analyzed the effect of the AR modules on students' learning intentions and CT competences. Finally, we present a discussion and elaboration on the research based on the relevant data measurements.

RELATED LITERATURE

Computational Thinking

CT first appeared in 1980 when Seymour Papert proposed a deeper contemplation on computers and suggested incorporating the changes computers have caused into children's learning and self-expression. The concept of CT was mentioned again in 1993 (Papert, 1980, 1993); however, it did not receive much attention until 2006 when Wing clarified the concept and propagated its application to problem solving. In his later research, Wing called on all educational research fields to emphasize CT as a core skill for K-12 education and develop a CT pedagogy (Wing, 2006, 2008, 2011). CT competence can be divided into the following four categories: decomposition, pattern recognition, pattern generalization and abstraction, and algorithm design. Wing (2008) pointed out that CT competency can be acquired through the successive cultivation of skills in the four aspects. Since then, CT has attracted growing attention from educators and education researchers and is considered a critical ability that enables students to grasp basic problem-solving skills (Qualls and Sherrell, 2010; Weintrop et al., 2016). In K-12 education, students' CT competency is mainly fostered through programming training (Goyal et al., 2016; Wei et al., 2020). CT can help students attain higher-level thinking processes, such as problem decomposition and innovative thinking (Barr and Stephenson, 2011; Shute et al., 2017). In addition to K-12 education, CT is also applicable to the field of higher professional education (Tang et al., 2020). In professional fields, CT can help with problem solving and analysis, further enhancing programming learning motivation. For students in nonprofessional information fields, CT can facilitate their understanding of how programming works and further enhance their interest in programming skills (Aoki et al., 2013). Through different courses, CT teaching can foster skills in various fields, such as mathematics, robotics, and music, and even integrate current IoT applications with AI technology learning (Benakli et al., 2017; Bell and Bell, 2018). Many studies have also developed relevant technological tools to support CT learning, such as augmented reality (AR) technology, virtual reality (VR) technology, and even robotic aids (Weintrop et al., 2014; Atmatzidou and Demetriadis, 2016; García-Valcárcel-Muñoz-Repiso and Caballero-González, 2019; Lin and Chen, 2020).

AR Technology

The key concept of AR is to expand the reality field. With the introduction of virtual information and objects, AR can strengthen the understanding of relevant information technology or enhance the understanding of a given object. AR was first

proposed as part of the reality–virtuality continuum by Milgram and Kishino (1994), who defined its theoretical foundation. AR consists of virtual and real environments, real-time interactive interfaces, and an overall environment of spatiality. The application of AR technology can strengthen users' perception of real objects and their interaction with virtual data. AR technology is widely used in engineering, science, humanities, medicine, and other fields due to its ability to augment information and overlay it on real scenes to strengthen users' comprehension and cognition (Van Krevelen and Poelman, 2010). In the educational field, advances in information technology have facilitated a transition from traditional face-to-face teaching to computer-aided teaching, and AR is widely used to assist students in conceptual learning (Bacca et al., 2014; Akçayir and Akçayir, 2017). Radu (2014) conducted a comprehensive review of 26 publications and produced a list of positive and negative effects of educational AR technology on students. Radu concluded that AR is beneficial to enhancing students' motivation, promoting collaboration among students, developing spatial abilities, and improving physical task performance. As for its negative effects, Radu noted that AR places an additional cognitive burden on students and can cause usability issues. However, the novelty of and feedback from interactions with AR information can increase students' interest in learning. Furthermore, AR allows students to directly interact with objects and scenes, which is difficult for traditional teaching tools to achieve. For abstract

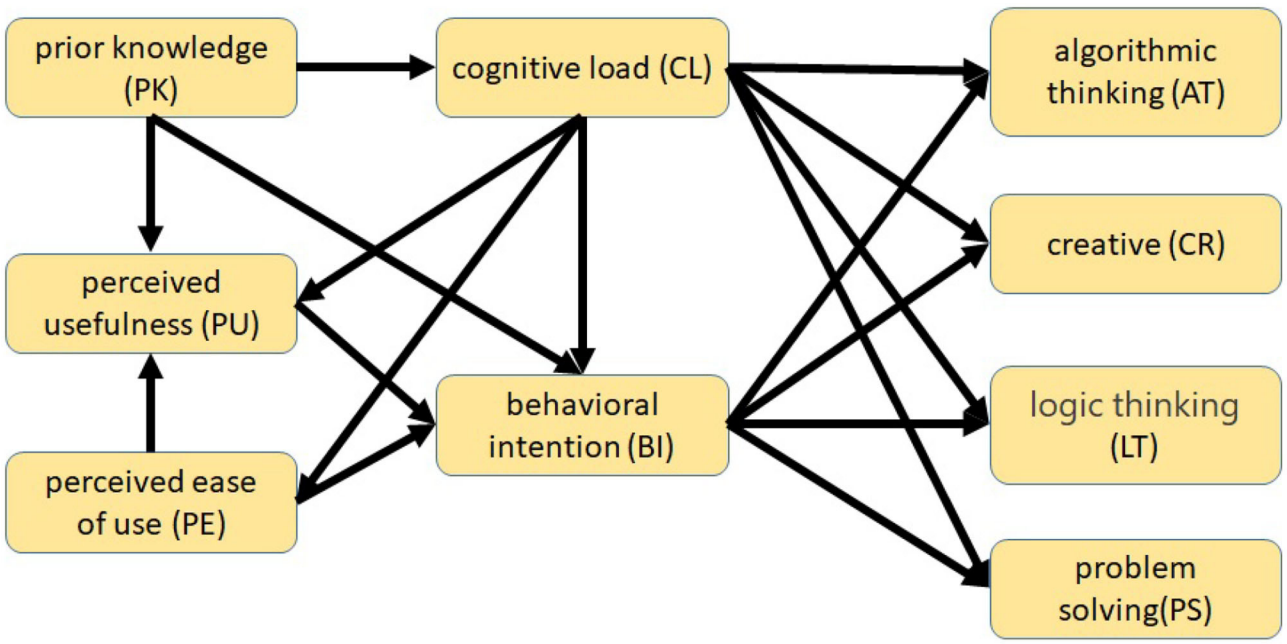

FIGURE 1 | Effect of introducing AR IoT on the outcome of CT competency training.

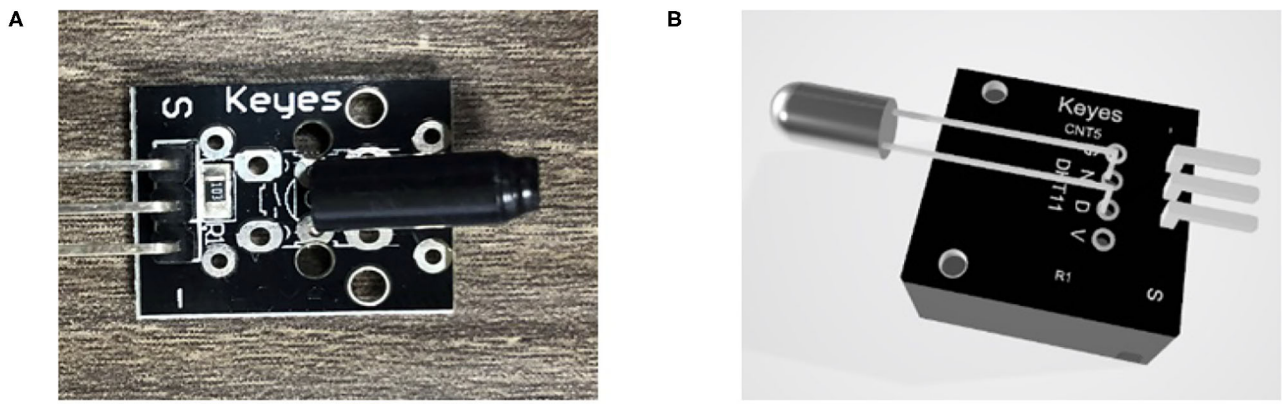

FIGURE 2 | (A) Sensor module and **(B)** 3D AR sensor module.

scientific concepts, in particular, AR can effectively improve understanding and build self-confidence in learning. Thus, using AR as a teaching tool can help students with scientific exploration and provide relatively unique educational benefits (Cheng and Tsai, 2013; Soltani and Morice, 2020). In AR, the interaction between virtuality and real scenes can facilitate students' interactive exploration of information. Hence, it is especially useful in the fields of science, technology, engineering, and mathematics (STEM) with respect to spatial abilities, practical skills, conceptual understanding, and scientific inquiry and learning (Ibáñez and Delgado-Kloos, 2018; Phupattanasilp and Tong, 2019).

RESEARCH FRAMEWORK AND DESIGN METHODS

Research Model

This study aimed to examine students' CT competency performance in AIoT courses with the aid of AR IoT applications. The overall research model is shown in **Figure 1**. This study referred to and modified the technology acceptance model to investigate students' intention to use AR IoT applications (Lijnse, 1995; Méheut and Psillos, 2004). The technology acceptance model is based on the theory of reasoned action and has inherited the essence of reasoned action. It posits that belief perceptions affect attitudes, which, in turn, affect behavioral intention; behavioral intention can have a significant and positive effect on system use. The technology acceptance model proposes two factors that can affect acceptance among information system users, namely, perceived usefulness and perceived ease of use. These two cognitive factors are considered to correspond to users' evaluation of performance and effort. The technology acceptance model can facilitate our exploration of the factors that influence system use. Perceived usefulness and perceived ease of use are both subject to the influence of external variables, i.e., factors related to the system or teaching model. In addition, this study introduced students' prior knowledge of IoT and AR, considered the effects of AR cognitive load on usage intention (Radu, 2014; Chang and Chen, 2018), and explored whether these factors can influence CT competency performance.

AIoT AR Application Design

The main objective of this study is to design an AIoT AR application and introduce it to the AIoT teaching environment to provide students with diverse knowledge and modes of thinking when they encounter overly complex AIoT scenarios with a wide range of considerations, so as to cultivate CT competency. First, this study used the Unity program and referred to the IoT sensor module kit to create a total of 37 IoT sensor modules, as shown in **Figure 2**.

In order to ensure that the AIoT AR module can be overlaid on application scenarios, ARCore was mainly used for preliminary construction. ARCore is an AR development platform launched by Google; it includes a set of new application programming interface (API) and frameworks. It combines a camera, an inertial measurement unit (IMU), a three-dimensional accelerometer, and a gyroscope (known as "sensor fusion") to obtain feature points and point cloud data in order to track certain points in different visual fields and attempt to identify their locations in reality. After acquiring their locations, simultaneous localization and mapping (SLAM) is incorporated to help ARCore locate the user (device) and identify the objects around the user.

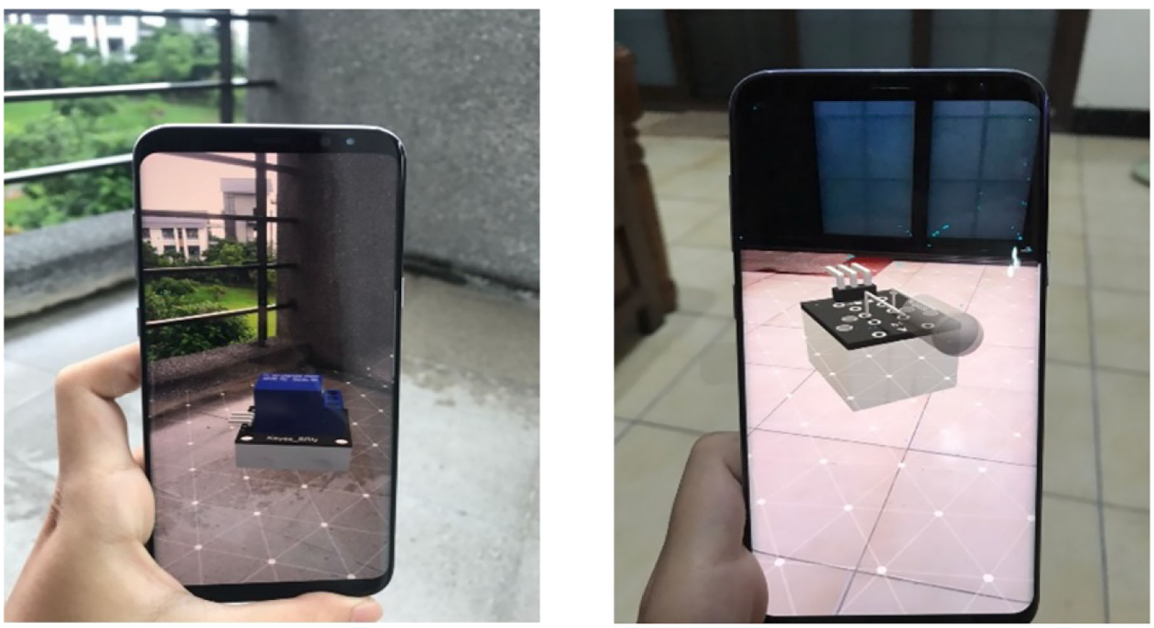

FIGURE 3 | AR module with ARcore.

Once the localization is completed, each frame is compared with the previous frame in the photographic image to identify similar points in order to confirm the user's relative distance and displacement distance, so as to ensure that the device's localized position maintains a relative distance in movement. The AR module as a whole can be imported into the application, as shown in **Figure 3**. The use of AR in the AIoT course provides a novel way with learning and thinking. The student not only views the 3D image of the sensor but tries to plan and deploy through 3D AR sensors in actual field scenes. Compared with the traditional way of thinking through pen and paper or slides, the AR can help students more easily think about problem solving and improve AIoT practice implementations.

Introducing the AR Application Into CT Planning

In this study, students who took the AIoT application practical courses were recruited as participants to help establish an AIoT curriculum. The curriculum plan is shown in **Figure 4**.

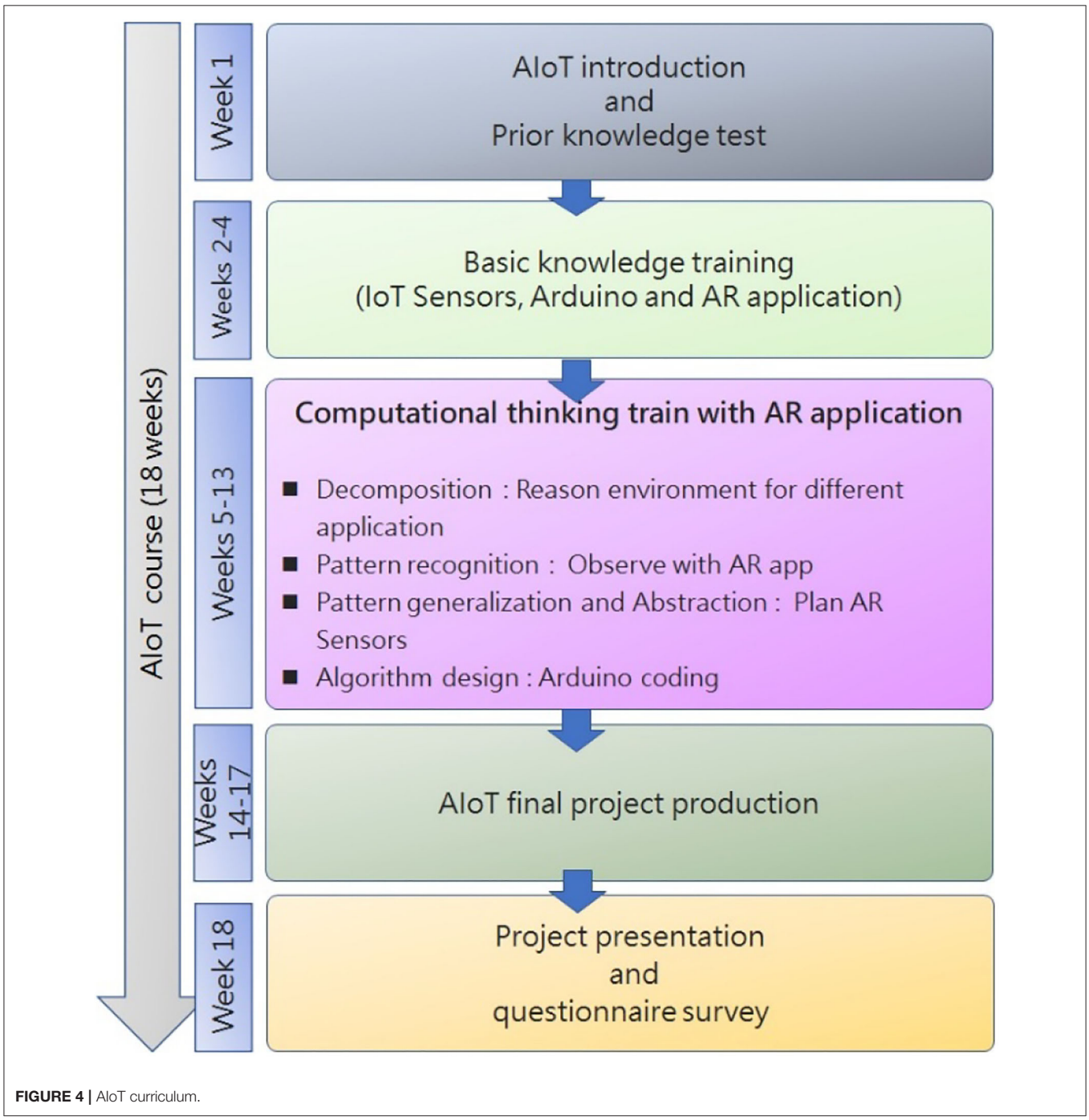

FIGURE 4 | AIoT curriculum.

Week 1 of the 18-week course introduced AIoT and the learning objectives. Students took a prior knowledge test on AIoT and AR to evaluate their preexisting abilities. Weeks 2–4 introduced sensor components, IoT Arduino coding, and AR application operation methods. In Weeks 5–13, students were divided into groups for three sessions of CT training. Each group used fixed sensors for various applications. Based on considerations of the scenarios' accessibility to the students, the selected applications included smart agriculture, smart homes, smart campuses, smart lighting, and smart transportation. Each training cycle lasted 3 weeks. In the first of each training cycle, students were asked to study the problems in the actual application environment, think about the problem in the context of AR applications, and select suitable AR sensor modules for placement design. In the second week, students were asked to think about the algorithms and coding required for each sensor based on the AR design plan. In the third week, each group was asked to present their report. As part of our research objectives, the AR module was used to teach AIoT courses in order to foster CT competence in the following four categories.

In the final specifying weeks of the course, each student used sensors to solve related problems independently. At the end of the semester, internal and external reviewers were invited for the project review. Each final project presentation was reviewed by an advisor and two professional industry experts. The rubric for the review was based on CT competences, including algorithmic thinking, creativity, logical thinking, and problem-solving skills. The total score was used as an indicator of the students' personal learning feedback and motivation. Higher scores indicated stronger learning motivation, and vice versa.

EXPERIMENTAL ANALYSIS

Data Collection

A total of 96 IoT students from two classes were invited to participate in the experiment. A total of 91 students completed the course and filled out the survey at the end of the semester. Due to the small number of participants, partial least squares structural equation modeling (PLS-SEM) was used to analyze the data (Henseler et al., 2009; Hair et al., 2014). This study's sample size was based on the 10-times rule, which proposes that 90 samples are required to investigate nine indicators (Chin and Newsted, 1999).

Data Collection

SmartPLS was used to analyze the relevant data from the survey. Data for survey items PU3 and BI2 were excluded because their factor loadings were below 0.7. The PU3 item is that I can shorten the time of learning AIoT with AR apps, and the BI2 item is that I am willing to spend some time in AR application to learn AIoT technology. Through detailed interviews, it is found that the main reason is that some students believe that the BI2 item requires extra time to study after class, which results in answer errors. Moreover, some students do not agree with AR corresponding to shortening the learning time according PU3. The results of the subsequent analysis are shown in **Table 1**. All items had a Cronbach's alpha and rho_A >0.7; the composite reliability (CR) of prior knowledge and cognitive load was slightly <0.7 but still within an acceptable range (Fornell and Larcker, 1981). The average variance extracted (AVE) for all items was >0.5, satisfying the criteria for the convergence validity of variable variances.

The discriminant validity of each construct was evaluated using the heterotrait–monotrait ratio (HTMT), and the results are shown in **Table 2**. All constructs met the requirements for correlation discriminant validity, at <0.9 (Henseler et al., 2016).

Bootstrapping, with 5,000 iterations, was then used to calculate the t-value, p-value, and R^2-value. The overall structure diagram is shown in **Figure 5**. According to the structural equation, students' intent to use the AR AIoT application was influenced by perceived usefulness and perceived ease of use. The overall R^2 value is 0.105, but the overall effect was small and was not affected by the technological cognitive load. Furthermore, students' intentions had corresponding effects on their CT competency performance in creativity, logical thinking, and problem solving. Thus, the results show that the introduction of AR AIoT into the course had a significant impact.

DISCUSSION AND STUDY LIMITATIONS

This study attempted to an AIoT course, aiming to integrate an AR application and CT competency to help students foster

TABLE 1 | Construct validity analysis.

	Cronbach's alpha	rho_A	CR	AVE
PK	0.713	0.724	0.682	0.624
PU	0.814	0.805	0.812	0.614
PE	0.751	0.812	0.802	0.754
CL	0.702	0.713	0.681	0.620
BI	0.852	0.852	0.715	0.574
AT	0.913	0.892	0.845	0.752
CR	0.721	0.745	0.785	0.542
LT	0.851	0.881	0.892	0.621
PS	0.749	0.785	0.712	0.674

TABLE 2 | HTMT of each construct.

	PK	PU	PE	CL	BI	AT	CR	LT	PS
PK									
PU	0.851								
PE	0.525	0.612							
CL	0.641	0.415	0.528						
BI	0.645	0.542	0.428	0.745					
AT	0.741	0.852	0.314	0.641	0.514				
CR	0.645	0.841	0.745	0.854	0.486	0.514			
LT	0.558	0.765	0.354	0.456	0.487	0.745	0.654		
PS	0.584	0.648	0.854	0.674	0.645	0.645	0.548	0.674	

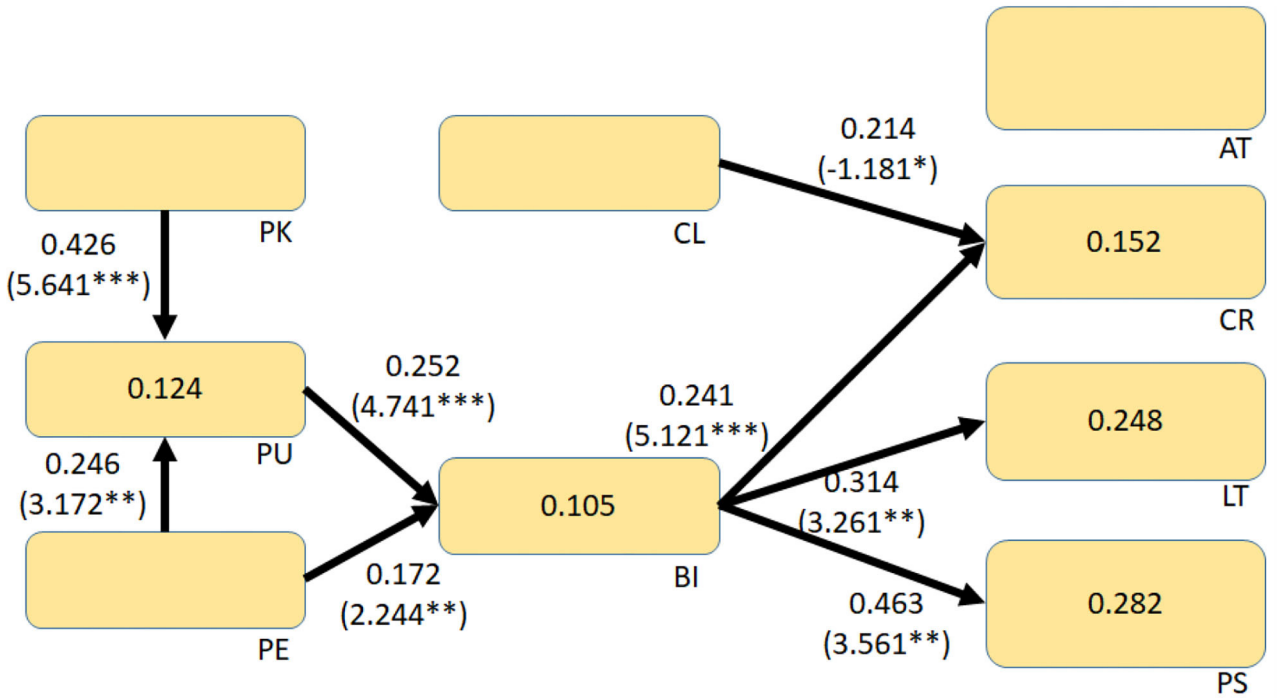

FIGURE 5 | Structural equation model. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

problem-solving skills and omitting creativity. This research model mainly explores the impact of the proposed AIoT learning on students' cognition, use intention, and CT skills under different prior knowledge and cognitive load situations. The following conclusions were drawn based on our results:

1. The proposed AIoT learning impacted CT competency performance.

   According to the results of the analysis, the introduction of the AR AIoT application designed in this study had an impact on CT competency performance in the areas of creativity, logical thinking, and problem solving. This shows that compared to having students think through problems in a regular classroom setting, the AR AIoT application allowed students to understand problems within actual scenarios and further refine overall application planning through the placement of AR sensors. The prior knowledge mainly explores the influence of students on the overall AR use intention to varying degrees. Perceived ease of use mainly explores whether students are easy to use AR applications, and its main impact is the design of AR applications without prior knowledge. However, prior knowledge is only relevant to cognitive usefulness but not to cognitive load and learning motivation. According to the results of the detailed interviews, some students believe that their main influence is on the ease of use of the application, and this application will continue to modify the user interface to improve the intention of use.
2. The AR application had No impact on cultivating students' algorithmic thinking of CT skills.

   Among the CT competences, algorithmic thinking mainly corresponds to programming and algorithm selection skills. In contrast, although the AR application can help students understand problems, at the current stage, it is still necessary to use computer programming for course coding exercises. Therefore, in this regard, the application does not improve the effectiveness of students' programming skills or algorithm exercises.
3. The technological cognitive load had little effect on students.

   In this study, it was originally hypothesized that the cognitive load of science and technology may affect students' usage intentions and learning outcomes (Radu, 2014). However, according to the experimental results, no effect was found on usage intention. The influence on CT competences was limited to negative effects on creativity. Thus, it can be speculated that at the current stage, this study mainly tested participants from the information discipline who had a certain level of prior knowledge and familiarity with AR applications; hence, the effect of this factor is not significant.

   Since the course used in this study is a course for information technology professionals, the study's results cannot be extended to the AR application's impact on usage intention and cognitive load in a non-information professional context. Future studies should attempt to help students cultivate algorithmic thinking using relevant technological approaches and conduct tests in non-information education fields.

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-SL proposed the whole research model theory and literature research. S-YC design 3D AR models and mobile apps. C-WT collect questionnaire data and analysis. Y-HL carried out course teaching and experimental design. All authors contributed to the article and approved the submitted version.

ACKNOWLEDGMENTS

The authors would like to thank the Ministry of Science and Technology of the Republic of China, Taiwan, for supporting this research under Contract MOST 108-2511-H-143-001 and MOST 109-2511-H-143-002.

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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.

frontiers in Psychology

ORIGINAL RESEARCH
published: 18 March 2021
doi: 10.3389/fpsyg.2021.634993

The Use of Deep Learning and VR Technology in Film and Television Production From the Perspective of Audience Psychology

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As the development of artificial intelligence (AI) technology, the deep-learning (DL)-based Virtual Reality (VR) technology, and DL technology are applied in human-computer interaction (HCI), and their impacts on modern film and TV works production and audience psychology are analyzed. In film and TV production, audiences have a higher demand for the verisimilitude and immersion of the works, especially in film production. Based on this, a 2D image recognition system for human body motions and a 3D recognition system for human body motions based on the convolutional neural network (CNN) algorithm of DL are proposed, and an analysis framework is established. The proposed systems are simulated on practical and professional datasets, respectively. The results show that the algorithm's computing performance in 2D image recognition is 7–9 times higher than that of the Open Pose method. It runs at 44.3 ms in 3D motion recognition, significantly lower than the Open Pose method's 794.5 and 138.7 ms. Although the detection accuracy has dropped by 2.4%, it is more efficient and convenient without limitations of scenarios in practical applications. The AI-based VR and DL enriches and expands the role and application of computer graphics in film and TV production using HCI technology theoretically and practically.

Keywords: AI technology, convolutional neural network, film and TV production, Computer Graphics, human-computer interaction

OPEN ACCESS

Edited by:
Mu-Yen Chen,
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Reviewed by:
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Southern Taiwan University of Science and Technology, Taiwan
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Specialty section:
This article was submitted to Human-Media Interaction, a section of the journal Frontiers in Psychology

Received: *29 November 2020*
Accepted: *05 February 2021*
Published: *18 March 2021*

Citation:
Tong Y, Cao W, Sun Q and Chen D (2021) The Use of Deep Learning and VR Technology in Film and Television Production From the Perspective of Audience Psychology. Front. Psychol. 12:634993. doi: 10.3389/fpsyg.2021.634993

INTRODUCTION

In recent years, as artificial intelligence (AI) technology develops continuously, algorithms and technologies based on deep learning (DL) have gradually permeated various aspects of daily life, and film and TV production are one of them (Lyczba, 2019). Films and television, especially films, are closely related to technologies. Films are born out of a technological revolution, and the developments of each technology bring changes to the film production industry (Kim, 2019). People are suffering from incredible pressure in modern society, and they walk into the cinema for the vent of emotions and audiovisual enjoyment. Film and TV special effects technologies are an effective means to create these audiovisual effects (Chen, 2019). The reality reflected by film and TV special effects is visual psychological reality.

As an industrial production, a means of communication, and an art form, films have always depended on technological innovation. The technology's application in films plays an important role in films' expressions. The pictures' movements and the images' modeling are

significant characteristics of the films. Films can be more attractive through excellent picture movements and image modeling (Belyaev et al., 2020). A film is an art form subject to mass media, and its visual appreciation can satisfy and comfort the audiences (Matbouly, 2020). Therefore, better usage of technologies in modeling and movements provides the audiences with a better experience and psychological feelings, so that the audiences look forward to the visual effects and scenes (Schmlzle and Grall, 2020). Meanwhile, how to better apply AI technology, especially the technology related to film and TV production, to bring more exciting and lifelike experience to the audience is also widely concerned (Abbasi and Jamei, 2019). Communication technology is also one of the critical contents in films and TV interface design. Human-computer interaction (HCI) technology provides numerous information and prompts through output or display devices. In turn, people will feed back relevant information, answers to the questions, and prompts to the computer through input devices. However, there are still some shortcomings in the real-time performance of the existing technologies, and the technical solutions that can meet the needs of multiperson, real-time, and 3D attitude data output at the same time still need to be studied. Meanwhile, there is also a lack of complete technical solutions of acquisition, analysis, output, and operation. Therefore, a series of technical solutions based on neural network structure to realize real-time human posture recognition and runtime output are proposed, which have better performance than traditional technologies for real-time, multiperson, 3D posture recognition and other requirements.

This exploration aims to study the application of virtual reality (VR) technology and DL-based technology in the field of HCI, the significance of the technology to the production of modern film and television works, and its impact on the audience's psychology under the development of AI technology. In film and TV production, audiences have a higher demand for verisimilitude and immersion of the works, especially in film production. Based on this, a 2D image recognition system and a 3D recognition system for human body motions based on the convolutional neural network (CNN) algorithm of DL are proposed; an analysis framework is constructed. The proposed systems are simulated on practical and professional datasets, respectively.

METHODS

Film and TV Production and Audience Psychological Changes With HCI Technology

In the AI technology era, VR and DL technologies based on DL have gradually permeated the film and TV industry, especially the film production industry (Nauryzbaev and Shomanova, 2018). Today's films have undergone dramatic changes from contents to forms. Such changes are brought about by the development of human society and technology, which are also products of the continuous changes in human aesthetic needs and audience psychology (Zhu, 2018). Digital technology breaks the restoration and shaping of the real world in film and TV operation, especially in film production. With brand-new AI technology, scenes and objects that do not exist in the real world can be created in films; images of different times and spaces in the real world can be combined, and real images and the illusory images can even be juxtaposed. Therefore, the audiences are immersed and enjoy the unprecedented audiovisual experience by integrating senses such as vision, hearing, gustation, and touch (Raney et al., 2018). Nowadays, human-computer interactive films, known as third-generation films, are also quietly changing the film industry. HCI is the most crucial factor that reflects the relationship between humans and technology. It makes the most sophisticated intelligent body, human, and the computer's automatic control system form a larger self-feedback loop. The audiences can experience the scenes and images in the movie through increasingly realistic virtual images. They can have a continuous sense of movement watching a single still image, which is also inseparable from audiences' psychological activities (Rogers, 2020). Except for the audiences' physiological "persistence of vision," the motion on the screen is originated from the fabrication of the audiences' psychological activities. Immersion glasses based on VR combined with multimode HCI improve the user's perception through VR glasses and multimode technology. Moving pictures are organized through the still pictures with personal thoughts, thus forming the cognitive experience of the "moving screen." With psychological influences, the audiences fully recognize and accept this false movement (Hamilton-Webb et al., 2019).

Research on the audiences' thinking modes and social life background reveals that their lives are inseparable from digital technologies in many aspects in the 21st century and full of AI-, VR-, and HCI-based products, which bring various convenient entertainment for them (Gruenewald and Witteborn, 2020). After digital technology is introduced to film production, boasting virtual effects in the illusory space fully meet the audiences' aesthetic expectations and needs in film language and picture effects (Harkema and André, 2020). Visual impacts are the most substantial aesthetic feelings that digital special effects bring to the audiences, which is a significant source of the film's visual aesthetics (Bramley et al., 2018). The 3D images' presentation, the digital Dolby sound system, and the VR technology's application have broken the pure visual appreciation limitations, and "watching" films becomes a multisensory aesthetic perception (Wu et al., 2019, 2020). In the dimension of film and TV production, animated film is taken as an example. The traditional animation production mode mostly uses the centralized way to make and render. After the emergence of 6G DL technology, it can achieve a high degree of computing and storage, which makes distributed cross-domain collaborative production possible. For example, DL +4k/8k shooting will realize real-time shooting, real-time transmission, cloud rendering, and cloud production. It achieves remote processing and multipoint coproduction, and effectively improves the efficiency and effect of film shooting; DL +VR/AR fully meets the new service requirements of the film and TV entertainment industry.

The new way of emotional experience involves almost all human sensory functions. The "concretization" of thinking, emotions, sounds, visions, touches, and inductions in the films

advances the original experience to an all-around experience, which is more authentic and profound (Colonnese and Phillips, 2018). The audiences in traditional film-watching feel alienated from the films due to the alienation 2D screen brings. However, the existing VR imaging technology's verisimilitude closes the gap between the subjects and the traditional objects in film watching. In 3D film production, the torus space is continually advancing toward realism in the virtual environment (Changwook et al., 2018). The AI-based DL algorithms' application and practice in film and TV production are analyzed, and a 3D film and TV production method based on CNN is proposed.

Human Action Recognition in 2D Images Based on CNN of DL

Many film companies have adopted schemes based on visual markers or sensors. The actors/actresses wear special clothing with visual markers or sensors. Then, a unique system is used to capture the positions of the human body's joints, thereby realizing human motion capture (Rogoza et al., 2018). Each camera estimates the human body motion in the 2D image in the current shooting frame according to the visual markers; next, the estimation results of multiple cameras are combined to generate the 3D motion data. Thus, the corresponding virtual character's actions are generated according to the data collected.

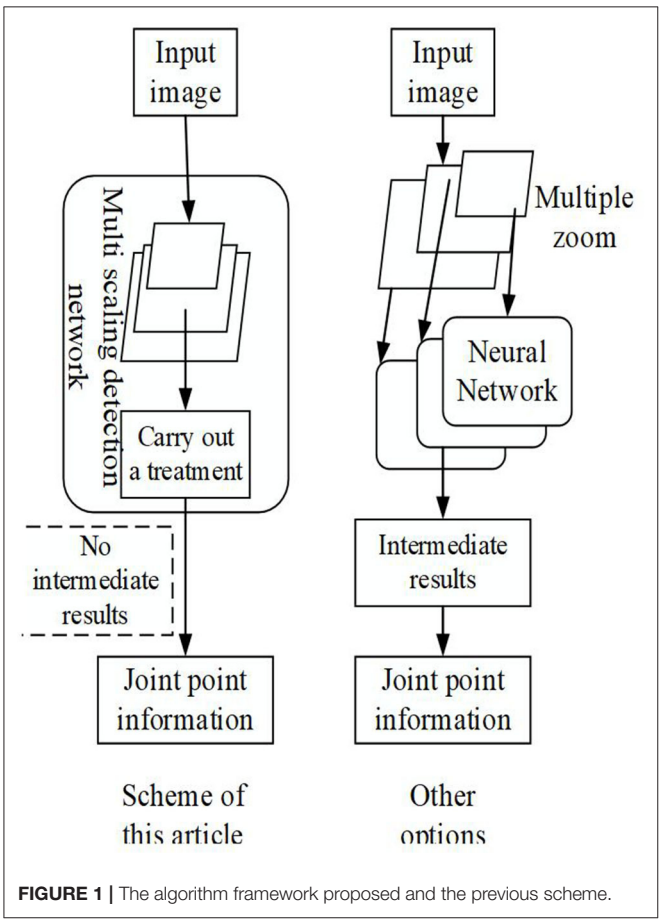

FIGURE 1 | The algorithm framework proposed and the previous scheme.

However, this scheme cannot fully meet the application needs, and there are still many limitations in practice. One reason is the limited real-time performance (Lv et al., 2014, 2017). Only Open Pose's high-end GPN can meet the real-time requirements, while the low-end cannot (Eline and Reijne, 2018). Many 3D motion estimation technologies that claim to be real-time rely on high-quality 2D image motion input, which takes time (Saunders et al., 2019). The other reason is that there are currently no complete schemes for 2D image motion extraction, 3D motions, and estimation. Therefore, many films, games, and VR companies need complete and impeccable schemes (Nie et al., 2019).

A single camera's RGB image is input to the proposed 2D image motion detection framework. Positions of the key points and some auxiliary information for key point groupings are output through the original neural network structure. Final positions for the human body's key points in images are obtained through the post-processing algorithms.

Figure 1 suggests that compared with other similar schemes, the scheme proposed can detect multiple scales in one execution without intermediate result representation, achieving the end-to-end and high-speed effects. Feature Pyramid Network (FPN) is adopted here to transform the human body movements in the 2D images into a form suitable for neural network output; it means that the human body movements are regarded as modeling, including multiple joints, as shown in **Figure 2**.

Each human joint point contains the information about the center 2D coordinates of the joint point, the type of the joint point, and the parent node. Since the full convolutional network (FCN) can only output the feature map, the preceding three kinds of information should be encoded into the feature map. Therefore, for the point (x, y) on the feature graph, the

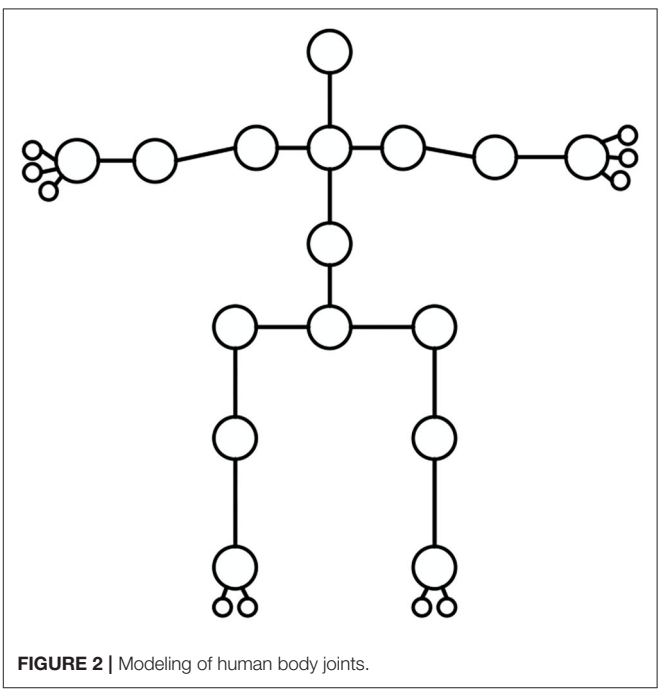

FIGURE 2 | Modeling of human body joints.

corresponding feature vector is:

$$\{P_C, TargetOffset\} \quad (1)$$

Among them, P_C represents the probability of the joint point type corresponding to the current position (x, y), while the 2D vector *TargetOffset* represents the relative offset between the coordinates of the parent node and the current joint point.

Therefore, for an input image with given width and height, the network will generate a Heatmap feature map and offset feature map. The feature vector with position (x, y) in Heatmap indicates the joint point type probability corresponding to the current point (x, y). Its value is the following vector:

$$\{P_{head}, P_{neck}, P_{shoulder}, P_{arm}, P_{hand}, P_{pelvis}, P_{knee}, P_{foot}, P_{background}\} \quad (2)$$

The network using offset position for output is selected instead of directly outputting the memory address of the target joint, because there is no good solution to achieve this goal. The network is required to directly output the offset of the target position, use a simple search to find the corresponding joint points near the target position, and connect them. Based on the above network task design, the corresponding end-to-end network structure is proposed.

ResNet34 is used as the network front-end structure, and the residual structure is adopted. After multiple rounds of convolution, the input image is scaled to a particular size. The deeper network performance can be effectively improved through residual links among layers. On this basis, if each convolutional feature map of CNN is detected separately, the feature pyramid hierarchy used here is generated. The lower-level convolution modules can detect more detailed objects, and the higher-level can detect larger ones. Thus, multiscale problems of the detected objects are well-solved. Meanwhile, the neural network loss function *Loss* is determined as:

$$Loss = Loss_{classification} + Loss_{target} \quad (3)$$

$$Loss_{classification} = \sum_{y=0}^{height} \sum_{x=0}^{width} \sum_{m}^{9} (C - \hat{C})^2 \quad (4)$$

$$Loss_{target} = \sum_{j=0}^{height} \sum_{i=0}^{width} ((x - \hat{x})^2 + (y - \hat{y})^2) \quad (5)$$

$Loss_{classification}$ is the classification loss; $Loss_{target}$ represents the target position loss; m represents the target position point; x and y are the horizontal and vertical coordinates of the target position point.

The Microsoft COCO dataset is a 2D image dataset provided by Microsoft, which is widely used in tasks such as target detection, motion detection, semantic segmentation, and power segmentation (Ma et al., 2019). It contains information about the human body key points in various scenarios. The COCO action detection dataset contains 120,000 sample pictures, including about 64,000 sample pictures of people. The 2D coordinates of the human body key points are manually labeled for these pictures (Tian et al., 2019). Therefore, the information of this dataset is chosen, and a series of data enhancement strategies is adopted to prevent overfitting, including images' random scaling and cropping, horizontal inversion, and random rotation to a certain angle.

3D Human Motion Presentation Based on CNN of DL

A 3D estimation algorithm for body motions with a single camera is proposed based on the DL-based 2D image recognition algorithm for human body motions. Compared with the 2D image recognition algorithm for human body motions, the 3D estimation algorithm for human body motions is much more difficult and complicated (Xu and Schiavone, 2019). A new multitask and multilevel motion estimation neural network algorithm is designed to estimate human postures through the joint positions in 3D space. As RGB images are input, motion joint positions in 2D images, deep information, and connection information are generated. The post-processing system generates all human body poses based on the information. This algorithm's effectiveness is verified by training real-life tasks with virtual datasets.

Figure 3 indicates the neural network algorithm's network structure for multitask and multilevel motion estimation of 3D human body motions. For a given image input, CNN is used for processing. Its three branches can produce three different outputs, and each output encodes a type of information used to reconstruct 3D motions. Quick post-processing reconstructs the final 3D motions through the input of three types of information.

Multitask neural networks are used to output 2D image motion information and 3D stereo information simultaneously (Sadak et al., 2019). A multilevel detection structure is used to maintain speed and accuracy. The second post-processing involves detecting, linking, and automatically matching the poses in the 2D image space and the depth in the 3D space (Shen et al., 2020).

As the 2D image recognition system for human body motions, the 3D human body motion is regarded as a directed graph, in which each joint point corresponds to a human body joint point M. Each joint point contains the following information:

$$(Class_m, X_m, Y_m, OffsetX_m, OffsetY_m) \quad (6)$$

$Class_{\mathrm{m}}$ donates the type of the current joint point, X_{m} and Y_{m} represent the current joint point's 2D coordinates, D_{m} is the distance between the current joint point and the camera, and $offsetX_{\mathrm{m}}$ and $offsetY_{\mathrm{m}}$ are the relative offset from the joint parent point of the current joint point to the current joint point.

From the pose-linking process, the 2D position can be reused. Therefore, depth D is the only additional information needed. According to the network output, the post-processing execution map F will convert 2D limb joint points to 3D space in the following ways:

$$F(X_j, Y_j, D) \rightarrow (X_{3D}, Y_{3D}, Z_{3D}) \quad (7)$$

The depth value is encoded as the relative depth of the world space, which is to make the mean value of the probability distribution of the depth value of the joint point as 0 as far as

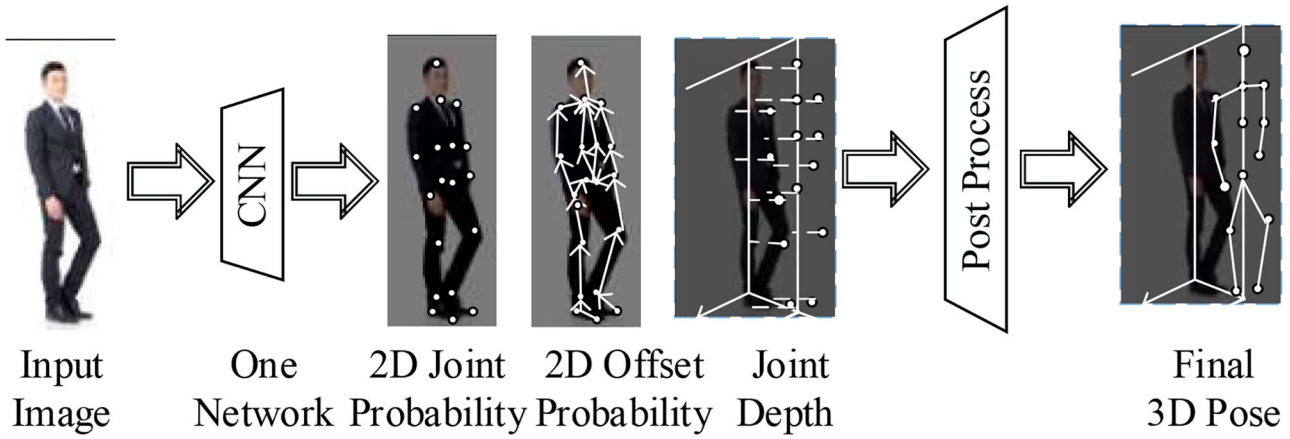

FIGURE 3 | The network structure framework of the 3D estimation algorithm for human body motions.

possible, in order to facilitate the learning of the neural network. The reason why relative depth is easier to learn than absolute depth is that it has nothing to do with the position of human body and only needs local information. This is consistent with the characteristics of CNN local receptive field.

The target joint point's position is calculated first to connect the joint points.

$$(TargetX_m, TargetY_m) = (X_m + OffsetX_m, Y_m + OffsetY_m) \quad (8)$$

A circular area with ($TargetX_m$, $TargetY_m$) as the center and R as the radius is searched. If there is a corresponding joint in a correct category in the circle, the current joint is linked to that joint. The search radius is calculated based on the target distance because the farther the parent joint is, the greater the errors are. **Figure 4** shows the specific calculation method.

$$l = \sqrt{OffsetX_m^2, OffsetY_m^2} \quad (9)$$

$$R = max(l * \alpha + (1 - \alpha), 1) \quad (10)$$

$Scale_{\text{depth}}$ is quickly calculated and multiplied by *Depth*, so that the correct human joint positions in camera space can be estimated without obtaining camera information.

3D pose-detection dataset rendered by computer graphics is used to assist training, which is an important part of training 3D pose recognition system. Joint Track Auto (JTA) datasets are selected for training. The source of data collection is Rockstar's game Grand Theft Auto 5. It adopts a physics-based rendering architecture, which can produce high-precision character animation. In addition, it contains many images of people with different postures and costumes for use and lots of scenes, and provides a variety of weather.

RESULTS AND DISCUSSION

Action Recognition Results of 2D Video Images

A series of algorithms in computer vision and image processing is invoked to expedite the research progress and improve the accuracy, and an open source algorithm library is used for some basic algorithms. The Open CV algorithm library is used in the image pre-processing and post-processing stages. The performance and result differences between the proposed scheme and the most widely used Open Pose are compared. The performance of the proposed algorithm and the Open Pose on the GTX 1050 graphics card is 35 and 4.7, respectively, while that on the GTX 1060 graphics card is 58 and 6, respectively. According to the results, in the software environment of CUDA9.2 and Tensorflow-gpu1.10, the performance of the proposed algorithm is 7–9 times higher than that of the most widely used and effective Open Pose under different hardware conditions (Zuixiong, 2020).

Open Pose human posture recognition project is an open source library with Caffe as the framework, which is developed by Carnegie Mellon University (CMU) based on CNN and supervised learning. It can realize the pose estimation of human action, facial expression, finger movement, and so on. It is suitable for single person and multiperson, and has excellent robustness, which is the first real-time multiperson 2D attitude estimation application based on DL in the world. A series of algorithms in the field of computer vision and image processing need to be called. In order to speed up the research progress and accuracy, some basic algorithms are directly called in the form of open source algorithm library. The Open CV algorithm library is called in the image preprocessing and post-processing phase, and the post-processing phase is written in C++ language (Cao et al., 2019).

Adam RMSprop with Nesterov momentum optimizer is used. The initial learning rate is set to 0.002. The adaptive learning rate decay of Keras is utilized. When the training loss function

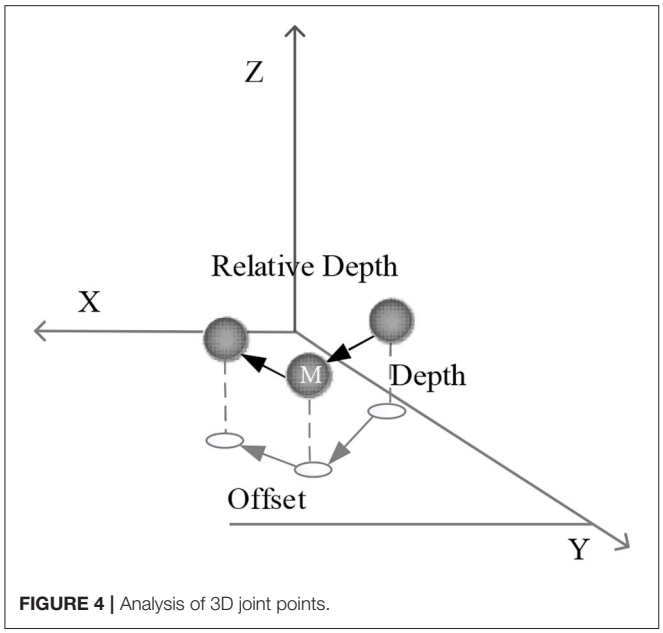

FIGURE 4 | Analysis of 3D joint points.

TABLE 1 | Detection accuracy comparison between the proposed algorithm and classification algorithm.

	Network link mapping (%)	Classification algorithm (%)
Accuracy detection	49.8	52.2
Trade-off		2.4

continuously traverses the train set for five times without decreasing, the learning rate is divided by 10.

Table 1 reveals the detection accuracy comparison between this algorithm and the classification algorithm for human body motions in 2D images.

The results prove the detection accuracy comparison between this algorithm and the classification algorithm for human body motions in 2D images in the Microsoft COCO dataset. Although the detection accuracy of the proposed algorithm is 2.4% lower, it has better real-time performance and fewer application scenarios limitations according to the operating performance.

3D Animation Presentation

Obtaining high-quality 3D stereo datasets is not easy, which hinders the 3D motion estimation research. One method of dataset capture is to use special clothing with sensors or markers. This type of clothing is often in black with complicated markers, limiting the scope of the characters' dressing.

For the data module, multiple dataset interfaces are designed first. There are two training datasets with different formats, so it is necessary to convert them into the same format through the dataset interface. Then, the Tensor Pack parallel sample generator loads the data of these dataset interfaces and integrates them into the final samples. Python language supports two parallel modes: multithreading and multiple processes. Python multithreading is limited by the global interpreter lock and can only load one bytecode instruction to execute at a time. Multiple processes communication is also very complex. Therefore, Tensor Pack library is selected to assist the parallel design.

TABLE 2 | Performance and speed comparison among the proposed algorithm and other schemes.

Method		MPJPE (mm)	Speed (ms)
Open pose	High accuracy	68.7	794.5
	High-speed mode	75.4	138.7
Method of this article		81.2	44.3

The neural network algorithm of multitask and multilevel 3D body motion estimation is evaluated in the test set of the JTA dataset. The RGB images are input and Mean Per Joint Position Error (MPJPE) is used to measure the network performances. **Table 2** shows the test results.

First, the 2D detection branch of the MS COCO 2014 dataset training network is used to initialize the network. Then, each time, a sample is randomly selected from the 2D or 3D dataset. It is considered that the use of training methods can make the training process more stable and shorten the training time. Not only 2D datasets or 3D datasets are used, but also a phased and random hybrid training strategy is used. On the one hand, it is hoped to solve the problem of long training time as much as possible. On the other hand, although the latest rendering scheme is used in the JTA dataset to produce high-quality images, such data still cannot be completely equivalent to the actual images taken in real life. Some real images are still needed to improve the generalization ability of the network in real scenes.

Therefore, first, the MS COCO 2014 dataset is used to train the two branches of 2D separately. This is equivalent to training a 2D pose recognition network. Since only one branch participates in the training, the number of parameters and the number of layers of the network are reduced, so the forward propagation and back propagation speed of the network are improved. 50–100 epochs are trained as the initialization of the network.

Next, JTA dataset + MSCOCO dataset are used for joint training. The specific methods are as follows.

1. A set of random numbers with 0-1 distribution is generated, whose length is equal to Batch size.
2. According to 0-1 distribution, loading data from JTA dataset or MSCOCO dataset is selected to form a Batch of training data.
3. For the dataset from MSCOCO, the back propagation of Depth branch is masked.
4. This Batch is added to training.

By using this training strategy, the accuracy of the network in the real pose detection task is successfully maintained, which is 5% higher than using only JTA dataset.

The results suggest that the running speed of the neural network algorithm of multitask and multilevel 3D body motion estimation is 44.3 ms, much lower than the Open Pose's 794.5 and 138.7 ms. Its MPJPE result is 81.2 mm, slightly higher than

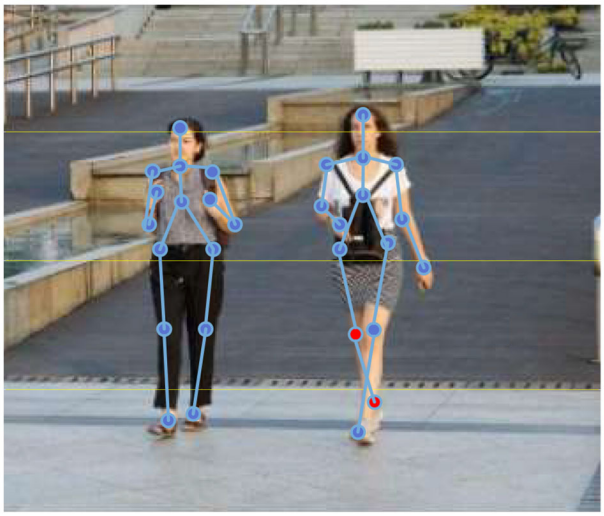

FIGURE 5 | The joint points recognition of the 3D motion in the JTA dataset.

the Open Pose's 68.7 and 75.4 mm. It indicates that the proposed algorithm is more efficient and convenient in practice.

The 3D motion detection dataset rendered by computer graphics is used to assist training, which is a significant part of the 3D human motion system training. **Figure 5** shows the 3D human motion recognition in the JTA dataset based on the multi-level-detection neural network framework.

The red joint points in the figure are the covered secondary joint points. The results prove that the proposed algorithm performs excellently with high accuracy recognition in 3D human body motions in the JTA dataset. It contains numerous information, such as people with different actions and in different clothes, and scenes in various weather conditions.

CONCLUSION

As AI technology's development, impacts of the DL-based VR technology and the DL technology on modern film and TV works production and audience psychology are studied. New technology developments promote new aesthetics in the era. In film and TV production, audiences have an increasing demand for verisimilitude and immersion of the works, especially in film production. Therefore, a 2D image recognition system for human body motions and a 3D recognition system for human body motions based on the CNN algorithm of DL are proposed here, and an analysis framework is established. The proposed systems are simulated on practical and professional datasets, respectively.

The results show that the computing performance of this algorithm in 2D image recognition is 7–9 times higher than that of the most widely used Open Pose method in software of CUDA9.2 and Tensorflow-gpu1.10. Although the detection accuracy has dropped by 2.4%, it is more efficient and convenient without limitations of scenarios in practical applications. The running speed of the neural network algorithm of multitask and multilevel 3D human body motion estimation is 44.3 ms, much lower than the Open Pose's 794.5 and 138.7 ms. Its MPJPE result is 81.2 mm, slightly higher than the Open Pose's 68.7 mm, and 75.4 mm, but it is more efficient and convenient in practice. Meanwhile, this algorithm performs excellently in the JTA dataset.

Real-time pose recognition and human pose generation technology based on DL are mainly explored. In computer graphics, human posture is extracted, analyzed, and transformed into 3D animation data that can be used in computer programs, and then it is output in real time, which is a very important application in computer graphics.

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 Gachon University Ethics Committee. The patients/participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

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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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.

frontiers in Psychology

ORIGINAL RESEARCH
published: 30 March 2021
doi: 10.3389/fpsyg.2021.642347

Attention-Based Deep Entropy Active Learning Using Lexical Algorithm for Mental Health Treatment

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With the increasing prevalence of Internet usage, Internet-Delivered Psychological Treatment (IDPT) has become a valuable tool to develop improved treatments of mental disorders. IDPT becomes complicated and labor intensive because of overlapping emotion in mental health. To create a usable learning application for IDPT requires diverse labeled datasets containing an adequate set of linguistic properties to extract word representations and segmentations of emotions. In medical applications, it is challenging to successfully refine such datasets since emotion-aware labeling is time consuming. Other known issues include vocabulary sizes per class, data source, method of creation, and baseline for the human performance level. This paper focuses on the application of personalized mental health interventions using Natural Language Processing (NLP) and attention-based in-depth entropy active learning. The objective of this research is to increase the trainable instances using a semantic clustering mechanism. For this purpose, we propose a method based on synonym expansion by semantic vectors. Semantic vectors based on semantic information derived from the context in which it appears are clustered. The resulting similarity metrics help to select the subset of unlabeled text by using semantic information. The proposed method separates unlabeled text and includes it in the next active learning mechanism cycle. Our method updates model training by using the new training points. The cycle continues until it reaches an optimal solution, and it converts all the unlabeled text into the training set. Our in-depth experimental results show that the synonym expansion semantic vectors help enhance training accuracy while not harming the results. The bidirectional Long Short-Term Memory (LSTM) architecture with an attention mechanism achieved 0.85 Receiver Operating Characteristic (ROC curve) on the blind test set. The learned embedding is then used to visualize the activated word's contribution to each symptom and find the psychiatrist's qualitative agreement. Our method improves the detection rate of depression symptoms from online forum text using the unlabeled forum texts.

Keywords: adaptive treatments, internet-delivered interventions, NLP, text clustering, word sense identification

OPEN ACCESS

Edited by:
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Reviewed by:
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Specialty section:
This article was submitted to Human-Media Interaction, a section of the journal Frontiers in Psychology

Received: *15 December 2020*
Accepted: *03 February 2021*
Published: *30 March 2021*

Citation:
Ahmed U, Mukhiya SK, Srivastava G, Lamo Y and Lin JC-W (2021) Attention-Based Deep Entropy Active Learning Using Lexical Algorithm for Mental Health Treatment. Front. Psychol. 12:642347. doi: 10.3389/fpsyg.2021.642347

1. INTRODUCTION

According to a new World Health Organization (WHO) survey, the COVID-19 pandemic has disrupted mental health services in 93% of countries worldwide[1]. In contrast, mental health demand has increased due to lockdown of affected areas as a prevention measure. Any lockdown results in increasing physiological stress factors that include fears of illness and uncertainty of the future (Troyer et al., 2020). Social isolation, lack of interactions during education, and/or work also causes emotional stress resulting in a generally worse state for public mental health. Front-line health workers also suffer from anxiety and depressive symptoms due to fear of illness, lack of protective equipment, social disconnection, and a high-stress environment. Depression instances have been shown to be high during lockdown (Karmen et al., 2015). Initially, it is a reaction to life that a person never imagined. Since there are many unknowns to what causes depression, various things are often connected to its research. Diverse information provided by vast and growing literature includes various reports on how to tackle depression. Extracting useful knowledge is still difficult because of these conflicting reports (Ebadi et al., 2020). A combination of recent events and longer-term and/or personal factors trigger depression rather than just a single immediate issue or event (Mukhiya et al., 2020a). Although everyone is different, identifying the cause or change in difficult circumstances cannot be possible always (Losada and Gamallo, 2018). The most important thing is to recognize the early signs and symptoms for depression and seek support at an early stage. Nowadays, numerous Internet forums and social media platforms enable individuals to contact each other and share their suffering, pain, and potential treatment options anonymously (Low et al., 2020). People worldwide can share their ideas and experiences without being exposed (Mühleck et al., 2019). Online detection can be a proactive and promising approach to distinguish high-risk people. It can encourage timely mediation and can help improve general well-being (Neuraz et al., 2020).

The WHO ranks *depression* as one of the world's most disabling diseases (James et al., 2018). It has become a common illness worldwide, with more than 264 million people affected (James et al., 2018). Depression that goes untreated may become more severe and cause lifelong suffering (Mazza et al., 2020). Depression, at its worst, can lead to suicide. WHO reported that close to 800, 000 people die due to suicide every year (James et al., 2018). Suicide is the second leading cause of death among 15–29-year olds. Between 76 and 85% of people in low- and middle-income countries receive no treatment for their disorder. Barriers to effective care include a lack of resources, lack of trained healthcare providers, inaccurate assessment, and social stigma associated with mental disorders (James et al., 2018). Social stigma, shyness, and anxiety about discussing the problem are the key barriers that keep patients reluctant to treatment. People often feel embarrassed, ashamed, and fear of having to undergo a probing examination of their psychological pain (Mukhiya et al., 2020b). For these reasons, they may not want to acknowledge that they are depressed or seek treatment.

The healthcare systems are facing a global challenge for preventing and treating mental health problems. The overburdened health system faces economic and technical pressure to develop an adaptive system that will reduce waiting time and provide intervention by reducing cost. Internet-delivered Psychological Treatment (IDPT) can help to overcome mental and physical distress for a large population and using fewer resources (Mukhiya et al., 2020b). Most of the existing solutions are tunnel-based, inflexible, and non-interoperable (Mukhiya et al., 2020c). Current models lack adaptive behavior, which in turn results in lower user adherence and more dropouts (Konrad et al., 2015). Treatments should be considerate of methods available for users to adopt the treatments. This user adoption can be achieved by using an IDPT system in a way that user behavior itself should be taken into consideration. This user behavior includes different preferences and needs according to their environment and mental health symptoms(Mukhiya et al., 2020b). In this study, we aim to extract depression symptoms from patient's authored text. We attempt to identify and visualize using the deep attention-based method. Mostly, a given patient expresses their mental health issues in their communication. Based on the patient's own words, we consider the extraction of the factors that result in depression-related symptoms. Using an online interactive tool (ICT) that provides contextual information and visualization for adequate mental health, we aim to assist in providing prevention measures.

This paper address how to extract depression symptoms in mental health interventions using Natural Language Processing (NLP) and attention-based in-depth entropy active learning. For this purpose, we propose the method based on synonym expansion by semantic vectors. We cluster the semantic vectors based on the semantic information derived from the context in which it appears. The resulting similarity metrics help to select the subset of unlabeled text by using semantic information. Our method separates unlabeled text and includes it in the next active learning mechanism cycle. Our method updates the model training by using the new training points. The cycle continues until it reaches the optimal solution, and it converts all the unlabeled text into the training set. The objective of this research is to increase the trainable instances using a semantic clustering mechanism. Our method helps to reduce data annotation tasks and helps in the generalization of the learning system. The proposed framework achieved 0.85 ROC that shows the synonym expansion semantic vectors help enhance training accuracy while not harming the results.

The rest of the paper is structured as follows. Section 2 outlines the related works. Section 3 outlines the main methodology used to set up the experiment, collect data, and build the model. Section 4 discusses the results and findings. Finally, section 5 concludes with summary and future works.

[1]https://www.who.int/news/item/05-10-2020-covid-19-disrupting-mental-health-services-in-most-countries-who-survey.

2. RELATED WORK

Several efforts have been attempted to improve depression detection using computer-aided methodologies. This section provides an overview of approaches that have been proposed in this regard.

Fliege et al. (2005) proposed an Item Response Theory (IRT) based Computer Adaptive Tests (CAT) to measure depressive symptoms (Depression-CAT, D-CAT). They aimed to develop an application using real patient data that measure depressive symptoms severity and promise to enhance measurement precision and reduce respondent's burden. Progress in measurement was achieved by utilizing an adaptive questionnaire rather than a static questionnaire. The information from previously replied questions was utilized to select the next most suitable questions. Asking those most relevant questions for every individual patient's CAT made it conceivable to introduce fewer things and accomplish greater measurement precision over the whole range of a construct. However, some problems remained unresolved. Such as the effect of differences in item order was unknown. It was also unknown that the varying response options within one test influences response behavior.

Lehrman et al. (2012) proposed another technique focusing on automatic analysis of short written texts on the bases of relevant linguistic text features to distinguish whether the authors of such texts are suffering from distress. It performed NLP using supervised machine learning. This study essentially concentrates on some fundamental supervised classification methods and text-based features to automatically classify mental affect states in short texts based on just a small dataset. This technique exemplifies a binary classification problem, where short texts are classified as either distressed or non-distressed. Four text classes were at a more fine-grained level: high distress, low distress, response, and happy. Any post expressing an active intent to harm someone or oneself was classified as high distress, while posts are only discussing bad feelings were usually classified as low distress—the annotated dataset of short written texts for the work. A dataset consisting of 200 posts from various public online forums dealing with mental well-being was utilized. Machine learning algorithms such as Naive Bayes, Maximum Entropy, and Decision Tree were applied to this dataset. They report an accuracy of 54.5% vs. a baseline of 30.5% when classifying four ways based on the level of distress.

Dinakar et al. (2014) presented a stacked generalization modeling approach to analyze online community youngsters under stress. In the first place, they trained an ensemble of base models for predicting individual labels, namely a support vector machine with a linear kernel (SVM-L), a radial basis function kernel (SVM-R), and a stochastic gradient boosted decision trees (GBDT) models. These models are trained for text classification to categorize into 23 themes. The SVM-L, SVM-R, and GBDT for each code were combined into a meta-feature set fed into a meta-classifier. The meta-features are made up of the individual base classifier. Features for base classifiers included unigrams, bigrams, part-of-speech bigrams, and tf-idf filtered via chi-squared feature selection and additional hand-coding features. The base classifiers' output was the vector of predictions. The decision function scores for each prediction, two along with the topic distribution from the L-LDA model for a given story then became meta-features for the suite of meta-learners. They analyzed 7,147 personal stories shared by distressed teenagers on a popular teen-help website.

Choudhury et al. (2013) used the behavior of youth and Twitter users in general to detect any sign of depression. They aimed to build a machine learning based model that can detect and rely on several signs from social media behavior to predict the potential depression of some users at early stages. The authors developed a crowdsourcing solution to the problem of developing a ground truth dataset. Annotators were recruited from Amazon Mechanical Turk and required to take a Center for Epidemiologic Studies Depression Scale test. They were asked a series of questions regarding their history of depression and current depression status. The Mechanical Turkers who finished the questionnaire were requested for their Twitter user name, which was then used to pull their Twitter feed, resulting in a ground truth depressed/not depressed dataset. After that, a machine learning classifier was trained on the depressed/not-depressed data using features derived from both the tweet text and network features such as several followers. That classifier was applied to an extensive dataset of geolocated Twitter data from the United States, yielding a strong positive correlation with Centers for Disease Control depression statistics. Choudhury et al. (2013) presented a study of predicting depression from tweets by analyzing more than 2 million posts of 476 users. The best performance was acquired by SVM classifier with a set of behavioral features, for example, the occurrence of pronouns, use of swearing and depression terms, tweet replies, just as posting time, and frequency.

Another experimental study has analyzed mental health phenomena in publicly available Twitter data (Chen E. et al., 2020). They gathered data for a range of mental illnesses quickly and cheaply to identify various mental health disorder symptoms such as depression, bipolar disorder, and seasonal affective disorder. They conducted a Linguistic Inquiry Word Count (LIWC) analysis of each disorder to measure deviations in each illness group from a control group, replicating previous findings for depression and providing new findings for bipolar, PTSD (Post-traumatic stress disorder), and SAD (Social-Anxiety Disorder) (Chen E. et al., 2020; McDonnell et al., 2020). Two language models, (1) a conventional unigram LM to inspect the likelihood of every whole word (2) a character 5-g LM to examine sequences of up to five characters, were utilized. Classifiers were built to distinguish each group from the control group, demonstrating a useful signal in each group's language and comparing these classifiers (McDonnell et al., 2020). After that, the correlations between their analytics and classifiers were analyzed to uncover relationships between them and derived insight into quantifiable and relevant mental health signals on Twitter.

Deep neural network (DDN) is another approach that can be utilized for detection of stress as done by Lin et al. (2014), in which the authors presented the analysis of data from four micro-blogs and compared the performance of their proposed four-layered DNN with traditional machine learning algorithms such as Random Forest, SVM, Naïve Bayes. For performance evaluation, they utilized three pooling methods: Max pooling,

mean-over-instance, and mean-over-time for each model. Each model performed well or worse, depending on the pooling method. However, the best results were acquired by DNN using mean-over-time pooling.

Neuman et al. (2012) presented another approach "Pedesis" that crawled websites for metaphorical relations in which depression was embedded and extracted the relevant conceptual domains with the NLP method of Dependency Parsing. The domain describes words or phrases that were metaphorical expressions of depression. Human experts further used this information to develop a "depression lexicon" with first- and second-degree synonyms. The lexicon was used to evaluate the level of depression in texts automatically or whether the text is dealing with depression as a topic.

Hidden patterns and high dimension features often help the neural network learn the distinct representation of feature space (Nguyen et al., 2019). The learned features are then used by the trained network to compute the conditional distribution of input vectors. The different architecture of the neural network is being proposed for the domain-specific applications. One of the basic principles is that the architecture is multi-layer perceptron. In this network, each hidden layer takes averaging layers of outputs to compute input from the previous layer and weights. The nonlinear activation function is used at the final/output layer of the network. They update the weights based on the loss function and gradient.

In supervised learning, the network is required to reduce the loss and considered as a nonlinear optimization problem. The weight and bias values are used to optimize the loss. The algorithms mostly fall under the gradient descent technique. The gradient-based techniques start with random points for each input vector. It then several iterations (epochs) are executed for a set of the instance (batches). The trainer computes the loss; it was made by computing the nonlinear objective function for the loss values and gradient. Then, weights are updated in a way that reduces the loss function (Nguyen et al., 2019). The loss is continuously reduced to the convergence point or optimal local minimum. The predictive ability of the neural networks comes from hidden layers and the structure of the architecture. The correct selection of several layers, architecture structure, layers, and hyperparameters helps solve complex problems. The higher-order representation of the input features vector is achieved using the network training (Cho et al., 2014). The learned higher feature representation helps to achieve generalization and increase predictive power. Modern research in the neural network selects the network with low computation complexity and has high prediction power. The number of architecture is proposed over the past two decades (Vinayakumar et al., 2017).

The major difference between architectures is the hidden layers, layers type, shapes, and connection between layers (Sze et al., 2017). Wainberg et al. (2018) introduced the methods for learning higher-dimensional features from the tabular data. The convolutional neural network (CNN) learns features embedding from the image pixels. The pixel data and variation among them increase the learning and predictive power of the network. The translation invariant pixel benefits the network (Wainberg et al., 2018). Many studies were conducted on learning and inference in the visual information processing system that includes wildlife application (Horn et al., 2018), X-ray scans (Rajpurkar et al., 2017), and autonomous driving (Siam et al., 2017). For sequential data, recurrent neural network (RNN) architecture was proposed and used in the natural language process domain, including machine translation, language generation, and time series analysis (Wu et al., 2016; Jouppi et al., 2017; Fawaz, 2020). The RNN model comprises an encoder and decoder framework where the encoder takes the input sequence and decodes it into the vector's fixed length. The model uses different gates to process the input features based on the loss function. The fixed-length vector sometimes loses relevant information (Cho et al., 2014).

Another issue with the RNN encoder and decoder model is the alignment of the input and output vector. Neighbor feature values influence the sequence. Another variant of RNN is the proposal of a new network named as attention mechanism (Cho et al., 2014). It applies the attention method of the input vector by giving certain weights to selected inputs. It makes this selection based on the prioritized importance and position of relevant information after that decoder used the position with context vector and corresponding weights for the higher feature representation. After that mode is then learned the weights to the RNN model for the predictions, the attention weights and context vector learned by using the architecture and feature representation (Lu et al., 2016). Several variations of the network include a soft, hard, and global architecture for the attention mechanism. They proposed the soft attention model (Bahdanau et al., 2015) to help reduce contextual information. The model used the average of the hidden states and then built the context vector. The approach helps to efficiently learn the input feature hidden pattern and reduce the loss.

In hard attention, Xu et al. (2015) computes the context vector from sampling the hidden states. The hard attention reduces the computation cost; however, tuning the architecture is very difficult as the convergence of architecture is difficult. Luong et al. (2015) propose another variation, i.e., local and global attention. Global attention is the intermediate version of soft and hard attention. The model picks the attention point for each input batch. This helps to reach convergence quickly. In the local attention model, they learn the position of the attention vector from the predictive function. The model predicts the attention position. Both local and global attentions are computationally efficient and require to be selected by analyzing the domain-specific data.

3. METHODOLOGY

This paper proposes the embedding training method for building a depression symptoms detection model. In this method, as shown in **Figures 1**, **2**, we used the cosine similarity to the PHQ-9 symptoms score. The trained lexical enhanced method is proposed to expand the knowledge and embedding word size for similarity. We explain the proposed method of extracting depression symptoms from the patient's authored text. An example of a patient from the anonymous user is mentioned in the text below.

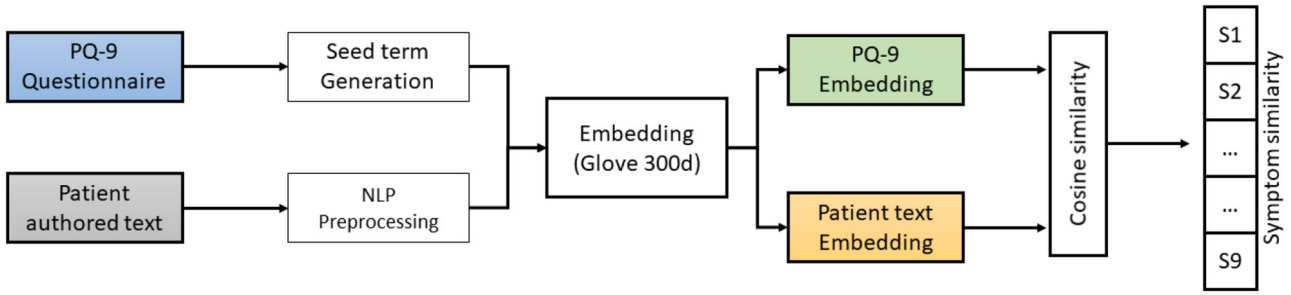

FIGURE 1 | A workflow architecture for estimating PHQ-9 symptoms from the patient-authored texts. PQ, psychometric questionnaire; NLP, natural language processing.

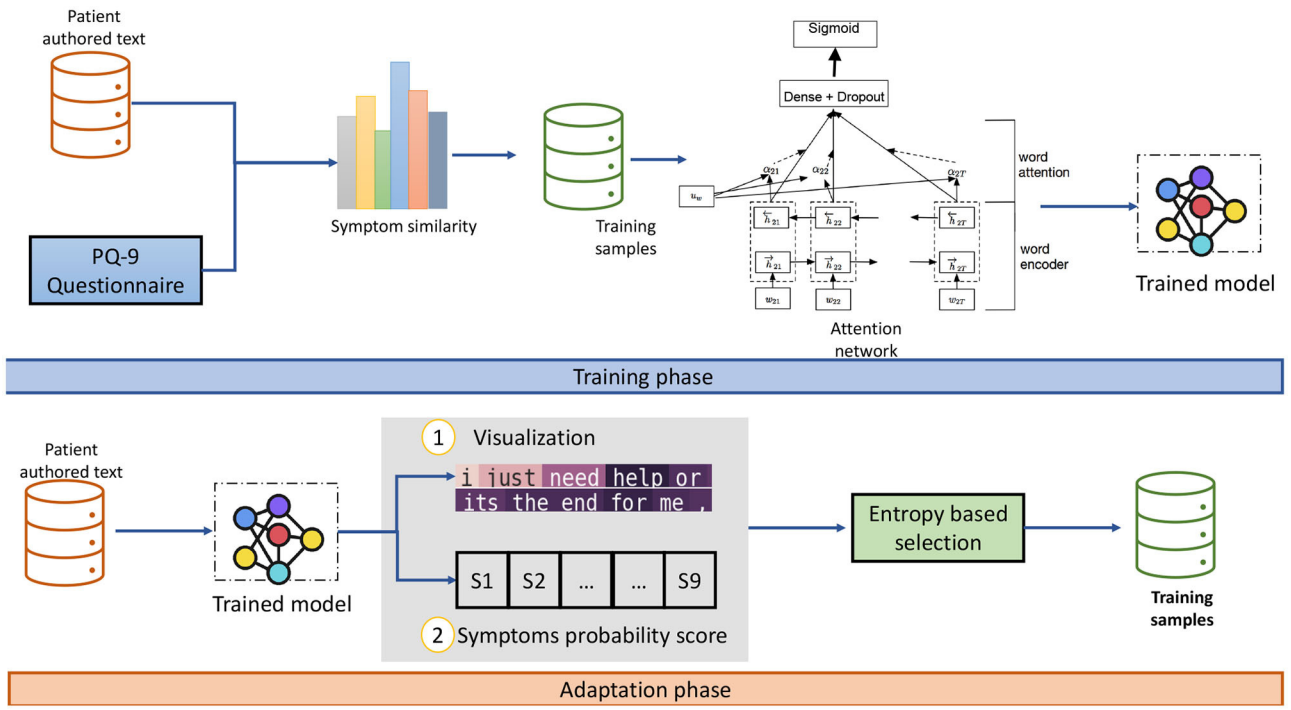

FIGURE 2 | A flow of training and adaption using attention based domain adoption. The visualization and symptoms similarity is suggested for the psychiatrist for note-making and suggesting patient remedy for certain symptoms.

I am currently in a pretty bad situation. My depression and anxiety are high, and I can't function or hold down a job or anything like that, so all I do is sit at home all day eating junk food. Each day is extremely boring and hard to get through yet I can't go out into society and function because of my anxiety and depression.

The diagnosis of mental health issues according to the classification of ICD10 (World Health Organization, 1993) is complicated. The discrepancy of diagnosis is the dynamic nature of symptoms and their degree depending on the patient, treated on a specific disease process at a particular time. Therefore, during the assessment process of mental health issues, the psychiatrists listen to the patient's outlines and extract useful additional information. The psychiatrist's method involves using the standard procedure of questionnaire-based analysis such as PHQ-9 and aided test to assess each assessment's diagnostic reliability according to clinical conditions of the individual with mental health issues. The questionnaire's schemas include symptoms types, their frequency, and summing the frequency to assign the score and then used the score to classify the intensity based on a predefined threshold. For instance, each symptom is represented with nine different questionnaires; those questionnaires' frequency helps classify the behavior into mild, moderate, or severe conditions. The approach is called "Clinical Symptom Elicitation Process" (CSEP) (World Health Organization, 1993). In this research, a major goal is to automate

TABLE 1 | PHQ-9 questionnaire and seed terms for each symptoms.

Symptoms	PHQ-9	Seed terms
S1	Little interest or pleasure in doing things	Interest
S2	Felling down depressed or hopeless	Feeling, depressed, hopeless
S3	Trouble falling or staying asleep or sleeping too much	Sleep, asleep
S4	Feeling tired or having little energy	Tired, energy
S5	Poor appetite or over eating	Appetite, overeating
S6	Feeling bad about yourself or that you are a failure or have let yourself or your family down	Failure, family
S7	Trouble concentrating on things such as reading the newspaper or watching television	Concentration, reading, watching
S8	Moving or speaking so slowly that other people could have noticed or the opposite being or restless that you have been moving around a lot more than usual	Moving, speaking, restless
S9	Thoughts that you would be better off dead or of hurt yourself	Dead, hurt, suicide

the process through the active learning procedure. Each category of the symptoms is labeled using the patient text's frequency, and overall clinical depression is calculated.

3.1. Psychometric Questionnaires (PQ)

There is the number of PHQ-9 for depression and PQ9 is one of the most used questionnaires (Kroenke et al., 2001). The proposed method uses the standard PHQ-9 questionnaire for patient authored text (Kroenke et al., 2001). It is a standard procedure to measure depression symptoms. In standard CSEP procedure, the psychiatrist asks each category's question and observes the patient's response to add the frequency into the class as follows:

a) score 0: not at all,
b) score 1: several days,
c) score 2: more than half the days, and
d) score 3: nearly every day.

The PHQ-9 method helps to extract nine distinct behavior types that incorporated DSM-V[2]. These nine symptoms categorize into different disorders such as sleeping, interest, concentration, and food disorder, as mentioned in **Table 1** and sample document[3]. After all question-based assessment, the psychiatrist calculates the assessment score. The assessment score indicates the depression level of the patient.

3.2. Seed Term Generation

In this research, seed term generation is used for keywords extracted from the PHQ-9 questionnaire. This section describes the generation of the word list of depression symptoms called depression seed term lexicon here. It contains a hand-chosen list of depression symptoms from common resources for psychiatrists, as mentioned in **Table 1**. Psychologists verified the list of depressive terms since it is critical to base a different synonym list. For each symptom, seed terms are handpicked, then by using Wordnet (Miller et al., 2009), associated hypernyms, hyponyms, and antonyms are extracted. Wordnet is a lexical database for English maintained and developed by Princeton University. Each category of words is maintained in the database, i.e., nouns, verbs, adjectives, and adverbs. Each word in the category possesses different synsets that are used to express unique concepts. The synsets are categorized into semantic and lexicon-based relations. For instance, words having the same synset are synonymous. Empirical analysis found that approximate top 5 terms are beneficial and correlated with original symptom terms. **Table 1** seed terms are extended using the Wordnet method. There are various lists of depression symptoms in different classification systems (Mukhiya et al., 2020a). These lists use either clinical or casual symptoms terms depending on whether the poll is a questionnaire to the patient or the clinician. Major classification systems for depression such as DSM-V[4] and ICD-10 (World Health Organization, 1993) are widely used depression scales that were merged to deduce a fine base list of symptoms (Mukhiya et al., 2020a).

3.3. Preprocessing

The preprocessing is an essential part of text processing. Each patient authored text is passed through a different process as follows:

1. Each text is processed and formatted into the UTF-8 encoding scheme. This helps to maintain consistency.
2. Convert each word into lowercase.
3. Remove the tabs or spaces around words.
4. Remove unique characters that do not convey any meaning (#, +, -, *, =, HTTP, HTTPS).
5. Convert text-based words into full words, e.g., *can't* by cannot and so on.

3.4. Word Embedding Using Emotional Lexicon

For emotion detection, several methods are proposed in the extensive NLP literature. However, emotional knowledge-based (EKB) systems have not yet been studied. EKB consists of a word sense lexicon and a learned diverse contextual embedding. We propose the embedding that takes contextually diverse words by combining the depression lexicon (based on word sense) and emotional knowledge from online forums. Emotional knowledge consists of words that represent context and feelings.

[2]https://www.psychiatry.org/psychiatrists/practice/dsm.
[3]https://www.uspreventiveservicestaskforce.org/Home/GetFileByID/218.
[4]https://www.psychiatry.org/psychiatrists/practice/dsm.

For each word token in the patient text, we extracted the word embedding using a 300 dimension pre-trained model for global vector for word representation (Glove) (Pennington et al., 2014). The Glove-based vector embedding is used to project the context in vector space. The embedding represents the learned sentence structure. The extracted embedding helps to captivate the semantic composition of the text. Each word vector is distributed based on the hypothesis that *"You shall know a word by the company it keeps"* (Charles, 2000). The *co-occurrence frequencies* of the vectorized words is calculated based on the linguistic patterns. The learned model is produced from the author's unique word and represented with a fixed-length vector. A similar word is located nearby. Most of the pre-trained embedding is for general-purpose communication. Therefore, a *pre-trained model* does not apply to emotional analysis. We extend the corpus by using the word sense model and transfer learning method of training the custom mental health model. The reason for this is that most of the embedding is trained on open-source data, i.e., *(Wikipedia texts)* and sentiment knowledge *(Twitter data)*. The word *sad* and *happy* convey the meaning of *feelings*. However, these words represent a different mental state. Therefore, it is needed to extend the embedding using word sense.

The emotional lexicon based on the word sense helps to show promising results. The fine grain classification can be achieved by using custom embedding for the classification of various symptoms. Part of speech tagging is used and extracted the words that contain the (*noun*, *verb*, *adverb*, and *adjective*). We used the corpus D consist of the set of texts, $D = \{t_1, t_2, \ldots, t_n\}$ and the *WordNet* is used to extract synonyms, antonyms, hypernyms, and physical meaning for each extracted part of speech. As a results, we get the emotion words $W = \{w_1, w_2, \ldots, w_K\}$ for each documents. The emotion represents a domain-specific contextual corpus. After that, vocabulary is built using the W set used to train the model. The resultant embedding is learned vector V, i.e., $V = \{v_1, v_2, \ldots, v_m\} \in \mathbb{R}^{m \times \delta}$ where δ is the word vector dimension. The sentence embedding is obtained by averaging each word vector in the patient author text. The vector represents word sense and emotional knowledge. The trained model is used to convert the patient author text into a vector and all nine symptoms from the PHQ-9 questionnaire lexicons. The corresponding two embeddings are passed to the cosine similarity method. For every nine symptoms, we have a similarity value ranging between $0 and 1$. Given two vectors, vector X, which is the patient author text, and vector Y, representing the symptoms lexicon, we use V to create textual features into semantically aware vectors. The similarity between two embeddings represents that authored text is closely related to certain symptoms, as shown in **Figure 2**.

3.5. Dataset

The dataset is gathered from an online forum, website, and social media site (Mukhiya et al., 2020a). Amazon Mechanical Turk[5] service is used to label the 500 texts (Mukhiya et al., 2020a). The remaining data are annotated by using the proposed embedding method. The labeling is done using the PHQ-9 rating method, i.e., such that 0 indicates not depressed, 1 mildly depressed, 2 moderately depressed, and 3 severely depressed (Mukhiya et al., 2020a). We convert the annotation into a binary class for each symptom, where 0 indicates the absence of symptoms and 1 indicates the presence of symptoms. The gathered data are shown in **Table 2**.

3.6. Deep Learning Model

As a **baseline**, we used a feedforward neural network. The Glove embedding is used to extract all the tokens from the text. The averaging method is used to average the comment length to a uniform size. The model consists of hidden layers $(30, 20, 10)$ with a ReLU activation function (Nair and Hinton, 2010). **Table 3** shows that our goal is multi-label classification (of nine distinct symptoms). The last layer contains the sigmoid function with nine units. The cross-entropy function is used as the loss function. The model is defined as follows:

$$\begin{aligned} \boldsymbol{h}_1 &= \text{ReLu}\,(\boldsymbol{x}\boldsymbol{W}_1 + \boldsymbol{b}_1) \\ \boldsymbol{h}_2 &= \text{ReLu}\,(\boldsymbol{h}_1\boldsymbol{W}_2 + \boldsymbol{b}_2) \\ \boldsymbol{h}_3 &= \text{ReLu}\,(\boldsymbol{h}_2\boldsymbol{W}_3 + \boldsymbol{b}_3) \\ \hat{\boldsymbol{y}} &= \sigma\,(\boldsymbol{h}_3\boldsymbol{W}_4 + \boldsymbol{b}_4) \\ J &= CE(\boldsymbol{y}, \hat{\boldsymbol{y}}) = -\sum_{i=1}^{6} y_i \log\left(\hat{y}_i\right) \end{aligned}$$

where

$$\begin{aligned} &\boldsymbol{x} \in \mathbb{R}^{B\times 300}, \boldsymbol{h}_1 \in \mathbb{R}^{B\times 30}, \boldsymbol{h}_2 \in \mathbb{R}^{B\times 20}, \boldsymbol{h}_3 \in \mathbb{R}^{B\times 10}, \\ &\hat{\boldsymbol{y}} \in \mathbb{R}^{B\times 6}, \boldsymbol{y} \in \mathbb{R}^{B\times 6} \end{aligned}$$

An ROC curve is used, true positive rate $[TPR = TP/(TP + FN)]$, and false-positive rate $(FPR = FP/(FP + TN)$ as performance metrics.

RNN with GRU is used, and LSTM cells as the RNN architecture performed well for the sequential task. The LSTM network allows for long-distance information preservation. In LSTM unidirectional architecture, a final time step of the hidden state can be fed into the output layer. We found that the element-wise average method overall timesteps' hidden state performed better for the input to the final layer of our architecture during empirical analysis. We also used the bidirectional LSTM architecture that read input token lists starting at the end and set one parameter for forward unrolled LSTM. Therefore, each token position has two input states that concatenate to form the output state, extending for the attention layer. The dropout ratio of $0:5$ is set to avoid overfitting and regulation of the LSTM layer.

$$\begin{aligned} \boldsymbol{i}_t &= \sigma\left(\boldsymbol{x}_t\boldsymbol{W}^{(i)} + \boldsymbol{h}_{t-1}\boldsymbol{U}^{(i)}\right) \\ \boldsymbol{f}_t &= \sigma\left(\boldsymbol{x}_t\boldsymbol{W}^{(f)} + \boldsymbol{h}_{t-1}\boldsymbol{U}^{(f)}\right) \\ \boldsymbol{o}_t &= \sigma\left(\boldsymbol{x}_t\boldsymbol{W}^{(o)} + \boldsymbol{h}_{t-1}\boldsymbol{U}^{(o)}\right) \\ \tilde{\boldsymbol{c}}_t &= \tanh\left(\boldsymbol{x}_t\boldsymbol{W}^{(o)} + \boldsymbol{h}_{t-1}\boldsymbol{U}^{(o)}\right) \\ \boldsymbol{c}_t &= \boldsymbol{f}_t \circ \boldsymbol{c}_{t-1} + \boldsymbol{i}_t \circ \tilde{\boldsymbol{c}}_t \end{aligned}$$

[5]https://www.mturk.com/.

$$\boldsymbol{h}_t = \boldsymbol{o}_t \circ \tanh(\boldsymbol{c}_t)$$

The attention method is proposed to utilize word importance in text (Yang et al., 2016). We added the attention method in addition to the LSTM layer. This addition helps to extract informative words for the classification task. The attention output vector is fed as the input to the dropout layer. The formal representation of the network is mentioned below. Traditionally, supervised learning required a large labeled dataset for the training of large networks. The label data are the main requirement and dependency of the application. The active learning model is the process to generate the relevant set of data that have the highest predictive significance to training a supervised model. The active learning model is used in applications where the amount of data is too large to do manual labeling. In this research, we used the similarity-based features to label a small set of data smartly and after that using the entropy-based instance selection method of train on the full dataset. The entropy-based instance selection mechanism (Holub et al., 2008) is adopted to expand the low number of instances and chose the data distribution. This process helps to expand knowledge with time.

$$\boldsymbol{v}_t = \tanh(\boldsymbol{h}_t \boldsymbol{W}_a + \boldsymbol{b}_a)$$
$$s_t = \boldsymbol{v}_t \boldsymbol{u}_a^{\top}$$
$$\alpha_t = \frac{\exp(s_t)}{\sum_{t=1}^{T} \exp(s_t)}$$
$$\tilde{\boldsymbol{h}} = \sum_{t=1}^{T} \alpha_t \boldsymbol{h}_t$$

4. EXPERIMENTAL RESULT AND ANALYSIS

First, the patient-authored text is converted into the emotional-based lexicon and trained on neural networks for experimentation. We used a 300 dimension Glove vector for vectorization. The embedding is used to convert a text and a nine symptom lexicon into a vector. Then, two vectors are used to find the similarity based on the cosine similarity. The similarity is used to label the text. The label text is then further trained on a different architecture. Next, the different architecture is evaluated based on an ROC curve, precision, and recall. For each architecture, we used Adam optimizer (Kingma and Ba, 2014), hyperparameter tuning is done by keeping the learning rate static to 0.0005, which in turn helps to reduce the training loss. **Table 4** shows the architecture performance, and the attention method helps achieve the highest ROC on the test set. For each architecture, we changed the cell type as well as the hidden size. In addition to the LSTM directional layer, we added the attention method to improve model performance.

Simultaneously, other models tend to overfit as they performed well on the training set but did not perform well on the development and testing set. Three steps were followed to prevent overfitting. First, the model was run for a longer time (1000, epochs). Second, the concept of early stopping methods was used to save the model progressively. Third, a gradient clipping method was used to ensure and avoid gradient issues (Chen X. et al., 2020).

The baseline model performance is shown in **Figure 3**. The training loss reached 0.45, and the testing loss is 0.33. The training ROC is 0.89, and the development set is 0.81. The model tends to overfit and has close to the upper left corner—the precision-recall curve under the different threshold value is

TABLE 2 | The statistical summary of the training and testing set.

Type	Statistics
Corpus size (Number of posts collected)	15,044
Number of sentences	133,524
Average sentences per post	8.87
Average words per post	232
Training set size (Number of posts)	14,944
Testing set size (Number of posts)	100

TABLE 4 | The mean ROC–Area Under the ROC Curve values of training and testing set.

Architectures	Train	Test
Baseline	0.89	0.81
LSTM	0.65	0.38
Bidirectional LSTM	0.91	0.8
Bidirectional_LSTM_Attention	**0.91**	**0.85**

The bold value represents the highest ROC-AUC value.

TABLE 3 | A snippets of dataset used.

Text	S1	S2	S3	S4	S5	S6	S7	S8	S9
It is too much to handle. The depression and anxiety. Tried so many ways to get better including varying cocktails of meds but I feel so hopeless. Last semester and I think I'm going to fail.	0	1	0	0	0	0	0	0	0
Having a very bad day today. Haven't even got dressed yet might not bother at all today. Don't really know why I keep going. Feel so very very sad and……	0	0	1	0	0	0	0	0	1
Hi all I'm after a bit of advice. I think my partner is depressed and I told him he needs to go to the doctors. He works away Monday to Friday and is stressed out at work working as a lorry driver he does long hours (70+ a week)…	0	1	0	0	0	0	1	0	0

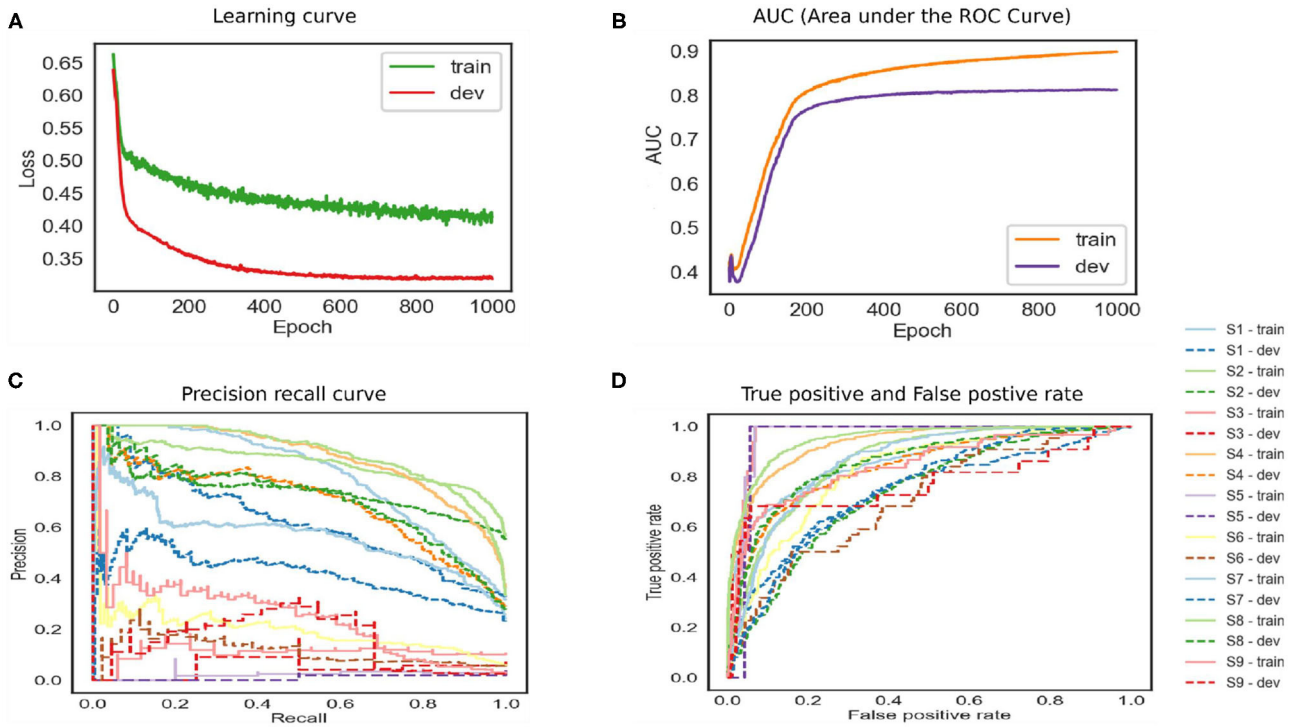

FIGURE 3 | The feed-forward neural network baseline model.

relatively low false-positive rate. The model did not perform well. Therefore, the architecture is not optimal for the given data. The depression data depend upon the sequence of words that were not preserved by a simple network. In other words, an architecture that favors sequences and stores important word information is most likely required for stronger results.

The LSTM network is shown in **Figure 4**. The training and developing loss is optimal as we set epochs as 20. However, the model achieved ROC 0.79. The precision–recall curve indicates that the model is not able to learn effectively. This model also does not perform well on this dataset. The model has to remove gradient issues as the cell has to move data from one cell to another. The cell becomes complex due to the computational cost of the gates. Moreover, the LSTM architecture required more fine tuning and training for a longer period. For real-time applications, the network should store information for a longer time to achieve human-level performance. For instance, human habits of dividing sources of information into small chunks for ease of remembering past events. Likewise for feedforward networks, LSTM also favors small weight initialization. In summary, LSTM behaves almost the same as a feedforward network.

The bidirectional model achieved high accuracy as shown in **Figure 5**. The reason for this is that the model runs in two directions from past to future and vice versa. The two hidden state models preserve the information from the future as well as the past. The two independent RNNs are parallelly performed that allow the networks to have backward and forward connections. The trained and development set has the lowest error. The precision–recall curve in the top corner represents high recall and high precision, which depicted the low false-positive and false-negative rates. The BILSTM model takes each hidden state, which depended upon the previous state. This creates a huge problem as the network is required to wait for data dependency. The long-range dependencies affect the performance as it is a challenge to memorize the information for a long time.

In **Figure 6**, the attention mechanism is used with a bidirectional LSTM. The model normalized attention weights to selected high-quality words that understood and correlated with the classifier. The model can have inadequate training and development set error. The training model achieved 0.91 ROC, and the development set is 0.85. The high-performance results in a high true positive rate. The results support the existence of essential words that help to classify the depression symptoms. The network also helps to reduce the computation cost by focusing on certain words. The reason is that the model can recognize the target word in the task, and it learned the subject's meaning in both directions. Due to the complex nature of the mental health data, a large number of vocabulary and grammatical permutations can increase the performance.

In **Figure 7**, the attention method is used to compute the normalized attention weights for every word in a sentence of a patient authored text; the visualization is used to help the psychiatrist to see the trigger points. The weights of qualitative

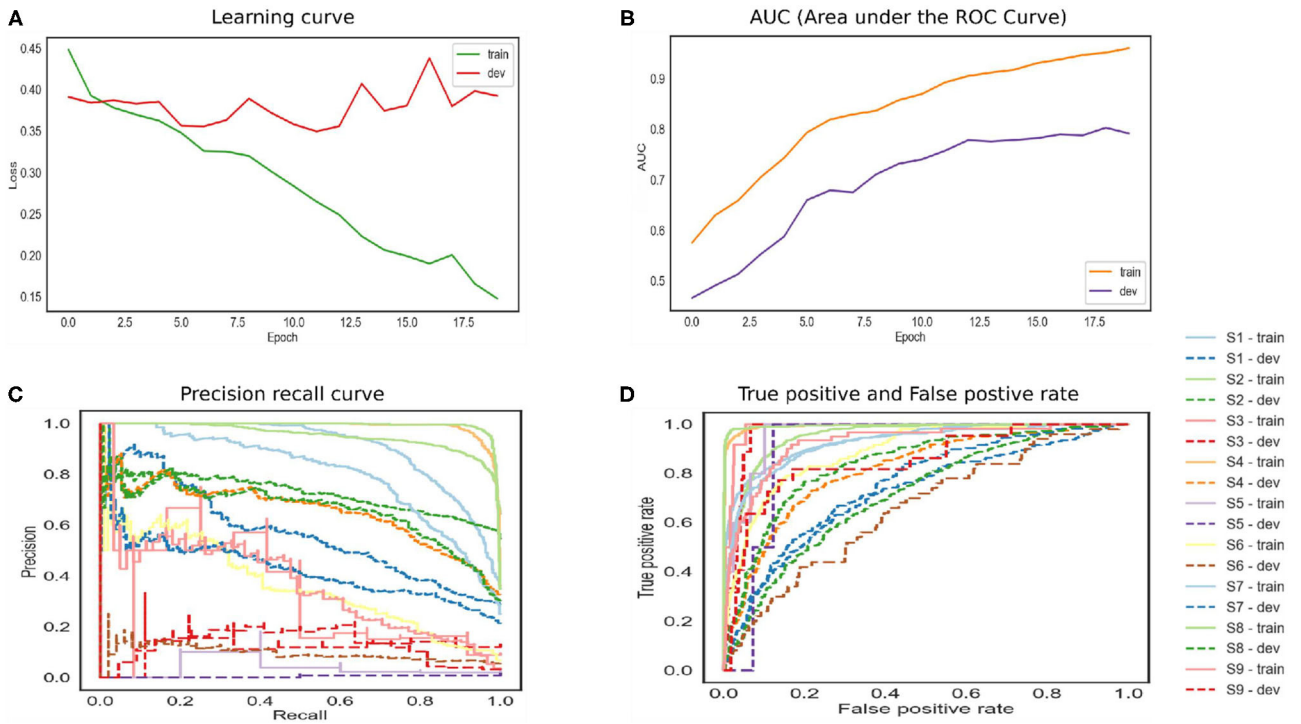

FIGURE 4 | The performance of Long Short-Term Memory (LSTM) model.

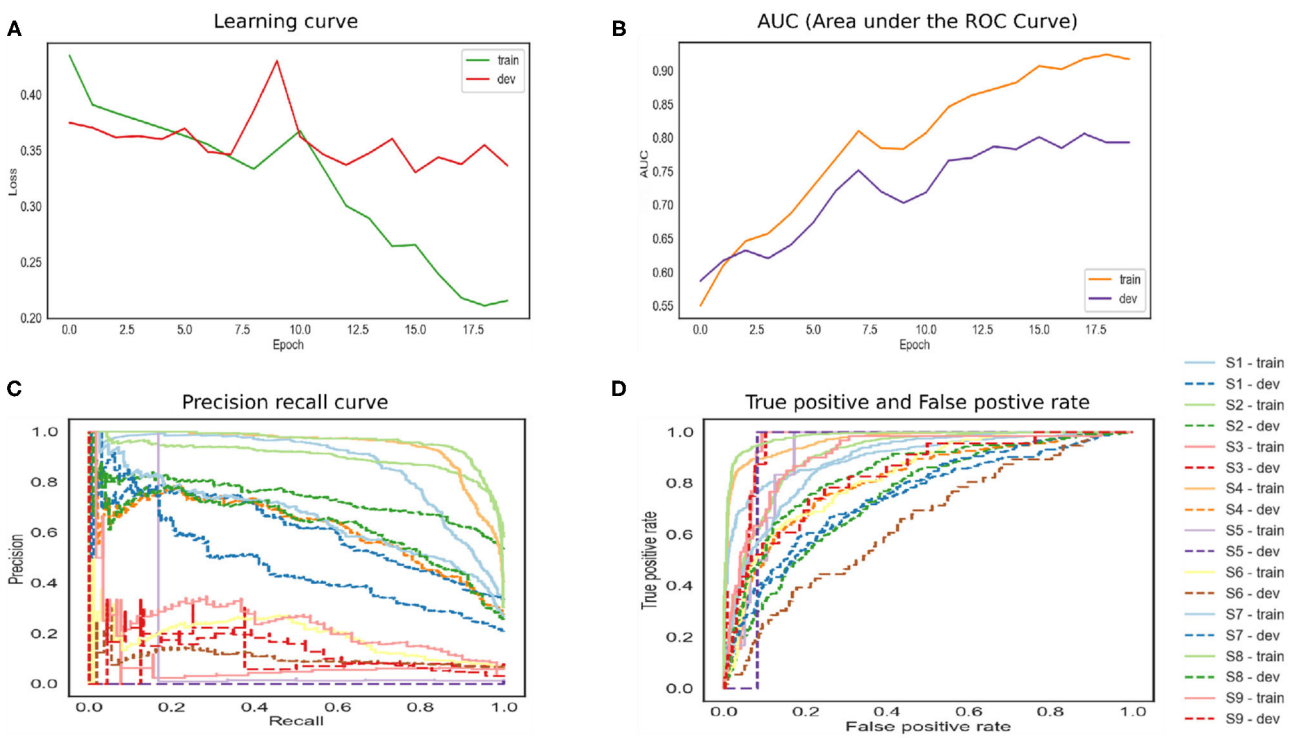

FIGURE 5 | The performance of bidirectional Long Short-Term Memory (LSTM) model.

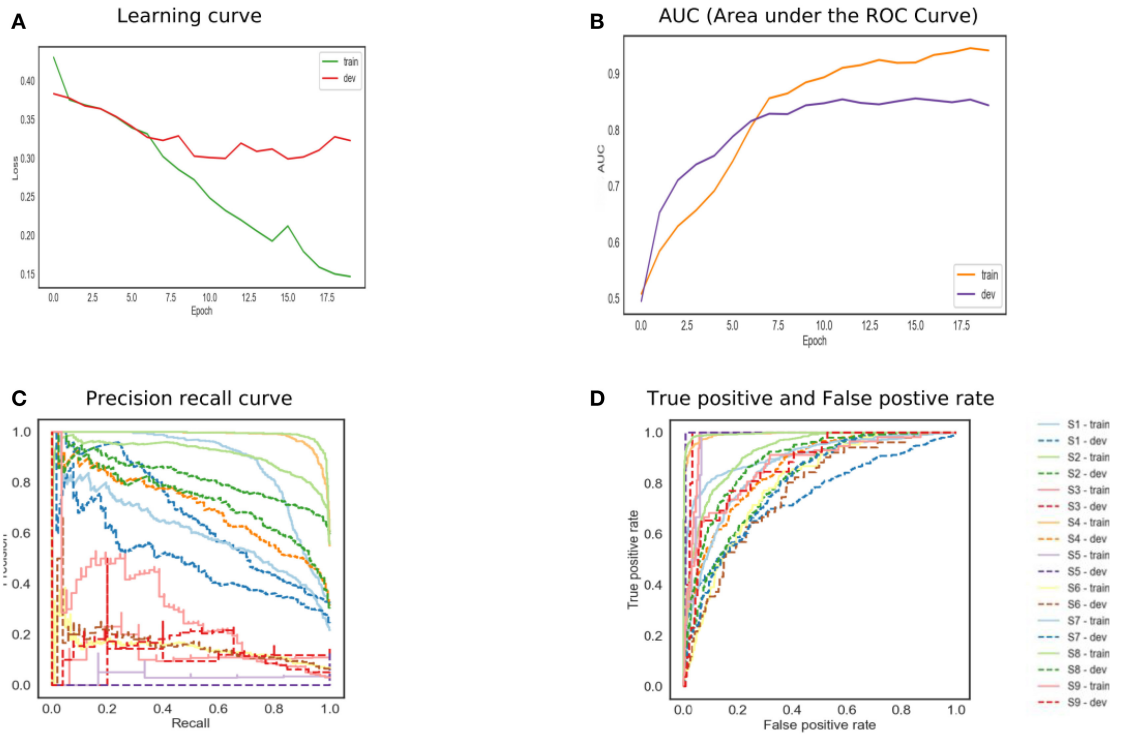

FIGURE 6 | The performance of bidirectional Long Short-Term Memory (LSTM) with attention.

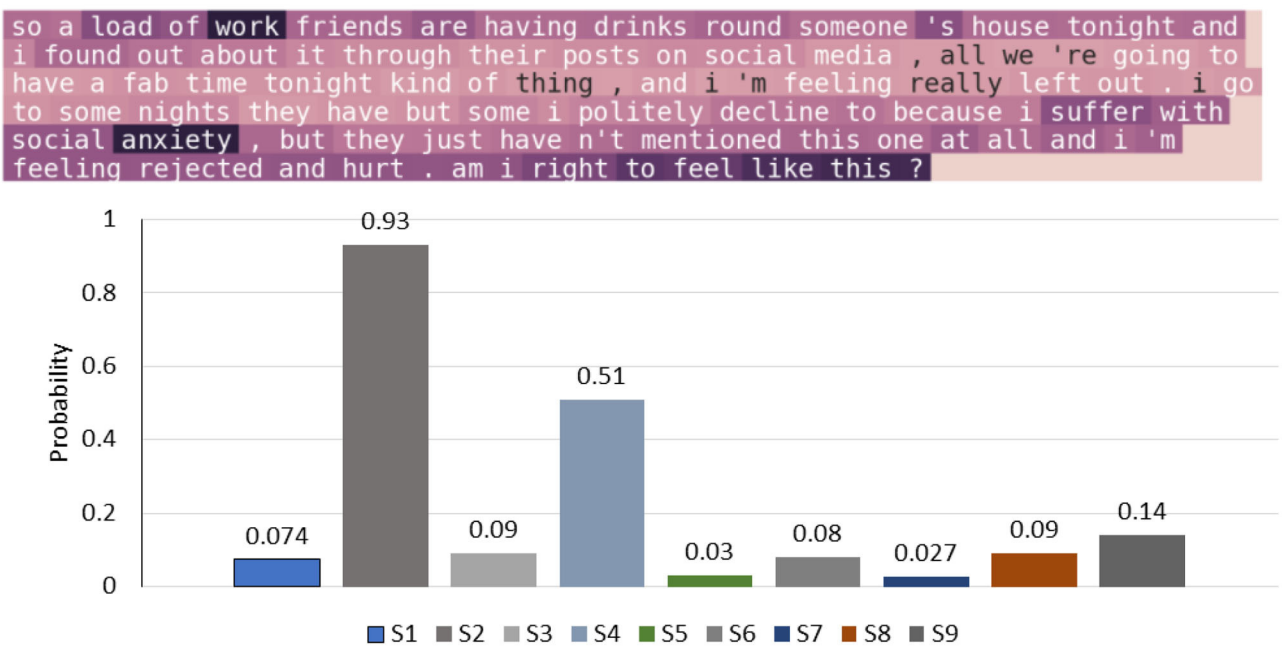

FIGURE 7 | An example patient-authored text and visualization of depression symptoms extracted by our approach.

words are highlighted, which represent *work, anxiety, feel, and suffer*; they indicate two symptoms, i.e., S1 (felling down depressed or hopeless) and S4 (feeling tired or having little energy). The model also successfully highlights the critical points and the relevant words for the symptoms that is helpful for classifications tasks.

5. CONCLUSION

The applications of NLP and deep learning for clinical text analysis have greatly improved in recent years. In the past studies, Patient's authored text data are used to extract symptoms, and a limited number of studies have been conducted to extract mental health symptoms. Moreover, adoption methods using mental health has also not been well discussed in related works. This paper presents a semi-supervised learning method for labeling and training an active learning model. The active learning model is able to expand its knowledge with timestamp. Through our symptom-based visualization system, as well as the symptoms themselves, psychiatrists is able to make and recommend relevant programs for adequate therapy effectively. In the designed system, IDPT helps with computerized exercises for psycho-education, and NLP helps to provide an elegant way to adapt and offer proper visualization. The LSTM and attention model help to achieve high accuracy for the prediction of symptoms. The bidirectional LSTM with an output attention layer was successfully able to perform multi-label classification for symptoms. The active learning model was able to expand knowledge with time. Our model achieved 0.85 ROC, helped to visualize the attention-based words, and recommended the suggested symptoms. The proposed method performs adaptation in IDPT systems that automatically learns from patient's authored texts for psycho-education exercises. Through our results, the adapted intervention provides personalized feedback on recommended exercises. In the future, we will try to embed a character-level text classifier, as well as stronger regulations that may be able to increase the performance of our model and reduce overfitting issue.

DATA AVAILABILITY STATEMENT

The data analyzed in this study is subject to the following licenses/restrictions: Dataset is available upon request. Requests to access these datasets should be directed to Suresh Kumar Mukhiya, Suresh.Kumar.Mukhiya@hvl.no.

AUTHOR CONTRIBUTIONS

UA and JL investigated the main idea and wrote the draft of the manuscript. GS revised and proofread the manuscript. SM and YL helped for the evaluation part of the experiments. All authors contributed to the article and approved the submitted version.

FUNDING

This research was supported by Western Norway University of Applied Sciences, Norway under project 2930010-10. Also, this publication is a part of the INTROducing Mental health through Adaptive Technology (INTROMAT) project, and partially funded by Norwegian Research Council (259293/o70).

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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.

frontiers in Psychology

ORIGINAL RESEARCH
published: 08 April 2021
doi: 10.3389/fpsyg.2021.634978

Design and Implementation of Intelligent Sports Training System for College Students' Mental Health Education

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In order to solve the problems of poor physical fitness of college students and low efficiency of college sport venues' management, an intelligent sports management system based on deep learning technology is designed by using information technology and human-computer interaction under artificial intelligence. Based on the Browser/Server (B/S) structure, the intelligent sports management system is constructed. The basic framework of Spring Cloud is used to integrate the framework and components of each part, and a distributed microservice system is built. The artificial intelligence recommendation algorithm is used to analyze the user's age, body mass index (BMI), and physical health status, and recommend sports programs suitable for students, thus realizing the intelligent sports program recommendation function. At the same time, the recommendation algorithm is used to complete the course recommendation according to the students' preferences, teaching distance, opening time, course evaluation, and other indexes, and the course registration system is constructed; after the analysis of the entity and the relationship between the entities of the intelligent sports system, the database relational model of the system is designed with the entity relationship (E-R) diagram. The results of the functional test show that the system can run well. In conclusion, the sports training environment instructional system based on artificial intelligence and deep learning technology can meet the teaching needs of colleges, improve the sports' quality for college students, and promote psychological education.

Keywords: intelligent sports system, college students' psychological education, deep learning, recommendation algorithm, artificial intelligence

OPEN ACCESS

Edited by:
Mu-Yen Chen,
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Reviewed by:
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Specialty section:
This article was submitted to Human-Media Interaction, a section of the journal Frontiers in Psychology

Received: *29 November 2020*
Accepted: *08 February 2021*
Published: *08 April 2021*

Citation:
Wang T and Park J (2021) Design and Implementation of Intelligent Sports Training System for College Students' Mental Health Education. Front. Psychol. 12:634978. doi: 10.3389/fpsyg.2021.634978

INTRODUCTION

On October 12, 2019, the Ministry of Education issued the *Opinions on Deepening Undergraduate Education and Teaching Reform and Comprehensively Improving the Quality of Personnel Training*. This opinion requires that the examination and graduation exit of colleges should be strictly controlled, the assessment of students' physical education courses should be strengthened, and those who fail to meet the requirements could not graduate. The results of the seventh national survey on students' physique and health have been published. The data show that the physical fitness of college students continues to show a downward trend. In particular, the speed, explosive

power, endurance, and other physical fitness indexes of male students aged 19–22 years old have decreased (Chen, 2019). Other studies show that a lack of sleep is common among college students. As high as 43.9% college students sleep fewer than 7 h a day, and 8.4% of them sleep <6 h; moreover, the sleep habits of college students are also worrying. 23.8% college students fall asleep after midnight, and the average bedtime is close to 1:00 a.m. (Qian et al., 2018). Mental health problems are common amongst college students. College students' anxiety is more common in China, and the detection rate is on the rise.

Strengthening exercises are key to improving the physical and mental health of college students (Wu et al., 2019). College is the transition stage of the mind from immaturity to maturity, and the cultivation of a healthy mental state in college students has attracted much attention (Wu and Wu, 2017). The study shows that, compared with college students who actively participate in sports, the risk of obesity among college students who lack exercise is 1.25 times higher (Zheng et al., 2018). Sports are essential to improve the mental health of college students, including sleep quality, anxiety, and depression of college students, and this has been confirmed by many evidence-based medical studies (Zhao and Yang, 2019). College campuses have unique sports resources but fail to prevent the lack of sports activities and mental problems of college students. Sports venues are an indispensable part of the teaching infrastructure of colleges, and their most basic function is to protect the physical and mental health of students (Li and Qu, 2019). The problems with sports teaching in colleges have existed for a log time. In recent years, due to the annual expansion of college enrollment, the number of teachers and amount of sports equipment is facing a shortage problem (Wu and Song, 2019). Many local colleges and universities lack enough diverse sports venues, and the inefficient sports venues and training environment system makes more students unwilling to carry out sports training and exercise (Wu et al., 2020). Using artificial intelligence technology to meet the development needs of education modernization and promote the transformation and reconstruction of education mode has become a widespread practice in the field of education.

Therefore, based on artificial intelligence information technology and deep learning technology, an intelligent sports management system is designed. The key technologies are introduced and analyzed, the system requirements are analyzed, and the database of intelligent sports management system is established. Based on the actual application needs, some problems and inconveniences existing in the management of sports venues and college students' sports training and teaching environment are solved, the required human and material resources are reduced, and the operation efficiency of sports venues are improved, so as to provide convenient and intelligent services for college students, improve the frequency of sports training and exercise of college students, and promote physical and mental health development.

METHOD

The Architecture of a Sports Management System Based on Artificial Intelligence and Human-Computer Interaction

Deep learning has become a research hotspot in the field of artificial intelligence. Various research results based on deep learning have been applied in practice. It is a method of learning data representation through machine learning. The recognizable feature representation can be obtained through learning multi-level combination, and finally mapped to the task target. With the idea of end-to-end interaction, a deep learning model can directly convert input into output. The process of feature extraction and feature mapping to target output are automatically completed by the model, which saves on the many tedious intermediate processes in traditional machine learning. Artificial intelligence is developing rapidly in various fields. The field of efficient sports is very suitable for the development of artificial intelligence because of its wide audience and the need for professional guidance.

For the architecture of an intelligent sports management system, there are a variety of technologies and methods to choose from. Native is a native application development mode, which can make full use of the functions of the software platform and API interface. The main advantages of Native are smooth running, high stability, and low energy consumption. However, there are some problems in cross platform development. Programmers and staff need to spend time and energy to solve the portability problem in cross platform development. It will take some time to solve this problem, and there are certain restrictions on the development, so the browser-based development mode is selected in this system.

Intelligent wearable devices are another innovative form of modern intelligent technology, and can be used to directly obtain a comprehensive index of the human body. In sports teaching, wearable devices based on human-computer interaction can be used to measure the body indexes of students in different sports states. Moreover, the use of intelligent wearable devices can enhance students' interest in sports and change their cognition of the limitations of sports (Yang et al., 2020). Based on the application of human-computer interaction equipment, the construction of sports management systems needs to combine artificial intelligence and deep learning technology.

Artificial intelligence education environment system is based on a new generation of information technology, such as deep learning algorithm, to build a learner-centered intelligent education environment throughout all aspects of the education process, and to achieve a more diverse, more accurate, and more personalized education environment (Zhao et al., 2019). In an intelligent sports management system, the Browser/Server (B/S) structure is adopted, which divides the system application into presentation layer, business logic layer, and data access layer (Yan et al., 2019). Among them, according to the top-down level in the three layers, the presentation layer is used to display the data and receive the data transmitted from the user from the outside to the internal, which is the interface closest to the user. Then,

the business logic layer operates the data layer, which plays an important role in the whole system. The bottom layer is the data access layer, which operates the database (Kravari and Bassiliades, 2019). The working principle of B/S structure is to connect to the database Server in many ways. Users send their own access requests to the Web server through the Browser. The Web server accepts and processes the requests, and then responds to the Browser. Finally, the Browser receives the response, parses and arranges relevant resource files, and displays the user page (Yi et al., 2019). B/S structure has many advantages, and any user scale will not affect the workload of maintenance and upgrading (Li et al., 2019). Therefore, the B/S three-tier structure is selected as the software architecture of the system, which simplifies the development, maintenance, and use of the system (Gómez et al., 2020). **Figure 1** shows the three-tier structure of B/S.

Artificial Intelligence Microservice Architecture Based on Deep Learning and Spring Cloud Method

In artificial intelligence technology, microservice architecture is used to decompose the original huge services into multiple microservices. Among them, each microservice can run independently and communicate with HTTP-based API using lightweight devices (Yin et al., 2020). Microservices and distributed architecture are becoming more and more popular, and Spring Boot based on REST is just such a service framework. The core of Spring Boot framework is automatic configuration. Using common frameworks in zero XML configuration greatly simplifies the development mode, improves the development efficiency, and shortens the development cycle of the project (Lin et al., 2019). Therefore, in this system, Spring microservice architecture is adopted to decompose the huge service into multiple microservices.

The development of deep learning technology is to promote the development of artificial intelligence. Therefore, there is a cloud server suitable for deep learning. In a deep learning network, each node layer learns to recognize a set of specific features based on the output of the previous layer. As the depth of the neural network increases, the features that nodes can recognize become more and more complex, because each layer will integrate and reorganize the features of the previous layer. Spring Cloud architecture based on deep learning technology can provide services perceptively. Spring Cloud is the epitome of microservice architecture based on the Spring Boot framework, and provides strong backing for microservice architecture. It is an aggregation of all components (Tian et al., 2019). To reduce the difficulty for users to build and maintain distributed systems, Spring Cloud supports a set of development tools for many common functions and cluster state management (Leffler et al., 2019; Morrison et al., 2019; Vaughn et al., 2019). Therefore, in this system, Spring Cloud is selected to let developers quickly build distributed microservice systems through the integration of good framework and components. The advantages of Spring Cloud are as follows: the maintainability of the system can be effectively improved through the improvement of the whole service project planning; the use threshold is relatively low; and due to the fast update speed of products, they are more popular in today's Internet era. **Figure 2** shows the component architecture of Spring Cloud.

Redis is a high performance Key-Value distributed memory database. Its source code is open source. It can support persistent logs and store a variety of data structures of different value types. This system uses Redis to cache data. The advantages of Redis mainly include the following points. Its operation object is the data in the memory, so its reading and writing speed is quite fast and the performance is very high. It supports multiple data types. The advantage of Redis is not only its performance, but also its ability to support multiple data structures, which is more attractive. In addition, compared with memcached, it has more than 1,000 times the maximum data storage capacity, so it can achieve more functions. It also supports a variety of persistence solutions to solve the problem of data loss in the event of memory database failure. In view of the above advantages, Redis technology is most suitable for caching. It reduces the read operation to the database to reduce the pressure of the server, and improves the response speed of the system.

Maven is a software tool for building and managing Java related projects. In the development process of a software project, developers need to carry out the same repeated steps: code editing, unit testing, packaging, publishing the project, and writing documents. These repetitive tasks create a high workload for developers. The emergence of Maven greatly facilitates the work of developers, who can focus on business logic and implementation. Therefore, in this system, Maven is used for project management.

Artificial Intelligence Recommendation Algorithm

In an intelligent sports management system, based on the construction of sports health knowledge ontology database, a hybrid intelligent sports scheme recommendation model is designed, and the similarity calculation algorithm used in solving the model is introduced.

Content-based recommendation is based on whether users liked the items in the past, to make a detailed analysis and obtain the characteristic attributes of the items that users like. Finally, it recommends similar items to users based on this feature attribute (Agans et al., 2020). Fitness equipment is used as an example. First, it is necessary to extract the attribute features from the content of fitness equipment. Which body parts can be exercised by the equipment is taken as feature attribute of the equipment. TF-IDF model is used to calculate the weight of each part (Li and Ning, 2020).

The vector model that defines the content of an item is as follows.

$$Content(i) = \{Q_{i1}, Q_{i2}, ...\} \tag{1}$$

Among them, Q_{ik} represents the weight of item i in the K position.

The vector expression that defines user m is as follows:

$$Profile(m) = \frac{1}{|S(m)|} \sum_{i \in S(m)} Content(i) \tag{2}$$

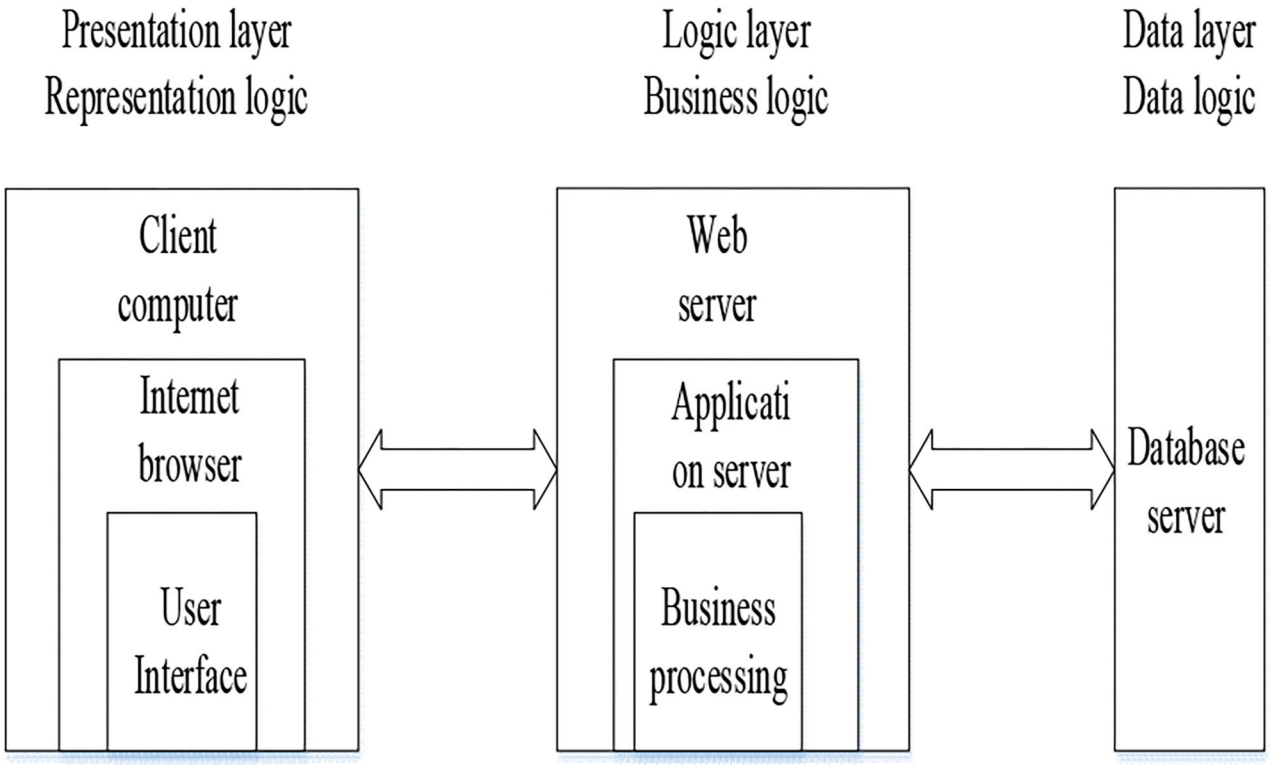

FIGURE 1 | B/S structure diagram.

Among them, $S(m)$ represents the item category selected by the user in the past.

Recommendations based on collaborative filtering first analyze users' interests and hobbies, find users with similar interests and hobbies, and then predict the interests of target users according to the preferences of similar users for some items, and finally recommend the items with a high prediction score to the target users (Renó et al., 2019).

In terms of similarity calculation equation, cosine similarity, co-occurrence similarity, and Pearson correlation coefficient are briefly introduced and used.

The calculation method of cosine similarity is to calculate the cosine value of the angle between two vectors, and take the cosine value as the basis to consider the similarity. Here, two n-dimensional vectors are shown as examples. If there are two vectors $\vec{a}, \vec{b}$, the cosine similarity between $\vec{a}$ and $\vec{b}$ can be expressed as follows.

$$sim(a,b) = 0.5 + 0.5\frac{\vec{a} * \vec{b}}{|\vec{a}| * |\vec{b}|} \tag{3}$$

The calculation equation of co-occurrence similarity is as follows.

$$W_{a.b} = \frac{|N(a) \cap N(b)|}{\sqrt{|N(a)||N(b)|}} \tag{4}$$

N(a) is the number of users who select item a, and $|N(a) \cap N(b)|$ is the number of users who select both a and b.

Pearson correlation coefficient is used to calculate the degree of closeness between the two variables. The equation is as follows.

$$p(x,y) = \frac{\mathrm{cov}(X,Y)}{\sigma_X \sigma_Y} = \frac{\sum_{i=1}^{n}(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum_{i=1}^{n}(X_i - \bar{X})^2}\sqrt{\sum_{i=1}^{n}(Y_i - \bar{Y})^2}} \tag{5}$$

Its value range is between [−1,1]. When the value is 1, it indicates that the two variables are positively correlated, which also means that the similarity is very high; when the value is 0, it indicates that the two variables have no relationship, which also means that the similarity is very low.

Construction of Artificial Intelligence Sports Scheme Recommendation Model

In order to realize the function of sports scheme making and recommendation in an intelligent sports management system, the specific field of sports health is selected for detailed understanding, research, and modeling. Combined with the information of users, such as age, height, weight, and health status, the sports scheme is generated and recommended to users.

The age, BMI index, and health status of users are analyzed, and the same sports scheme is recommended to users. Based

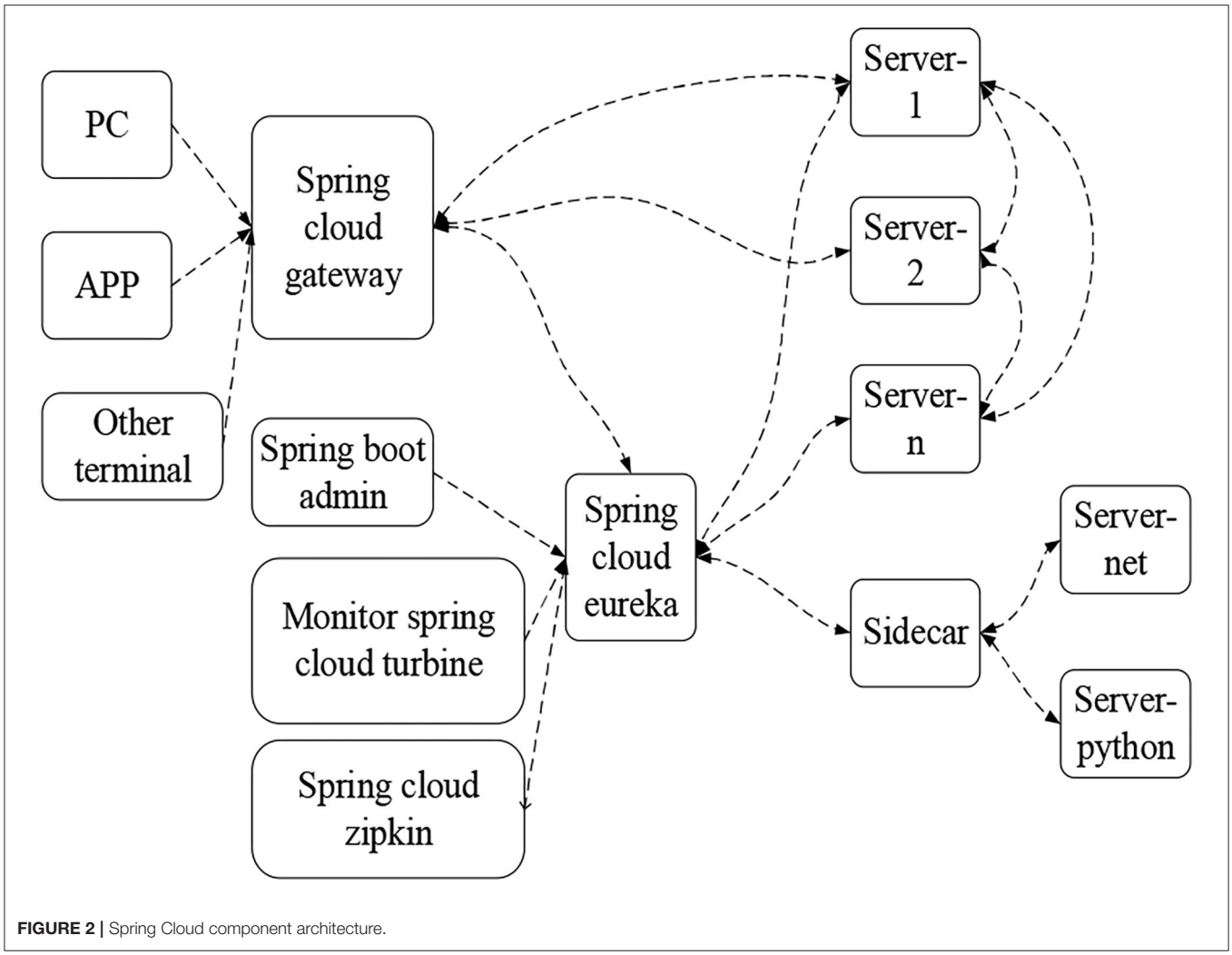

FIGURE 2 | Spring Cloud component architecture.

on the traditional cooperative recommendation algorithm, combined with the knowledge of sports health, a case reasoning model based on ontology similarity calculation is designed to realize the recommendation function of sports scheme in intelligent sports management system. By analyzing the mature sports scheme cases in sports rehabilitation and sports prescription, and combining with the advice of doctors and health care professionals, the recommendation model is designed. **Figure 3** is the sports scheme recommendation model.

Demand Analysis of Artificial Intelligence Sports Training Environment System

At present, most college sports venues are mainly operated and managed manually. Personnel registration and reservation work lead to increased costs and high error rates (Bharathi and Selvarani, 2019). For sports that both teachers and students like, the venue is usually full, so if students want to exercise on the field, they must make an appointment as soon as possible. However, the venue management personnel and users cannot accurately grasp the real-time information of the site status. As a result, some idle venues have no one to exercise, some venues are full of staff, and resources cannot be reasonably utilized, which cannot ensure the efficient operation of venues. Therefore, it is urgent for researchers to develop an advanced information management software system for college sports training.

The system requirements mainly include the following points.

(1) It must have basic functions, such as user registration and login.
(2) It supports the user to book in the browser.
(3) It can add, modify, and delete user information in the background management.
(4) It can give different discount functions according to different roles.
(5) It can let users see the status of all the site information at a glance, and the administrator can operate the site on and off the shelf.
(6) It allows users to reserve parking spaces and venues.
(7) It allows users to rent and return fitness equipment.

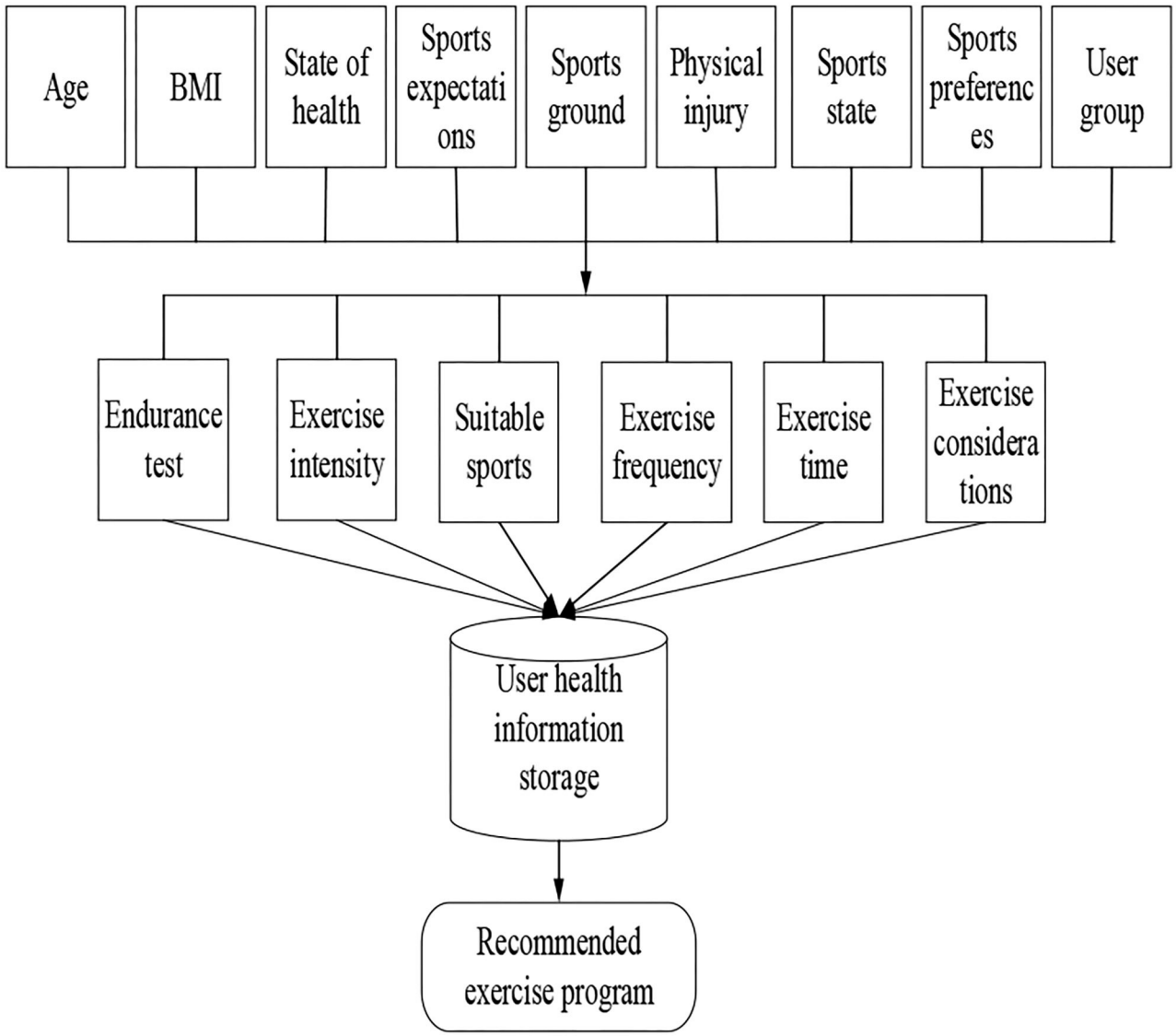

FIGURE 3 | Sports scheme recommendation model.

(8) It allows the administrator to manage information and generate reports.
(9) It recommends fitness equipment and sports schemes to users according to the combination recommendation algorithm.

Database Structure of Artificial Intelligence System

Database design is an important part of system requirement analysis and design. It is directly related to whether the system can be realized and the performance after implementation. In software engineering, database design determines the data storage structure in software development according to the needs of the first party.

An entity relationship (E-R) diagram is composed of entity, attribute, and relation. The following **Figure 4** is the E-R diagram of the two main modules of venue information and course information.

Each entity of the venue module and its ownership attributes are explained as follows in **Figure 5**.

(1) User-included attributes: student name, phone number, venue type, time session, venue, and equipment used;
(2) Venue-included attributes: venue name, venue address, venue description, venue service, and venue evaluation;
(3) Staff-included attributes: number, name, age, position, and phone number.

Each entity of the course module and its attributes are explained as follows.

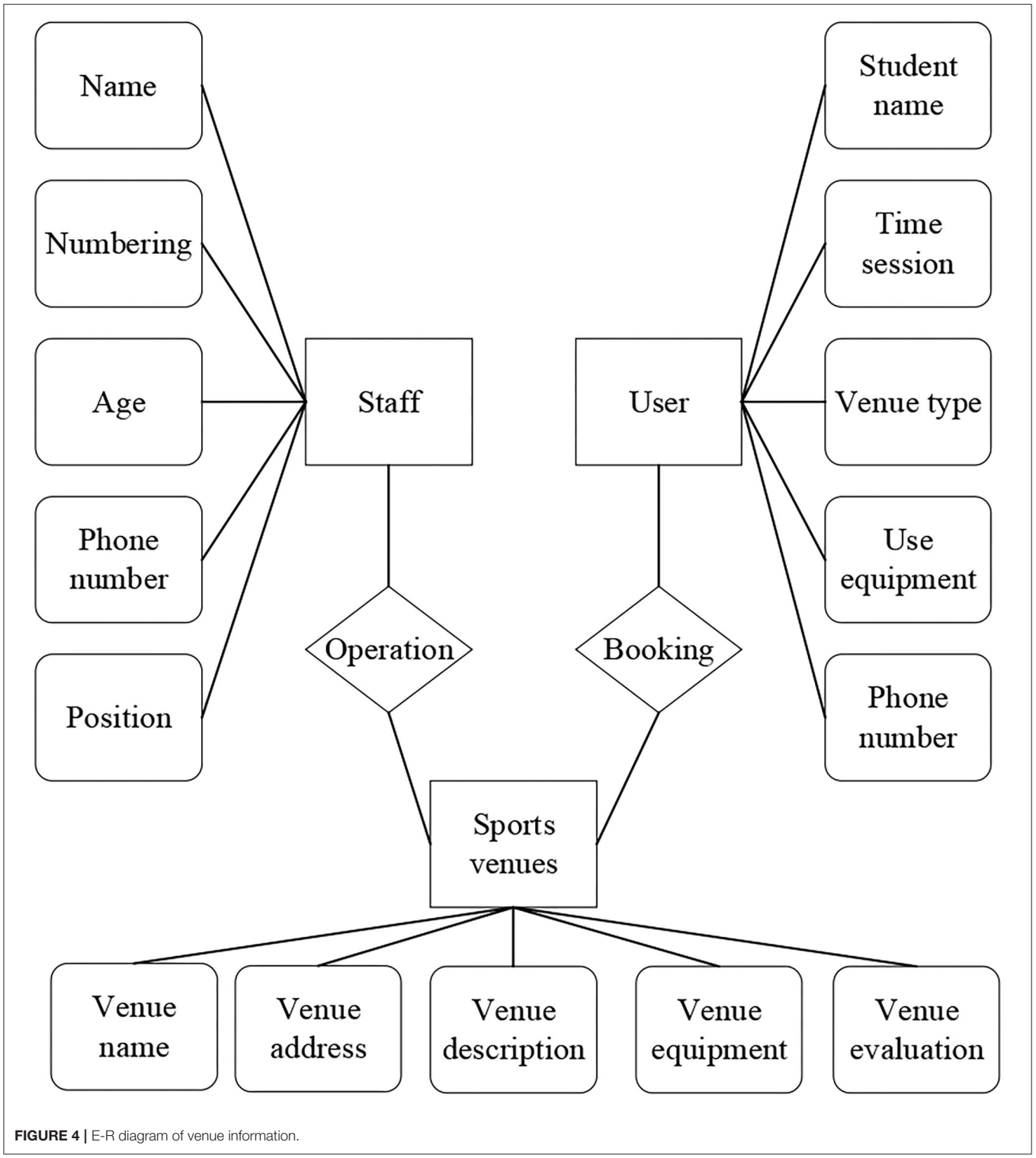

FIGURE 4 | E-R diagram of venue information.

(1) User-included attributes: student name, phone number, state of health, and free time;
(2) Course-included attributes: course name, course address, course description, and course price;
(3) Teacher-contained attributes: teacher ID, name, phone number, teacher level, and teaching program.

Intelligent sports management system architecture is a closed-loop structure, including the user (student) end, venue end, athlete end, and PC management system. In the student end, the school can easily and quickly carry out some operations and enjoy the learning stadium services through the system, mainly made up of the home page, venues, courses, sports, and personal

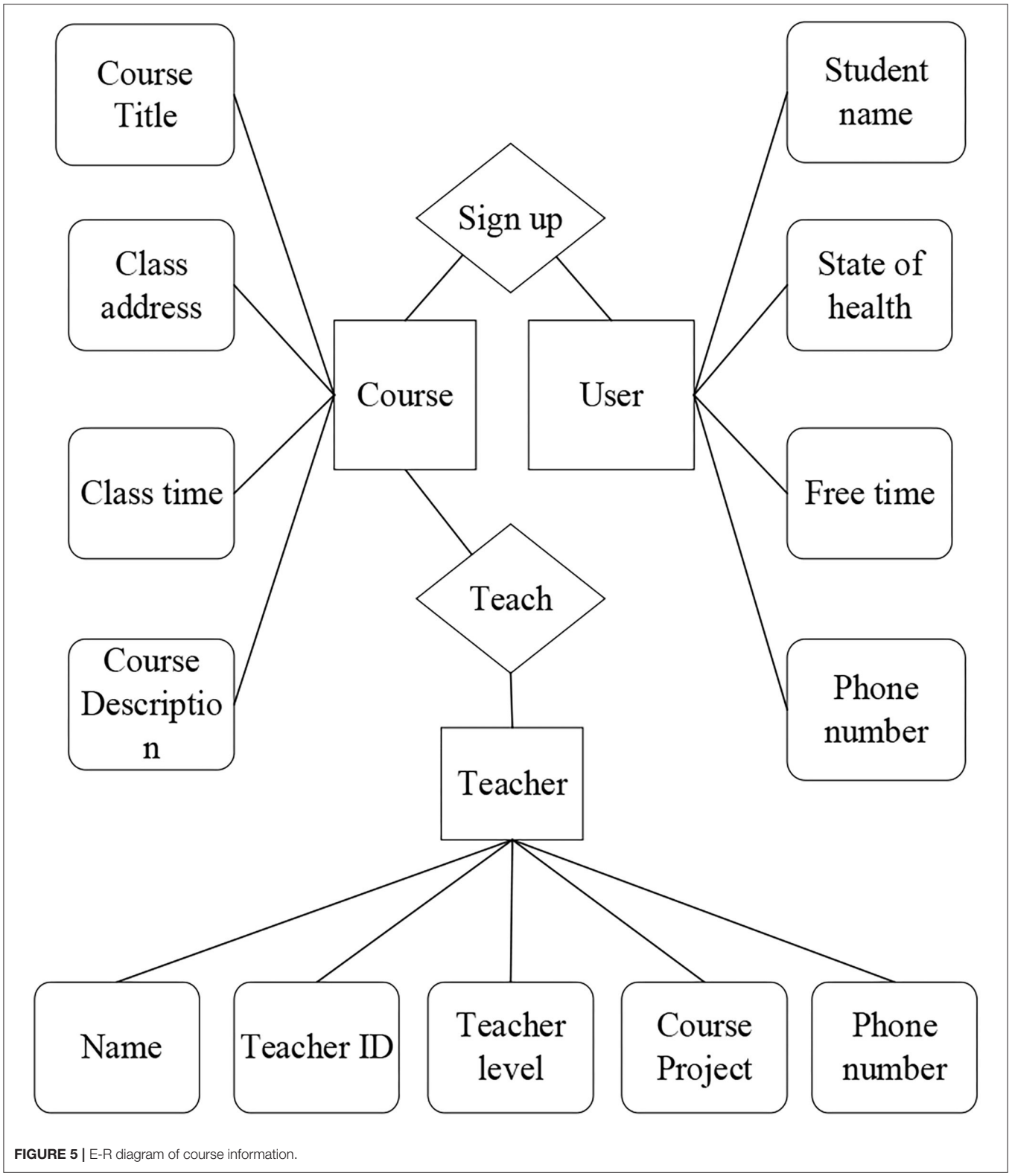

FIGURE 5 | E-R diagram of course information.

home page. The home page mainly includes city selection and weather and temperature information display, sports scheme recommendation and view, fast retrieval of required venues, sports list and news announcement, notice and private messages, and other functional modules. The venue module mainly includes the functional modules of venue reservation, venue

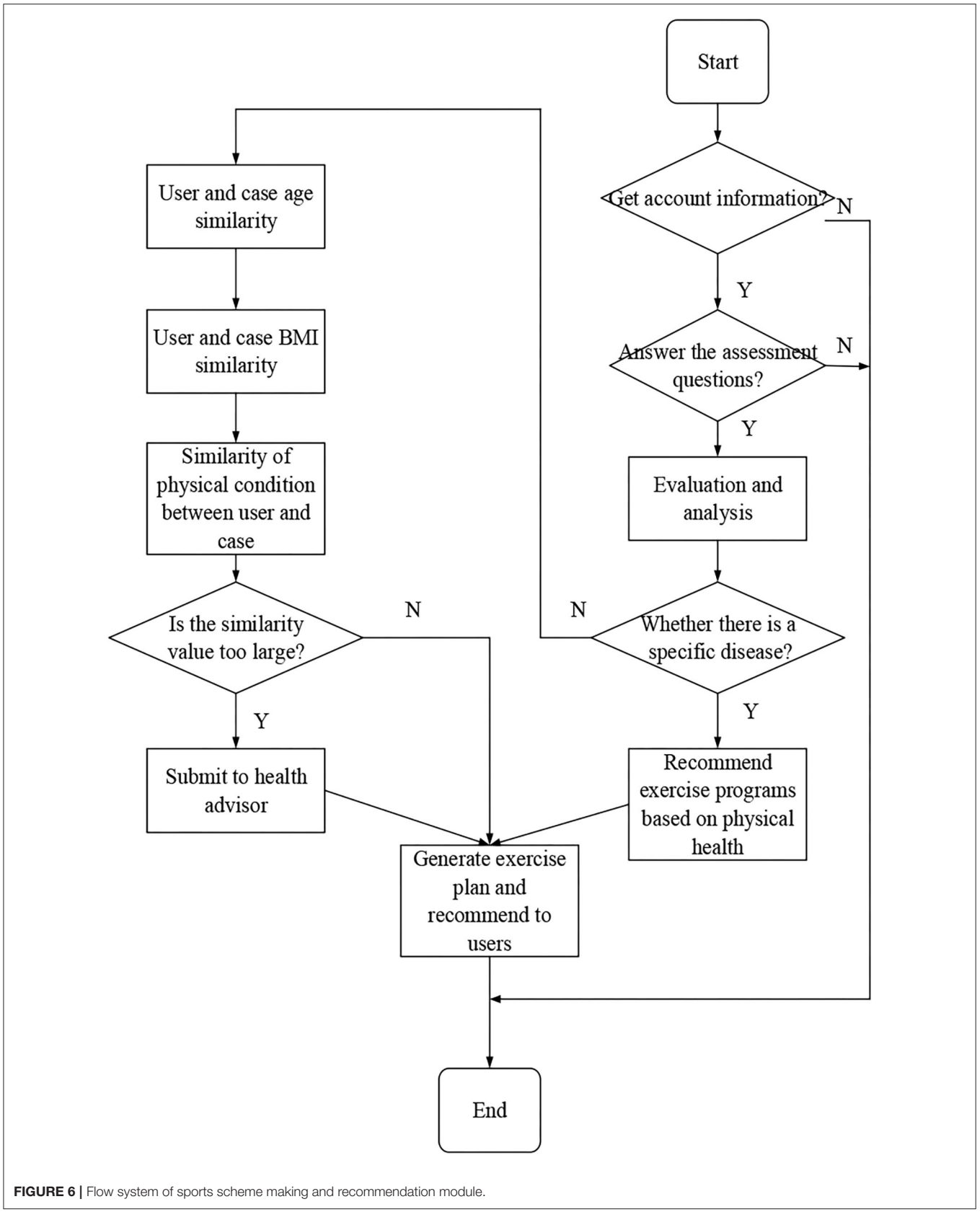

FIGURE 6 | Flow system of sports scheme making and recommendation module.

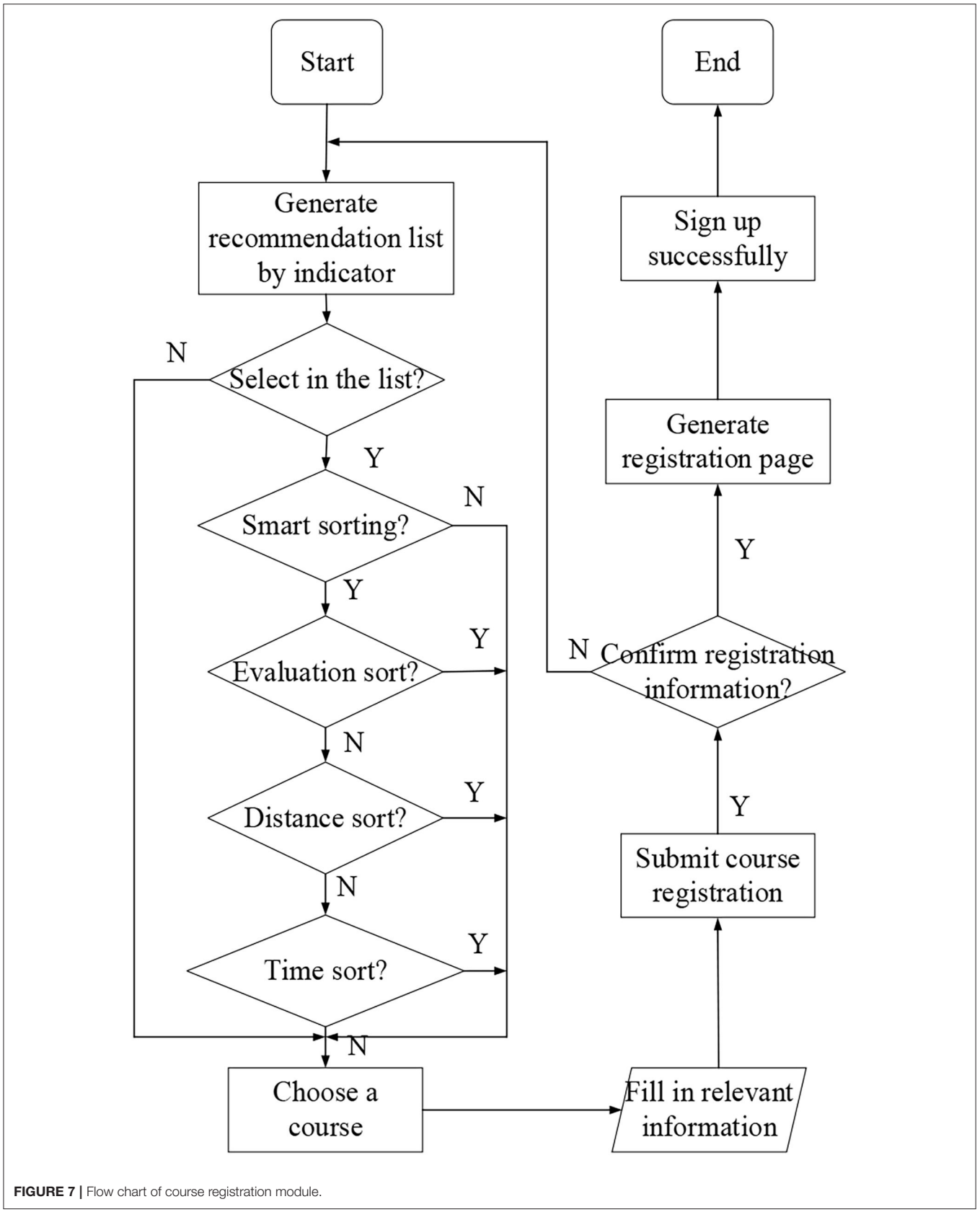

FIGURE 7 | Flow chart of course registration module.

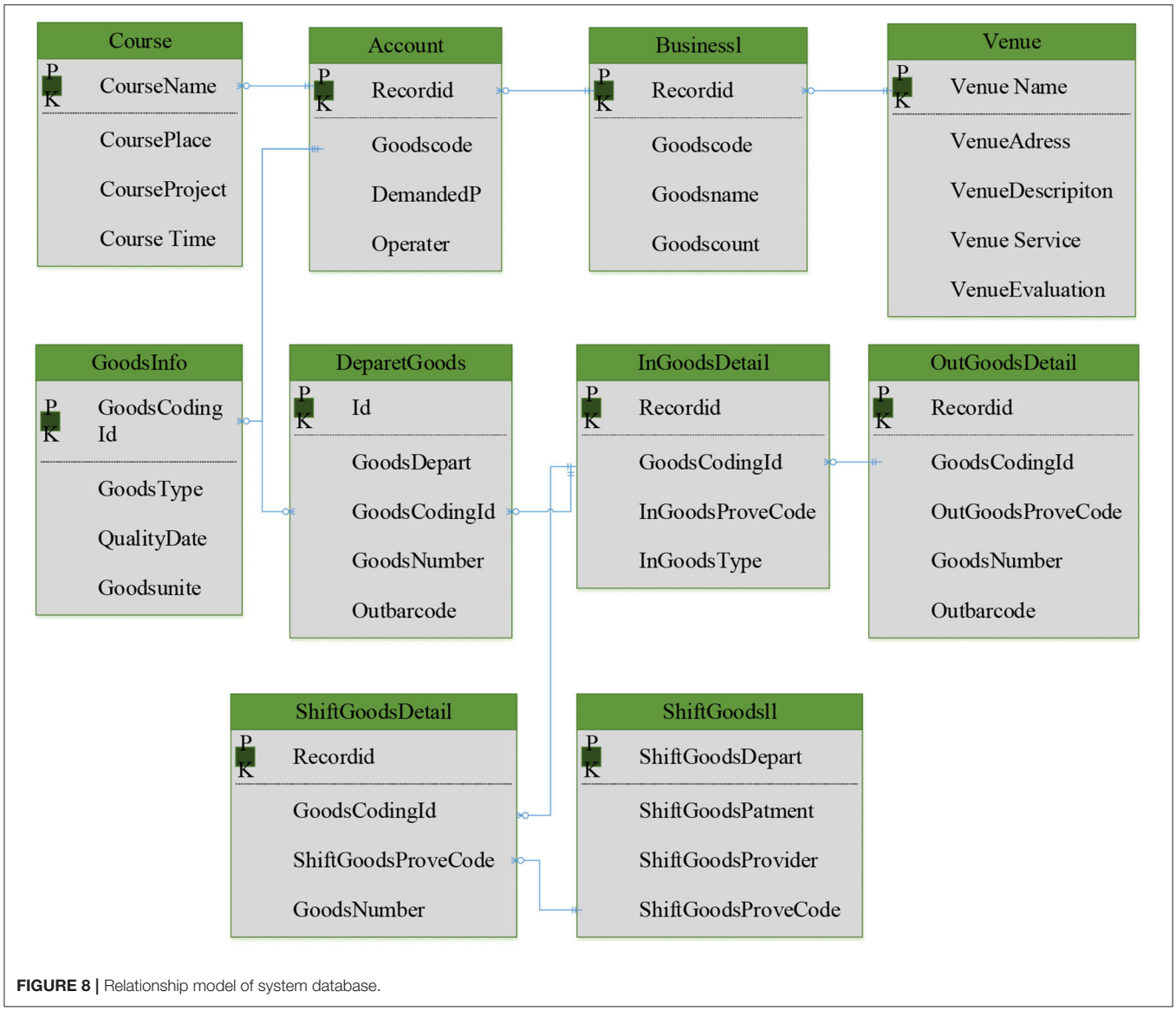

FIGURE 8 | Relationship model of system database.

retrieval, and venue recommendation. The course module mainly includes course retrieval, course recommendation, course reservation, and other functional modules. The sports module includes the development and recommendation of sports programs, the view of the sports program, the exchange and sharing of some information, news, and sports experience about the sports circle, and other functional modules. The personal home page module mainly includes account management, data setting and modification, my account, venue reservation and course registration information, and recommendation and sharing modules.

The Relationship Between Sports Lifestyle and Mental Health of College Students

Sports lifestyle refers to the stable situation and behavior characteristics of all sports activities, which are caused by certain values of individuals, groups, or all members of the society, and meet these multi-level needs under certain social conditions. The sports lifestyle of college students is closely related to the sports training environment instructional system in colleges and universities. In exploring the influencing factors of mental health, sports lifestyle has become an important variable to explain the differences in health amongst students. It has become a common understanding to use sports lifestyle to promote and change people's mental health. Kim provided a physiological basis for the relationship between sports lifestyle and mental health, and studied that sports lifestyle could improve their neurological function, maintain a good state of mind, and relieve tension, anxiety, and depression (Kim et al., 2020). Throughout the research process of sports lifestyle and mental health, previous research on sports lifestyle mostly used self-made questionnaires, which only made statistical analysis on sports time, frequency, intensity, and sports events; the summary of sports lifestyle

TABLE 1 | Booking system functional test.

Use case identification	OnlingBooking_001
Test project	Venue reservation
Test method	BLACK BOX
Test item	Basic operation and data verification of venue reservation
Input/operation	Open the user app; Search for the required venues; Identify venue types and projects; Check the booking status; Choose sports time; Specific site number; Submit booking information.
Expected result	Display the correct venue information; Show the daily booking situation; Normal selection of idle sessions; Display correct booking information after submission.
Actual results	Booking submitted successfully; Consistent with the actual results; Consistent with the PC display.

was incomplete, and there was almost no research on the relationship between sports lifestyle and mental health. Based on this situation, the authoritative physical activity rating scale and the internationally recognized symptom checklist 90 (SCL-90) questionnaire are used to study the relationship between sports lifestyle and the mental health of contemporary college students. On the one hand, it can make college students pay attention to their own sports lifestyle and their own mental health; on the other hand, the influence of sports lifestyle on mental health can be studied, which can indirectly promote mental health by guiding students' sports life, and provide new ideas for the promotion of college students' mental health.

Research on the Effect of Intelligent Sports System on College Students' Mental Health

Shanghai X University is selected as the source of the respondents. The Physical Activity Rating Scale-3 (PARS-3), Self-Rating Depression Scale (SDS), and Self-Rating Anxiety Scale (SAS) are used. The class is taken as a whole, and random cluster sampling is conducted to analyze the differences of depression and anxiety among college students with different amounts of exercise. A total of 569 electronic questionnaires are distributed and 510 are recovered. After the invalid questionnaires, such as those with random filling, are eliminated, 496 valid questionnaires are obtained.

Questionnaire Design and Survey Tools

PARS-3 scale is compiled by Japanese psychologist Takao Hashimoto. The Chinese version of the scale is used in the survey, which mainly reflects the physical exercise in the past month. Domestic research shows that the Chinese version of PARS scale can better evaluate the amount of physical exercise of ordinary college students; its internal consistency reliability is 0.796∼0.856, split half reliability is 0.794∼0.8, and test-retest reliability is 0.82. The scale involves three indexes: intensity, time, and frequency of physical exercise. Each index is scored by five levels. The intensity and frequency are respectively "1–5 points," and the time is "0–4 points." The higher the intensity is, the longer the time is and the higher the frequency is, the higher the score is and the greater the amount of exercise is. The calculation equation of the amount of exercise is "intensity × time × frequency," so the score range of the scale is "0∼100 points." According to the relevant research of domestic predecessors, the classification standard of college students' exercise amount is as follows: "$\leq$ 19 points is a small amount of exercise (insufficient physical exercise), 20–42 points is a medium amount of exercise, and $\geq$ 43 points is a large amount of exercise." SCL-90 is used as the mental health scale. The validity of each symptom is 0.77–0.99, which has good reliability and validity. The scale is divided into 10 dimensions of somatization, obsessive-compulsive symptoms, interpersonal sensitivity, depression, anxiety, hostility, phobia, paranoia, psychoticism, and other, with a total of 20 items. For each question, five levels of scoring standards are set up from "no" to "serious," respectively, which are assigned as "1," "2," "3," "4," and "5" points. The lowest total score is 90 points, and the highest score is 450 points. The lower the score is, the lighter the symptoms are, and the better the psychological condition is.

RESULTS AND DISCUSSION

Application of Artificial Intelligence Sports Scheme Recommendation Algorithm

When the users want to obtain the sports scheme, the intelligent sports management system will prompt them to answer several simple questions to make an evaluation, and the system will obtain some personal information of their registered account to use. Once the users are not allowed to access, the following series of operations are not carried out, and users' choice is respected. APP will not take the initiative to use some users' personal information and push sports programs to them. Only when users know and allow it will the system will obtain some information of their account, such as age, height, weight, and gender, and calculate and analyze it. If users do not fill in the relevant information when registering the account, the system will add some corresponding questions in the evaluation stage to let them answer. After the analysis and evaluation of the information, the system will make a score and classification for users, mainly including the score of chest muscle, heart and lung, abdomen, flexibility, and lower limbs. By scoring, the system can know some conditions of users, such as sports ability and whether they usually exercise or not. According to the classification of users, combined with the completed knowledge base, using the reasoning method based on case and rule, the system selects the sports scheme and recommends it to users. **Figure 6** is the flow system of sports scheme making and recommendation module.

TABLE 2 | The influence of different amount of exercise on college students' anxiety.

Amount of exercise		Anxiety score
Small amount of exercise		45.32
Medium amount of exercise		43.58
Large amount of exercise		38.49
Group comparison		$p < 0.001$***
Multiple comparisons (LSD correction)	Small and medium	$p < 0.001$***
	Small and large	$p < 0.001$***
	Medium and large	$p = 0.154$

***$p < 0.001$.

TABLE 3 | Effect of different exercise amount on depression of college students.

Amount of exercise		Depression score
Small amount of exercise		52.94
Medium amount of exercise		47.68
Large amount of exercise		41.36
Group comparison		$p < 0.001$***
Multiple comparisons (LSD correction)	Small and medium	$p < 0.001$***
	Small and large	$p < 0.001$***
	Medium and large	$p = 0.005$**

**$p < 0.05$; ***$p < 0.001$.

Implementation of Course Registration Module of Intelligent Sports System

The course recommendation and course registration module is mainly for the registered users. Before enrolling for the course, users should first find courses that meet their own requirements. The system can generate the course recommendation list through the recommendation model according to the user's basic information and course information. Users view courses according to the course recommendation list. At the same time, they can also display the course list by manually selecting the course type and sorting the list conditions. The default sorting method is intelligent sorting, which is mainly used to display the courses that meet the user's requirements according to the user's information, and then according to distance, opening time, course evaluation, and so on. After obtaining the course list, users can select the courses that meet their requirements through the detailed information of courses. The detailed information of the course includes course time, teaching address, course introduction, course evaluation, curriculum schedule, and course requirements, which help users better understand the course. After finding the right course, users can sign up for the course and wait for the class opening notice. The course opening notice will be informed to users by a short message service and client message. **Figure 7** shows the flow chart of course recommendation and course registration.

Database Model Design of Artificial Intelligence Sports Management System

On the basis of fully understanding the process of an intelligent sports management system, the system data flow is analyzed, and then the corresponding database relational model is sorted out. After the understanding of entities, relationships among entities, and their attributes, the data types and storage methods of each entity are analyzed. E-R diagram is used to design a database relational model. **Figure 8** shows the system relationship model.

System Test

After the development of the system, it is used to test whether the function of the system is consistent with the function specification written in the requirement analysis. Function test case list usually includes use case identification, test project, test method, test item, input/ operation, expected result, actual result, and so on. The purpose of use case identification is to distinguish between positioning and modification at that time. Input/operation refers to the introduction and description of functions, and then the input and operation steps are briefly described. Finally, the actual test results are compared with the expected results to see if there is any difference. The following is the intelligent sports management system venue booking use cases, as shown in **Table 1** below.

Effect of Intelligent Sports System on Mental Health of College Students

The data analysis of the questionnaire shows that 64% of sample students increased their weekly exercise frequency after the promotion of the school intelligent sports training system. **Table 2** shows the differences in anxiety and depression scores of college students with different amounts of exercise.

As shown in **Table 2**, there are significant differences in anxiety scores among groups with different amounts of exercise ($F = 3.64$, $p < 0.001$). Compared with the group with a small amount of exercise, the anxiety scores of groups with medium and large amounts of exercise are significantly lower (LSD correction, $p < 0.001$).

As shown in **Table 3**, there are significant differences in depression scores among groups with different amounts of exercise ($F = 26.42$, $p < 0.001$). Compared with the group with a small amount of exercise, the groups with medium and large amounts of exercise have significantly lower depression scores (LSD correction, $p < 0.001$). Compared with the group with a medium amount of exercise, the depression score of the group with a large amount of exercise is significantly lower (LSD correction, $p = 0.003$).

CONCLUSION

Based on the B/S structure, the intelligent sports management system is constructed. The basic framework of Spring Cloud is used to integrate the framework and components of each part, and a distributed microservice system is built; age, BMI index, and physical health status are analyzed, the same sports scheme is recommended to users, and the intelligent sports program

recommendation function is realized. After the entity and the relationship between the entities of the intelligent sports system are analyzed, the database relational model of the system is designed with E-R diagram. The functional test results show that the system can accurately display the venue information, complete the online booking, and show the compatible effect on multiple systems. The data analysis results of the questionnaire survey show that there are significant differences in the scores of anxiety and depression among groups with different amounts of exercise; the larger the amount of exercise is, the lower the scores of anxiety and depression are.

The design goal of this system is to use artificial intelligence information technology to develop a set of college sports venues' network intelligent management systems. By installing a browser on the mobile phone or computer, users can log in to the college venue system; college students can achieve registration. Physical education teachers in colleges and universities can release course information and provide guidance for college students' extracurricular exercise, so that there is no conflict between extracurricular exercise and physical education in the venues, and the utilization rate of venue resources can be improved. College students can better carry out sports in class and after class, which can improve their physical fitness and stimulate their sports vitality and physical and mental health.

In this exploration, the main functions of the designed intelligent sports training management system in colleges and universities can be basically realized, but there are still many problems to be improved. It is necessary to optimize the system continuously from the aspects of function, performance, operability, compatibility, and security; with the accumulation of system data, it is necessary to consider the use of big data, data mining, and other advanced technologies to establish a data warehouse to conduct statistical analyses of various data of college students' sports training, so as to provide data support for school sports management decision-making.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because The dataset was restricted by the university labs regulations. Requests to access the datasets should be directed to Ting Wang, ktwphd83@sina.com.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Catholic Kwandong University Committee. The patients/participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2021.634978/full#supplementary-material

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