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The role of teachers' emotions in students' outcomes: From the perspective of interpersonal emotions

Edited by
Xiying Li, Zhongling Pi, Wenli Chen, Xiangen Hu and Harrison Hao Yang

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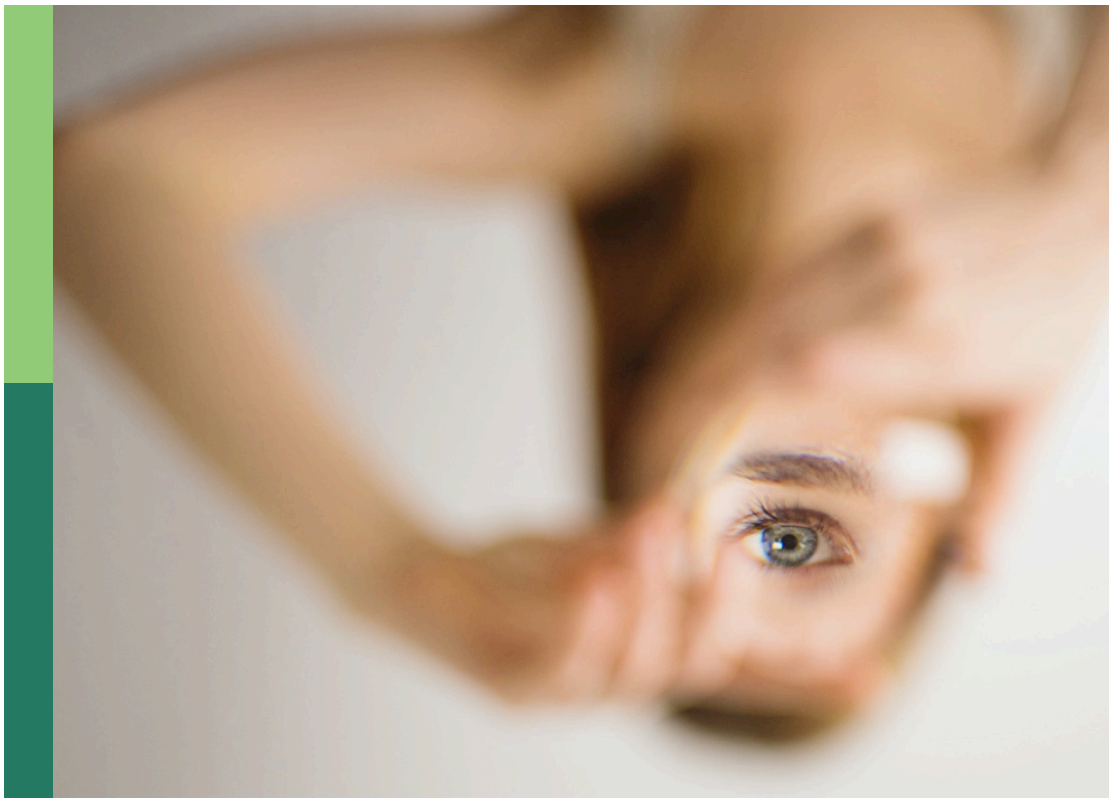

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The role of teachers' emotions in students' outcomes: From the perspective of interpersonal emotions

Topic editors

Xiying Li — Shaanxi Normal University, China
Zhongling Pi — Shaanxi Normal University, China
Wenli Chen — Nanyang Technological University, Singapore
Xiangen Hu — University of Memphis, United States
Harrison Hao Yang — State University of New York at Oswego, United States

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Antonio P. Gutierrez de Blume,
Georgia Southern University,
United States

*CORRESPONDENCE
Xiying Li
flyee@snnu.edu.cn

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Editorial: The role of teachers' emotions in students' outcomes: From the perspective of interpersonal emotions

Zhongling Pi[1], Harrison Hao Yang[2], Wenli Chen[3], Xiangen Hu[4] and Xiying Li[1,*]

[1]Key Laboratory of Modern Teaching Technology, Ministry of Education, Shaanxi Normal University, Xi'an, China, [2]School of Education, State University of New York, Oswego, NY, United States, [3]National Institute of Education, Nanyang Technological University, Singapore, Singapore, [4]Department of Psychology, University of Memphis, Memphis, TN, United States

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Editorial on the Research Topic
The role of teachers' emotions in students' outcomes: From the perspective of interpersonal emotions

Teachers' emotions

Emotions are part of our daily life. Emotions are feelings from judgments relative to specific events and can be intense and directed (Linnenbrink-Garcia et al., 2016). Being a teacher is frequently described as an emotional profession (Frenzel et al., 2016, 2018; Sutton, 2004). Teachers experience various discrete emotions in response to different situations, including interactions with others (e.g., students, colleagues, principals, and parents), reactions to teaching events, and appraisals of teaching events and the educational system (Sha et al.; Shen et al.). Teachers produce either positive emotions (e.g., pride, enjoyment, satisfaction, and happiness) or negative emotions (e.g., boredom, anger, anxiety, and frustration) or mixed emotions in each of these situations. Therefore, it is not surprising that teachers report experiencing various discrete emotions.

However, not all these emotions are always appropriate in the teaching context, as each discrete emotion is accompanied by unique actions and feelings (Cheng et al.). Teacher emotions are multi-faceted processes involving cognition, emotional experience, emotional arousal, and emotional behaviors and actions within the teaching context (Frenzel et al., 2016). For example, teachers who feel pride in their students may be confident, arousal, alert, and have positive action tendencies in their jobs. By contrast, teachers who feel boredom may produce spiritless facial expressions and postures and even experience job burnout. To be professional, teachers try their best to present an appropriate emotional image to their students by regulating their emotions (Sha et al.; Shen et al.).

Teachers' emotions can be classified by their valence (e.g., positive, negative) and physiological arousal (e.g., activating, deactivating; Cheng et al.). It is commonly believed that teachers should present positive emotions (Cheng et al.; Wang et al.). Specifically, teachers' positive emotions elicit a positive classroom climate and good relationships with others, resulting in good educational outcomes (e.g., teachers' occupational wellbeing and students' motivation and learning performance).

Teachers' emotions provide essential information about their feelings, intentions, or motives, thus enabling the students to respond adequately and adapt their behaviors (Pekrun, 2006; Jennings and Greenberg, 2009; Reyes et al., 2012; Keller and Becker, 2021). For example, when students gratuitously shut down during class, it is better for teachers to present happy or angry emotion. If teachers present happy, it is difficult for students to recognize the negative consequences of gratuitously shutting down during the class. The study by Cheng et al. compared the effects of teachers' positive, negative, and neutral emotions. They found that the teacher's positive emotions enhanced students' self-reported pleasure, the teacher's negative emotions enhanced students' productivity, and the teacher's neutral emotions enhanced students' collaborative satisfaction and a greater willingness to continue collaborating with their group. Therefore, researchers should further test whether teachers' positive emotions inevitably lead to good educational outcomes and whether their negative emotions are not.

The influences of teachers' emotions

Teachers' emotions influence not only their occupational health and wellbeing but also students' learning and development (Liu and Wang; Sha et al.; Valentín et al.). The objective of the Research Topic entitled "*The Role of Teachers' Emotions in Students' Outcomes: From the Perspective of Interpersonal Emotions*" is to systematically explore the effects of teachers' emotions on students' outcomes. It aimed to understand the antecedent variables, consequence variables, and the mechanism regarding teachers' emotions in various settings (e.g., traditional face-to-face classroom and video lectures) from a dynamic perspective.

Regarding the influences of teachers' emotions on their outcomes, the studies by Sha et al. and Shen et al. found that teachers' emotional intelligence influenced their wellbeing and mental health, which was mediated by cognitive reappraisal, expression repression, and perceived organizational justice. Regarding the influences of teachers' emotions on students' outcomes, the study by Liu and Wang tested the effect of teachers' emotions on preschool children's social behaviors.

Some studies in this Research Topic also recognize the importance of teachers' emotions in online learning. For example, the study by Wu et al. observed that one of the most significant differences between different presentation styles was the number of emotional words used by instructors in MOOCs. Furthermore, the studies by Valentín et al. and Wang explored whether teachers' enhanced emotions influenced students' learning from texts and video lectures. They found that teachers' enhanced emotions reduced students' cognitive load and improved their motivation and learning performance.

The research studies in this Research Topic make significant contributions to the area of teachers' emotions. Furthermore, these studies also have both theoretical and practical implications. It is suggested that teachers' emotions cannot be regarded as isolated from social, cultural, and political environments, but they are intertwined, a process called emotional transmission in the teaching context (Frenzel et al., 2018). Therefore, teachers' emotions are dynamic rather than static. However, most previous studies regarded teachers' emotions as a static variable by measuring their emotions at one time and testing their relationships with other variables (e.g., students' emotional responses; Wang et al.). A transmissive and dynamic perspective on the possible roles of teachers' emotions is still lacking. Further work should understand the role of teachers' emotions in educational contexts by dynamic measures (e.g., experience sampling).

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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

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Can MOOC Instructor Be Portrayed by Semantic Features? Using Discourse and Clustering Analysis to Identify Lecture-Style of Instructors in MOOCs

Changcheng Wu[1,2], *Junyi Li*[3]*, *Ye Zhang*[3], *Chunmei Lan*[4], *Kaiji Zhou*[3], *Yingzhao Wang*[5], *Lin Lu*[3] and *Xuechen Ding*[6,7]*

[1] Faculty of Artificial Intelligence in Education, Central China Normal University, Wuhan, China, [2] School of Computer Science, Sichuan Normal University, Chengdu, China, [3] College of Psychology, Sichuan Normal University, Chengdu, China, [4] School of Life Science and Technology, University of Electronic Science and Technology of China, Chengdu, China, [5] Xiaoping Executive Leadership Academy, Guangan, China, [6] Department of Psychology, Shanghai Normal University, Shanghai, China, [7] The Research Base of Online Education for Shanghai Middle and Primary Schools, Shanghai, China

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Edited by:
Xiying Li,
Shaanxi Normal University, China

Reviewed by:
Yan Dong,
Beijing Normal University, China
Zhiqiang Ma,
Jiangnan University, China
Xiaofei Qi,
Durham University, United Kingdom

***Correspondence:**
Junyi Li
junyili@sicnu.edu.cn
Xuechen Ding
dingxuechen_psy@163.com

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Nowadays, most courses in massive open online course (MOOC) platforms are xMOOCs, which are based on the traditional instruction-driven principle. Course lecture is still the key component of the course. Thus, analyzing lectures of the instructors of xMOOCs would be helpful to evaluate the course quality and provide feedback to instructors and researchers. The current study aimed to portray the lecture styles of instructors in MOOCs from the perspective of natural language processing. Specifically, 129 course transcripts were downloaded from two major MOOC platforms. Two semantic analysis tools (linguistic inquiry and word count and Coh-Metrix) were used to extract semantic features including self-reference, tone, effect, cognitive words, cohesion, complex words, and sentence length. On the basis of the comments of students, course video review, and the results of cluster analysis, we found four different lecture styles: "perfect," "communicative," "balanced," and "serious." Significant differences were found between the different lecture styles within different disciplines for notes taking, discussion posts, and overall course satisfaction. Future studies could use fine-grained log data to verify the results of our study and explore how to use the results of natural language processing to improve the lecture of instructors in both MOOCs and traditional classes.

Keywords: semantic features, lecture style, MOOCs, LIWC, Coh-Metrix

INTRODUCTION

Nowadays, multimedia learning environment, learning management system, intelligent tutoring system, and massive open online course (MOOCs) provide great opportunities to generate big data in education. Researchers from various disciplines have conducted many interesting studies in the fields of educational data mining and learning analytics. Most researchers paid much attention to analyze student data that were generated from different kinds of learning platforms (DeFalco et al., 2018; Kai et al., 2018). It helps to address personal learning demands of students and improve the quality of individualized learning. However, teaching is an important part of education as well. If the data of instructors

in various teaching platforms can be fully applied, the educational data mining can provide instructors with service and further benefit students. Among various learning platforms, MOOCs has obviously become a popular way to learn for many students around the world. MOOCs provide students with opportunities to a personalized learning environment (Evans et al., 2016) and enables them participate in the cooperative learning through the discussion forum and peer evaluation. Many scholars have conducted studies about MOOCs from the perspective of the characteristics of the learners, learning effect, and course design (Khalil and Ebner, 2014; Poce, 2015; Wang and Baker, 2015), but few scholars analyzed the teaching complexity and the instructors in MOOCs (Ross et al., 2014). Teaching in traditional classes is different from the teaching in MOOCs in many aspects, such as the size of class, prior knowledge of students, and the expense of the course. Nowadays, most courses in MOOC platforms are xMOOCs, which are based on the traditional instruction-driven principle. Course lecture (i.e., course videos) is still the key component of the course. Hence, analyzing the lectures of instructors of xMOOCs would be helpful to evaluate the course quality and provide feedback to MOOCs instructors, which will further benefit learning of the students. One straightforward way is to describe large-scale MOOC lectures through natural language processing. For example, what semantic characteristics do these MOOC lectures have? Does any potential and valuable pattern exist among these semantic characteristics? Do these potential patterns associate with the learning of students? Here we define these semantic patterns that emerged from MOOC lectures as the "lecture style" of the current study. Specifically, the operational definition of lecture style is as follows: the results of cluster analysis based on the semantic features of a given MOOC video (for more details, see section Data Analysis).

When it comes to the quality of MOOCs, researchers have summarized some evaluation systems. For example, Yousef et al. (2014) conducted a large-scale survey of the learners and instructors who have the experience of MOOCs and summarized an evaluation standard of MOOCs. They found that the lectures of instructors play a vital role in the quality of MOOCs. Quality matters rubric is also a widely used evaluation rubric of online courses. This rubric makes raters mark the courses from the eight dimensions of learning objectives, namely, interactivity, usability, etc. (Matters, 2014). Integrating with the survey investigation and focus groups interview, Poce (2015) evaluates MOOC through the clarity and comprehensibility of the lecture, course design quality, etc. In the evaluation of traditional classes, the classroom instruction or course videos were often evaluated by the trained observers or experts using the mature rubric (National Board Resource Center., 2010, which is complicated and cannot avoid the subjectivity in questionnaire investigation. To address this issue, some people tried to use natural language processing to evaluate the lectures instructors of math classes (Araya et al., 2012). They extracted the semantic features from the lectures of the instructors and established several classifiers to automatically predict whether a specific category of math content (e.g., factions) or teacher practice (e.g., reasoning or immediate feedback) was covered by instructors. The results of the classifiers were compared with the experts who were invited to rate the course videos of math classes. They found that the agreements between classifiers and the raters were satisfactory. This may be a new method to evaluate the course quality. It inspires us to evaluate the lectures of the instructors in MOOCs by using natural language processing, and explore the effects of different lecture styles on the learning of students.

In their study, the linguistic inquiry and word count (LIWC) was used to count word categories related to mathematics content and teacher practice (Araya et al., 2012). With the assumption of the words people use in daily life reflect who they are and the social relationships they are in, Pennebaker et al. (2001) developed LIWC, which mainly focus on analyzing the language people use from the perspective of word frequency. Psychologists have conducted many studies in different fields by using LIWC. For example, Rude et al. (2004) found participants who are experiencing physical and emotional pain tend to have their attention drawn to themselves and subsequently use more first-person singular pronouns. Gunsch et al. (2000) found that more self-references (e.g., "I") were present in positive political advertisements compared with mixed and negative political advertisements, whereas more other-references (e.g., "she") were present in negative advertisements compared with positive and mixed advertisements. Researchers also applied LIWC in the field of education; Pennebaker et al. (2014) analyzed more than 50,000 essays from 25,000 students and found that word use was related to the grades of students over all 4 years of college. Robinson et al. (2013) tested whether differences in the use of linguistic categories in written self-introductions at the start of the semester predicted final course performance at the end of the semester, and the results supported their hypothesis. Based on these empirical studies, it is reasonable to use LIWC to analyze the different language use of the lectures of instructors in MOOCs.

Although LIWC is a powerful transparent text analysis program that counts words in psychologically meaningful categories, deeper discourse characteristics are still needed to analyze the lectures in MOOCs. Researchers in the field of discourse analysis proposed a multilevel theoretical framework for discourse processing (Graesser et al., 2011; Dowell et al., 2016). They identified six levels from the shallower to the deeper, including words, syntax, explicit textbase, situation model, discourse genre and rhetorical structure, and pragmatic communication. Our study relates at least to the first three levels of this theoretical framework. The first two levels (i.e., words and syntax) were addressed by LIWC. The third level in our study is textbase, which contains explicit ideas in the text that preserve the meaning. The basic units of meaning in the textbase is proposition. Proposition includes a predicate and one or more arguments. Cohesion is considered an important theoretical construct that measures the overlap between propositions in the textbase. It provides linguistic clues to make connections between an adjacent pair of sentences (Atapattu and Falkner, 2018). Higher level of cohesion in text has been found to facilitate comprehension for many readers (Gernsbacher, 1990) and is particularly important to low-knowledge readers (McNamara, 2001). When there is a lack of cohesion, an idea, relationship, or event must often be inferred by the leaner (McNamara et al., 2010). Learners with low prior knowledge lack sufficient

ability generate the inferences needed to meaningfully connect constituents in low cohesion texts (O'reilly and McNamara, 2007). Cohesion is important to the lectures in MOOCs as well. Just like reading comprehension, a lecture with greater cohesion may help students to connect the discourse constituents and construct coherent meanings. In fact, the coherence assumption was one of the central theoretical constructs in the constructivist theory of discourse comprehension (Graesser et al., 1994). They assumed that students routinely try to construct coherent meanings and connections among text/discourse constituents unless the text/discourse is poorly organized. Therefore, cohesion is an essential discourse feature in the present study. Coh-Metrix will be used to extract the cohesion of the lectures in MOOCs (Graesser et al., 2004; Gao et al., 2016), and one of its central purposes is to examine the role of cohesion in distinguishing text types and in predicting text difficulty. Many studies have suggested that Coh-Metrix can be used to detect subtle differences in text and discourse (McNamara et al., 2010), and it has been widely applied in the studies of education. For example, the previous study has demonstrated that the increase in cohesion can help the students with low prior knowledge to understand the meaning of texts (O'reilly and McNamara, 2007), but the increase in cohesion does not work for the students with higher prior knowledge. As a matter of fact, students with higher knowledge can benefit from low cohesion texts because they were forced to fill in the conceptual gaps in the texts and they have sufficient knowledge to do that (McNamara, 2001; O'reilly and McNamara, 2007; Dowell et al., 2016).

On the basis mentioned above, we proposed three research questions for the current study, which are as follows: (1) Can the lectures styles of MOOC instructors be portrayed by using natural language processing? (2) What are the semantic characteristics of different lecture styles in different discipline? (3) How are the lecture styles of MOOC instructors in different disciplines associated with learning engagement (e.g., discussion posts and notes taking) and course satisfaction? To address these questions, we collected 129 course transcripts from Coursera and edX (including humanities, social science, and science), and extracted the semantic features of the lectures the instructors in MOOCs by using LIWC and Coh-Metrix. Then, cluster analysis was used to detect different lecture styles of MOOC instructors. Finally, we used ANOVA to explore the effects of different lecture styles on the learning engagement of students and perception of the course, including the number of discussion posts, notes taken, and overall course satisfaction.

METHOD

Data Collection

The datasets in the current study are course-level data, which consist of two parts, namely, text data and student data. The first part of the data was collected from the two major MOOC platforms (i.e., Coursera and edX). Convenience sampling was conducted to collect a total of 129 course transcripts (in English), and each transcript includes all sessions of MOOC. These courses cover three disciplines (humanities: 24.8%, social science: 38%, science: 37.2%), and the proportion of different discipline is relatively uniform. The average number of words per course is around 100,000 words, which ensures the robustness of the analysis results.

The second part of the data (i.e., student data) was collected from MOOC College of Guokr.com, one of the largest MOOC learning communities in Mainland China. This community offers online learners a platform where they can voluntarily evaluate MOOCs and share their opinions with fellow online learners. The community also provides various learning assistance tools, including a service for learners to take notes while taking a MOOC, as well as study groups and discussion boards for individual MOOCs. We collected the student data of the 129 courses. The student data refer to the ratings and learning engagement of the student (i.e., the number of notes taken per course and the number asynchronous discussion posts per course). Student ratings involves four dimensions, which are as follows: the amount of knowledge gained, teacher participation, interest, and curriculum design. The items include "Is the course substantial and valuable?" (The amount of knowledge), "Does the teacher participate in communication or interaction?" (Teacher participation), "Is the course interesting and attractive?" (Interestingness), and "Is the structure of the curriculum reasonable and sufficient?" (Curriculum design). A 10-point Likert scale was used, and the average of these four ratings was calculated to indicate overall course satisfaction.

Extracting Semantic Features

Linguistic inquiry and word count 2015 and Coh-Metrix were used to extract semantic features from the course transcripts of instructors in 129 MOOCs. LIWC provides texts summary information (e.g., text length, sentence length, analysis style, etc.), function words (e.g., pronouns, articles, prepositions, etc.), cognitive processes (e.g., see, hear, and feel), emotional words (e.g., positive emotions, anger, anxiety, and sadness), biological processing (e.g., body, health, sex, etc.), drive (e.g., power, affiliation, etc.), grammatical features (e.g., verbs, adjectives, quantifiers, etc.), and informal words as the first-class semantic indices. Each first-class semantic index involves several second-class and third-class indices.

To test the cohesion of the lectures, Coh-Metrix was chosen as a supplement to LIWC. We chose referential cohesion as the index of cohesion in the present study. It refers to the degree to which there is an overlap or a repetition of words or concepts across sentences, paragraphs, or the entire text. Referential cohesion was widely investigated in the psychological studies of discourse processing (McNamara et al., 2010). Previous studies have found that lexical sophistication, syntactic complexity, and cohesion were related to the quality of writing (Kyle and Crossley, 2016; Kim and Crossley, 2018). Pronouns, emotional words, and other indices of LIWC were also found to be important in the psychological studies of discourse processing (Sexton and Helmreich, 2000; Tausczik and Pennebaker, 2010; Pennebaker, 2013; Kacewicz et al., 2014). More importantly, these semantic features could be mapped to the multiple levels of the theoretical framework of discourse analysis by Graesser et al. (2011). Thus, the following semantic features were extracted in the present study:

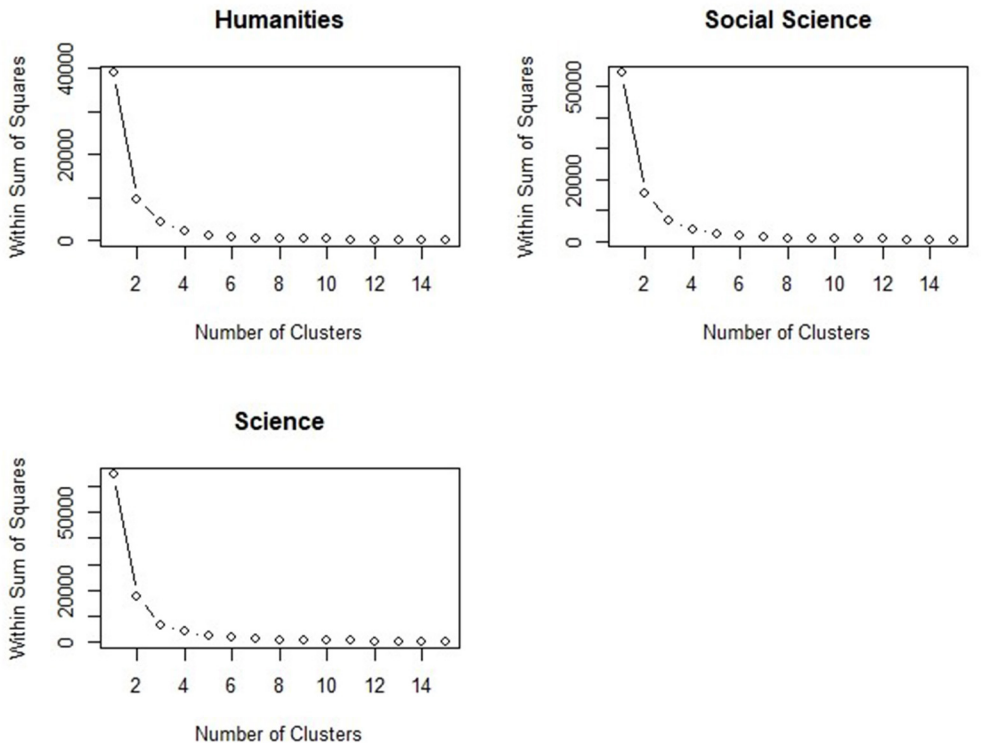

FIGURE 1 | Number of clusters chosen by within sum of squares.

1. Self-reference (i.e., I, me, my, and we);
2. Emotional words, including positive emotions and negative emotions (i.e., anger, anxiety, and sadness);
3. Sentence length (the number of words contained in each sentence);
4. Cognitive words (including causality, comparison, certainty, insight, and other dimensions);
5. Big words (words with more than six letters are considered as complex words or big words in English);
6. Tone (a high number is associated with a more positive, upbeat style; a low number reveals greater anxiety, sadness, or hostility);
7. Cohesion (i.e., coreference cohesion local, the proportion of adjacent sentence pairs in the text that shares a common noun argument).

Data Analysis

As Coh-Metrix can only analyze the texts with a length <10,000 words, the transcript of each course was sliced into several fragments with a length of 8,000–9,000 words. Then we aggregated the semantic indexes of all fragments. All data preprocessing was completed in R 3.4.3 and Microsoft Excel.

Cluster analysis (cluster package, https://cran.r-project.org/web/packages/cluster/index.html) was conducted on the selected seven semantic indices to portray the lecture styles of MOOC instructors in different disciplines. We transformed all the semantic features into *Z*-score to avoid the effect of a different variable scale. Then we performed *k*-means algorithm with Euclidean distance. The *k* value was assigned with a value from 1 to 15. Due to the sensitivity of choosing the initial center points in the clustering method, 25 initial center points were set for the configuration. Subsequently, ANOVA was conducted to explore the effects of different clusters (i.e., lecture styles) within different disciplines on the number of asynchronous discussion posts, notes taken, and course satisfaction. These results would help us to understand how different lecture styles in MOOCs influence the students learning and the perception of the courses.

RESULTS

Descriptive statistics of student ratings and semantic features between the three disciplines have been conducted. Please see the results in Appendix. Here, we mainly focus on the results of cluster analysis and inferential statistics.

Results of K-Mean Cluster Analysis

In all the disciplines (humanities: 38 courses, social science: 49 courses, science: 48 courses), the within sum of squares showed a significant downward trend when the number of clusters changed from one to three, and this decreased trend became slighter when the number cluster changed from four to 15 (see **Figure 1**). It suggested that three clusters would fit the data well in the present study. Then we conducted three K-mean cluster analysis within different disciplines (i.e., each discipline has three clusters). For

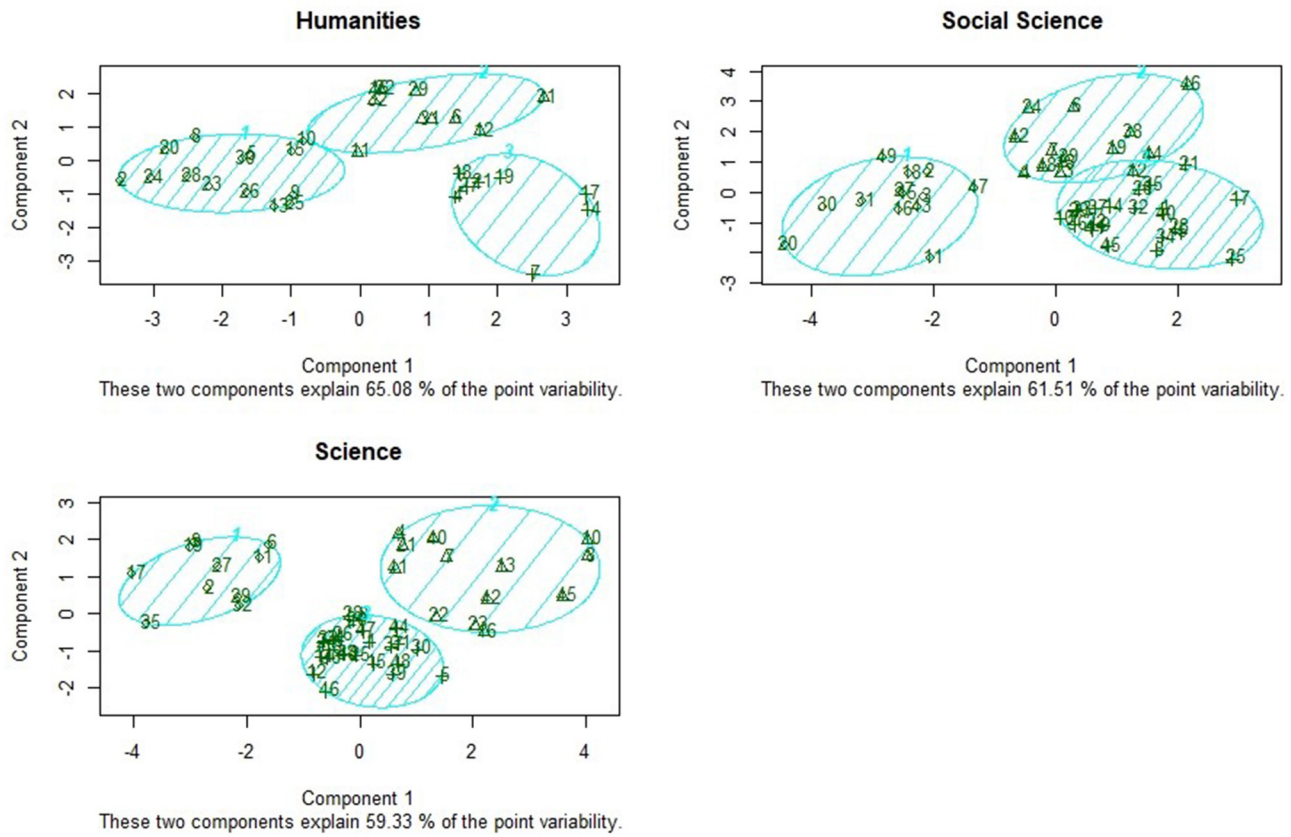

FIGURE 2 | Two-dimensional representation of clusters.

humanities, 14, 10, and 8 courses were classified as Cluster A to Cluster C, respectively. For social science, 13, 14, and 22 courses were classified as Cluster D to Cluster F, respectively. As for the science, 10, 13, and 25 courses were included from Cluster G to Cluster I.

Figure 2 presented a cluster amount of three classes within different disciplines. The datasets were reduced to two components (i.e., *X*-axis and -axis in **Figure 1**) by using principal component analysis. Except that Cluster E and Cluster F only have a small fraction of overlap in social science, the results of clustering were acceptable in general.

We calculated the cluster means (the mean value of *z*-score for each text feature) for different disciplines. **Figure 3** showed those text features of different clusters in each discipline. In humanities, the most obvious characteristic of Cluster A was that the values of affect and cognitive words were higher than the rest of the clusters, and the score of self-reference was large as well. Cluster B had the highest score of cohesion and self-reference, and the lowest score of sentence length and big words. The scores of self-reference, tone, and cognitive processing of Cluster C were the lowest among all the clusters, whereas, the score of sentence length and big words were the largest, suggesting that those instructors who were categorized into Cluster C prefer to use long sentence, complex words, and negative tone when they deliver a speech. In social science and science, both Cluster F and Cluster H have the highest sentence length and big words, and lowest tone, cohesion, and self-reference. In fact, they were similar to Cluster C. Cluster D, Cluster G, and Cluster B were similar as well, considering they all have the highest value of cohesion, self-reference, less big words and short sentence length. As for the Cluster E and Cluster I, the scores of the text features basically surrounded the mean values.

In addition, the result of Pearson correlation analysis showed that both sentence length and big words have significant negative correlation with self-reference ($r = -0.40$, $p < 0.001$; $r = -0.61$, $p < 0.001$); tone and cohesion have significant positive correlations with self-reference ($r = 0.33$, $p < 0.001$; $r = 0.32$, $p < 0.001$); and emotional words and cognitive words were not correlated with self-reference ($r = 0.06$, $p = 0.48$; $r = 0.17$, $p = 0.06$).

Naming for the Clusters

In order to present the process of naming clusters intuitively, we selected two courses from Cluster G and Cluster C as the examples. The first course belongs to Cluster G. The second course belongs to Cluster C. **Figure 4** presents the beginning of the two courses. It can be seen clearly that the self-reference of the first course (at the left hand side) was low, and there were three long sentences and many complex vocabularies at the beginning

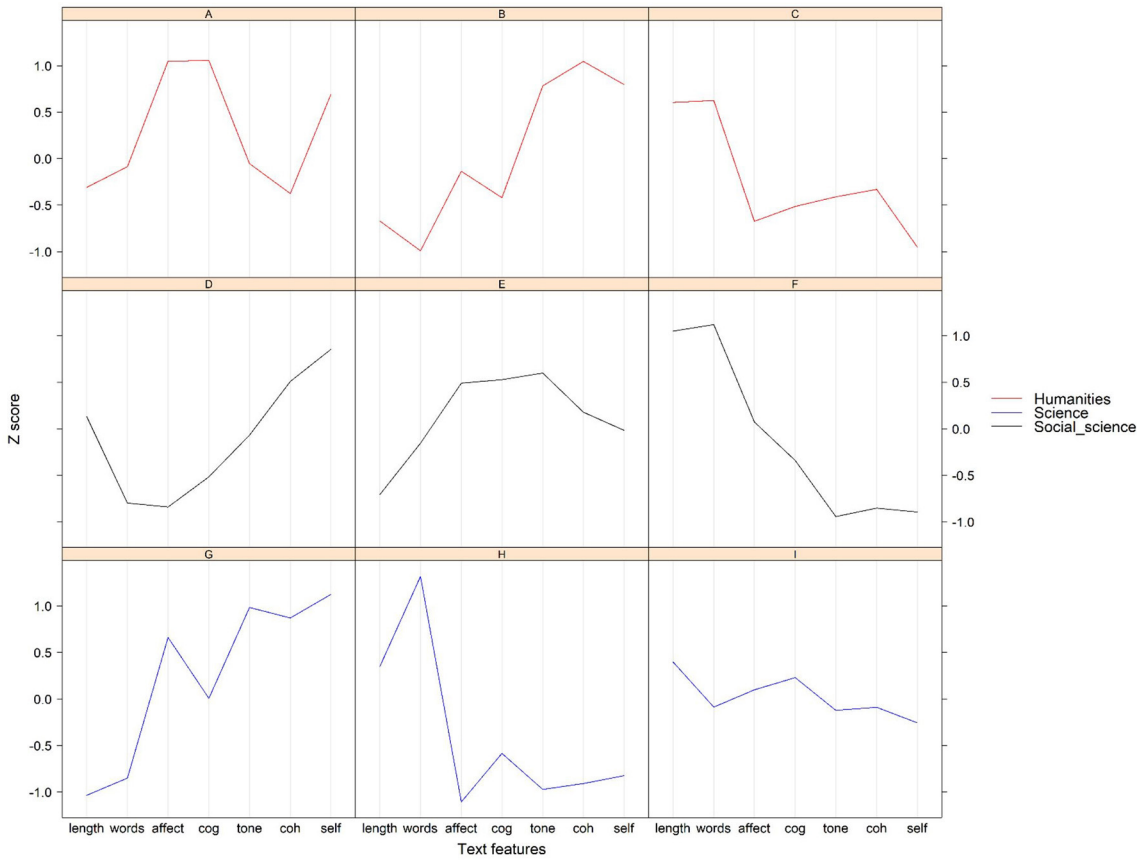

FIGURE 3 | Semantic features of lecture styles in different disciplines.

of the course; whereas the second course (at the right hand side) used many self-reference words, and the sentences in this course were easy to understand. The comments from the students of two courses were also consistent with data analysis results. The following presents some of these comments:

Student A: "Some instructors in this course are serious, some are cute, and the most impressive lesson is an instructor with curly hair took us to local movie studio. The majority of the time we just watched teachers read their slides." (Cluster C)

Student B: "…the lecture of professor is really old-fashioned, but I think it is funny to some extents…" (Cluster C)

Student C: "I feel this course may only suitable for small crowd of people, especially for the artistic youth. Although the content of course is really abundant, the lecture style of teachers is too monotonous, which makes us easy to fall asleep during watching those videos." (Cluster C)

Student D: "The instructor has a lovely English accent, and the curriculum is reasonable. It is friendly for the beginners." (Cluster G)

Student E: "The content is not boring, and it is easy to understand, the instructor is interesting as well. The length of the course video is suitable." (Cluster G)

Student F: "The instructor is approachable and humorous, I like him very much!" (Cluster G)

On the basis of cluster analysis, course video reviews, and student comments, we named the four clusters in the present study as follows: perfect (Cluster A), balanced (Cluster E and I), communicative (Cluster B, D, and G), and serious (Cluster C, F, and H).

The Results of ANOVA

An ANOVA was conducted with asynchronous discussion, notes taken, and overall course satisfaction as dependent variable, and the lecture styles within each discipline as independent variables and course popularity (i.e., the number of learners who followed the course) as the covariates. **Table 1** presented the results of ANOVA and *post-hoc* test. The results of ANOVA showed that there were significant differences of asynchronous discussion ($F = 11.32$, $p = 0.002$, $\eta^2 = 0.28$) and notes ($F = 11.61$, $p = 0.000$, $\eta^2 = 0.30$) for humanities among the three lecture styles. Only significant difference of notes ($F = 22.13$, $p = 0.000$, $\eta^2 = 0.20$) between the different lecture styles was found in social science. As for the science, significant differences of notes ($F = 5.42$, $p = 0.008$, $\eta^2 = 0.20$), discussion ($F = 4.50$, $p = 0.016$, $\eta^2 = 0.13$), and course satisfaction ($F = 3.59$, $p = 0.035$, $\eta^2 = 0.13$) between the three lecture styles were found. Furthermore, we conducted *post-hoc* analysis by using TukeyHSD test, and the results of *post-hoc* test were presented in **Table 2**.

FIGURE 4 | Comparison of two lecture styles (Serious vs. Communicative).

DISCUSSION

In summary, the present study extracted the semantic features of 129 MOOC transcripts and found four lecture styles (i.e., perfect, communicative, serious, and balanced). Specifically, "perfect" (Cluster A), "communicative" (Cluster B), and "serious" (Cluster C) lecture styles were found in humanities. As for the social science and science, three lecture styles emerged from these courses, namely, "communicative" (Cluster D and G), "balanced" (Cluster E and I), and "serious" (Cluster F and H). Then we collected student rating data from one of the largest MOOC learning communities in Mainland China and attempted to figure out how these lecture styles influence the learning of students. The results of ANOVA and *post-hoc* analysis indicated that learning engagement and course satisfaction were significantly different between different lecture styles within each discipline.

Different Lecture Styles in MOOCs

The results of cluster analysis suggested that it is possible to portray MOOC instructors by using natural language processing, which answered research question 1 in the present study. There was almost no overlapping fraction in **Figure 3** in any discipline, indicating the results of clustering were quite acceptable. The four types of lecture styles of MOOCs had distinctive characteristics. Similar to our results, recent studies have revealed that linguistic characteristics of texts vary across different genres and academic disciplines (Graesser et al., 2014; Medimorec et al., 2015). The most significant difference between the "perfect" presentation style and other styles in our study were the number of emotional words and cognitive words used by instructors. The *Z* scores of emotional words and cognitive words of "perfect" style were larger than 1, whereas those of the other types were <0.5. The usage of more cognitive words represents more cognitive processing (including causality, comparison, certainty, and insight) in teaching, which may benefit student learning. For example, researchers found learners read text more quickly when two-clause sentences are connected with a causal word/phrase compared with text in which a connective is neutral (Cain and Nash, 2011). Atapattu and Falkner (2018) suggested that the causal connectives in the academic discourse might improve discourse processing of the learners. Previous studies also found a moderate correlation between the cognitive activation in classroom instruction and the learning achievement (Hugener et al., 2009). Meanwhile, higher-order thinking and understanding are dependent on a high quality of cognitive learning activities in teaching (Hugener et al., 2009). High use of emotional words in the "perfect" lecture style represents an emotional speech to some extent. Researchers have found that positive emotions favor the activation of cognitive resources, which fosters task-related learning processes (Ainley et al., 2005) and metacognition (Artino and Jones, 2012). These evidences explain why we named this type of lecture as "perfect."

As for the other lecture styles, the instructors who have "serious" style rarely used self-reference words, probably because they only focused on the presentation of course materials and relatively ignored the existence of students when they delivered their speech in MOOCs. For example, they barely introduced themselves in their speech, and rarely used "we" to establish potential connection with students. Since we have found a positive correlation between use of first-person and cohesion, it is not surprising that the cohesion of "serious" style was almost the lowest. Two of the most notable features of "serious" courses were complex words and long sentence, and we found significant negative correlations between the two features and self-reference. Instructors who have "serious" lecture style probably prefer to use written language in their lecture (lowest cohesion, lowest self-reference, most big words, and many long sentences) rather than oral language. Also, the score of big words and sentence length were almost the largest in any discipline, suggesting that the effect of the number of terminologies in different disciplines on lecture

TABLE 1 | The differences of notes, discussions, and course satisfaction between different clusters within the three disciplines (the followers per course was controlled as covariates).

Groups	*F*	*p*	η^2	*M*	*SD*
Humanities: notes	11.32	0.002**	0.28		
Cluster A				77.40	46.17
Cluster B				59.00	26.36
Cluster C				24.57	23.82
Humanities: discussions	11.61	0.000***	0.30		
Cluster A				42.80	20.94
Cluster B				48.50	16.32
Cluster C				18.29	5.01
Humanities: satisfaction	3.03	0.064	0.13		
Cluster A				8.66	0.56
Cluster B				8.89	0.49
Cluster C				8.06	0.74
Social science: notes	22.13	0.000***	0.20		
Cluster D				24.23	22.19
Cluster E				64.59	53.69
Cluster F				69.15	43.41
Social science: discussions	2.36	0.131	0.06		
Cluster D				25.21	38.21
Cluster E				65.09	76.71
Cluster F				32.23	29.35
Social science: satisfaction	2.63	0.111	0.20		
Cluster D				8.07	0.91
Cluster E				8.76	0.30
Cluster F				8.33	0.68
Science: notes	5.42	0.008**	0.20		
Cluster G				23.15	18.60
Cluster H				45.20	28.35
Cluster I				49.88	30.71
Science: discussions	4.50	0.016*	0.13		
Cluster G				39.54	40.74
Cluster H				11.40	8.98
Cluster I				47.52	34.29
Science: satisfaction	3.59	0.035*	0.13		
Cluster G				9.00	0.32
Cluster H				8.04	0.60
Cluster I				8.29	1.04

"Perfect": Cluster A; "Communicative": Cluster B, Cluster C, and Cluster G; "Serious": Cluster C, Cluster F, and Cluster H; "Balanced": Cluster E and Cluster I.
$^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

TABLE 2 | The results of multiple comparisons by using TukeyHSD test.

Comparisons	Mean difference	95% CI of mean difference	*p*
Humanities notes			
Cluster B - Cluster A	−18.40	−56.96 ∼ 20.16	0.475
Cluster C - Cluster A	−52.83	−86.49 ∼ −19.17	0.002**
Cluster C - Cluster B	−34.43	−70.46 ∼ 1.60	0.063
Humanities: discussions			
Cluster B - Cluster A	5.70	−11.34 ∼ 27.74	0.69
Cluster C - Cluster A	−24.51	−39.39 ∼ −9.64	0.001**
Cluster C - Cluster B	−30.21	−46.14 ∼ −14.29	0.000***
Humanities: satisfaction			
Cluster B - Cluster A	0.23	−0.52 ∼ 0.97	0.733
Cluster C - Cluster A	−0.60	−1.25 ∼ 0.05	0.074
Cluster C - Cluster B	−0.83	−1.52 ∼ −0.13	0.017*
Social science: notes			
Cluster E - Cluster D	40.16	3.63 ∼ 76.69	0.028*
Cluster F - Cluster D	44.73	3.57 ∼ 85.88	0.030*
Cluster F - Cluster E	4.56	−32.82 ∼ 41.94	0.953
Social science: discussions			
Cluster E - Cluster D	39.88	−7.86 ∼ 87.61	0.118
Cluster F - Cluster D	7.02	−46.76 ∼ 60.79	0.947
Cluster F - Cluster E	−32.86	−81.70 ∼ 15.98	0.244
Social science: satisfaction			
Cluster E - Cluster D	0.69	0.17 ∼ 1.21	0.007**
Cluster F - Cluster D	0.26	−0.33 ∼ 0.85	0.537
Cluster F - Cluster E	−0.43	−0.96 ∼ 0.10	0.137
Science: notes			
Cluster H - Cluster G	22.05	−5.98 ∼ 50.07	0.149
Cluster I - Cluster G	26.73	3.94 ∼ 49.51	0.018*
Cluster I - Cluster H	4.68	−20.25 ∼ 29.61	0.892
Science: discussions			
Cluster H - Cluster G	−28.14	−61.73 ∼ 5.45	0.117
Cluster I - Cluster G	7.98	−19.33 ∼ 35.29	0.760
Cluster I - Cluster H	36.12	6.24 ∼ 66.00	0.014*
Science: satisfaction			
Cluster H - Cluster G	−0.96	−1.80 ∼ −0.12	0.022*
Cluster I - Cluster G	−0.71	−1.39 ∼ −0.02	0.041*
Cluster I - Cluster H	0.25	−0.50 ∼ 1.00	0.696

"Perfect": Cluster A; "Communicative": Cluster B, Cluster C, and Cluster G; "Serious": Cluster C, Cluster F, and Cluster H; "Balanced": Cluster E and Cluster I.
$^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

style was not as important as we thought. Previous study has found that the most common mistake instructors make is the lack of engagement during the teaching, which will make the lecture of the instructors become tedious and students will find it hard to concentrate on the lecture content (Richards and Velasquez, 2014). Instructors who have "serious" lecture styles may probably not be able to engage students during their teaching. For example, the use of "we" and "us" suggests social interaction, which helps the students sense that they are part of a class when engaging with the MOOC video (Pennebaker et al., 2007; Atapattu and Falkner, 2018). "Serious" instructors rarely use these self-reference words in their lecture video. However, the data in the present study could not verify this hypothesis directly, and further empirical studies are still needed to compare the engagement of instructors between different lecture styles.

"Communicative" lecture style (i.e., Cluster B, D, and G) almost had the opposite semantic features when compared to "serious" style. Self-reference and cohesion of the "communicative" style were higher than other styles, whereas the scores of big words and the words in per sentence were relatively low, indicating that the speeches of these instructors may be quite colloquial. According to the comments of students, we found

communicative instructors were often welcomed by students. Perhaps communicative lecture style conveys more enthusiasm. A study conducted by Guo et al. (2014) found learners engaged more with the course when instructor was speaking fast, which is similar to the communicative instructors in the present study. The researchers speculated that the fast-speaking instructors convey more energy and enthusiasm. "Serious" lecture style did not have obvious characteristics when compared with other styles. The course satisfaction of Cluster G (communicative) was significantly higher than that of Cluster I (balanced) and H (serious) in science. In general, all the semantic features of "balanced" lecture style (i.e., Cluster E and I) were located around the average level, which means that this lecture style probably does not have salient characteristics.

Impact of Lecture Style on Course Satisfaction, Discussion, and Notes

The differences of discussion and notes between the four different lecture styles were not significant in our initial study (Li et al., 2017), because of the neglect of discipline. The present study addressed this issue and found that different lecture styles had distinct semantic features, and they also had significant effects on the overall course satisfaction. In both humanities and science, instructors with "communicative" styles were more satisfied than the others. These instructors had higher level of self-reference, cohesion, and tone, which makes them to be perceived as amiable teachers (according to the comments of students). However, the "balanced" lecture style was evaluated as more satisfactory than "communicative" and "serious" styles in social science. This is probably because of the lower level of affect words, cognitive words, and tone of the "communicative" lecture style in social science, whereas the "balanced" style had higher level of affect words, cognitive words, tone, and less complex words and long sentences.

As for the learning engagement, Guokr MOOC community provides many learning tools, including a function for learners to take notes while taking a MOOC, as well as study groups and discussion boards for individual MOOCs. Many students who are not proficient in English prefer to participate in discussion in this community because they may obtain language support from the discussion forum. Therefore, the number of discussion posts and notes taken by students in each course were viewed as indices of learning engagement. Previous study has found that teacher–student interaction has a positive effect on student learning in terms of perceived motivational and cognitive learning quality of the student (Seidel and Prenzel, 2006). Similar to their study, we found that the number of discussion posts for the "communicative" lecture style in humanities was significantly larger than "serious" lecture style. Since instructors with "communicative" style were more likely to use oral language, they probably paid more attention to teacher–student interaction, which triggered more discussion. The "balanced" lecture style in science yielded more discussion posts than the others, but there was no significant difference of discussion posts between the three lecture styles in social science. It seems like the "balanced" lecture style only works for science probably because the "balanced" lecture style in science was more likely to trigger the cognitive processing of students, considering it yielded more notes taken than the other styles.

The major MOOC platforms did not provide note-taking function for MOOC learners, and many Chinese students would take notes directly on Guokr MOOC community. Notes taken reflected the cognitive processing of course content. Researchers have found that note-taking activities benefit students in exercising their self-regulated learning skills, which is an important cognitive activity in learning (Lawanto and Santoso, 2013). Also, the benefits of note-taking activity include development of higher-order thinking skills (Hohn et al., 1989; Kobayashi, 2005), and improvement of the concentration of students (Konrad et al., 2011). We found significant differences for the number of notes taken among different lecture styles. Specifically, the number of notes taken in Cluster A (perfect) was significantly higher than that of Cluster C (serious) style in humanities. Consistent with the result of cluster analysis, the "perfect" lecture style yielded a higher level of cognitive processing (i.e., notes taking), which may help students in their learning process and successfully increase their learning achievement (Lawanto and Santoso, 2013).

Interestingly, the notes of Cluster F (serious) was significantly more than Cluster E (balanced) and D (communicative) in social science. Even though the "serious" lecture style was perceived as tedious or verbose (according to the comments of students), it still yielded the higher level of cognitive processing than the other lecture styles in social science. Also, the notes of Cluster I (balanced) was significantly more than Cluster G (communicative) in science. Although the cohesion of the "serious" and the "balanced" lecture style was low, higher knowledge learners can benefit from low cohesion, because lower cohesion forces them to generate inferences to fill in the conceptual gaps (Dowell et al., 2016). Furthermore, the "serious" lecture style MOOCs was not appreciated by the comments of students, but the other sides of the courses (e.g., reasonable curriculum design, abundant course materials, effective course assignments) might affect cognitive processing of the students as well.

Limitations and Future Directions

Some limitations of the current study should be noted. First, we did not acquire the permission to obtain the academic performance data, specific information about student profile, and other detailed data about learning engagement (e.g., the fine-grained log data) for the 129 MOOCs. We can only use the public data from a third-party MOOC community to explore the influence of different lecture styles on course satisfaction, discussion, and notes taken. Thus, it is hard to draw the conclusions in regard to the impacts of lecture-styles. Second, as Coh-Metrix can only analyze a small text (i.e., <10,000 words), we had to slice the course transcript into several pieces and then aggregate the results of all slices. This process was time-consuming, causing our sample size (i.e., 129 courses) to be relatively small. Third, we only selected seven semantic features from over 200 features to portray MOOC instructors according to previous studies and our own teaching experience. This

procedure may cause information loss; perhaps automatic feature selection is a good choice as well. Fourth, the student rating data was obtained from Chinese learners. Non-native English speakers may not have good enough language skills to evaluate English MOOCs.

Future studies should acquire more detailed data about student learning in MOOCs, especially the fine-grained log data about learning progress of the students. It will allow researchers to explore the longitudinal effects of different lecture styles on the learning (e.g., engagement, affect, performance, and self-regulated learning) of the students. It is necessary to consider the effect of moderators (e.g., demographics and teaching experience) as well, especially on how teachers with different experiences moderate the effect of lecture styles on the learning of students. In addition, tracing the changes of semantic features of new teachers and providing feedback to their lecture might be helpful to improve their presentation skills. According to the current study, it seems like a good lecture should be emotional and rational. However, it may be difficult for instructors to give emotional lectures to the camera without immediate feedback from students. Moreover, simply encouraging instructors to use more emotional and cognitive words in the lecture may make instructors feel confused and have no operability. Thus, how to use the results of natural language processing to improve lectures of instructors in MOOCs is worth exploring in the future. Finally, the analysis of MOOC lecture style can also be extended to traditional classes. It might help to improve the quality of traditional courses by analyzing the presentation recording, course video, and standardized test.

CONCLUSIONS

The results of the current study have provided answers to our three research questions. First, the lecture styles of MOOC instructors can be well-identified by natural language processing. We found that four different lecture styles emerged from 129 MOOCs, which are as follows: "perfect," "communicative," "balanced," and "serious." Second, each lecture style in different disciplines has its unique semantic characteristics. Third, the lecture styles of MOOC instructors have significant effects on learning engagement and overall course satisfaction. However, it should be noted that it is not feasible to judge which lecture style is the best or the worst without considering the instructional contexts (e.g., discipline). And more importantly, the present study only provides initial evidence with certain drawbacks.

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 authors.

AUTHOR CONTRIBUTIONS

CW and JL contributed to the study's conception and design. Material preparation and data collection were performed by YZ and CL. Data analysis was performed by KZ, LL, XD, and YW. The first draft of the manuscript was written by JL and XD. All authors commented on previous versions of the manuscript, read, and approved the final manuscript.

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Would It Be Better if Instructors Technically Adjust Their Image or Voice in Online Courses? Impact of the Way of Instructor Presence on Online Learning

Mingze Yuan[1], *Jialing Zeng*[1,2], *Aihua Wang*[1] *and Junjie Shang*[1]*

[1] *Lab of Learning Sciences, Graduate School of Education, Peking University, Beijing, China,* [2] *Department of Human Development, Teachers College, Columbia University, New York, NY, United States*

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***Correspondence:**
Junjie Shang
jjshang@pku.edu.cn

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This study investigated the effects of the changes in the image and voice of instructors in online video courses on online learner's learning achievement, social presence, learning satisfaction, and academic emotion. Two simultaneous online experiments were conducted with 122 college students in the image experiment, where the course videos varied in terms of the instructor's image (original image, face-beautified image, virtual image, and no image), and 93 college students in the voice experiment, where the course videos varied in terms of the instructor's voice (original voice, mutated voice, computer-synthesized voice). The results showed that learners viewing videos without instructor images had better learning achievements and less academic boredom relative to those who viewed videos with instructor images. However, the real instructor images were able to promote learners' learning satisfaction of instructor-student interaction more than no image and virtual image and promote satisfaction of instructor teaching more than virtual image. Meanwhile, learners' evaluation of the real instructor images was better than that of the virtual instructor image, and their evaluation of the face-beautified instructor image was better than the original image. Moreover, learners evaluated real instructor voices better than the computer-synthesized voice. In addition, the linear regression analysis revealed that the evaluations of both instructor's image and voice had a positive relationship with learners' social presence, learning satisfaction, and enjoyment, whereas they had a negative relationship with learner's boredom. And the evaluation of the instructor's image positively predicted student's transfer learning achievement. Thus, we suggested that the way of instructor presence should be well-designed and integrated with the course's instructional design and image and voice processing technology can be applied to assist online video course development.

Keywords: online education, video courses, instructor presence, image and voice, online learners

INTRODUCTION

Since the outbreak of COVID-19 in 2020, online education has been strongly promoted worldwide, as it provides highly convenient, flexible, and commonly shared online resources for students. Schools all over the world have carried out the educational practice of online learning. In a survey conducted by the Chinese Ministry of Education (2020), as of May 8, 2020, there were 1,454 universities in China conducting online learning, 1.03 million teachers have offered 1.07 million online courses, and a total of 17.75 million college students have participated in online learning. However, inherent problems such as lack of autonomous learning, and insufficient interaction with the learning resources have become increasingly prominent, which may become obstacles restricting the development of online education.

Researchers have carried out a lot of research and discussion around how to produce higher-quality video courses and improve the effectiveness of online education. Among these studies, whether instructors should present and how to present in the online courses is a crucial issue in the field of both research and social practice. The image and voice of instructors in online courses are key elements that must be considered in video course design.

The Role of Instructor Presence

Instructor presence refers to the presence of multimedia elements such as instructor image and voice in video courses. Based on the different ways of presenting, the current research of instructor presence mainly discussed these multiple dimensions: (1) audiovisual dimension, such as showing only instructor's voice or both the image and voice; (2) time dimension, such as the continuous presence or intermittent presence; (3) fidelity dimension, such as the presence of real instructor image or virtual instructor image; (4) position and ratio dimension, such as the position of the instructor image in the screen; (5) the way of recording, such as embedded and fusion; (6) instructor's demeanor, such as instructor's facial expressions, gestures, eye gazes and etc.

Previous studies have shown that instructor presence had many effects on online learning, including social presence, cognitive load, learning satisfaction, attention, etc. Social presence refers to the degree to which a person is regarded as a "real person" and the degree of perception of connection with others in the process of using media to interact with others (Short et al., 1976). Researchers proposed that, compared with traditional classrooms, online learners lacked an immersive and interactive feeling, which may increase the psychological distance between the learner and the instructor, and adversely affected the learning achievement (Swan, 2003). Presenting the instructor's image or interspersing with social cues, such as gestures, eye gazes, etc., was able to help enhance learner's sense of social presence, stimulate learning motivation and participation, and promote knowledge construction (Richardson and Swan, 2001; Mayer et al., 2003; Dunsworth and Atkinson, 2007).

For the cognitive load, as the individual's cognitive resources are always limited, instructors should effectively utilize learner's cognitive resources to avoid overload, thereby enhancing learning achievement in online learning (Sweller, 1994). As a result, many researchers believe that instructor image is one kind of extra information that can lead to redundant information in the visual channel. When instructor image is presented in the online course videos, it increases extraneous load and hinders the learner's information processing integration (Mayer, 2005; Homer et al., 2008; Kizilcec et al., 2014).

Learning satisfaction is a subjective experience of learners in the learning process, which is often used as a crucial indicator to measure learner's learning situations and the success of teaching (Zhu, 2012). Previous studies have found that the way of the presence of learning materials in online video courses had an impact on learner's learning satisfaction (Zhang et al., 2006). Moreover, Kizilcec et al. (2014) also found that adding instructor's image to course videos was able to prompt learners to produce positive emotional responses, and instructor presence may help increase learner's learning satisfaction.

Furthermore, attention is the orientation and concentration of mental activity to a certain object, which means that attention is a selective cognitive activity. Individuals always selectively pay attention to certain information while ignoring other information accordingly. Psychological studies have found that individuals were highly sensitive to facial information (Gullberg and Holmqvist, 2006). At the same time, facial attention also represents a cultural habit—maintaining eye contact means concentration, interest, and participation (Kendon, 1967; Bavelas et al., 2002). Therefore, theories and eye movement studies have consistently found that the presence of instructors would significantly attract the attention of learners (Choi and Johnson, 2005; Day et al., 2006).

Learner preference is a kind of subjective evaluation for online video courses, which reflects learner's attitudes, emotions, and satisfaction with the courses. It is important for the production and evaluation of online courses. Many studies showed that learners were more inclined to choose online courses with the presence of instructors, thought that these courses were more interesting and were more likely to persist in learning (Kizilcec et al., 2015; Wilson et al., 2018).

From different theoretical perspectives, previous empirical studies did not find consistent effects of instructor presence on online learning. On the one hand, many studies found that instructor presence was able to increase learner's sense of social presence and interest, promote attention investment, stimulate positive emotions, and improve academic performance (Guo et al., 2014; Kizilcec et al., 2014). On the other hand, there were also studies that showed instructor presence did not have a significantly positive impact on online learner's social presence, cognitive load, and academic performance, and may even have a negative impact on learning achievement (Homer et al., 2008). This was partly due to external factors such as experimental design, measurement tools, and teaching style. However, it may also result from the way and quality of instructor presence. According to a survey of 218 MOOC courses from mainstream MOOC platforms worldwide, 94.5% of the course videos showed instructors on the screen, whereas only 5.5% of the videos did not show instructor image at all (Yang et al., 2015). It can

be said that, from the perspective of social practice, instructor presence seems to have become the "standard configuration" of current online video courses. Compared with whether instructors should present, the way the presence of instructor may be a more practical issue. Current studies mainly focused on whether instructors were present, as well as the instructor's presence's location, time, instructor's facial expressions, gestures, etc. Less concentration was given to the effect of instructor image and voice on online learning.

The Role of Instructor's Image and Voice

The presence of an instructor image refers to a person's head, face, neck, and facial features, conveying a large amount of information such as age, gender, health, and emotions. It was found that human's perception of facial attractiveness was very fast (Olson and Marshuetz, 2005). Individuals can quickly perceive and judge differences in facial attractiveness even for visual information that flashed by (13 ms). Attractive images can often trigger people's positive and pleasant emotional experience, prompt people to have a willingness to approach them, and even affect people's judgments of their personality, abilities, and other intrinsic characteristics (Jones et al., 2004), which was also known as "face preference" or "face stereotype" (Dion et al., 1972). Face preference plays an important role in people's mate selection, employment, promotion, and learning as well. Studies have shown that face preference may affect learning by influencing learner's attention, emotion, and motivation.

Previous studies have found that highly attractive faces would attract participant's attention more, produce longer attention spans, and prolong the time it takes for participant's attention to leave and shift to follow-up cognitive tasks (Maner et al., 2007; Sui and Liu, 2009; Leder et al., 2010; Mitrovic et al., 2016). When faces appeared as distractors at the same time as the target cognitive task, highly attractive faces were more likely to produce attentional distractions, cause inhibition of return, and lead to performance degradation (Lindell and Lindell, 2014; Valuch et al., 2015; Hung et al., 2016). When faces were tracked targets, highly attractive faces can promote the distribution and maintenance of attention and improve tracking performance (Liu and Chen, 2012; Li et al., 2016).

Some researchers believe that people's attention to faces may occupy cognitive resources and interfere with other learning tasks, while other researchers propose that learning is a relatively long-term process, and the positive emotions evoked by faces may have a moderating positive effect on learning (Cubukcu, 2013). They can stimulate learner's motivation and promote learning performance (Yang et al., 2014). Westfall et al. (2016) have discussed the influence of instructor's image on learners' learning. They instructed participants to listen to a lecture while watching a photo of an instructor with high or low attractiveness. After the lecture, they completed the task of recognizing the content of the lecture. It was found that participants who watched the photo of the highly attractive instructor performed better than those who watched the photo of an instructor with low attractiveness. As a result, the researchers believed that the positive emotions evoked by the instructor's image positively influenced participants' learning. This has also been confirmed by brain science research. Related studies showed that attractive faces can be used as a reward stimulus to activate the reward system of the observer's brain, such as the nucleus accumbens, amygdala, orbitofrontal cortex, and prefrontal cortex. The release of dopamine in these brain areas will be promoted, which makes individuals feel motivated and happy (Aharon et al., 2001; Kranz and Ishai, 2006; Winston et al., 2007; Cloutier et al., 2008).

Similarly, individuals have preferences for voice (Zuckerman and Driver, 1989). Instructor voice plays an important role in online learning as well. Shoufan (2019) analyzed more than 2,300 "Like" or "Dislike" evaluations of online video courses to investigate the reasons and found that the voice of the instructor was a crucial reason for learners to evaluate the quality of the course. For example, many learners would like a course because the instructor's voice was "confident" and "clear," whereas some learners would dislike a course as the instructor's voice was "monotonous," "boring," or "unclear." In addition, through research on instructors with pronunciation difficulties, it turned out that any form of voice impairment may affect learner's learning performance (Rogerson and Dodd, 2005).

Some researchers also discussed the influence of computer-synthesized voice on online learning. According to the voice effect theory (Craig and Schroeder, 2017), compared with the voice synthesized by computers, the way of using instructor's voice recording in the video course was more able to promote learner's deep learning and enhance learning performance. Although instructor voice recording is more in line with the learner's preferences, with the development of voice synthesis technology, the difference between computer-synthesized voice and the human voice is rapidly shrinking, and it has broad future development prospects (Chiou et al., 2020).

The Role of Video and Audio Processing Technology

Technological innovation has brought new changes to instructor presence in online courses. With the support of video beautification, expression capture, voice synthesis, and other emerging technologies, people can conveniently process the image and voice of instructors. This has greatly enriched the way of instructor presence, and its application scenarios are broad. For example, facial expression capture technology and virtual imaging technology allow instructors to project facial expressions, movements, mouth shapes, etc. on virtual characters to replace real people. Moreover, computer voice synthesis technology allows instructors to directly convert the text to voice and add it to video courses without recording by themselves.

Technological innovation will undoubtedly influence future online learning activities. From the perspective of face performance and voice performance, attractive faces and voices can trigger more positive emotions in learners and promote learning. Therefore, it is undoubtedly a positive value to adopt images and voices that learners prefer. On the other hand, different instructor's images and voices will also affect learner's social presence, cognitive

load, learning satisfaction, and attention distribution. For example, attractive images and voices may increase the learners' attention to the instructor and reduce their attention to the learning materials and contents. Furthermore, compared with the original image of the instructor, the virtual image may reduce learners' sense of social presence, which in turn affects the learning performance. The new technologies have added many new questions to existing research.

The Present Study

As a result, this study verified the effects of changes in the image and voice of instructors in online video courses on online learning, including online learner's learning achievement, social presence, learning satisfaction, and achievement-related emotion. And we examined the relationship between learner's evaluation of different ways of instructor image and voice and their learning achievement, social presence, learning satisfaction, and achievement-related emotion. We carried out two simultaneous online experiments. In the first experiment, to examine the effects of the changes in instructor's image on online learning, participants learned a video course with the same content but different images of the same instructor, in one of four conditions: (1) original image, (2) face-beautified image, (3) virtual image, (4) no image. In the second experiment, to explore the impact of the changes in instructor's voice on online learning, participants learned the same video course without the instructor's image, in one of three conditions: (1) original voice, (2) mutated voice, (3) computer-synthesized voice. Based on theories and the results of previous studies, we hypothesized:

1. Compared with learners viewing video courses with instructor image, learners viewing video courses without instructor image would show better learning achievement, lower levels of social presence and satisfaction, and more sense of negative emotion.
2. Compared with learners viewing video courses with the virtual image, learners viewing video courses with the real instructor's image would show better learning achievement, lower levels of social presence, satisfaction, and evaluation, and more sense of negative emotion.
3. Compared with learners viewing video courses with the instructor's original image, learners viewing video courses with the face-beautified image would show lower learning achievement, higher levels of satisfaction and evaluation, and more sense of positive emotion.
4. Compared with learners viewing video courses with the instructor's voice, learners viewing video courses with the computer-synthesized voice would show worse learning achievement, lower levels of social presence, satisfaction and evaluation, and more sense of negative emotion.
5. Compared with learners viewing video courses with the instructor's original voice, learners viewing video courses with the mutated voice would show higher levels of satisfaction and evaluation, and more sense of positive emotion.

METHOD

Participants and Design

In the image experiment, college students from 31 universities in China ($N = 122$, 60 males and 62 females) aged 17–28 years ($M_{age} = 23.38$, $SD_{age} = 2.4$) were recruited and randomly assigned to learn one of the four course versions, including original image ($N = 32$), face-beautified image ($N = 30$), virtual image ($N = 29$), and no image ($N = 31$). None of the students reported having prior knowledge about the content presented in the course.

In the voice experiment, we recruited 93 college students (55 males and 38 females) from 17 Chinese universities aged 18–27 years ($M_{age} = 23.32$, $SD_{age} = 2.12$), who were randomly assigned to study using one of the three course versions, including original voice, mutated voice, and computer-synthesized voice. There were 31 participants in each condition. One thing worth mentioning is that students in the no image group in the image experiment and the original voice in the voice experiment were the same. All the students reported no prior knowledge about the learning content.

Based on the information that they provided in the basic information questionnaire, all participants had normal vision and hearing. They all provided written informed consent and received five dollars for participating in this experiment.

Materials

Video Courses

The video courses were recorded for this study, which lasted about 9 min. The learning content was based on the Chinese national-level MOOC "*Paleography*" describing the meaning, origin, and related allusions of paleography. The learning content and course videos were reviewed by experts to ensure that the content was correct and the difficulty was moderate. The content, slides, duration, and speed of each version were consistent, whereas the forms of instructor presence were different.

For the image experiment, there were four conditions with the instructor's original voice as shown in **Figure 1**. (1) Original image: the original image of the female instructor was presented. (2) Face-beautified image: the instructor's image was treated with lightening and smoothing of the skin. (3) Virtual image: the instructor's image was replaced by a female 2D cartoon virtual image. The virtual image would follow the changes in the face of the real instructor to make corresponding mouth shapes and expressions. (4) No image: there were only the slides on the screen without the instructor image.

For the voice experiment, the video courses were processed into three versions without the instructor image. (1) Original voice: this version was the same as the no image version in the image experiment. (2) Mutated voice: the voice has been transposed, and we appropriately raised the teacher's pitch (about 1 chromatic scale). According to related research on voice preference (Feinberg et al., 2008; Fraccaro et al., 2013), within a certain range, the attractiveness of female voices with higher pitch is also relatively higher. (3) Computer-synthesized voice: the computer-synthesized voice provided by the iFlytek dubbing platform was adopted. The voice had been used more than 4.5

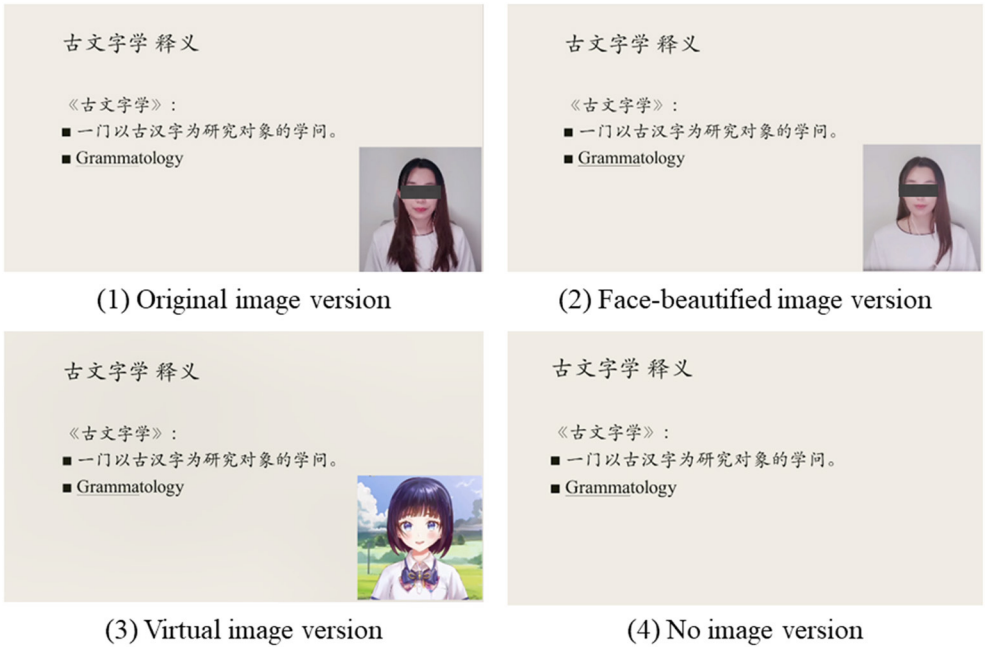

FIGURE 1 | Screen shots of the four versions in the image experiment (after privacy treatment).

million times on-demand on the platform, which was widely used and had good results.

Measurements

The basic information questionnaire included ten items about the learner's gender, age, grade, physical health, such as abnormal vision or hearing, the learning experience in paleography, etc.

The prior knowledge test contained four multiple-choice items (total 4 points) and five true-or-false items (total 5 points) to measure learners' prior knowledge about paleography with a full score of 9. Each multiple-choice item had four answer choices, but only one correct answer (e.g., "In which dynasty did Chinese research atmosphere of paleography form? A. Spring and Autumn and Warring States Period; B. Qin and Han Dynasties; C. Tang and Song Dynasties; D. Ming and Qing Dynasties"). And one example of the true-or-false questions was "Is philology the study of the semantics, grammar, and phonetics of ancient Chinese?" All the items in the test were developed by the researchers and examined by one paleography expert to ensure expert validity. The higher the score on this test indicated a higher degree of prior knowledge. There was no significant difference among the four groups in the image experiment [$F_{(3, 188)} = 0.46$, $p = 0.71 > 0.05$, partial $\eta^2 = 0.01$; **Table 1**] and across the three groups in the voice experiment [$F_{(2, 90)} = 0.92$, $p = 0.40 > 0.05$, partial $\eta^2 = 0.02$; **Table 2**].

The learning performance test: assessed the learners' mastery of the knowledge described in the video course after watching the course video, including a retention test and a transfer test. *The retention test* included 10 multiple-choice items (total 10 points) and five true-or-false items (total 5 points) with a total score of 15 to test learners' retention of key concepts in the video course. For the multiple-choice questions, learners needed to choose one correct answer from four answer choices (e.g., "What is the original meaning of Chinese character 'zhi'? A. Rest; B. Sunset; C. Stop; D. Toes"). And one example of the true-or-false question was "Is philology an auxiliary tool for people to study history?" The transfer test included eight multiple-choice items with one correct answer (total 8 points) and two multiple-choice items with more than one correct answer (total 2 points) with a total score of 10 to measure learners' ability to transfer the knowledge learned from the video course to solve problems not taught in the course. For example, one of the questions with one correct answer was "Which Chinese character in modern Chinese corresponds to a certain character in ancient Chinese?" whereas one of the questions with more than one correct answer was "Which of the following Chinese characters belong to the category of 'characters' in ancient Chinese?" All the items in both tests were developed by the researchers and examined by one paleography expert to ensure expert validity. The higher the score on both tests indicated a higher degree of knowledge retention or knowledge transfer.

Social presence questionnaire: A Chinese revised version of the social presence questionnaire developed by Kim and Biocca (1997) was adopted in this study to measure learner's social presence. The questionnaire used a 7-point Likert scale ranging from 1 (totally disagree) to 7 (totally agree) and consisted of eight items. The odd-numbered items were scored positively, while the even-numbered items were scored in reverse. The final score of this scale was the sum of ratings for each item. One example of the item was "When the video ended, I felt like I had returned to the real world from a trip." The social presence questionnaire showed high internal consistency (Cronbach's $\alpha = 0.83$).

TABLE 1 | Means and standard deviations of all dependent variables for each condition in the image experiment.

Dependent variable	Original image ($N = 32$)	Face-beautified image ($N = 30$)	Virtual image ($N = 29$)	No image ($N = 31$)
Prior knowledge	4.41 (1.88)	4.10 (1.73)	4.52 (1.68)	4.10 (1.62)
Retention	9.78 (2.30)	10.00 (2.96)	9.55 (2.46)	11.39 (1.82)
Transfer	7.13 (1.70)	7.07 (1.62)	6.93 (2.03)	8.10 (1.68)
Social presence	30.72 (8.76)	30.67 (8.43)	29.69 (7.35)	31.23 (8.92)
Satisfaction (T)	24.63 (3.24)	24.30 (3.85)	22.28 (3.74)	23.71 (3.85)
Satisfaction (C)	15.69 (2.35)	15.57 (2.64)	14.55 (2.43)	15.77 (2.36)
Satisfaction (I)	11.44 (1.97)	10.73 (2.70)	9.93 (2.43)	9.84 (2.48)
Satisfaction (E)	12.09 (1.75)	11.83 (2.28)	11.28 (1.89)	12.03 (1.68)
Satisfaction	63.84 (8.18)	62.43 (10.11)	58.03 (8.77)	61.35 (8.90)
Enjoyment	14.31 (3.03)	14.70 (3.03)	14.55 (2.93)	15.84 (2.78)
Boredom	11.88 (4.01)	12.00 (4.46)	11.48 (3.64)	9.16 (3.80)
Image evaluation	11.38 (1.56)	12.30 (1.70)	9.55 (1.99)	–

T, C, I, and E, respectively, represent the instructor teaching, learning content, instructor-learner interaction, and learing environment and equipment of satisfaction.

TABLE 2 | Means and standard deviations of all dependent variables for each condition in the voice experiment.

Dependent variable	Original voice ($N = 31$)	Mutated voice ($N = 31$)	Computer synthesized voice ($N = 31$)
Prior knowledge	4.10 (1.62)	4.58 (1.43)	4.16 (1.53)
Retention	11.39 (1.82)	10.42 (1.96)	11.19 (1.89)
Transfer	8.10 (1.68)	7.48 (2.13)	7.58 (1.89)
Social presence	31.23 (8.92)	33.45 (7.99)	33.52 (9.24)
Satisfaction (T)	23.71 (3.85)	23.23 (3.56)	22.84 (3.87)
Satisfaction (C)	15.77 (2.36)	15.55 (2.69)	15.61 (2.80)
Satisfaction (I)	9.84 (2.48)	9.90 (2.90)	10.68 (2.12)
Satisfaction (E)	12.03 (1.68)	12.03 (1.87)	11.61 (1.84)
Satisfaction	61.35 (8.90)	60.71 (9.97)	60.74 (9.16)
Enjoyment	15.84 (2.78)	15.39 (3.23)	15.32 (2.80)
Boredom	9.16 (3.80)	10.48 (3.92)	10.29 (4.16)
Voice evaluation	11.06 (2.25)	10.71 (2.65)	9.39 (1.99)

T, C, I, and E, respectively, represent the instructor teaching, learning content, instructor-learner interaction, and learing environment and equipment of satisfaction.

The higher the score on this scale meant a higher level of social presence.

Learning satisfaction questionnaire: was from the video course learning satisfaction questionnaire revised by Yang (2014). There were four factors, including instructor teaching (total 6 items), learning content (total 5 items), instructor-learner interaction (total 3 items), learning environment and equipment (total 3 items), and 17 items on a 5-point scale in the questionnaire. The final score of each factor was the sum of ratings for each item, and the final score of this scale was the sum of scores of all the factors. Examples of items in each factor included "The instructor is serious in class and cares about learners' learning", "The content in the video attracts me and helps me", "Through video learning, I can fully participate in the learning process", and "I am satisfied with the normal operation of the video course". The learning satisfaction questionnaire showed moderate-to-high internal consistency (instructor teaching Cronbach's $\alpha = 0.87$; learning content Cronbach's $\alpha = 0.79$; instructor-learner interaction Cronbach's $\alpha = 0.78$; learning environment and equipment Cronbach's $\alpha = 0.81$). The higher the score on each factor meant a higher level of satisfaction.

Achievement-related emotion questionnaire: was from the online learning achievement-related emotion questionnaire of Artino and Jones (2012), which was able to measure learner's emotional levels of enjoyment and boredom in online learning. It consisted of two factors (enjoyment and boredom), 9 questions, on a 5-point scale. There were four items in the enjoyment factor and five items in the boredom factor. The final score of each factor was the sum of ratings for each item. Examples of the items in each factor included "I enjoy studying the course" and "I would rather do something else than study the course." The internal consistency of the achievement-related emotion questionnaire was high (enjoyment Cronbach's $\alpha = 0.86$; boredom Cronbach's $\alpha = 0.90$). The higher score on the two factors meant higher levels of enjoyment and boredom, respectively.

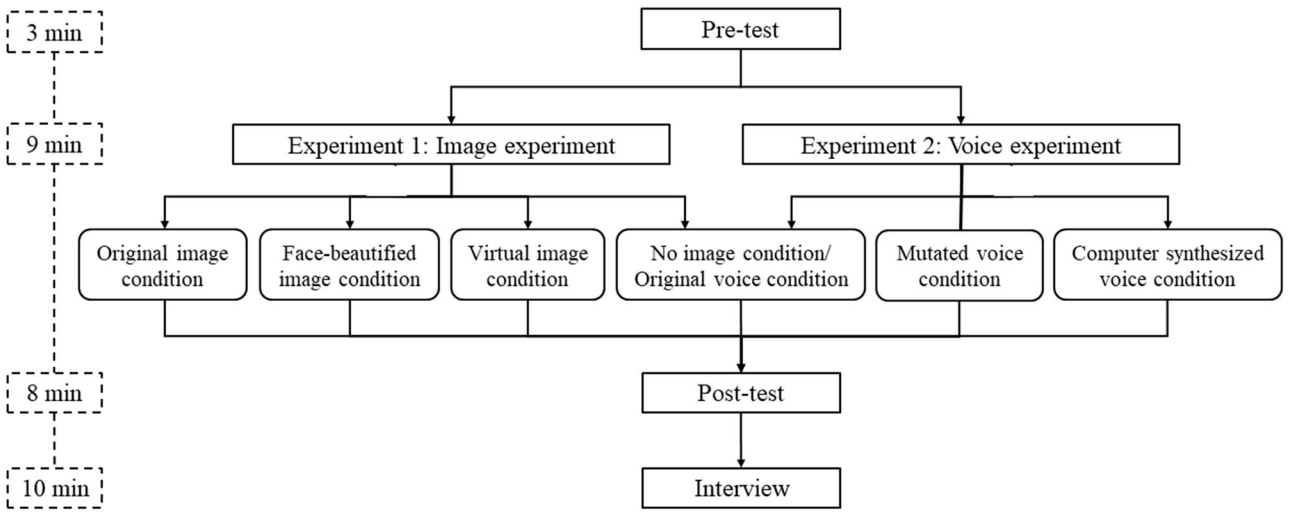

FIGURE 2 | Diagram of experiment design.

Instructor's image/voice evaluation questionnaire: In order to investigate learner's evaluation of instructor's image/voice, evaluation questionnaires were developed by the researcher. Both the instructor's image evaluation questionnaire and voice evaluation questionnaire included two items and used a 7-point Likert scale. The final score of each scale was the sum of ratings for each item, with higher score indicating a higher level of evaluation. The image evaluation items consisted of "I think the instructor looks decent and generous" and "I think the instructor has a good image and makes me feel comfortable." And the voice evaluation items included "The instructor speaks clearly, expresses fluently, and speaks at a moderate speed" and "I think the instructor's voice is mellow and attractive." The instructor's image evaluation questionnaire showed high internal consistency (Cronbach's $\alpha = 0.87$) and the instructor's voice evaluation questionnaire showed moderate internal consistency (Cronbach's $\alpha = 0.70$).

Procedure

The study was conducted online and in individual sessions of ∼30 min. Two experiments including the image experiment and voice experiment were carried out simultaneously. As shown in **Figure 2**, all the learners first completed the pre-test, consisting of the basic information questionnaire and the prior knowledge questionnaire. All the learners first completed the pre-test, consisting of the basic information questionnaire and the prior knowledge questionnaire. Then they were randomly assigned to one of the conditions, given a link to the video course, and instructed to use a laptop and wear headphones to watch the video individually within the specified time. Immediately after finishing the video course, learners took the post-test, including the learning performance test, social presence questionnaire, learning satisfaction questionnaire, achievement-related emotion questionnaire, and instructor's image/voice evaluation questionnaire. Finally, semi-structured interviews with learners were conducted to collect their feedback on their learning experience.

RESULTS

To compare the differences in learning performance, including retention and transfer, of the four experimental groups in the image experiment and the three experimental groups in the voice experiment, we conducted two analyses of covariance (ANCOVAs), with the prior knowledge as the covariance, the conditions as the independent variables, and the retention scores or the transfer scores as the dependent variables. The reason that the ANCOVA method was chosen for this analysis and the prior knowledge was used as the covariance was that, although we did not find a statistically significant difference in the pre-test among the four groups in the image experiment and across the three groups in the voice experiment, there were differences in the pre-test scores among the groups in both experiments, and the ANCOVA method was able to eliminate the possible unwanted variance on the dependent variable and increased test sensitivity (Tabachnick and Fidell, 2013). Moreover, the one-way analysis of variance (ANOVA) was employed to test differences in social presence, satisfaction, achievement-related emotion, and image evaluation/voice evaluation across the experimental groups in the two experiments. Descriptive statistics (means and standard deviations) of the image experiment and the voice experiment were presented in **Tables 1**, **2**, respectively. Furthermore, two linear regressions were conducted to examine the relationship between learners' evaluation of different ways of instructor presence and other variables to further understand how the changes in the image and voice of instructors influenced online learning. The results of the correlation coefficients were present in **Tables 3**, **4**, and the results of the linear regression were present in **Figures 3**, **4**. In addition, interviews were transcribed and analyzed to further understand the results found in this study.

TABLE 3 | Correlation coefficients of each variable and image evaluation ($N = 122$).

Variable	Image evaluation	
	Correlation	***p***
Retention	0.117	0.268
Transfer	0.223*	0.034
Social presence	0.300**	0.004
Satisfaction	0.555**	0.000
Enjoyment	0.376**	0.000
Boredom	−0.306**	0.003

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

TABLE 4 | Correlation coefficients of each variable and voice evaluation.

Variable	Voice evaluation	
	Correlation	***p***
Retention	0.095	0.368
Transfer	0.078	0.455
Social presence	0.299**	0.004
Satisfaction	0.612**	0.000
Enjoyment	0.616**	0.000
Boredom	−0.522**	0.000

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

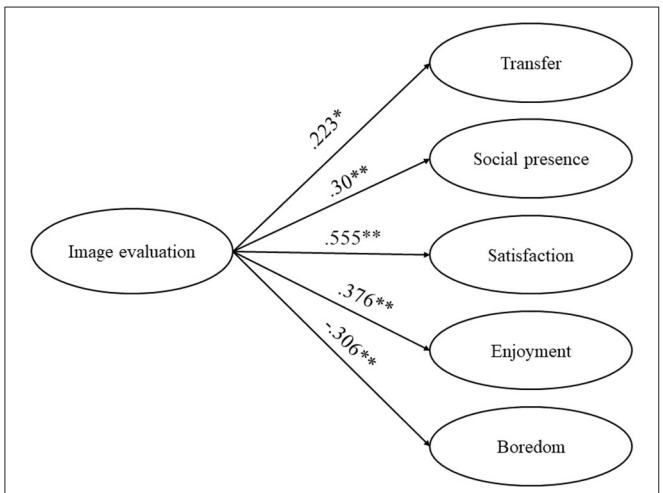

FIGURE 3 | Results of the linear regression of image evaluation on each variable.

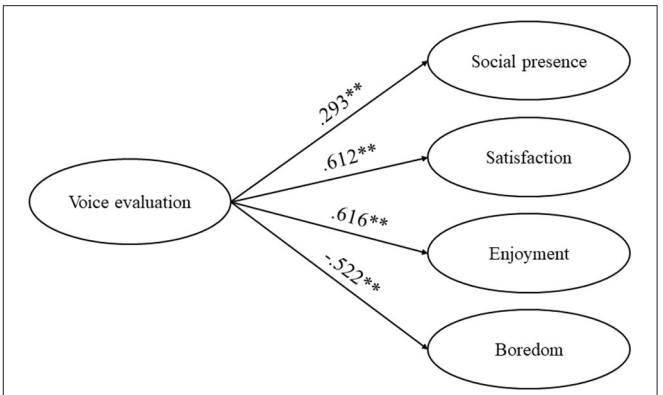

FIGURE 4 | Results of the linear regression of voice evaluation on each variable.

The Effects of Instructor's Image on Online Learning

Learning Performance

ANCOVA showed that there was a significant difference on retention and transfer across the four groups, $F_{(3, 117)} = 4.187$, $p = 0.007 < 0.01$, partial $\eta^2 = 0.097$; $F_{(3, 117)} = 2.933$, $p = 0.036 < 0.05$, partial $\eta^2 = 0.07$, respectively. As predicted in the first hypothesis, *post-hoc* LSD tests on retention and transfer found that the no image group showed significantly higher performance than the original image group, respectively, $MD = 1.61$, $p = 0.009 < 0.01$; $MD = 0.97$, $p = 0.031 < 0.05$, the face-beautified image group, respectively, $MD = 1.39$, $p = 0.027 < 0.05$; $MD = 1.03$, $p = 0.024 < 0.05$, and virtual image group, respectively, $MD = 1.84$, $p = 0.004 < 0.01$; $MD = 1.17$, $p = 0.012 < 0.05$, whereas the other group comparisons showed no significant difference both on retention and transfer.

The above results indicated that learners who used the video course without the instructor's image benefited more than learners who viewed the video course with the instructor's image. Moreover, the ways of the presence of instructor image did not influence online learning.

Social Presence

The ANOVA on social presence showed no significant difference among the four groups, $F_{(3, 118)} = 0.173$, $p = 0.914 > 0.05$, partial $\eta^2 = 0.004$, indicating that instructor image presence had no significant impact on online learner's social presence.

Satisfaction

We conducted five ANOVAs to examine the difference in satisfaction across four groups, with the instructor teaching satisfaction, learning content satisfaction, instructor-learner interaction satisfaction, learning environment and equipment satisfaction, and the whole satisfaction as the dependent variables, respectively. The results showed that there was a significant difference in instructor-learner interaction satisfaction across the four groups, $F_{(3, 118)} = 3.04$, $p = 0.032 < 0.05$, partial $\eta^2 = 0.072$. As predicted in the first and third hypotheses, post hot LSD tests revealed that the original image group had significantly higher instructor-learner interaction satisfaction than the virtual image group, $MD = 1.51$, $p = 0.016 < 0.05$, and the no image group, $MD = 1.60$, $p = 0.009 < 0.01$.

Although no significant difference in instructor teaching satisfaction and the whole satisfaction was found across the four groups, $F_{(3, 118)} = 2.388$, $p = 0.072 > 0.05$, partial $\eta^2 = 0.057$; $F_{(3, 118)} = 2.265$, $p = 0.085 > 0.05$, partial $\eta^2 = 0.054$,

respectively, the virtual image group showed significantly lower instructor teaching satisfaction than the original image group, $MD = -2.35$, $p = 0.013 < 0.05$, and the face-beautified image group, $MD = -2.02$, $p = 0.034 < 0.05$, and the virtual image group showed significantly lower satisfaction than the original image group, $MD = -5.81$, $p = 0.014 < 0.05$.

These results suggested that, in online learning, compared with the video courses without the instructor's image, the video courses with the original image of the instructor were able to enhance the learner's sense of instructor-learner interaction. In addition, compared with the video courses with the real instructor's image, the use of the virtual instructor's image would reduce learners' satisfaction with instructor-learner interaction and instructor teaching.

Achievement-Related Emotion

We conducted two ANOVAs to investigate the effects of instructor image on online learner's achievement-related emotion, with enjoyment and boredom as the dependent variables, respectively. The ANOVA on boredom showed significant differences across the four groups, $F_{(3, 118)} = 3.434$, $p = 0.019 < 0.05$, partial $\eta^2 = 0.08$. *Post-hoc* LSD tests revealed that, of the four groups, the no image group reported lower levels of boredom than the original image group, the face-beautified image group, and the virtual image group (respectively, $MD = -2.71$, $p = 0.008 < 0.01$; $MD = -2.84$, $p = 0.006 < 0.01$; $MD = -2.32$, $p = 0.026 < 0.05$), indicating that the presence of instructor image had caused the learner's emotion of boredom.

Image Evaluation

The ANOVA results showed a significant difference in image evaluation across the original image group, the face-beautified image group, and the virtual image group, $F_{(2,88)} = 18.696$, $p = 0.000 < 0.01$, partial $\eta^2 = 0.298$. As predicted in the third hypothesis, the results of *post-hoc* LSD tests indicated that the learner's evaluation of the virtual image was significantly lower than the original image and the face-beautified image (respectively, $MD = -1.82$, $p = 0.000 < 0.01$; $MD = -2.75$, $p = 0.000 < 0.01$). Moreover, as predicted in the second hypothesis, their evaluation of the face-beautified image was significantly higher than the original image, $MD = 0.93$, $p = 0.041 < 0.05$.

These results suggested that, compared with the virtual cartoon image, online learners preferred the image of the real instructor. Furthermore, the video beautification had a certain effect on improving the image of real instructors.

To further explore the relationship between image evaluation and other variables, respectively, five linear regression analyses were conducted. The correlation results for each variable were shown in **Table 3**. Among these variables, image evaluation had a statistically significant positive relationship with transfer ($r = 0.223$), social presence ($r = 0.3$), satisfaction ($r = 0.555$), and enjoyment ($r = 0.376$), whereas it had a statistically significant negative relationship with boredom ($r = -0.306$). As a result, these five variables were included in the linear regression analyses, with the image evaluation as the independent variable, and the five variables as the dependent variable, respectively in the five analyses.

As shown in **Figure 3**, the statistically significantly positive effects of image evaluation on transfer ($\beta = 0.223$, $B = 0.191$, $p = 0.034 < 0.05$, $R^2 = 0.05$), social presence ($\beta = 0.30$, $B = 1.18$, $p = 0.004 < 0.01$, $R^2 = 0.09$), satisfaction ($\beta = 0.555$, $B = 2.487$, $p = 0.000 < 0.01$, $R^2 = 0.309$), and enjoyment ($\beta = 0.376$, $B = 0.54$, $p = 0.000 < 0.01$, $R^2 = 0.141$) were all significant, while image evaluation was the independent variable that significantly negatively predicted boredom ($\beta = -0.306$, $B = -0.593$, $p = 0.003 < 0.01$, $R^2 = 0.094$).

The above results showed that learner's better evaluation of instructor image was able to predict higher transfer score, more sense of social presence and enjoyment, and higher satisfaction of the course, whereas learners who had higher image evaluation had less sense of boredom.

The Effects of Instructor's Voice on Online Learning

Learning Performance

ANCOVA did not find a significant effect of conditions on retention and transfer across the three voice group, respectively, $F_{(2, 89)} = 2.818$, $p = 0.065 > 0.05$, partial $\eta^2 = 0.06$; $F_{(2, 89)} = 1.075$, $p = 0.346 > 0.05$, partial $\eta^2 = 0.024$, suggesting that the changes in the voice of the instructor did not affect online learner's learning performance.

Social Presence

The results of ANOVA showed that there was no significant difference in social presence among the three groups, $F_{(2, 90)} = 0.112$, $p = 0.894 > 0.05$, partial $\eta^2 = 0.002$, indicating that different ways of instructor's voice in online video courses did not influence online learner's sense of social presence.

Satisfaction

No significant effect of instructor voice on instructor teaching satisfaction, learning content satisfaction, instructor-learner interaction satisfaction, learning environment and equipment satisfaction, and the whole satisfaction was found in the results of ANOVA, suggesting that the instructor's voice did not affect online learner's satisfaction of the course.

Achievement-Related Emotion

There was no significant difference in enjoyment and boredom across the three groups, respectively, $F_{(2, 90)} = 0.283$, $p = 0.754 > 0.05$, partial $\eta^2 = 0.006$; $F_{(2, 90)} = 1.007$, $p = 0.37 > 0.05$, partial $\eta^2 = 0.022$, showing that these three groups were not different on sense of enjoyment and boredom.

Voice Evaluation

The ANOVA on voice evaluation showed a significant difference in voice evaluation of the three voice course versions, $F_{(2, 90)} = 4.527$, $p = 0.013 < 0.05$, partial $\eta^2 = 0.091$. As predicted in the fourth hypothesis, learner's evaluation of computer-synthesized voice was significantly lower than the evaluations of original voice and mutated voice, respectively, $MD = -1.68$, $p = 0.005 < 0.01$; $MD = -1.32$, $p = 0.027 < 0.05$, while there was

no significant difference in voice evaluation between the original voice group and the mutated voice group.

These results suggested that online learners had a lower evaluation of computer-synthesized voice than the voice of a real teacher. In addition, the voice changing system did not significantly enhance the instructor's voice.

We conducted four linear regression analyses to examine the relationship between voice evaluation and other variables, respectively. According to **Table 4**, voice evaluation had a significant positive relationship with social presence ($r = 0.299$), satisfaction ($r = 0.612$), and enjoyment ($r = 0.616$), while it had a statistically significant negative relationship with boredom ($r = -0.522$). Thus, we included the four variables in the linear regression analyses, with the voice evaluation as the independent variable, and the four variables as the dependent variable, respectively in the four analyses.

Based on **Figure 4**, the significantly positive effects of voice evaluation on social presence ($\beta = 0.293$, $B = 1.062$, $p = 0.004 < 0.01$, $R^2 = 0.086$), satisfaction ($\beta = 0.612$, $B = 2.359$, $p = 0.000 < 0.01$, $R^2 = 0.374$), and enjoyment ($\beta = 0.616$, $B = 0.75$, $p = 0.000 < 0.01$, $R^2 = 0.379$) were all significant, while voice evaluation was the independent variable that significantly negatively predicted boredom ($\beta = -0.522$, $B = -0.863$, $p = 0.000 < 0.01$, $R^2 = 0.273$).

These results showed that learners with higher voice evaluation had more sense of social presence and enjoyment, and were more satisfied with the course, while learners with higher voice evaluation had less sense of boredom.

DISCUSSION AND CONCLUSION

This study investigated the effects of the changes in the image and voice of instructors in online video courses on online learning. We carried out two online experiments simultaneously. In the first experiment, we examined the effects of the changes in instructor's image on online learner's learning achievement, social presence, learning satisfaction, and academic emotion, and examined the relationship between learners' evaluation and their learning achievement, social presence, learning satisfaction, and academic emotion. In the second experiment, we explored the impact of the changes in instructor's voice on online learner's learning achievement, social presence, learning satisfaction, and academic emotion, and examined the relationship between learners' evaluation and these variables. The findings are discussed below.

First, learners viewing the no image course version showed significantly higher learning achievements and less academic boredom. One possible explanation is that the instructor image attracts more attention of learners, which adds extraneous cognitive load and interferes with the cognitive processing activities of learners (Mayer, 2005; Day et al., 2006). For example, some learners (10.3%) reported in the interview that "*The cartoon image of the virtual instructor was very novel and cute. I couldn't help but stare at the image during the learning process. As a result, I missed a lot of knowledge.*" At the same time, the learner's learning motivation may also play a role. As the subjects were all college students who had already known the topic of the course through the recruitment information in advance, they may all have a high level of interest in the course topic and learning motivation. For example, most learners (77.2%) expressed their interest in learning the content of this course in the interview. Therefore, in the learning process, there may be conflicts between their subjective learning motivation and objective cognitive interference, which induces learner's negative emotions (Kizilcec et al., 2014). However, the presence of instructor image also had a certain positive impact on online learning.

Both the two ways of the real instructor image's presence can significantly promote learners' learning satisfaction of instructor-student interaction. The reason may be that the presence of a real instructor's image enables learners to directly observe the instructor's appearance, facial expressions, gestures, etc., and gives students a sense of interaction and communication with the instructor (Dunsworth and Atkinson, 2007). In the interview, some subjects (22.6%) viewing the video courses without instructor image pointed out that "*There was no interactive content involved in the course learning*" and "*It felt like watching slides instead of taking a course with an instructor.*"

Second, learners evaluated the two kinds of the real instructor image significantly better than the virtual one. Meanwhile, the two kinds of real instructor image led to significantly higher learning satisfaction of instructor-student interaction and instructor teaching. This may be related to the maturity of the image processing technologies, the design of virtual instructor image, learner's personal preference, and learner's perception of the instructor (Short et al., 1976; Jones et al., 2004). Although the current facial expression capture technology can make the avatar follow the person's facial changes to make corresponding mouth shapes, expressions, blinking movements, etc., it is lacking in sensitivity and expressiveness. The virtual image still cannot fully restore the demeanor of a real teacher. And the avatar cannot further convey more complex emotional signals such as eye expressions and micro-expressions. Moreover, there are various types of virtual images. As learners have different evaluations of different teachers, different virtual images may also affect learner's perception and evaluation. This study used a 2D cartoon girl image as the instructor's image. Compared with the 3D realistic style character image, the 2D image may make learners feel a stronger sense of virtuality and weaker simulation. At the same time, the image of a younger girl may also give learners the impression of low qualifications and weak teaching ability, thereby reducing learners' learning satisfaction.

Furthermore, combining the interview data, we found that the learners' personal preferences also played an important role in virtual image group students' learning. Some subjects (13.8%) preferred the image of the anime style, thus they expressed more like for the virtual instructor and that they would pay more attention to the virtual instructor during the learning process. However, some subjects (37.9%) had low acceptance of cartoon images. They hardly paid attention to the virtual teacher during the learning process and tended to make a lower evaluation of the virtual instructor image. In addition, the subjects did not know the way the virtual image was generated, which was based on the real instructor. In the interview, many subjects (44.8%)

said that they did not perceive the virtual image as a human teacher, but as an auxiliary teaching agent. This difference in perception may also affect learners' evaluation of instructor image and learning satisfaction.

However, there was no significant difference in learning achievement between the virtual image group and the two instructor image groups. Although the image of the virtual instructor is still inferior to the image of the real instructor in the overall evaluation, it will not have a significant negative impact on the learning effect. In the future, we can flexibly choose different virtual images to appear on the video according to the teaching needs, but we should pay special attention to the need to choose the appropriate image according to the preference of learners to better support online learning.

Third, compared with the instructor's original image, the application of the face-beautified image was able to significantly improve learners' evaluation of the image, but it did not show an obvious effect on learning achievement, satisfaction, and achievement-related emotion. This shows that video beautification technology has a certain effect on improving the image of teachers, but it is not a core factor that affects the learning process and effect. The educational value of video beautification, virtual image, and other technologies may not be reflected in the direct promotion of learning, but more as an auxiliary tool for video design.

In the dimension of social presence, no significant difference was found across the experimental groups. This shows that, in order to truly enhance the learners' sense of social presence, it is not enough to simply add the instructor's image to the video. The video needs to be designed well and meticulously, such as flexibly presenting instructor images according to the needs of teaching activities. For example, when the learner needs to pay attention to the instructor, the instructor's image should be presented; when the learner needs to pay attention to the teaching materials, the instructor's image should be hidden.

Furthermore, it was found that image evaluation had a significant positive relationship with transfer, social presence, satisfaction, and enjoyment, whereas it had a significant negative relationship with boredom. This can partly be explained by face preference, that is, attractive faces can trigger learner's positive emotions and contribute to the learning process (Dion et al., 1972; Cloutier et al., 2008; Yang et al., 2014). Therefore, in the process of video production, it is necessary to notice that the image of the instructor is not the core factor that affects the learning process and effect, but also to realize that the image of the instructor has an important influence on the psychological feelings of learners, such as the emotions of the learners. We need to comprehensively use image processing technology in practice to show a good instructor image as much as possible.

Fourth, the evaluations of both the original voice and the mutated voice by students were significantly higher than the computer-synthesized voice, but there was no significant difference in learning achievement, social presence, satisfaction, and achievement-related emotion between the computer-synthesized voice group and the real instructor voice groups. In the interview, only a few subjects (6.5%) clearly stated that the instructor's voice was like artificial intelligence robots. Most of the subjects (51.6%) only felt slightly strange, such as the unusual pronunciation of individual words of the instructor, but they were not sure or were unexpected that the instructor's voice was not from a real person. The rest of the subjects had no special perception of the computer-synthesized voice. This finding indicates that with the advancement of voice synthesis technology, the quality of computer-synthesized voice is gradually approaching the voice of real instructors. Although psychologically learners still tend to prefer real instructors' voices, it is increasingly difficult for them to tell the differences between the real instructor's voice and the computer-synthesized voice (Chiou et al., 2020). Therefore, in the future, it may become a new trend to use computer voice synthesis technology to replace real instructor dubbing, and to design and produce learning materials quickly, conveniently, and at low cost.

Finally, compared with the instructor's original voice, we did not find the effect of mutated voice on satisfaction, achievement-related emotion, and evaluation. This may be related to the design and production of video materials. In the production process of the video material, we only performed a slight pitch shifting process on the original sound's pitch (increased by about 1 chromatic scale). This simple and slight process made the difference between the two sounds relatively limited, showing no obvious impact on learners' perception of the voice and learning process. Moreover, we processed it to raise the pitch instead of lowering it. This is based on the related research of voice preference showing that, within a certain range, the pitch of the female voice has a positive relationship with its attractiveness level (Fraccaro et al., 2013). However, its influence on the learning process has not been confirmed by empirical studies. Therefore, this study provides evidence that the pitch of female instructor voice in online video courses does not influence online learning.

In the interview, some subjects (35.5%) also pointed out that "*I felt the instructor's voice very young.*" In addition, it was found that changes in pitch may affect learners' perception of the instructor's speaking speed and the effect of information reception. In the mutated voice group, nearly half of the subjects (48.4%) reported, "*The instructor's speaking speed was too fast, and many knowledge points passed quickly.*" In fact, we only changed the pitch of the instructor's voice, and all other aspects, including the instructor's speaking speed, were not changed. Learners in other experimental groups did not report the same thing. As a result, we believe that the changes in the pitch of the instructor's voice may be a potential research topic. For example, some research found that people felt lower-pitched voices more leadership and prestige (Anderson and Klofstad, 2012; Klofstad et al., 2012; Tigue et al., 2012). Thus, raising the pitch of the instructor's voice may not be an appropriate method to increase the attractiveness of the voice. On the contrary, it may reduce the learner's judgment of the instructor's competence. Proper pitch reduction of the instructor's voice may make the sound more calm, clear, and convincing, thereby enhancing learning.

In addition, the evaluation of the instructor's voice positively predicted social presence, learning satisfaction, and enjoyment, but negatively predicted boredom. This result partially supports the voice preference (Zuckerman and Driver, 1989; Shoufan, 2019). Based on this, we should pay attention to the in-depth

research and application of voice synthesis technology to reduce the cost and technical threshold of the production of learning materials. Moreover, we need to study the voice characteristics that can promote the information reception and processing, and use this to improve the quality of voices in course videos and learning resources.

LIMITATIONS AND FUTURE RESEARCH

The following limitations to the current study should be considered. Firstly, we did not measure the learner's attention to the video course, which is an important factor influencing the learning process (Pi et al., 2019). Learner's attention can be examined by eye movements metrics, such as the mean fixation duration, dwell time over the AOI, the ratio of pupil size change, etc., which can reflect learner's participation and cognitive load (Zu et al., 2019). Future research needs to combine eye movement analysis to enhance the objectivity of data collection. Secondly, we conducted online experiments which may lead to unknown or uncontrollable influences on the learning process during the experiments. For example, due to a lack of external constraints, learners may be too relaxed and lax, which affects the credibility of the collected data. Thirdly, in terms of the experimental material design, this study utilized 9-min video materials, which were shorter than the 40-min traditional class materials. Moreover, we only designed single-sex instructors and did not consider the possible impact of instructor's gender differences on learning (Valuch et al., 2015). The instructor's image conveys a lot of information, including gender. Researchers believe that averageness, symmetry, and sexual dimorphic features are the three main factors affecting facial attractiveness (Rhodes, 2006). Among these factors, sexual dimorphic features are the characteristics of masculine or femininity. People prefer images of their favorite gender (Mitrovic et al., 2016). As a result, learners may have different evaluations and perceptions of instructors of the same sex or the opposite sex. In addition, there were differences in the instructor's clothes and hairstyles between the real image groups and the virtual image group. Future research needs to further explore the effects of instructor's gender on learning and keep instructor's clothes and hairstyles the same in different conditions. Finally, this study only recruited college students as the participants in experiments and did not recruit younger learners such as elementary and middle school students. College students' learning habits are more mature, who may be less sensitive to changes in the image and voice of instructors compared with younger learners. Future research needs to be conducted to generalize the results of this study by recruiting learners of different ages.

With the rapid development of online education, instructor presence research will also continue to deepen. Combining the findings and limitations of this research, we believe that there are three points that can be the focus of future research. Firstly, this study focused on online learners. However, it is also worth studying that how instructors, as the main body of presence, view the image presence and what impact this may have on their teaching attitudes and behaviors. For example, will the presence of instructor image increase the pressure on instructors who lack experience in online teaching? Will the application of video beautification or virtual image technology help promote teachers' self-confidence and ease the discomfort when facing the camera? Secondly, this study pays more attention to the measurement of indicators directly related to learning, but there are also some external factors that may also have an important impact on online teaching and learning. For example, in online teaching or communication, we often tend to encourage students to turn on the camera to enhance the sense of interaction. However, due to various reasons, learner's willingness to turn on the camera is generally low. The use of virtual images and other technologies may be able to encourage learners to lay down their psychological burdens, increase their willingness to participate in the interaction, and promote the improvement of learning effects. Finally, there are many ways to process both the image and the voice. This study only investigated the impact of the 2D cartoon image and the slight rise of instructor voice pitch on learning. More research needs to be conducted to explore what kind of image or voice is most suitable for online learning, and what preferences do learners of different ages, genders, and majors have? Future research is needed to provide a reference for more scientific and personalized curriculum design.

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 to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

MY and JS conceived the study. JS and AW contributed to the supervision. MY conducted the experiment and collected the data. MY and JZ analyzed and interpreted the data and contributed to the writing of the manuscript. All authors have read and agreed to the published version of the manuscript.

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Applying Control-Value Theory and Unified Theory of Acceptance and Use of Technology to Explore Pre-service Teachers' Academic Emotions and Learning Satisfaction

*Changcheng Wu[1], Xue Gong[1], Li Luo[1], Qingling Zhao[1], Shan Hu[2], Ya Mou[3,4] and Bin Jing[1]**

[1] School of Computer Science, Sichuan Normal University, Chengdu, China, [2] Department of Laboratory and Equipment Management, Sichuan Normal University, Chengdu, China, [3] Faculty of Artificial Intelligence in Education, Central China Normal University, Wuhan, China, [4] Shuang Liu Middle School, Chengdu, China

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Shuliang Mo, Central China Normal University, China

***Correspondence:**
Bin Jing
1097385350@qq.com

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Academic emotions refer to the emotions related to achievement activities or outcomes. Academic emotions are directly related to learning performance and have been recognized as critical to learners' learning satisfaction and learning effectiveness in the online learning context. This study aimed to explore the relationship between academic emotions and learning satisfaction and their underlying mechanisms in massive open online courses (MOOCs) learning context using mediation models. This study adhered to the theoretical frameworks of the control-value theory (CVT) and the unified theory of acceptance and use of technology (UTAUT). Participants were 283 pre-service teachers who volunteered from a normal university in Southwestern China. Results revealed that: (a) academic emotions did not predict learning satisfaction; (b) learning interest and technology acceptance fully mediated the influence of academic emotions on learning satisfaction; (c) the four dimensions of technology acceptance did not mediate the relationship between academic emotions and learning satisfaction. This study integrated CVT and UTAUT models, and the results emphasized the importance of academic emotions and learning satisfaction in CVT and provision of additional support for UTAUT. Therefore, these findings have significant implications for improving the quality of MOOCs in the post-pandemic era.

Keywords: academic emotion, learning satisfaction, MOOC, CVT, UTAUT, learning interest, technology acceptance

INTRODUCTION

In 2020, the coronavirus disease 2019 (COVID-19) resulted in a pandemic (Zis et al., 2021); thus, higher education was affected worldwide. Subsequently, all walks of life advocated home isolation and reduce outgoing to alleviate the spread of the virus. Most educational institutions worldwide have also been shut since March 2020 (Jiang et al., 2021). Accordingly, local governments have been encouraged to endorse online learning platforms through Internet education resources

to ensure the health and safety of learners and prevent the spread of the pandemic to schools (Iosif et al., 2021). This phenomenon has forced many normal universities to switch to massive open online courses (MOOCs) (Ministry of Education of the People's Republic of China, 2020). These technology-focused online learning environments play an important role in pre-service teachers' learning. The academic emotions experienced in these contexts are pivotal for their cognitive and emotional development (Graesser, 2020). Many pre-service teachers have expressed that transitioning from normal university to student teaching or to teaching as a novice teacher can be an emotional and disturbing period (Hascher and Hagenauer, 2016). Thus, it is especially necessary to conduct further research on the academic emotions of pre-service teachers during MOOC learning amidst the COVID-19 pandemic.

The success of MOOC learning is typically evaluated through online learning satisfaction (Hew et al., 2020; Jiang et al., 2021). Some studies have suggested that learning satisfaction is correlated with strong intentions and willingness to participate in MOOCs (Al-Samarraie et al., 2018; Salam and Farooq, 2020), lower MOOC dropout rates (Hew et al., 2020), and improved learning performance (Al-Fraihat et al., 2020). Despite the heavy monetary investments for new technological aspects by MOOCs' platform developers, learners are not fully satisfied due to barriers such as difficulty to achieve openness, lack of interactive communication, and poor learning experience (Jiang and Zhao, 2018; Jiang et al., 2021). Therefore, further investigation is required to identify the determinants of learning satisfaction. Previous studies mainly used cognitive learning performance as the evaluation index for MOOC instructing quality (Barajas and Gannaway, 2007). The field of higher education has conducted several studies on learning satisfaction at the emotional and psychological levels (Shen et al., 2013; Al-Samarraie et al., 2018; Jiang et al., 2021), with ordinary university students as participants. However, few scholars have performed research with the specific subsample of pre-service teachers. Chen and Sun (2020) examined the learning satisfaction of pre-service teachers in a Chinese normal university and reported that moderate learning satisfaction levels, with a lot of room for improvement. Moreover, learners demonstrated lowest satisfaction levels with the hardware facilities.

According to the control-value theory (CVT), academic emotions influence learners' motivation to learn, their learning strategies, and self-regulated learning, thereby influencing their learning achievement (Pekrun, 2006). Existing studies in the field of education have also shown that learners' learning is closely related to their academic emotions (e.g., Artino and Jones, 2012; Noteborn et al., 2012; Owens et al., 2014; Zu et al., 2021). However, existing literature on academic emotions is majorly focused on traditional face-to-face instruction modules, and studies on academic emotions during MOOC instruction modules amidst the pandemic are relatively limited.

Moreover, the effectiveness of implementing information technology or systems is determined through user acceptance (Davis, 1989; Chao, 2019). This criteria extends to learners' perception of the MOOC platform during the pandemic. Venkatesh et al. (2003) developed the unified theory of acceptance and use of technology (UTAUT), which is a popular framework in technology acceptance research. UTAUT is an integrated model incorporating eight models and prominent theories, including the technology acceptance model (TAM), theory of reasoned action, and theory of planned behavior (Chao, 2019). It aims to predict or explain new technology adoption and facilitate the understanding of technology acceptance (Chao, 2019).

Therefore, this study aimed to address these study gaps and employed CVT and UTAUT models to further explore the relationship between academic emotions and learning satisfaction among pre-service teachers. The following section elaborates on the CVT and UTAUT models and their association.

THEORETICAL FRAMEWORK

Control-Value Theory

MOOC learning is supplemented by intense emotional experiences (Yu et al., 2020). CVT proposes that academic emotions are emotions related to achievement activities or outcomes (Pekrun, 2006). CVT is a theoretical framework that examines the relationship between academic emotions and learning satisfaction (Pekrun, 2006). Academic emotions are learner's feelings associated with their learning process and outcomes. The learning process involves learners' relatively stable and long-term emotional states and their complex subjective experience (Pekrun, 2006). Accordingly, CVT acts as an integrative framework to analyze the underlying causes and consequences of emotions experienced within achievement and academic contexts (Pekrun, 2006). Although control (i.e., expectations that persistence at studying can be enacted, and that it will lead to success) and value (i.e., the perceived importance of success) are the direct antecedents of academic emotions, we primarily emphasize the latter part of the framework (i.e., emotion and learning + achievement), while focusing on the relevant theory (**Figure 1**). Academic emotions are classified as positive activating (e.g., enjoyment), negative activating (e.g., frustration), and negative deactivating (e.g., boredom) (Pekrun, 2017) according to valence (i.e., positive and negative) and activation (i.e., physiologically activating states and deactivating states). However, this study primarily focuses on the distinction between positive and negative emotions (i.e., valence) (Pekrun, 2017). Several existing studies have employed the CVT framework and explored the control and value antecedents of pre-service teachers' emotions (e.g., Hascher and Hagenauer, 2016; Stephan et al., 2019; Jenßen et al., 2021). However, most of these studies consider pre-service teachers as "educators" in the teaching internship process. Particularly, there is a lack of research on pre-service teachers' emotions in the field of "school education" (Stephan et al., 2019). Stephan et al. (2019) demonstrated that pre-service teachers who engage in face-to-face instruction module experience different emotions than those involved in MOOC learning. Pre-service teachers engaged in MOOCs reported higher boredom, anxiety, and anger, and lower enjoyment than those involved in face-to-face courses. Overall, they experienced more positive than negative

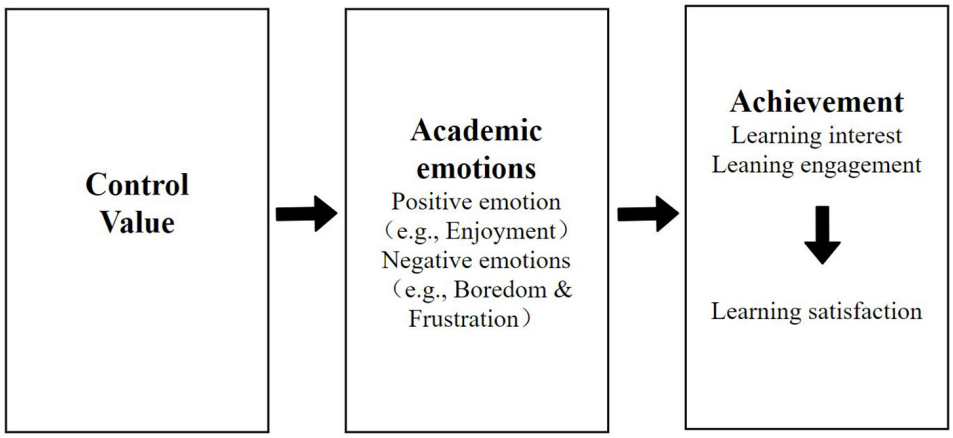

FIGURE 1 | Control-value theory (Pekrun, 2006). A solid arrow shows the direction of the prediction.

emotions in teacher education courses. In line with these findings, it should be noted that MOOCs were introduced to teacher education before face-to-face courses. The novelty of online learning contexts for both learners and lecturers may have caused the inability to adapt to the new learning standards (Stephan et al., 2019).

In CVT, learning satisfaction is considered the "achievement" (Pekrun, 2006) and is defined as the learners' perception regarding the curriculum, learning experience, and value of obtaining education from an educational institution (Ke and Kwak, 2013; Hew et al., 2020). Hennig-Thurau et al. (2001) found that quality of instruction and learning satisfaction are important factors in maintaining learning loyalty. Learning satisfaction is an integral outcome for learners, as it influences their motivation levels, which is an important psychological factor that impacts their learning (Bolliger and Martindale, 2004; Hew et al., 2020). Moreover, learning satisfaction is an important variable, as it shares a strong positive correlation with learners' perceived quality of instruction in all learning contexts (Hew et al., 2020). In the field of education, learning satisfaction has become a critical topic of interest for evaluating learning performance, and it acts as an essential factor actualizing the learning goals (Al-Fraihat et al., 2020). Zu et al. (2021) showed that pre-service teachers' positive activating emotions (e.g., enjoyment and pride) can significantly positively predict their blended learning satisfaction, while negative deactivating emotions (e.g., boredom) demonstrated no significant effects on blended learning satisfaction. The existing findings on negative emotions have been inconclusive. A previous study argued that negative emotions impact cognition and behaviors negatively (Owens et al., 2014), thus reducing learning satisfaction (Lee et al., 2021). Conversely, some studies suggested that negative emotions promote the usage of metacognitive strategies and positively predict learning performance (e.g., Artino and Jones, 2012; Noteborn et al., 2012). This phenomenon indicated that negative emotions may not reduce learning satisfaction.

Learning interest can be regarded as "motivation to learn" (Pekrun, 2006). It refers to the immediate emotional response to certain conditions and/or stimuli in the learning context, manifested in enthusiasm and participation; it also encompasses an intrinsic motivation to continue learning (Rotgans and Schmidt, 2011). Existing literature suggested that pre-service teachers are not very interested in participating in the *Educational Theory* course (Geng, 2009). However, the current literature lacks research on the factors influencing the learning interest of pre-service teachers. Additionally, studies on learning interest have indicated that changes in academic emotions may be crucial in generating and sustaining interest (e.g., Pekrun et al., 2002; Pekrun, 2005, 2017; Silvia, 2006; Nummenmaa and Nummenmaa, 2008). For example, when learners experience positive emotions in the learning process (e.g., enjoyment and contentment), their interest is peaked. Conversely, negative emotional experience (e.g., boredom and frustration) reduce their interest (Nummenmaa and Nummenmaa, 2008; Pekrun, 2017). Many researchers have also revealed that changes in learning interest will generate different learning outcomes, whereby higher learning interests produced improved learning outcomes (e.g., Artino and Jones, 2012; Guo et al., 2020). Additionally, evidence indicated that higher learning interest improved learning satisfaction and increased the intention to continue participating in MOOCs, thereby, reducing the MOOC dropout rate (e.g., Hong et al., 2016; Al-Samarraie et al., 2018; Tsai et al., 2018; Salam and Farooq, 2020). Similarly, Chang and Chang (2012) observed a strong association between learner's motivation and learning satisfaction. Furthermore, Dziuban et al. (2013) highlighted that learner's online learning interest can significantly predict their satisfaction with the learning system.

CVT can efficiently explain the relationship between learners' academic emotions and engagement (Pekrun, 2016). In this study, learning engagement refers to the learners' efforts toward achieving their desired goals during the learning process (Jung and Lee, 2018). Learning engagement emphasizes the importance of behavioral engagement (e.g., taking notes while watching instructional videos or peer discussion) in learning activities. Additionally, it shares positive associations with emotional engagement, such as learning interest or satisfaction

(Fredricks et al., 2004; Wang et al., 2021). Moreover, pre-service teachers' engagement within teacher education contexts is not only important for their own learning, but it may also influence their future teaching practice (Saini and Abraham, 2019). Carini and Kuh (2003) suggested that pre-service teachers with active and collaborative learning experiences are more likely to use similar methods in their own teaching practice. Furthermore, Cakir (2013) identified pre-service teachers' learning motivation and perceived academic challenges as the most important predictors of learner engagement. However, few existing studies have explored the causes and consequences of pre-service teachers' learning engagement during learning activities. Currently, educators face one of the major challenges of creating a positive learning environment within the classroom, with the aim of increasing learner participation and reducing dropout rates (Gao et al., 2020), since learning satisfaction is closely associated with dropout rates (Hew et al., 2020). Therefore, we believe that learning engagement is closely related to learning satisfaction. In addition, academic emotions are considered to be key predictors of learner engagement (e.g., Fredricks et al., 2004; Pekrun, 2016; Garn et al., 2017). Evidence has demonstrated that positive emotions promote learning engagement, while negative emotions do not (e.g., Pekrun et al., 2010, 2011; Owens et al., 2014; Zhen et al., 2017). Accordingly, learners with more positive emotions are more likely to participate in learning, while learners who experience negative emotions are more likely to disengage in the learning process (King and Gaerlan, 2014). However, Turner and Schallert (2001) found that for some learners, some negative emotions, such as shame, can also increase learners' learning motivation and prompt learners to change their learning behaviors. The exact impact of academic emotions on learning engagement is yet to be explored. Similarly, the relationship between learning engagement and satisfaction is also controversial. A previous study revealed that learning satisfaction can be improved through active learning, group discussion, and other learning engagement behaviors that can induce higher learning experience and reflection (Fisher et al., 2018). However, Luo et al. (2019) held opposing views and believed that learning engagement levels cannot be used to predict learning satisfaction. Thus, the predictive paths from academic emotions to learning engagement and from learning engagement to learning satisfaction are still debated widely and require further research.

Unified Theory of Acceptance and Use of Technology

Teo et al. (2008a) used the technology acceptance model (TAM) to explore how perceived ease of use and utility, as well as subjective norms and facilitating conditions as external variables, predict pre-service teachers' attitudes toward computer technology usage. The study revealed perceived usefulness as the strongest predictor of attitudes toward technology use. Additionally, Teo et al. (2008b) demonstrated that perceived usefulness, perceived ease of use, and computer attitudes are important determinants of pre-service teachers' behavioral intention to use, which can be identified by exploring technology acceptance. In this study, technology acceptance is defined as pre-service teachers' acceptance of the rain classroom MOOC learning platform (an artificial intelligence instruction tool divided into computer and mobile terminals, mainly used in higher education fields, within universities to deliver MOOC instruction in China) (Wang, 2017). Previous empirical findings have displayed that as an extension of TAM, UTAUT is the most effective model for analyzing technology acceptance (Venkatesh et al., 2003; Chao, 2019). Recently, more and more information technologies have been widely adopted to complement higher education. These technology-oriented contexts play an important role in MOOC learning. For instance, the rain classroom platform has been widely used by Chinese universities to complement MOOCs and blended learning models. Moreover, amidst the COVID-19 pandemic, it has provided free and efficient online instruction opportunities to millions of university learners and teachers (Jiang et al., 2021).

The UTAUT model contains four latent variables—performance expectancy (i.e., perceived utility of the rain classroom), effort expectancy (i.e., perceived difficulty of using the rain classroom), social influence (i.e., the effect of instructor or peer's opinion on individual behavior), and facilitating conditions (i.e., learners have the required resources and knowledge to use the rain classroom) (Venkatesh et al., 2003; Zhou, 2011). In addition, it contains two dependent variables—behavioral intention to use the system and usage behavior (Venkatesh et al., 2003). Furthermore, technology usage is found to be moderated by gender, age, experience, and willingness to use (Venkatesh et al., 2003). Despite the wide acceptance of the UTAUT model, doubts exist about its ability to elucidate individuals' technology acceptance (Chao, 2019). Some researchers have suggested that the UTAUT model's predictive ability for technology acceptance can be enhanced by increasing the number of external variables (e.g., Zhou, 2011; Lee et al., 2017; Al-Samarraie et al., 2018; Chao, 2019; Chea and Luo, 2019; Lu et al., 2019). Thus, the original UTAUT model has been extended. Some researchers have incorporated perceived enjoyment (i.e., perceived pleasure and enjoyment of using the rain classroom) (Lee et al., 2017; Chao, 2019). Recent research has incorporated perceived enjoyment into the UTAUT model and found that it can be used as an antecedent of performance and effort expectancy (Lee et al., 2017). Prior studies also demonstrated a relationship between the dimensions of technology acceptance and learning satisfaction. For example, perceived enjoyment and effort expectancy can significantly influence learning satisfaction (Zhou, 2011; Chao, 2019; Lu et al., 2019), whereas performance expectancy and social influence cannot significantly predict learning satisfaction (Zhou, 2011; Al-Samarraie et al., 2018).

Relationship Between Control-Value Theory and Unified Theory of Acceptance and Use of Technology

CVT model was developed upon analyzing the causes and consequences that influence academic emotions within achievement and academic contexts (Pekrun, 2006), while

the UTAUT model was based on the communications and information science approach (Zhou, 2011); however, there are some overlaps between these two perspectives. For example, both these theories focus on elucidating learning behaviors and learning activity outcomes. Zhou (2011) extended the UTAUT model by introducing learning satisfaction. The research findings revealed that the dimensions of technology acceptance predict learning satisfaction (Zhou, 2011). Similarly, CVT also proposes the certain antecedents of learning satisfaction (e.g., self-regulation, motivation, emotion, and environment) (Pekrun, 2006). Therefore, both these models may partially predict similar results but using different perspectives.

CVT and literature review specifically indicated that learning interest and engagement directly impacted learning satisfaction. Academic emotions can also directly or indirectly influence learning satisfaction. Meanwhile, academic emotions can directly predict learning interest and engagement. Moreover, UTAUT and some existing studies that the dimensions of technology acceptance may influence learning satisfaction. In addition, an important feature of the UTAUT model is that it can be extended by introducing external variables to enhance its predictive ability. Prior information technology studies have attempted to integrate emotion-related constructs (e.g., perceived enjoyment, computer playfulness, and emotional usability) (Lee et al., 2017; Chea and Luo, 2019). However, these studies have not adequately focused on emotions. Furthermore, these emotion-related constructs are measures of emotional responses to the relevant technologies and do not address individuals' core emotional experiences. Thus, Chea and Luo (2019) incorporated personal emotional experiences to the UTAUT model for the first time to boost its robustness. However, their research was conducted in a laboratory with a small sample size (n = 67). Therefore, their study findings may not be suitable for generalization.

Consequently, despite the distinct origins and unique terminologies adopted by CVT and UTAUT, these perspectives complement one another and may supplement explanations regarding the relationship between the academic emotions and learning satisfaction among pre-service teachers in the MOOC learning context.

The Present Study

The current study integrates CVT and UTAUT to develop a mediating model. This research primarily aims to extend previous study findings by examining the relationship between pre-service teachers' academic emotions and learning satisfaction in-depth amidst the COVID-19 pandemic.

Subsequently, we proposed the following hypotheses:

H1: Positive and negative emotions will positively and negatively predict learning satisfaction, respectively.

H2: Learning interest, learning engagement, and technology acceptance will mediate the effects of academic emotions on learning satisfaction.

H3: The four dimensions of technology acceptance will mediate the effect of academic emotions on learning satisfaction.

MATERIALS AND METHODS

Context

The context of this study was the "*Computer Science Fundamentals*" online course. This course taught basic computer knowledge skills, which are necessary for normal university pre-service teachers. Additionally, this course played an important role for pre-service teachers to master appropriate information education methods in the era of information technology and formed certain educational abilities. The entire course was broadcasted live by the instructor. Each course module contained instructional videos, learning forums, assignments, and tests. The rain classroom was used as an instruction platform for the MOOCs. Pre-service teachers were allowed to post messages on the screen and in the discussion area and respond to messages in real-time. Furthermore, data regarding the learning status for pre-service teachers was specifically recorded in real-time and could be exported by the backstage of the learning platform.

Participants

Participants were 283 pre-service teachers (195 females) from a normal university in Chengdu, Sichuan Province, in Southwestern China. Their ages ranged from 17 to 24 (M_{age} = 18.96, SD_{age} = 0.86) years. Of these, over 70% were experienced in using the rain classroom. They belonged to five different majors.

Data Collection

Data were collected online in May 2020. A researcher uploaded the questionnaire to WJX[1]—an online survey tool. All participants attended the Computer Science Fundamentals course taught by one of our researchers, where they were invited to participate in this research. During the class, participants were informed regarding the study purpose and a researcher distributed questionnaires to them. Participants voluntarily and anonymously completed this online questionnaire in approximately 10 min.

Instruments

Academic Emotions Measurement

Data were collected using the adapted version of Achievement Emotions Questionnaire (AEQ). Pekrun et al. (2011) develop the AEQ based on CVT (Pekrun, 2006). We selected three dimensions of AEQ to evaluate pre-service teachers' academic emotions in this study—enjoyment (4 items, e.g., "I am enjoying the online course," α = 0.88), boredom (5 items, e.g., "I feel bored while studying the online course," α = 0.95), and frustration (4 items, e.g., "I feel very frustrated when studying the online course," α = 0.95). Enjoyment was classified as a positive emotion, while boredom and frustration as negative emotions (Pekrun, 2017). All the items were rated using a 5-point Likert-type scale (1 = *strongly disagree* to 5 = *strongly agree*). The overall internal consistency (α) coefficient of this questionnaire was 0.84. For each dimension, the total score was the average of all the item scores across that dimension.

[1] www.wjx.cn

Learning Interest Measurement

In this study, we used the adapted version of the Learning Interest Questionnaire developed by Rotgans and Schmidt (2011). Moreover, pre-service teachers' learning interest was evaluated using two dimensions of this questionnaire with two items each: attention focus ("I am fully focused in this online course" and "I am not distracted by other things," $\alpha = 0.59$) and subjective emotion ["I enjoy the topic of this online course" and "Presently, I feel bored (reverse scored)," $\alpha = 0.72$]. All items were rated using a 5-point Likert-type scale (1 = *strongly disagree* to 5 = *strongly agree*). The overall internal consistency (α) coefficient of this questionnaire was 0.82. For each dimension, the total score was the average of all the item scores across that dimension.

Technology Acceptance Measurement

Data were collected using the adapted version of the Technology Acceptance Questionnaire developed by Venkatesh et al. (2003). Pre-service teachers' attitudes and acceptance toward MOOC instruction were evaluated using four selected dimensions: perceived enjoyment (7 items, e.g., "Learning on this online course platform is a pleasant thing," $\alpha = 0.97$), social influence (3 items, e.g., "The instructor encouraged me to use this online course platform to learn," $\alpha = 0.88$), effort expectancy (4 items, e.g., "It's easy for me to use this online course platform proficiently," $\alpha = 0.88$), and performance expectancy (4 items, e.g., "Using this online course platform to learn has improved my learning efficiency," $\alpha = 0.96$). All items were rated using a 7-point Likert-type scale (1 = *strongly disagree* to 7 = *strongly agree*). The overall internal consistency (α) coefficient of this questionnaire was 0.95. For each dimension, the total score was the average of all item scores across that dimension.

Learning Engagement Measurement

The backstage learning data of the rain classroom were recorded and exported to examine the learning engagement of pre-service teachers across three aspects. It included the total number of slides viewed, the frequency of check-in into the class, and the frequency of reading the bulletin board. The total score for learning engagement was the average score across after adding all three categories.

Learning Satisfaction Measurement

Data were collected using the adapted version of the Chinese-language Learning Satisfaction Questionnaire developed by Yang (2014). Pre-service teachers' learning satisfaction was evaluated using three dimensions in this questionnaire: instructor instructing (2 items, e.g., "Overall, I am satisfied with the instructing of this online course," $\alpha = 0.91$), teaching content (5 items, e.g., "The learning content in this online course attracted me and helped me to learn," $\alpha = 0.86$), and learning context (5 items, e.g., "Overall, I am satisfied with the learning context and equipment for this online course," $\alpha = 0.86$). All items were rated on a 5-point Likert-type scale (1 = *strongly disagree* to 5 = *strongly agree*). The overall internal consistency (α) coefficient of this questionnaire was 0.94. The overall total score was the average across all item scores, while the total score for each dimension was the average of all item scores in that dimension.

Data Analysis

All statistical analyses were performed using SPSS 22.0 and Mplus 8.3 software. First, we computed descriptive statistics and Pearson's correlation coefficients for all variables and their corresponding relationships. Second, mediating effects were analyzed by standardizing all scores (Z-Score) and performing structural equation modeling (SEM). Third, DiCiccio and Efron (1996) recommended implementing a minimum of 2,000 replicates while performing Bootstrap analysis; however, in this study, we used 5,000 replicates to improve the estimation, but it required more computing time (Banjanovic and Osborne, 2016). In the current study, statistical significance was set at $p < 0.05$. Additionally, Pekrun (2018) suggested that learners' academic emotions will demonstrate significant gender differences. Therefore, gender was controlled for as a covariate in the analyses; it was coded 1 = male, 2 = female.

RESULTS

Descriptive Statistics and Correlation Analysis

Table 1 presents the mean, standard deviation, and correlation coefficients for all variables.

The results revealed significant positive correlations between positive emotion (i.e., enjoyment), learning interest, learning engagement, technology acceptance, and learning satisfaction ($0.14 < rs < 0.79$, $ps < 0.05$). Conversely, negative emotions (i.e., boredom and frustration) reported significant negative correlations with learning interest, learning engagement, technology acceptance, and learning satisfaction ($-0.49 < rs < -0.13$, $ps < 0.05$). Furthermore, significant positive correlations were also reported between positive emotion, perceived enjoyment, social influence, effort expectancy, performance expectancy, and learning satisfaction ($0.43 < rs < 0.55$, $ps < 0.01$). Negative emotions showed significant negative correlations with perceived enjoyment, social influence, effort expectancy, performance expectancy, and learning satisfaction ($-0.40 < rs < -0.26$, $ps < 0.01$).

Assessment of Structural Equation Modeling Model

This study implemented a mediation model (**Figure 2**) to examine the direct effects of academic emotions on learning satisfaction. To ensure conciseness in the model, all insignificant path coefficients and confidence intervals were deleted from the initial model. This model demonstrated a good data fit [$X^2/df = 3.71$, Comparative fit index (CFI) = 0.93; Tucker-Lewis index (TLI) = 0.91, Root Mean Square Error of Approximation ($RMSEA$) = 0.09]. **Figure 2** displays the hypotheses testing results for the direct and indirect path coefficients of this mediation model. The results suggested that there was insignificant direct effect of academic emotions on learning satisfaction. Moreover, positive and negative emotions were significant positive and negative predictors of learning interest ($\beta = 0.41$, $p < 0.001$; $\beta = -0.47$, $p < 0.001$, respectively) and technology acceptance

TABLE 1 | Descriptive statistics and correlation analysis of each variable.

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Enjoyment (Positive emotion)	1																	
2. Boredom	−0.34**	1																
3. Frustration	−0.29**	0.76**	1															
4. Attention focus	0.45**	−0.46**	−0.40**	1														
5. Subjective emotion	0.47**	−0.46**	−0.41**	0.75**	1													
6. Perceived enjoyment	0.53**	−0.36**	−0.25**	0.52**	0.53**	1												
7. Social influence	0.43**	−0.27**	−0.24**	0.51**	0.41**	0.64**	1											
8. Effort expectancy	0.45**	−0.26**	−0.22**	0.52**	0.49**	0.69**	0.78**	1										
9. Performance expectancy	0.55**	−0.38**	−0.28**	0.55**	0.55**	0.84**	0.66**	0.71**	1									
10. Instructor instructing	0.46**	−0.35**	−0.31**	0.53**	0.55**	0.59**	0.58**	0.62**	0.60	1								
11. Teaching content	0.51**	−0.40**	−0.33**	0.55**	0.59**	0.71**	0.64**	0.69**	0.71**	0.84**	1							
12. Learning context	0.52**	−0.38**	−0.30**	0.51**	0.52**	0.69**	0.59**	0.64**	0.69**	0.68**	0.78**	1						
13. Negative emotions	−0.34**	0.94**	0.94**	−0.46**	−0.47**	−0.33**	−0.27**	−0.26**	−0.35**	−0.35**	−0.39**	−0.36**	1					
14. Learning interest	0.49**	−0.50**	−0.43**	0.93**	0.94**	0.56**	0.49**	0.54**	0.59**	0.58**	0.61**	0.55**	−0.49**	1				
15. Learning engagement	0.11	−0.12*	−0.13*	0.14*	0.14*	0.07	0.16**	0.15*	0.13*	0.11	0.12*	0.15*	−0.13*	0.15**	1			
16. Technology acceptance	0.55**	−0.36**	−0.28**	0.59**	0.56**	0.90**	0.86**	0.88**	0.91**	0.67**	0.77**	0.74**	−0.34**	0.61**	0.14*	1		
17. Learning satisfaction	0.54**	−0.41**	−0.34**	0.58**	0.60**	0.72**	0.66**	0.71**	0.72**	0.91**	0.94**	0.90**	−0.40**	0.63**	0.14*	0.79**	1	
18. Gender	0.11	−0.18**	−0.09	0.15*	0.05	0.08	0.18**	0.08	0.10	−0.02	0.04	0.10	−0.14*	0.11	0.06	0.12*	0.05*	1
M	3.67	2.24	2.06	3.77	3.85	5.13	5.63	5.55	5.32	4.30	4.19	4.11	2.15	3.81	13.84	5.41	4.20	1.69
SD	0.80	0.97	0.99	0.76	0.78	1.23	1.03	0.99	1.19	0.62	0.54	0.67	0.92	0.72	3.52	0.99	0.56	0.46

*M, mean; SD, standard deviation; *p < 0.05; **p < 0.01. Convert all data to a standardized form (Z-Score).*

(β = 0.53, $p < 0.001$; β = −0.25, $p < 0.01$, respectively), respectively. Furthermore, learning satisfaction was significantly positively predicted by learning interest (β = 0.20, $p < 0.05$) and technology acceptance (β = 0.76, $p < 0.001$). However, learning engagement was not predicted by academic emotions, and it did not predict learning satisfaction. Regarding gender, it significantly predicted negative emotions (β = −0.17, $p < 0.05$), revealing fewer negative emotions among females than males (Pekrun, 2018).

Mediating Effects Analysis

The Bootstrapping method was employed to examine the direct and mediating effects of academic emotions on learning satisfaction (**Table 2**). We discovered that learning interest and technology acceptance fully mediated the effects of positive emotions ($g = 0.08$, $p < 0.05$; $g = 0.40$, $p < 0.001$, respectively) and negative emotions ($g = -0.09$, $p < 0.05$; $g = -0.19$, $p < 0.01$, respectively) on learning satisfaction. However, learning engagement did not report any mediating effect on the relationship between academic emotions and learning satisfaction.

Assessment of Structural Equation Modeling Model (Four Dimensions of Technology Acceptance)

Technology acceptance was found to significantly mediate the relationship between academic emotions and learning satisfaction. Therefore, we developed another mediating model

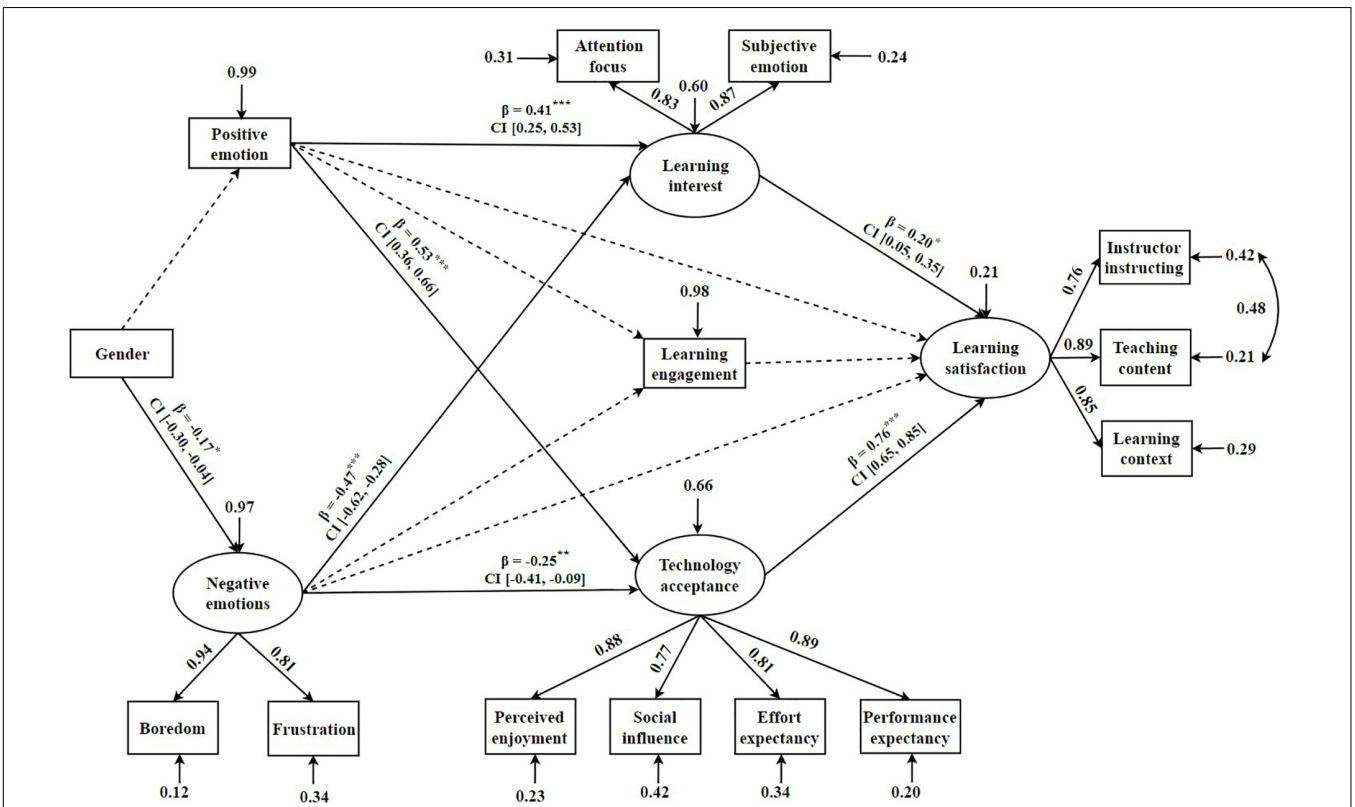

FIGURE 2 | Mediation model for effects of academic emotions on learning satisfaction. The solid arrow represents the significant path, and the dotted arrow represents the insignificant path. β is the path coefficient. CI, confidence interval. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

TABLE 2 | Bootstrapping analysis of the mediating effect test.

Dependent variable	Independent variable	Mediating variable	Direct effect	Mediating effect	LLCI	ULCI
Learning satisfaction	Positive emotion	Learning interest	0.04	0.08*	0.02	0.16
		Learning engagement	0.04	—	−0.004	0.02
		Technology acceptance	0.04	0.40***	0.28	0.53
	Negative emotions	Learning interest	−0.05	−0.09*	−0.20	−0.03
		Learning engagement	−0.05	—	−0.02	0.01
		Technology acceptance	−0.05	−0.19**	−0.31	−0.08

LLCI, lower level of confidence interval; ULCI, upper level of confidence interval.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.*

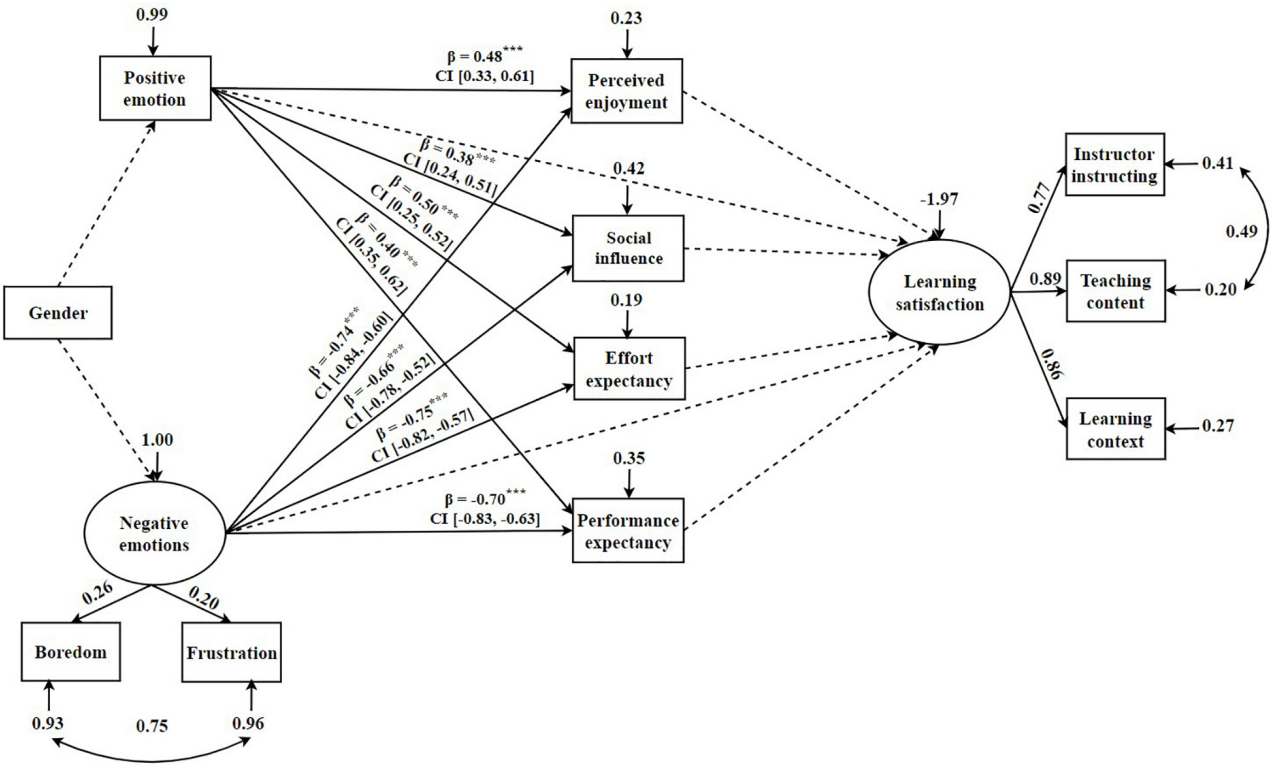

FIGURE 3 | Mediation model for the effects of academic emotions on learning satisfaction through the four dimensions of technology acceptance. The solid arrow represents the significant path, and the dotted arrow represents the insignificant path. β is the path coefficient. CI, confidence interval. ***$p < 0.001$.

(**Figure 3**) to explore the effects of the four technology acceptance dimensions in depth.

Furthermore, we deleted the insignificant path coefficients and furthermore, we deleted the insignificant path coefficients and confidence intervals from this model. The model fit coefficients were: $X^2/df = 4.83$, $CFI = 0.94$, $TLI = 0.90$, $RMSEA = 0.12$. **Figure 3** displays the hypotheses testing results for the direct path coefficients of the mediation model. The results revealed that academic emotions did not predict learning satisfaction. Positive emotions significantly positively predict perceived enjoyment ($\beta = 0.48$, $p < 0.001$), social influence ($\beta = 0.38$, $p < 0.001$), effort expectancy ($\beta = 0.50$, $p < 0.001$), and performance expectancy ($\beta = 0.40$, $p < 0.001$). Moreover, negative emotions demonstrated a significant influence on perceived enjoyment ($\beta = -0.74$, $p < 0.001$), social influence ($\beta = -0.66$, $p < 0.001$), effort expectancy ($\beta = -0.75$, $p < 0.001$), and performance expectancy ($\beta = -0.70$, $p < 0.001$). However, none of the four dimensions of technology acceptance predicted learning satisfaction. Similarly, academic emotions were also not predicted by gender.

DISCUSSION

Stupnisky et al. (2019) suggested that pre-service teachers may be particularly susceptible to emotions due to their academic and professional expectations. In addition, teachers are at a higher risk of job burnout during their early teaching period, and they eventually quit their job due to the high levels of negative emotions (Vesely et al., 2014); thus, we believed that it was pertinent to examine their emotions during their learning phase as pre-service teachers. This study offered additional evidence for CVT and supported UTAUT extension by highlighting the importance of academic emotions and learning satisfaction in CVT. We found that academic emotions were not direct predictors of learning satisfaction. Learning interest and technology acceptance mediated the relationship between academic emotions and learning satisfaction.

Mediating Effects of Learning Interest and Technology Acceptance

This study extended the initial model tested by Chea and Luo (2019) and introduced academic emotions in CVT into the extended model as the antecedent variable of UATUT. Furthermore, we found that academic emotions had no significant predictive effect on learning satisfaction (rejecting H1). However, this study finding was not consistent with some previous study results (e.g., Pekrun et al., 2010; Artino and Jones, 2012; Gong et al., 2016). Conversely, the findings regarding the relationship between pre-service teachers' negative emotions and learning satisfaction were consistent with that of Zu et al. (2021), which indicated that negative emotions cannot directly predict learning satisfaction. This finding may have emerged due to the complexity of academic emotions.

For instance, negative emotions (e.g., boredom and frustration) are negatively correlated with cognitive engagement, learning strategy use, and learning performance amidst traditional face-to-face learning contexts (Pekrun et al., 2011). However, in the MOOC context, some negative emotions, such as frustration, may motivate learners to learn better and employ more learning strategies (Artino and Jones, 2012; Noteborn et al., 2012), thus exerting different influences on learning performance and satisfaction. Therefore, a simple linear correlation could not be established in the relationship between academic emotions and learning satisfaction.

We also observed that both learning interest and technology acceptance mediated the effect of academic emotions on learning satisfaction. However, learning engagement did not report a significant mediating effect (partially supporting H2). Accordingly, the more positive the pre-service teachers' academic emotions, the higher their learning interest and technology acceptance, thereby improving their learning satisfaction. Similarly, the more negative their academic emotions, the lesser their learning interest and technology acceptance, which resulted in decreased learning satisfaction. The above findings verified the perspective offered by Pekrun et al. (2002); Silvia (2006), and Pekrun (2017), that academic emotions are closely related to learning interest. Academic emotions can generate and maintain the learning interest in educational content (Krapp, 2005). The current research results further confirmed the previous empirical findings (Nummenmaa and Nummenmaa, 2008). That is, interest in online learning was associated with positive emotional experience. In addition, Zhang et al. (2006) highlighted that learners with high learning interest will tend to display positive learning performance and high learning satisfaction. Chang and Chang (2012) observed that there is a strong association between learners' motivation and their learning satisfaction. Similarly, Dziuban et al. (2013) reported that learners' learning interest can significantly predict their satisfaction with the online learning system. Therefore, the current study results were consistent with all the abovementioned research conclusions.

The integration model demonstrated a significant mediating effect of technology acceptance. Subsequently, we explored the mediating effects of the four dimensions of technology acceptance (i.e., perceived enjoyment, social influence, effort expectancy, and performance expectancy). We found no significant mediating effects of these four dimensions of technology acceptance on the relationship between academic emotions and learning satisfaction (rejecting H3). However, academic emotions significantly predicted all four dimensions of technology acceptance. This finding is consistent with previous study results (Chea and Luo, 2019). Accordingly, the more positive pre-service teachers' academic emotions, the higher their technology acceptance. Conversely, the more negative their academic emotions, the lower their technology acceptance. Furthermore, Chea and Luo (2019) proposed that academic emotions can enhance the predictive ability of UTAUT; this proposition confirmed our study results. However, numerous existing studies have demonstrated the strong influence of both perceived enjoyment and performance expectancy on learning satisfaction (e.g., Zhou, 2011; Chao, 2019), where they identified the factors promoting learning satisfaction; these findings were inconsistent with the current study results. Moreover, some studies have reported that effort expectancy had a significant impact on learning satisfaction, while social influence demonstrated no significant impact (e.g., Zhou, 2011; Al-Samarraie et al., 2018; Chao, 2019) but our results revealed that neither effort expectancy nor social influence promotes learning satisfaction. Therefore, further research is required to examine the relationship between technology acceptance and learning satisfaction.

Contrary to previous research results indicating that learners with positive academic emotions are more willing to exert efforts into learning and have higher learning engagement levels (e.g., Fredricks et al., 2004; Pekrun et al., 2010; King and Gaerlan, 2014; Pekrun, 2016; Garn et al., 2017; Zhen et al., 2017), our study suggested that positive emotions failed to stimulate learning engagement. This may be caused by the generic action tendency of positive emotions; thus, they did not generate specific actions (Guo and Wang, 2007). This phenomenon may have resulted in insignificant prediction of learning engagement. Negative emotions also did not predict learning engagement, demonstrating inconsistent results with previous research findings, which showed that negative emotions exert a negative influence on cognition and behaviors (e.g., Pekrun et al., 2011; Owens et al., 2014) and hinder learning engagement further (Zhen et al., 2017). Some scholars pointed out that within MOOC learning contexts, learners experiencing frustration will motivate themselves to learn successfully (e.g., Artino and Jones, 2012; Noteborn et al., 2012) and enhance learning engagement in the learning process. Similarly, contrasting Fisher et al.'s (2018) perspective but verifying Luo et al.'s (2019) finding regarding the lack of impact of degree of behavioral engagement on learning satisfaction, this study revealed that learning engagement did not predict learning satisfaction significantly. Moreover, the current study is novel because most existing research on learning engagement was conducted in face-to-face classrooms, while our study explores the online classroom with pre-service teachers as participants amidst the COVID-19 pandemic. Data regarding learning engagement was recorded on the learning platform itself. Simultaneously, the insignificant results could also be explained by the lack of expertise of instructors and learners for operating the platform.

Education Implications

The current results supported the CVT and UTAUT models and have important implications for educators and researchers, who are interested in improving the learning satisfaction of MOOC learners. Teachers can particularly improve learners' learning satisfaction by promoting positive emotions while reducing their negative emotions. Positive emotions can stimulate learners' learning interest and their technology acceptance, which is conducive to improving their learning satisfaction. Additionally, this study confirms the important role of academic emotions in adopting technology. This paper also provides good practical insight for MOOC platform developers, recommending the integration of learners' emotional aspects into the system design (Chea and Luo, 2019).

LIMITATION AND FUTURE WORK

This study has several limitations, which can be profitably addressed to stimulate future research. First, the evaluation dimensions of academic emotions are not adequately thorough. Future studies should consider including the arousal degree of academic emotions in the measures. Another consideration is to incorporate machine learning, eye-tracking, and electroencephalogram technology to detect the changes in learners' academic emotions during their learning process (Guo et al., 2019). Second, learner engagement was measured using frequency records in this study. Further research should assess learning engagement levels through the quality of their engagement. Third, this study employed a limited sample size. In the future, longitudinal research with a larger sample size can facilitate more diverse data collection and further verify the predictive ability of various dimensions of technology acceptance in CVT.

CONCLUSION

The current study revealed that academic emotions did not predict learning satisfaction directly, but indirectly predicted learning satisfaction through learning interest and technology acceptance. Accordingly, the higher the positive emotions of pre-service teachers, the higher their learning interest and technology acceptance, thereby improving their learning satisfaction; conversely, the higher their negative emotions, the lower their learning interest and technology acceptance, thereby reducing their learning satisfaction. However, upon further exploration we discovered that none of the four dimensions of technology acceptance reported significant mediating effects.

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

CW contributed to the study's conception and design. LL, QZ, and SH performed the material preparation and data collection. XG, YM, and BJ performed the data analysis. BJ, XG, and CW wrote the first draft of the manuscript. All authors commented on previous versions of the manuscript, read, and approved the final manuscript.

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Exploring the Relationship Among Teacher Emotional Intelligence, Work Engagement, Teacher Self-Efficacy, and Student Academic Achievement: A Moderated Mediation Model

*Li Wang**

School of Chinese Literature and Media, Hubei University of Arts and Science, Xiangyang, China

In recent years, many studies have been done to identify the factors that affect teacher emotions at schools. However, the empirical evidence on how teachers' emotions influence students' outcomes and performance is not extensive. Against this background, this study explored the correlation between teacher EI and student academic achievement and possible mechanisms may lie in this relationship. A sample of 365 Chinese teachers from 25 public middle schools participated in this study by completing measurements of teacher EI, teacher work engagement, and teacher self-efficacy. The student academic achievement was assessed by the grades of the previous term (February to June 2020) reported by the students. The results indicated that teacher work engagement partially mediated the path from teacher EI and student academic achievement. Moderated mediation further showed that teachers with high self-efficacy had a more significant positive impact on the relationship between teacher work engagement and student academic achievement than teachers with low self-efficacy. The limitations of this study were also discussed.

Keywords: teacher emotional intelligence, work engagement, teacher self-efficacy, student academic achievement, moderated mediation effect

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Zhongling Pi,
Shaanxi Normal University, China

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Xinxin Guo,
University of Eastern Finland, Finland
Mengxiang Wang,
Beijing Union University, China
Jessie Chen,
University of Eastern Finland, Finland

***Correspondence:**
Li Wang
xiaqiuwang@hotmail.com

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INTRODUCTION

Emotions are complex psycho-physiological processes triggered by subjectively important events in an individual's life (Eisma and Stroebe, 2021). They have been studied by psychologists for more than a century (Berridge, 2018). Some researchers claimed that teaching is an emotional process, in which teachers manage, scrutinize, and control their feelings to achieve teaching effectiveness, to inspire students, and to create a positive environment for learning (Schonert-Reichl, 2017). The study of teacher emotions has increased remarkably since the mid-1990s, which has led educators to pay more attention to the relevance of emotional intelligence to their work (Yin, 2012; Maamari and Majdalani, 2019).

Emotional intelligence (EI), a term coined by Salovey and Mayer (1990), is usually concerned with how people perceive, regulate, and express their own personal emotions as well as other people's feelings (Maamari and Majdalani, 2019). The current understanding of emotional

intelligence in the academic domain mainly consists of two aspects: ability emotional intelligence (ability EI) and trait emotional intelligence (trait EI). The first model conceptualizes EI as a form of a cognitive ability that involves understanding and distinguishing emotional signals and information, while the second sees EI as a personality trait that is related to typical behavior (Bar-On and Parker, 2000; Lu et al., 2016). These two different models have led to the distinct measurement methods and underlying empirical bases of EI (Davis and Nichols, 2016). Considerable research on EI has found that high EI is associated with positive life outcomes, such as developing positive social relationships, identifying others' emotional states, adjusting to others' perspectives, enhancing communication, and managing behavior (Miao et al., 2017). In addition, low levels of EI are seen as a tendency toward self-destructive and deviant behaviors (Curci et al., 2014; Davis and Nichols, 2016), such as taking illegal drugs and consuming excessive amounts of alcohol, having poor relationships with friends, being absent from school without authorizations and expelled from school, and having feelings of depression (Brackett et al., 2004; Davis and Humphrey, 2014).

In the realm of education, scientific literature has also manifested the association between EI and successful outcomes. For example, Palomera et al. (2008) found that high levels of emotional intelligence in teachers play a significant role in teaching. Similarly, studies by Extremera and Fernández-Berrocal (2013) showed that students with a high degree of emotional intelligence are more likely to have better academic scores, psychological adjustment, social relationships, and social behavior. While a large body of research examining the relationship between teacher EI and their educational work, or between student EI and their various outcomes, empirical evidence on how teacher emotions affect student outcomes and performance is rare. Based on Frenzel's (2014) reciprocal model of the antecedents and consequences of teachers' emotions, we wanted to know if teachers' high emotional intelligence was somehow beneficial to their students. Therefore, the present study, using a structural equation modeling approach, aims to explore the correlation between teacher EI and student academic achievement and possible mechanisms may lie in this relationship.

MATERIALS AND METHODS

Participants and Procedure

The sample was composed of 365 teachers from 25 public middle schools of Hubei province in the center of China. The 365 participants included 198 males (54%) and 167 females (46%). 37% of the sample were in grade seventh, 35% were in grade eighth, and 28% were in grade ninth. The average age of the participants was 38.4 years (SD = 5.3 years). The teachers' average experience in terms of years was 6.7(SD = 2.1). There were about 72% of the participants held a bachelor's degree, 24% held a master's degree, and 4% held a doctoral degree. Prior to the investigation, the researcher contacted the school administrators by emails or phones, and asked them to invite their teachers to participate this research. The questionnaires were originally designed in English. The researchers translated and back-translated the English language of the questionnaires, and then conducted data collection with the Chinese version. The questionnaires were accompanied by a covering letter explaining the purpose and process of the project. The participation in this survey was voluntary. Participants could withdraw at any time during the survey, and all of their answers were confidential and anonymous.

Measures

The teacher EI was assessed with the Wong and Law's Emotional Intelligence Scale (WLEIS: Wong and Law, 2002). It is a 16-item self-report EI measure that comprises 4 sub-scales: self-emotion appraisal (SEA; 4 items—"I have good understanding of my own emotions"), others' emotion appraisal (OEA; 4 items—"I am a good observer of others' emotions"), use of emotion (UOE; 4 items—"always tell myself I am a competent person"), and regulation of emotion (ROE; 4 items—"I am quite capable of controlling my own emotions"). Participants' response was recorded using a 7-point Likert type scale from 1 = "totally disagree" to 7 = "totally agree." The Cronbach's alpha of teacher EI for this study was 0.843.

The teacher work engagement was assessed using the ETS (Klassen et al., 2013). It is consisted of 16 items. These items are distributed in four dimensions: cognitive engagement (CE; 4 items), example: "while teaching, I work with intensity"; emotional engagement (EE; 4 items) and example: "I am excited about teaching; social engagement with the students" (SEC; 4 items), example: "In class, I care about the problems of my students"; and social engagement with the colleagues (SES; 4 items), example: "At school, I value the relationships I build with my colleagues." The measure is rated on seven-point Likert scales ranging from 1 = "never" to 7 = "always." In the current sample, the Cronbach's alpha of teacher work engagement was 0.893.

The teacher self-efficacy is assessed with TSES (short form), developed by Tschannen-Moran and Woolfolk Hoy (2001). It is a 12-item measure that comprises 3 sub-scales: efficacy in student engagement (4 items—"How much can you do to motivate students who show low interest in schoolwork?"), efficacy in instructional strategies (4 items—"To what extent can you craft good questions for your students?"), and efficacy in classroom management (4 items—"How much can you do to motivate students who show low interest in schoolwork?"). The measure is assessed by a 9-point Likert scale from 1 to 9, ranging from "none" in the "a great deal." The Cronbach's alpha coefficient of TSES was 0.866.

The students' academic achievement was assessed by the grades of the previous term (February to June 2020) reported by the students. A class average score was assigned to the corresponding teacher participant. It was calculated based on one mandatory subject in the Chinese education curriculum: mathematics. Students' grades were ranged from 1 ("insufficient") to 5 ("outstanding") so higher scores indicate better academic performance.

Data Analysis

Structural equation modeling (SEM) was utilized to test our hypotheses. The software used to perform SEM analyses was Mplus version 7.4 (Muthén and Muthén, 2015). First, we conducted a total effect analysis to test the relationship between teacher EI and student academic achievement (H1). Then, we conducted a mediation analysis to test the mediating effect of teacher work engagement on the relationship between teacher EI and student academic achievement (H2). Finally, we performed a moderated mediation model to test the moderating effect of teacher self-efficacy on the relationship between teacher work engagement and student academic achievement (H3), as well as on the mediating effect of teacher work engagement abovementioned.

Particularly, we used the Latent Moderated Structural Equations (LMS) method to construct the latent interaction term of teacher work engagement and self-efficacy (Cheung and Lau, 2017). Moreover, we employed the bootstrapping method to determine the significance of the mediating effect of teacher work engagement and the moderated mediating effect, because both effects involve the product of two path coefficients (Zhao et al., 2010; Hayes, 2015). Specifically, we used 1,000 bootstrapped resamples to compute the 95% confidence intervals (CI) of the mediating effect and the moderated mediating effect. The focused effects can be determined as significant if the 95% CI did not contain zero (Preacher and Hayes, 2008).

HYPOTHESIS DEVELOPMENT

Teacher EI and Student Academic Achievement

According to Bar-On (2010), EI is a component of positive psychology that has significant implications for human performance, wellbeing, and subjective wellbeing. In the context of education, teacher EI is an important personal resource when teachers are faced with the demands of their profession (Valente et al., 2020). EI has been categorized by Chan (2004) into four dimensions: emotional appraisal, positive regulation, empathic sensitivity, and positive utilization. Emotional appraisal refers to the assessment of self-emotions (e.g., knowing the reasons for mood changes), positive regulation refers to the regulation of self-emotions (e.g., expecting good things to happen), empathic sensitivity refers to the recognition of others' emotions (e.g., recognizing emotions from facial expressions), and positive utilization refers to the use of emotions (e.g., solving problems in positive emotions).

Reviewing the previous literature on teacher EI, the majority of studies focuses primarily on the impact of teacher EI on various teacher outcomes. For example, some researchers have explored the relationship between teacher EI and self-efficacy (e.g., Moafian and Ghanizadeh, 2009). In the study of Singh and Jha (2012), they pointed out that teachers' EI was highly relevant to their efficacy and to improve their performance. Similarly, Wu et al. (2019) found that teachers with higher EI tended to exhibit a higher level of self-efficacy. In their study, the participants demonstrated a greater motivation to teach and fewer intentions to quit the profession. Teacher EI and "burnout" have also been explored. Overall, empirical findings have shown that teachers with high scores in the highest-level dimension of EI show lower levels of exhaustion or burnout (e.g., Platsidou, 2010; Pishghadam and Sahebjam, 2012). Additionally, some studies have examined the relationship between teacher EI and job commitment. According to these studies, EI has a positive impact on teachers' energy, focus, and persistence (e.g., Naderi Anari, 2012; Mérida-López et al., 2017).

While a large body of research indicates that teacher EI is positively correlated with various teacher outcomes, studies on the association between teacher EI and student outcomes are rare and have yielded mixed results. For example, Curci et al. (2014) argued that teacher EI contributes to student achievement by enhancing students' perceived competence and self-esteem. Contrary to Curci et al. (2014), Koifman (1998) found no link between teacher EI and student achievement. Against this background, future research involving these two variables is necessary to be done.

Academic achievement refers to the educational outcomes of a person at educational institutions (Cheng et al., 2019). Educational institutions are not just places where knowledge is imparted, but places where educators inspire and support students (Welmilla, 2020). Modern educators are supposed to control their emotions and, equally important, establish good interactions and connections with students when providing effective instruction. Teachers with high EI levels tend to be more concerned about their students (Alam and Ahmad, 2018). They can better perceive the needs of students and respond to those needs positively. According to Welmilla (2020), teachers with high emotional intelligence are good at engaging students in learning activities, which has a positive impact on student learning outcomes. Based on the empirical evidence provided in the above section, we hypothesize that as:

> *H1a*: Teachers' emotional intelligence is positively related to student academic achievement.

Mediation Effects of Teacher Work Engagement

Teacher work engagement is a motivational concept that refers to teachers' voluntary allocation of physical, cognitive, and emotional resources directed at the range of tasks demanded by a teaching role (Christian et al., 2011). It is a positive, enduring, work-related mindset (Schaufeli et al., 2002). According to Klassen et al. (2013), teacher work engagement includes three domains: cognitive-physical, emotional, and social. Sometimes, these three domains are incorporated into one higher-order engagement construct, in which each domain is experienced simultaneously or holistically (Klassen et al., 2013).

According to the Job demands–resources model (Bakker and Demerouti, 2017), personal resources are one of the key factors influencing work engagement. The EI, as one of the personal resources, contributes significantly to work engagement. Reviewing the previous literature, the growth of research on

the correlation between EI and work engagement in school settings has been rapid (Mérida-López et al., 2017; D'Amico et al., 2020). These studies pointed out that teacher EI is strongly related to all three work engagement dimensions. For example, Mérida-López and Extremera (2017) argue that EI can help teachers reduce burnout and thus have a positive impact on teachers' engagement in their work.

Additionally, teacher work engagement is also considered a predictor of student academic performance (Addimando, 2019). According to Basikin (2007), engaged teachers are adept at giving students a high level of attention during the learning process, developing appropriate strategies that assist them in understanding the behavior of students, creating good lesson plans, and assessing student performance effectively in the learning process. Furthermore, a teacher who is engaged in the classroom and actively involved in developing a healthy student-teacher relationship will promote students' engagement and thereby improve students' academic achievement (Addimando, 2019). Thus, we propose that as:

> *H1b*: Teacher work engagement has a mediation effect on the relationship between teacher EI and student academic achievement.

Moderating Effects of Teacher Self-Efficacy

Self-efficacy reflects a person's beliefs about his or her capacities to execute specific actions required to produce a given achievement (Bandura, 1997). In the educational setting, teacher self-efficacy refers to teachers' self-referent judgments or perceptions about their abilities to successfully complete teaching-related tasks and bring about desired outcomes of students (Klassen et al., 2011). According to the model of teacher self-efficacy structure (Tschannen-Moran and Woolfolk Hoy, 2001), teacher self-efficacy includes three aspects, which are self-efficacy for classroom management, self-efficacy for instructional strategies, and self-efficacy for student engagement. These three dimensions have high reliability, and factor analysis confirms the presence of higher-order dimensions of teacher self-efficacy in teachers' perceived ability to perform teaching-related tasks (Perera et al., 2019).

Prior studies have revealed that efficacious teachers who believe themselves having the ability to successfully execute teaching tasks are more likely to be engaged in their work (Granziera and Perera, 2019). In other words, teachers with a strong sense of efficacy tend to be more enthusiastic and committed to their work. For instance, Skaalvik and Skaalvik (2014) discovered that higher levels of teacher self-efficacy led to greater levels of work engagement among school teachers. Longitudinal evidence conducted by Simbula et al. (2011) has also supported the view that teachers' self-efficacy generalizes their engagement to their work. Similarly, Lu et al. (2016) revealed that the levels of teacher self-efficacy may significantly influence their persistence, commitment, and teaching behaviors in working with challenging students. Teachers' self-efficacy has also been noted to be one of the most significant factors that affect students' achievement (Kim and Seo, 2018). According to Tschannen-Moran and Woolfolk Hoy (2001), teachers who are confident in their ability to teach and in their ability to motivate students tend to have a greater effect on their students' academic performance even if the students lack academic motivation. The findings of Kim and Seo (2018) are consistent with the study of Tschannen-Moran and Woolfolk Hoy (2001). They stated that teachers with high levels of self-efficacy know the importance of their teaching confidence and how their beliefs take their students toward success in academic learning. Drawing on these evidences, we propose the hypothesis as follows:

> *H2*: Teacher self-efficacy moderates the positive relationship between teachers' work engagement and students' academic achievement, such that this relationship is strong for high (vs. low) self-esteem.

RESULTS

Preliminary Analyses

Table 1 displays the means and standard deviations of correlations among variables examined in this study. Teacher EI is positively correlated with student academic achievement, providing preliminary evidence for H1. Teacher work engagement is positively correlated with teacher EI and student academic achievement, offering preliminary evidence for H2. As these variables except for academic achievement were measured by self-report scales, common-method bias was checked using Harman single-factor testing (Podsakoff and Organ, 1986). The testing yielded 11 factors with eigenvalues higher than one and the first factor only accounted for 20.216% of the total variance, so common-method bias is not a salient issue in this study.

Table 2 shows the results of the total effect of teacher EI on student academic achievement. The fit goodness of the total effect model is acceptable: $\chi^2 = 252.354$, df = 243, $\chi^2/df = 1.038$, CFI = 0.994, TLI = 0.993, RMSEA = 0.010 (Hu and Bentler, 1999). H1 proposes that teacher EI is positively related to student academic achievement. As is shown in **Table 2**, teacher EI can positively predict student academic achievement ($b = 0.572$, $p < 0.001$). Therefore, H1 is supported.

Mediating Effect Analysis

Table 3 shows the results of the mediating effect of teacher work engagement. The fit goodness of the total effect model is acceptable: $\chi^2 = 849.355$, df = 733, $\chi^2/df = 1.159$, CFI = 0.973, TLI = 0.971, RMSEA = 0.021 (Hu and Bentler, 1999). H2 proposes that teacher work engagement mediates the relationship between teacher EI and student academic achievement. As is shown in **Table 3**, teacher EI can positively predict teacher work engagement ($b = 0.452$, $p < 0.001$), and also, teacher work engagement can positively predict student academic achievement ($b = 0.580$, $p < 0.001$). Furthermore, the bootstrapping 95% CI for the mediating effect [$b = 0.262$, 95% CI = (0.156, 0.456)] does not

TABLE 1 | Descriptive statistics and correlations (N = 365).

Variable	M	SD	1	2	3	4
1. Emotional intelligence	4.859	1.018	–			
2. Work engagement	4.728	1.054	0.277**	–		
3. Self-efficacy	6.650	1.262	0.239**	0.433**	–	
4. Academic achievement	3.622	1.141	0.342**	0.502**	0.403**	–

**$p < 0.01$.

TABLE 2 | Total effect of teacher EI on student academic achievement.

Predictors	*B*	*SE*	*value of p*
Control variables			
Teacher gender	−0.108	0.110	0.323
Teacher age	−0.140	0.066	0.033
Teaching experience	0.145	0.048	0.003
Teacher education level	0.141	0.100	0.158
Class gender ratio	−0.371	0.955	0.698
Grade_7th	−0.325	0.137	0.017
Grade_8th	−0.241	0.138	0.080
AFI	0.156	0.049	0.001
Independent variable			
Teacher emotional intelligence	0.572	0.108	<0.001
R-square	0.224		

B, unstandardized coefficient; SE, standard error; and grade was dummy coded (1 = 7th, 2 = 8th, and 3 = 9th).

contain zero, indicating that the examined mediating effect is statistically significant (Zhao et al., 2010). Thereby, H2 is supported. As the direct effect of teacher EI on student academic performance is still significant ($b = 0.312$, $p = 0.001$), teacher work engagement partially mediates the positive association between teacher EI and student academic performance.

Moderated Mediation Effect Analysis

Table 4 presents the results of the moderated mediation model. Since the LMS method do not provide traditional model fit indices, we followed the procedures recommended by Maslowsky et al. (2015) to access the fit goodness of the moderated mediation model. First, we ran a null model which excludes the latent interaction term (i.e., Teacher work engagement × Teacher self-efficacy), the result showed that this null model fits well ($\chi^2 = 1509.717$, df = 1,274, χ^2/df = 1.185, CFI = 0.960, TLI = 0.958, RMSEA = 0.023). Second, we used log-likelihood ratio test to evaluate whether the model fit of the full model (i.e., the moderated mediation model including the latent interaction term) is significantly better than that of the null model. As indicated by the results of the log-likelihood ratio test {$\chi^2 = -2[(-30175.443) - (-30171.076)] = 8.734$, df = 1, $p = 0.003$}, the model fit of the full model is significantly better than that of the null model. Therefore, we can conclude that the moderated mediation model is also a well-fitted model (Maslowsky et al., 2015).

As is shown in **Table 4**, the path coefficient of the interaction term is significant and positive ($b = 0.162$, $p = 0.002$), indicating that the moderating effect of teacher self-efficacy on the association between teacher work engagement and student academic achievement is significant. Simple slope test was further conducted and the result showed that as: when teacher self-efficacy is low (M-SD), the path coefficient from teacher work engagement to student academic achievement is 0.326, but when teacher self-efficacy is high (M-SD), the path coefficient from teacher work engagement to student academic achievement is 0.641. The difference between the two coefficients is also significant ($diff = 0.315$, $p = 0.004$). Consequently, the relationship between teacher work engagement and student academic achievement is stronger for high (vs. low) teacher self-efficacy (see **Figure 1**), supporting H3. We also tested whether the mediating effect of teacher work engagement is moderated by teacher self-efficacy, and the results showed that the index of the moderated mediation is significant [index = 0.085, bootstrapping 95% CI = (0.032, 0.174) excluding zero]. Hence, teacher self-efficacy moderates the mediating effect of teacher work engagement.

DISCUSSION

Main Findings

The present study used a moderated mediation to examine whether teacher work engagement would mediate the link between teacher EI and student academic achievement, and whether teacher self-efficacy would moderate the relationship between teacher work engagement and student academic achievement. Overall, our findings supported our hypotheses.

Consistent with our hypothesis, this study showed that teacher EI, as an important personal resource, could be a significant factor for students' academic achievement. This finding does not support the results of such previous research performed by Koifman (1998), which found that teacher EI did not affect student achievement. This difference may be culturally related. Zhang and Zhu (2008) claimed that each culture has its unique emotional patterns, which have different meanings and effects on its members. In general, people from collectivist cultures perceive the self as a communal, relational entity that is connected to others. In the Chinese educational context, teachers play a dominant role in the classroom. Chinese students are more likely than Western students to have dependent relationships with their teachers.

Another major finding of this study was that teacher work engagement partially mediates the positive association between teacher EI and student academic achievement as the mediation model verification shows. Although quite a number of research

TABLE 3 | Mediating effect of teacher work engagement.

Predictors	Teacher work engagement			Student academic achievement		
	B	*SE*	*value of p*	*B*	*SE*	*value of p*
Control variables						
Teacher gender	−0.101	0.116	0.386	−0.050	0.100	0.616
Teacher age	−0.068	0.082	0.409	−0.101	0.067	0.132
Teaching experience	0.014	0.060	0.813	0.137	0.051	0.007
Teacher education level	0.074	0.114	0.514	0.097	0.091	0.285
Class gender ratio	−0.816	0.917	0.374	0.103	0.894	0.908
Grade_7th	−0.373	0.153	0.015	−0.109	0.130	0.403
Grade_8th	−0.322	0.156	0.039	−0.054	0.131	0.683
AFI	0.034	0.048	0.488	0.137	0.049	0.005
Independent variable						
Teacher emotional intelligence	0.452	0.115	<0.001	0.312	0.090	0.001
Mediator						
Teacher work engagement				0.580	0.085	<0.001
R-square	0.178			0.415		

B, unstandardized coefficient; SE, standard error; and grade was dummy coded (1 = 7th, 2 = 8th, and 3 = 9th).

TABLE 4 | Mediating effect of teacher work engagement moderated by teacher self-efficacy.

Predictors	Teacher work engagement			Student academic achievement		
	B	*SE*	*value of p*	*B*	*SE*	*value of p*
Control variables						
Teacher gender	−0.097	0.111	0.380	−0.028	0.097	0.773
Teacher age	−0.071	0.079	0.373	−0.113	0.064	0.080
Teaching experience	0.010	0.059	0.863	0.136	0.048	0.005
Teacher education level	0.069	0.111	0.531	0.051	0.087	0.561
Class gender ratio	−0.725	0.771	0.347	0.092	0.891	0.917
Grade_7th	−0.374	0.150	0.013	−0.089	0.126	0.483
Grade_8th	−0.305	0.153	0.046	0.016	0.128	0.902
AFI	0.026	0.047	0.578	0.123	0.047	0.008
Independent variable						
Teacher emotional intelligence	0.527	0.137	<0.001	0.235	0.100	0.018
Mediator						
Teacher work engagement				0.483	0.083	<0.001
Moderator						
Teacher self-efficacy				0.388	0.119	0.001
Interaction term						
Teacher work engagement × Teacher self-efficacy				0.162	0.053	0.002
R-square	0.222			0.436		

B, unstandardized coefficient; SE, standard error; and grade was dummy coded (1 = 7th, 2 = 8th, and 3 = 9th).

has supported the relationship between teacher EI and work engagement (Mérida-López et al., 2017; D'Amico et al., 2020), as well as teacher work engagement and student academic achievement (Basikin, 2007; Addimando, 2019), to our knowledge, this study is the first to explore the mediating role of teacher work engagement between teacher emotional intelligence and student academic achievement. Consistent with our hypothesis, teacher EI could predict student academic achievement through the indirect effect of teacher work engagement. In other words, emotional intelligence can help teachers reduce burnout and thus become more engaged in the classroom, which in turn will improve student academic achievement.

Our findings confirmed that teacher self-efficacy played a moderating role in the influence of teacher work engagement on student academic achievement. Prior studies have revealed that teachers with a strong sense of efficacy exhibit greater levels of engagement (Skaalvik and Skaalvik, 2014; Granziera

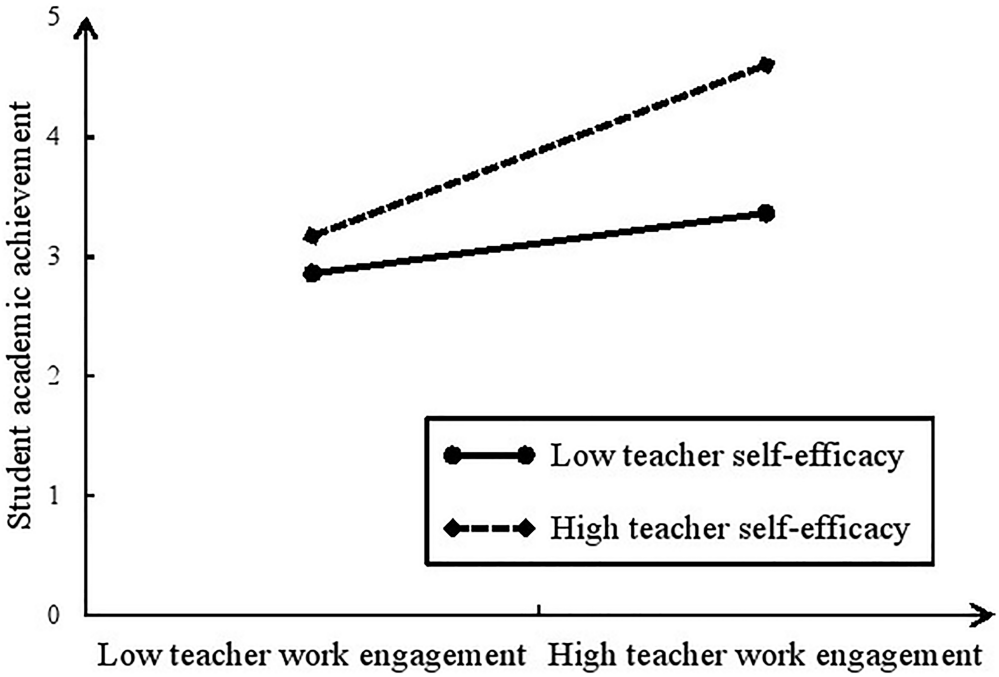

FIGURE 1 | The moderating effect of teacher self-efficacy.

and Perera, 2019) and have a more positive impact on students' academic learning (Tschannen-Moran and Woolfolk Hoy, 2001; Kim and Seo, 2018). However, those studies did not explore the moderating role of teacher self-efficacy between teacher work engagement and student academic achievement. This study found that teachers with high self-efficacy had a more significant positive impact on the relationship between teacher work engagement and student academic achievement than teachers with low self-efficacy. Our findings also support the opinion that teachers with higher levels of self-efficacy appear to view teaching challenges as a controllable factor and are more likely to use innovative teaching methods in order to help their students succeed (Basikin, 2007).

Limitations

The limitations of the current study should be mentioned. First, only students and teachers from Chinese schools were assessed, which is a small number, which may affect the representativeness of the sample. A large sample of students and teachers from different countries, different ages, and different cultures will more accurately reveal the influence of teacher EI on student academic achievement. Second, this study only focuses on the influence of teacher EI, self-efficacy, and work engagement on student academic achievement, and does not involve student EI, self-efficacy, and work engagement. These factors also have an important impact on student academic achievement, and their influencing mechanism and joint effect are worth further study. Third, there may be other mediators, moderating variables, and relationship models. Individual emotion, personality characteristics, school atmosphere, family atmosphere, and peers may play a mediating or moderating role in the relationship between teacher EI and student academic achievement. This study establishes a moderated mediation model between teacher self-efficacy and work engagement about student academic achievement but does not exclude the possibility of multiple and mediated moderating models.

CONCLUSION

In sum, the present study may be the first study to investigate the correlation between teacher EI and student academic achievement by examining a moderated mediation model. It reveals that the relationship between teacher EI and student academic achievement could be mediated by teacher work engagement. Besides, the link between teacher work engagement and student achievement is moderated by teacher self-efficacy. Our study hopes that EI training will be considered as part of the training program for pre-service teachers. In addition, schools can provide EI training to teachers who face difficulties with classroom control or expect to build good relationships with students.

DATA AVAILABILITY STATEMENT

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

AUTHOR CONTRIBUTIONS

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

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Linking Emotional Intelligence to Mental Health in Chinese High School Teachers: The Mediating Role of Perceived Organizational Justice

*Sha Shen[1,2], Tianqi Tang[2], Hong Shu[2], Saidi Wang[3], Xiangli Guan[4], Xiangdong Yan[5], Yanli Wang[2], Yun Qi[2] and Rui Feng[6]**

[1]Key Laboratory of China's Ethnic Languages and Information Technology of Ministry of Education, Northwest Minzu University, Lanzhou, China, [2]College of Educational Science and Technology, Northwest Minzu University, Lanzhou, China, [3]Gansu 24 Refractive New Media Technology Co., Ltd., Lanzhou, China, [4]Teacher Education College, Yu Xi Normal University, Yu Xi, China, [5]Shanghai Hui Ye (Lan Zhou) Law Office, Lanzhou, China, [6]School of Journalism and Media, Yangzhou University, Yangzhou, China

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Jiangxi Normal University, China

***Correspondence:**
Rui Feng
frzx0519@163.com

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Compare with other professions, teachers are reported to have a higher risk of poor mental health. This study examined the relationships between emotional intelligence, perceived organizational justice, and mental health among Chinese high school teachers. Three hundred and eighty-one high school teachers, with their age range between 21 and 50 years, were administered the Emotional Intelligence Scale, Perceived Organizational Justice Scale, and Mental Health Scale. The result found that emotional intelligence and perceived organizational justice directly influence the mental health of high school teachers. In addition, perceived organizational justice mediated the association between emotional intelligence and mental health. Moreover, the present study analyzes the different role of subtypes of perceived organizational justice on the relationships between emotional intelligence and mental health, and the results showed that the mediating effects of perceived distributive justice and interactive justice on emotional intelligence and mental health are not significant, only the perceived procedural justice mediated the relationships between emotional intelligence and teachers' mental health. The results are discussed in a conceptual context.

Keywords: emotional intelligence, mental health, perceived organizational justice, high school teachers, teachers' health

INTRODUCTION

With the strict requirements of the society on the professional development of teachers, contemporary teachers face more psychological pressure than before (Ali et al., 2021; Hollett et al., 2021). In addition, teachers have to assume multiple roles (Naylor, 2001), which makes them more prone to psychological problems (Narayanappa et al., 2016; Yang et al., 2019). Thus, compared with other professions, teachers are reported to have a higher risk of poor mental health (Stansfeld et al., 2011; Kidger et al., 2016). Riches of studies indicated that mental health is important for teachers (e.g., Narayanappa et al., 2016; Navinés et al., 2016). The mental health of teachers not only has a strong impact on teaching skills that in turn can affect the academic achievement of students (Yang et al., 2019), but also influences developing

and establishing good relationships with students (Jennings and Greenberg, 2009), which is associated with worse mental health of students (Kidger et al., 2012; Plenty et al., 2014). The mental health of high school teachers is more important, because a number of mental problems develop in adolescence (e.g., Kim-Cohen et al., 2003; Joinson et al., 2017) and the mental health of teachers is closely related to that of students (Klusmann et al., 2016; Harding et al., 2019). Therefore, more research is needed to further clarify the factors and mechanisms that affect the mental health of high school teachers. This question is important because identifying the determinants and mechanisms of mental health among high school teachers is a critical early step for implementing interventions.

Teachers often face negative emotions in their interactions with students, family members, and colleagues (Travers, 2017); it is reasonable that emotional intelligence is regarded as one of the factors influencing mental health of teachers (Antinienė and Lekavičienė, 2017). Emotional intelligence is defined as "the extent to which a person processes emotional information adequately" (Mayer et al., 2000, 2016). Ample evidence showed that emotional intelligence is associated with classic indicators of mental health significantly (e.g., Cejudo, 2016; Singh and Bhardwaj, 2016). For example, Lea et al. (2019) used meta-analyses method to investigate the relationships between emotional intelligence and mental health, and found that higher emotional intelligence is associated with lower levels of depression, anxiety, and psychological distress and less likely to suicide (García-Sancho et al., 2014). A follow-up study showed that the students who with high emotional intelligence had fewer symptoms of depression and anxiety over time (Antinienė and Lekavičienė, 2017), and an international research has confirmed that high emotional intelligence can significantly improve the level of mental health (Kaur, 2019).

Although the previous studies indicated that emotional intelligence is related to mental health, the specific mechanisms involved in the association remain unclear. For example, mental health may be influenced by emotional intelligence through perceived organizational justice (POJ). POJ refers to employees' perception of fairness in their organizations (Eib et al., 2017), when individuals realize that a decision or process is unfair, they may develop a negative attitude toward work, reduce motivation to work (Skarlicki and Folger, 1997; Cordes, 2010). According to the emotional intelligence theory proposed by Salovey and Mayer (1990), teachers with higher emotional intelligence can better manage and use their emotions and those of others in school, can communicate well with other colleagues and leaders in school, and promote an understanding of organization-related factors and equity factors in organizations. On the contrary, individuals with relatively low emotional intelligence have difficulty in controlling their emotions and are prone to organizational injustice. In line with this model, POJ has been shown to be associated with emotional intelligence (Zeidner et al., 2004; Ouyang et al., 2015). For instance, Ouyang et al. (2015) found that there is a significant correlation between POJ and emotional intelligence. Specifically, higher level of emotional intelligence is associated with higher level of POJ. In addition, researchers have been investigating new psychosocial stressors, such as organizational justice in the context of mental health (Ferrie et al., 2006). Studies have shown that POJ is not only a major determinant of behavior and attitude outcomes, but also an important psychosocial predictor of individual health (Weiss et al., 1999). Previous studies have shown that there is a significant association between POJ and mental health. Specifically, lower level of POJ is associated with worse mental health (e.g., Hayashi et al., 2011; Rai, 2015). So, does POJ mediates the relationships between emotional intelligence and mental health?

In addition, based on the previous literature, POJ including three basic aspects: perceived distributive justice, perceived procedural justice, and perceived interactional justice. Perceived distributive justice refers to perception of fairness in rewards or resources that are allocated, perceived procedural justice represents an individual's view of the fairness of the process by which the administration makes decisions, and perceived interactional justice refers to the fairness of interpersonal treatment perceived by individuals in the process of decision implementation (Colquitt and Greenberg, 2003, p. 159). These subtypes of POJ are conceptually distinct (Erdogan, 2002; Ambrose and Arnaud, 2005) and have different influencing factors and different influences on individuals (Colquitt et al., 2001; Erdogan, 2002). To the authors' knowledge, no research has investigated the role of different subtypes of POJ in the relationships between emotional intelligence and mental health among teachers. So, does perceived distributive justice, perceived procedural justice, and perceived interactional justice play different roles in the relationships between emotional intelligence and mental health among high school teachers?

The present study investigates whether the relationships between emotional intelligence and mental health influenced by POJ among high school teachers. More important, the present study investigates whether the subtypes of POJ play different roles in the relationships between emotional intelligence and mental health. Based on previous studies, the present study hypotheses that the POJ mediates the relationships between emotional intelligence and mental health, and perceived distributive justice, perceived procedural justice, and perceived interactional justice play different roles in the relationships between emotional intelligence and mental health among high school teachers.

MATERIALS AND METHODS

Participants

The participants were 401 high school teachers from three high schools in northern city using utilizing convenience sampling technique. The age range was 21–50 ($M = 35.95$, $SD = 7.78$). Any high school teacher who did not participate in a similar study can volunteer to participate. After excluding 20 incomplete questionnaires (5%), a total of 381 responses of participants (182 males and 199 females) were used in the present study. Other demographic information is presented in **Table 1**.

TABLE 1 | Socio-demographic characteristics of the participants ($n = 381$).

	Groups	Frequency (%)
Gender		
Female	182	47.8
Male	199	52.2
Age		
<35	178	46.72
36–45	154	40.42
46–50	49	12.86
Education ground		
College degree	44	11.55
Bachelor degree	327	85.83
Graduate degree	10	2.62
Grade of teaching		
Senior one	124	39.90
Senior two	132	37.27
Senior three	125	22.83

TABLE 2 | Descriptive statistics and correlations for all variables ($n = 381$).

Variable	*M* (SD)	1	2	3
Emotional intelligence	56.15 (12.22)	1		
Perceived organizational justice	52.9 (11.24)	0.21**	1	
Mental health	71.86 (8.76)	0.46**	0.45**	1

**$p < 0.01$.

At the end of the experiment, all participants received a gift worth 30 RMB. The research proposal was approved by the local academic committee.

Measures

Emotional Intelligence Scale

The Emotional Intelligence Scale (EIS) consists of 16 items (Law et al., 2004) and some examples of items including "I have a good understanding of my own emotions" and "I always knew if I was happy or not." Each item is answered on a seven-point scale (1 = strongly disagree and 7 = strongly agree). The scores used in the present study were calculated by summing all the scores of each item, and higher scores indicated higher emotional intelligence. The Chinese version of EIS has satisfactory reliability and validity (e.g., Hu et al., 2016; Geng, 2018). In the present study, the EIS's Cronbach alpha coefficient was 0.93.

Perceived Organizational Justice

The scale of POJ consists of 20 items (Niehoff and Moorman, 1993) and some examples of items including "I feel I am being rewarded fairly considering the responsibilities" and "My work is arranged fairly." Each item is answered on a five-point scale (1 = strongly disagree and 5 = strongly agree). The scores used in the present study were calculated by summing all the scores of each item, and higher scores indicated experiencing higher level of organizational justice. This scale is frequently used in China and has good validity and reliability (Ouyang et al., 2015). In the present study, the POJ's Cronbach alpha coefficient was 0.91.

Mental Health Scale

The scale of mental health scale (MHS) consists of 30 items (Cheng et al., 1990) and some examples of items including "how much sleep about worry?" and "been feeling giddy?." Each item is answered on a five-point scale (5 = strongly disagree and 1 = strongly agree). The scores used in the present study were calculated by summing all the scores of each item, and higher scores indicated experiencing better mental health. This scale is frequently used in China and has good validity and reliability (Cheng et al., 1990). In the present study, the MHS's Cronbach alpha coefficient was 0.90.

Procedure

We contacted principles of three high schools in the northern city of China to describe the purpose of the present study. They approved the study and allowed questionnaires to be sent to teachers. 401 teachers volunteered to take part in the survey. All questionnaires were completed in the school office after the teachers had completed informed consent.

Ethics

This study is based on the Declaration of Helsinki and its subsequent amendments. The study protocol was approved by the Ethics Committee of the Northwest Minzu University.

Analytical Strategy

SPSS 25.0 was used to analyze the data. First, we established the relationships between emotional intelligence, mental health, and POJ by the correlation analysis. Then, we conducted the two-step procedure proposed by Anderson and Gerbing (1988) and used SPSS macro PROCESS program to examine the mediating effects.

RESULTS

Descriptive Statistics and Correlations for Emotional Intelligence, POJ, and Mental Health

The descriptive statistics and the correlation test were conducted for emotional intelligence, POJ, and mental health and the results were shown in **Table 2**. The results showed that emotional intelligence, POJ, and mental health were significantly correlated ($p < 0.01$).

The Analysis of the Mediating Role of POJ Between Emotional Intelligence and Mental Health

In order to analyze the effect of emotional intelligence on mental health and the role of POJ, SPSS macro PROCESS

program was used to test the mediating effect. The mediation model testing needs to estimate the parameters of two regression equations: First, the direct effect of independent variable (emotional intelligence) on dependent variable (mental health); Second, the mediating effect (indirect effect) of POJ on the independent variable (emotional intelligence) and the dependent variable (mental health).

If the model meets the following conditions, the mediation effect exists as: (1) Emotional intelligence has a significant effect on mental health; (2) Emotional intelligence has a significant effect on POJ; and (3) POJ has a significant effect on mental health. The results of regression analysis are shown in **Table 3**. The results showed that emotional intelligence predicted mental health significantly ($\beta = 0.46$, $t = 10.03$, $p < 0.001$). In addition, emotional intelligence predicted POJ significantly ($\beta = 0.20$, $t = 4.07$, $p < 0.001$), while POJ predicted mental health significantly ($\beta = 0.37$, $t = 8.69$, $p < 0.001$). As shown in **Figure 1**, POJ plays a mediating role on the relationships between emotional intelligence and mental health.

In order to obtain reliable results of mediating effect, the mediation effect was further tested using the non-parametric percentage Bootstrap which corrected by deviation. If the confidence interval of 95% Bootstrap does not contain 0, the mediating effect is significant. The results are shown in **Table 4**. The direct effect value of emotional intelligence on mental health is 0.27, accounting for 82% of the total effect. The 95% interval is [0.21, 0.33], indicating that the direct effect is significant. The indirect effect of POJ on emotional intelligence and mental health is 0.05, accounting for 18% of the total effect, with a 95% interval of [0.26, 0.88], indicating a significant mediating effect.

The Analysis of the Different Role of the Subtypes of POJ Between Emotional Intelligence and Mental Health

In order to analyze the effect of emotional intelligence on mental health and the different role of subtypes of POJ, SPSS macro PROCESS program was used to test the mediating effect. The three dimensions of POJ were conducted as multiple mediating variables. As shown in **Figure 2**, the results showed that the mediating effects of perceived distributive justice and perceived interactive justice on emotional intelligence and mental health are not significant, only the mediating effect of perceived procedural justice on emotional intelligence and mental health was found [$\beta = 0.44$, $p < 0.001$, SE = 0.03, $t = 9.16$, 95% CI = (0.71, 1.16)], and the mediating effect accounted for 21.2% of the total effect.

TABLE 3 | The test of mediation effect ($n = 381$).

Variable	Model 1			Model 2		
	Mental health			Mental health		
	Effect of value	SE	*t*	Effect of value	SE	*t*
Emotional intelligence	0.46	0.03	10.03***	0.38	0.03	8.97***
Perceived organizational justice				0.37	0.033	8.69***
R2		0.21			0.34	
F		12.95***			10.97***	

***$p < 0.001$.

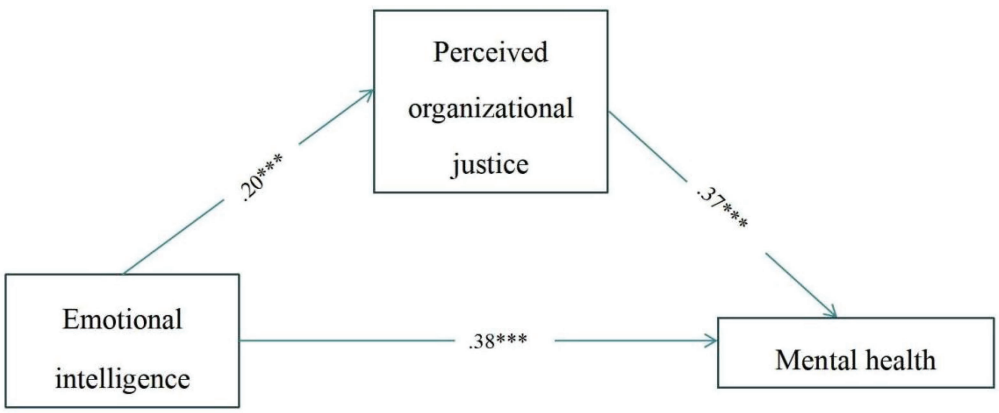

FIGURE 1 | The model of emotional intelligence, perceived organizational justice (POJ), and mental health.

DISCUSSION

The main aim of the present study was to examine the mediating effect of POJ on emotional intelligence and mental health among Chinese high school teachers. The results of this study showed that POJ mediates the relationships between emotional intelligence and mental health. More importantly, the present study also investigated the different role of subtypes of POJ and found only the perceived procedural justice mediates the relationships between emotional intelligence and mental health of teachers. The results of the present study expand the reports of potential causes of teacher's mental health from other studies (Yang et al., 2019; Halladay et al., 2020; Ain et al., 2021) and also reveal the determinants and mechanisms between emotional intelligence and teachers' mental health. As a result of the analysis which was conducted for examining the direct role of emotional intelligence on mental health was found significant prediction. Riches of previous studies also found out that emotional intelligence had a significant relationship with mental health (e.g., García-Sancho et al., 2014; Lea et al., 2019). The present study found a direct predict effect of emotional intelligence on mental health. This is in line with the emotional intelligence theory (Salovey and Mayer, 1990), according to which, emotional intelligence is an important kind of ability to regulate and understand own and others' emotions (Mayer et al., 1990). Teachers often face negative emotions (Travers, 2017), and teachers with high emotional intelligence are more likely to monitor their own feelings and emotions, and are good at using this information to guide their own thinking and actions. As a result, they are more likely to be in good mental health.

In addition, the present study emphasizes that POJ accounted for the relationships between emotional intelligence and mental health among high school teachers. This is in line with the emotional intelligence theory (Salovey and Mayer, 1990), according to which, individuals with relatively low emotional intelligence have difficulty in controlling their emotions and are prone to organizational injustice. In addition, this is in accordance with job demands-resources model (Demerouti et al., 2001). According to the job demands-resources model, the higher an individual's POJ is, the more resources they feel they have, which will weaken the impact of job requirements and alleviate individual's mental health, which implies that a high sense of organizational justice associated with better mental health.

More importantly, the present study found only the perceived procedural justice mediates the relationships between emotional intelligence and teachers' mental health. The results in line with conservation of resources theory (COR). According to COR theory, individuals strive to conserve and utilize psychological resources, such as energy and personal identity (Halbesleben et al., 2014). The theory holds that the resource loss is more critical than the resource gain (Hobfoll, 1989). The perception of procedural justice mainly comes from whether the allocation process of resources is fair or not. If individuals perceive that the allocation process is unfair to themselves, they will perceive that their resources are reduced. Such perception of reduced resources will exert pressure on individuals and lead them to adopt some defensive strategies to avoid resource loss in future (Halbesleben et al., 2014), thus leading to a decline of their mental health.

There are some limitations in this study. First, this study is cross-sectional, no causal conclusions can be drawn. More longitudinal studies should be conducted in the future to verify the causal relationship among these variables. Second, this study was conducted among Chinese teachers, the results obtained may

TABLE 4 | Bootstrap analysis of significance test of mediation effect ($n = 381$).

The path	Effect of value	Effect of the amount (%)	Bootstrap 95% confidence interval down line	Bootstrap 95% confidence interval upper line
Direct effect (A → C)	0.27	82%	0.21	0.33
Indirect effect (A → B → C)	0.05	18	0.26	0.88
Total effect	0.33	100	0.26	0.39

A, emotional intelligence; B, perceived organizational justice; and C, mental health.

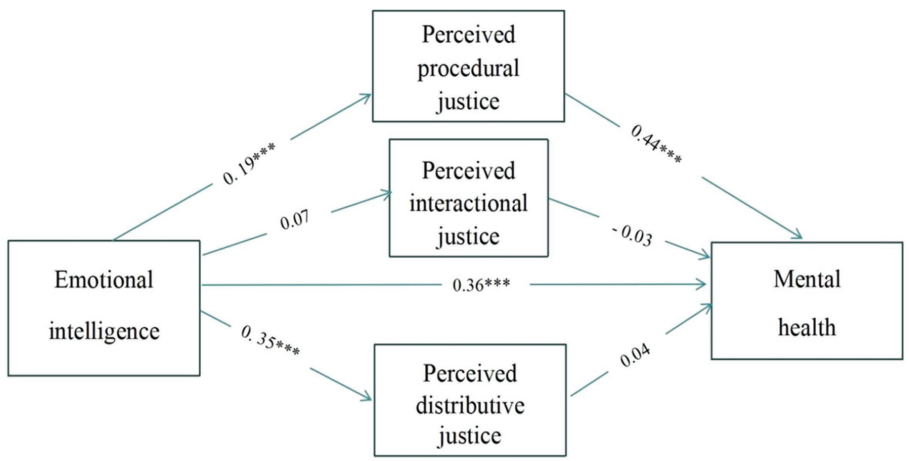

FIGURE 2 | The model of emotional intelligence, different of subtypes of perceived organizational justice and mental health.

not be generalized to relevant populations in other countries. Third, the participants were mostly from northern cities of China, the representativeness of the sample should be expanded in future studies.

Despite its limitations, this study is the first attempt to investigate the underlying mechanism of POJ between emotional intelligence and mental health among Chinese high school teachers. The results indicate that emotional intelligence influences mental health by POJ, and only the perceived procedural justice mediates the relationships between emotional intelligence and teachers' mental health. These results may provide valuable information for the intervention design aimed at reducing the factors affecting teachers' mental health. On the one hand, improving teachers' emotional intelligence through training can influence the relationships between emotional intelligence and mental health. On the other hand, for teachers with low emotional intelligence, the relationships between emotional intelligence and mental health can be affected by improving perceived procedural justice.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Ethics Committee of the College of Educational Science and Technology of Northwest Minzu University. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

SS, XG, RF, and SW proposed the original thoughts. TT, XY, YW, YQ, and HS collected the data. All authors contributed to the article and approved the submitted version.

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Teacher's Emotional Display Affects Students' Perceptions of Teacher's Competence, Feelings, and Productivity in Online Small-Group Discussions

Xuejiao Cheng[1,2†], *Han Xie*[1†], *Jianzhong Hong*[1*], *Guanghua Bao*[1] *and Zhiqiang Liu*[3*]

[1] *Key Laboratory of Adolescent Cyberpsychology and Behavior (Ministry of Education), School of Psychology, Central China Normal University, Wuhan, China,* [2] *Department of Psychology, School of Humanities and Social Sciences, Hubei University of Medicine, Shiyan, China,* [3] *Center of Students' Psychological Development, Department of Students' Affairs, Yancheng Polytechnic College, Yancheng, China*

Teacher's emotions have been shown to be highly important in the quality and effectiveness of teaching and learning. There is a recognized need to examine the essential role of teacher's emotions in students' academic achievement. However, the influence of teacher's displays of emotions on students' outcomes in small-group interaction activities, especially in the online environment, has received little attention in prior research. The aim of the present study was to explore the relationship between teacher's different emotional displays and students' perceptions of the teacher's competence, as well as students' collaborative feelings and productivity in online small-group discussions. Using a three-level between-subjects design, 74 participants were randomly divided into four-member groups comprising a teacher and three other participants. All the groups were asked to discuss an open-ended realistic problem using online software, during which the teacher's display of emotions varied (positive vs. negative vs. neutral). The participants' self-reported questionnaire data (perception of the teacher's competence, students' feeling of pleasure, collaborative satisfaction, and willingness to continue collaborating) and productivity (number of effective ideas expressed within a given time) were measured to compare the participants who were exposed to different emotional displays. As expected, the results showed that the participants who received the teacher's positive emotional display reported that they experienced higher levels of pleasure during the task. However, in contrast to our expectations, those under the negative emotional display condition showed a significantly higher level of productivity in the group task. In addition, compared to emotional display, the participants' perceptions of the teacher's competence were rated significantly higher under the neutral condition, and they reported higher levels of collaborative satisfaction and greater willingness to continue collaborating with their group. The findings have the potential benefit of informing educational practice on whether teachers should display their emotions in a small-group discussion or how they should display emotions following adjustment for the relative aim of the teaching activities.

Keywords: teacher's emotional display, students' perceptions, students' productivity, online learning, small-group discussion

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Zhongling Pi,
Shaanxi Normal University, China

Reviewed by:
Xin Zhao,
The University of Sheffield, United Kingdom
Xin Tang,
University of Helsinki, Finland

****Correspondence:***
Jianzhong Hong
jhong@mail.ccnu.edu.cn
Zhiqiang Liu
lzq200412@126.com

† These authors share first authorship

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INTRODUCTION

Collaborative learning can occur in a wide variety of forms, and small-group learning has received researchers' constant attention (Micari and Pazos, 2014; Pai et al., 2015). Multiple students engage in a process together toward a shared learning goal, and, preferably, the group membership ranges from three to five (Wang et al., 2017). A common belief is that meaningful interactions, which refer to the interaction behaviors with personal productivity efforts, can afford opportunities to promote academic outcomes and achieve positive social effects (Tolmie et al., 2010; Micari and Drane, 2011). However, productive behavior among students working does not come easily, which limits the desired effects of small-group learning in educational practice (Slavin, 2014; Wang et al., 2017). To address the gap between the desired value and practice outcomes, various ways to prompt small-group learning have been examined from different perspectives, such as training learners' communication skills, structuring the interaction process, and improving communication (Cohen, 1994; Lou et al., 2001; Jermann and Dillenbourg, 2008; Rummel et al., 2009).

Although numerous studies exist, some researchers consider that inadequate attention is placed on the emotional aspects of small-group learning, which is a pitfall for interaction in such settings, especially in the case where collaborative learning is adjusted from face-to-face education to web-based blended learning through various digital media and collaborative communication tools (Kreijns et al., 2003; Jeong and Hmelo-Silver, 2016; Wang et al., 2017). For example, researchers have proposed that emotional physical cues in online collaboration are relatively lacking in vocal intonation or body language, compared with traditional offline communication (Robinson, 2010). Given this, our study focused on the emotions of teachers and students in the context of communication in online small-group learning, where teacher's emotions are an important factor affecting various aspects of the teaching–learning practice (Meyer and Turner, 2006; Hagenauer et al., 2016; Hansen and Mendzheritskaya, 2017).

Teacher's Emotional Display and Students' Outcomes

Abundant evidence shows that teacher's emotions greatly influence their well-being (Yin et al., 2016), job satisfaction (Yin, 2015), and professional development (Saunders, 2013). Besides the influences on a teacher's own professional life, researchers have proposed that studies may explore the effect of teacher's emotions as a dynamic factor in interpersonal communication or from the perspective of social interactions (Hagenauer et al., 2016). For example, Meyer and Turner (2006) argue that emotions are ubiquitous in education and are important for understanding instructional interactions. As demonstrated in a series of studies, teacher's emotions, especially positive emotions, are associated with students' reports of their motivation. Other students' outcomes, including academic achievement, well-being, and multidimensional development are all assumed to have relationships with teacher's emotions and interaction behaviors (Rosiek, 2003). Given that students are the direct recipients of the influence of teacher's interaction behaviors and interactions with students are frequently emotionally laden, several aspects have been considered to investigate the role of teacher's emotional display on students (Uitto et al., 2015; Hagenauer et al., 2016).

Teacher's Emotional Display and Students' Perceptions of Teacher's Personality

Emotional displays are considered a salient source, and people engaged in social interactions often judge personality traits (e.g., attractiveness, trustworthiness, dominance, and competence) based on certain emotional displays (Keltner and Haidt, 1999; van Kleef, 2009). For example, Hess et al. (2000) used a mix of experimental designs to study the influence of emotional displays on the judgments of 145 Caucasian and Japanese perceptions of dominance and affiliation (Hess et al., 2000). Their results showed that happy emotional displays are tightly linked to a high level of dominance and affiliation and angry emotional displays of people are perceived as low in affiliation and dominance. Such an association between emotional display and perception of personality traits is essential for interpersonal interaction, as it shapes the kinds of strategies to interact with other people, the degree of behavioral productivity in the collaborative process, and whether to continue the interaction (Krumhuber et al., 2007; Van Kleef et al., 2010; Cheng et al., 2013; Fang et al., 2018).

Similarly, studies related to the effects of emotional display on people's perceptions have been conducted in the education environment (Hansen and Mendzheritskaya, 2017; Mendzheritskaya and Hansen, 2019). Researchers have found that the display of emotions, as well as teacher's actions, intentions, or beliefs, have interactional relevance in the context of real education interactions (Frith and Frith, 2006). In other words, students tend to connect their teacher's display of emotions with their teacher's personality traits, which can further affect other learning outcomes related to interaction. For example, several experimental studies examining the effect of teacher's emotional display on students' judgment of the teachers indicate that teacher's "hot" vs. "cold" display correlated with more positive ratings of the teacher, such as "more sociable" and "more humane" (Widmeyer and Loy, 1988; Mendzheritskaya and Hansen, 2019). Other learning-related outcomes, such as student–teacher relationships, teacher's popularity, and teacher's evaluation can be influenced by the connection of emotional display and perceptions of teacher's personality traits (Dong et al., 2021).

However, whether these existing findings can be generalized to small-group learning in an online environment is a question of interest for further investigation. This is because the forms of emotion displayed in online interactions differ from those in traditional communication (Kreijns et al., 2003). In traditional interaction communication, we often use multiple sources of information, such as facial expressions, vocal expressions, and other behaviors to create perceptions about an interaction partner (Scherer, 2003; Oosterhof and Todorov, 2009). However, the sources of emotional information in online interactions, especially emotional information related to physical cues are not well-presented. Therefore, continued investigation in an online environment is necessary.

In addition, many personality traits can be used to judge another person in social interaction (Judd et al., 2005; Todorov et al., 2005). Fiske et al. have proposed the elemental dimensions underlying person perception, namely competence and warmth (Fiske et al., 2002). They suggested that personal perceptions are subject to evolutionary pressures and people must judge other's intentions (relating to warmth) and ability to act on those intentions (relating to competence) (Fang et al., 2018). Given the increasing evidence that the relationship between emotional displays and perceived warmth is robust, more attention should be given to the relationship between emotional displays and perceived competence (Knutson, 1996; Todorov et al., 2005; Fang et al., 2018). Therefore, the first purpose of this present study was to investigate the question of whether or how different displays of teacher's emotions affect students' perceptions of teacher's competence in the interactions of small-group learning in the context of the online environment.

Teacher's Emotional Display and Students' Feeling of Pleasure, Satisfaction, and Willingness to Continue Collaborating

The relationship between the emotional display of teachers and students' perceptions has been explored within the framework of emotional transmission (Mendzheritskaya and Hansen, 2019). Emotional transmission (synonym for emotional contagion) means that in daily interactive activities, emotions such as happiness, anger, and sadness can be directly or indirectly "transmitted," like an infection, from one person to another in a short time (Zeng and Zhu, 2019). Based on emotional transmission theory, it is hypothesized that teacher's and students' feelings or perceptions are interrelated (Becker et al., 2014). These assumptions were further validated by scientific evidence. Some examples are positive emotional displays of teachers (enjoyment or emotional support) that had a good influence on students' feeling of pleasure and reduced students' boredom and frustration (Frenzel et al., 2009).

Nevertheless, empirical support for the relationship between teacher's emotions and students' feelings or perceptions is still scarce (Becker et al., 2014; AlSagri and Ykhlef, 2016). Some researchers contend that little attention has been paid to emotion transmission among group members, which is more complicated (Zheng et al., 2020). For small-group learning in education, when the teacher joins a small group, he or she is indeed a member of the group. The teacher's display of emotions has an influence on the students' feeling of pleasure, and similarly, this process also happens among other group members. Exploring how the teacher's display of emotions is transmitted in small-group interactions in which the teacher is a member of the group can provide empirical and theoretical insight into the emotional transmission and provide further guidance for collaborative practice.

Furthermore, collaborative satisfaction and willingness to continue collaborating are two crucial variables of perceptions toward collaborative small-group learning. Typically, collaborative satisfaction refers to the level at which students' experiences meet their expectations (Alqarni, 2021). The willingness to continue collaborating refers to the degree of the members' willingness to continue collaborating with this group in the future. Previous studies usually used retrospective data from three aspects to assess the group members' perception of collaborative satisfaction: satisfaction with the collaborative atmosphere, satisfaction with the interactive process, and satisfaction with group results (Gladstein, 1984). The total score of the three aspects representing the members' collaborative satisfaction and the responses on a Likert scale was used to assess the group members' willingness to continue collaborating in the usual practice. As pointed out earlier, students tend to connect their teacher's display of emotions with their personality traits or competence while interacting, which consequently impacts their satisfaction with the interaction in the collaboration, as well as whether to continue collaborating (Krumhuber et al., 2007; Van Kleef et al., 2010; Cheng et al., 2013; Fang et al., 2018). In view of this, the second purpose of this study was to reveal the emotion transmission in small-group members during online discussions. Specifically, we aimed to explore how teacher's display of emotions influences students' feelings of pleasure, collaborative satisfaction, and willingness to continue collaborating during emotion transmission.

Teacher's Emotional Display and Students' Collaboration Behavior

Recent studies show that emotional displays can influence collaboration among members of a small group according to the contextual meaning of the expressions (de Melo et al., 2021). This conclusion is supported by existing studies. For example, van Doorn et al. conducted three vignette studies focusing on the impact of an interaction partner's emotional display on others' sense-making process of collaborative or completive behavior (Van Doorn et al., 2012). The authors found that compared with happiness or disappointment, anger display will make others experience less collaborative behavior and that people are more willing to express collaborative or prosocial behavior (van Doorn et al., 2015).

However, existing studies on the relationship between emotional display and collaboration mainly employ the SoMi Paradigm, in which collaborative behavior was often represented using the proportion of Player A's (i.e., confederate) selection of "unique object" and "not unique object" (Van Kleef et al., 2010; Van Lange et al., 2013; de Melo and Terada, 2020). It should be noted that the collaborative behavior in this paradigm was conceptualized as a collaborative decision based on the cognition of others' psychological state, emotions, and behavioral intention during interpersonal dynamic processes (Kai et al., 2018). There is some distinction between collaborative decisions and real collaborative behavior, especially in the education environment. Given this, we decided to use the simulation-group discussion task to investigate the effects of emotional display on collaborative behavior (participation behavior during discussions) in an online small group. The level of collaboration was evaluated based on the real-group members' behavioral productivity (the number of effective ideas expressed in the simulation discussion process).

Moreover, when a teacher forms a part of a group in a social context of learning interaction, the display of his/her

emotion, either positive or negative, may be regarded as feedback to other group members' actions, thoughts, emotions, needs, attitudes, wills, intentions, etc. (Sarsar, 2017). Many researchers believe that positive teacher's emotional displays are a type of motivational feedback and seem to be conducive to a range of desirable outcomes, including encouraging students to seek to learn more about a specific topic or helping students to remain engaged in the small-group learning process (Kim and Keller, 2007; Sarsar, 2017; de Melo and Terada, 2020). However, there are some exceptions. Results from the study of the negative emotional display indicate that some negative emotions, such as anger display, can have positive effects on students, as it signals high expectations for the students (Butler, 1994; Frenzel et al., 2020). Considering that motivation and teacher's expectations are both important factors affecting students' behavior, the inconsistent conclusions warrant continued empirical attention to the relationship between teacher's emotional display and student outcomes, especially in a collaborative environment. Therefore, the third purpose of this study was to explore the open question of how different emotional displays affect behavioral productivity among group members in small-group learning.

In summary, productive collaborative learning is rarely spontaneous, and the teacher's display of emotions is a powerful educational tool that may enhance various aspects of students in small-group work. However, there is limited research on teacher's display of emotions and its impact on students' outcomes in online education, especially in text-based synchronous online small-group discussions. This study contributes to closing this gap in the literature. Specifically, the following issues were addressed in this study:

1. How do different emotional displays of teachers affect students' perceptions of teacher's competence in interactions during online small-group learning?
2. How do teacher's displays of emotions influence students' feelings of pleasure, satisfaction, and willingness to continue collaborating in a small-group discussion when the teacher is a member of the group?
3. How do teacher's different emotional displays affect students' productivity among group members in small-group discussions?

The Present Study

The present study tested the influence of teacher's display of emotions on students' judgments regarding the teacher's competence, collaborative perceptions (feeling of pleasure during the group task, collaborative satisfaction, willingness to continue collaborating), and productivity in online group interaction. We manipulated the teacher's display of emotions (positive vs. negative vs. neutral) using emoticons from a software platform and recorded behavioral productivity during a creative discussion task (an open-ended realistic problem) in an online small group. Previous studies on the relationship between teacher's display of emotion and students' perceptions in a face-to-face environment were used as a reference (Van Kleef et al., 2010; de Melo and Terada, 2020). Given that the cognitive process of collaboration in online groups is similar to that of face-to-face groups, based on the theories and the results of previous studies discussed, the following hypotheses were developed: H1: Compared with an emotional display, participants experiencing neutral emotional display may rate the levels of teacher's competence higher. H2: Compared with the neutral emotional display condition and the negative condition, participants who experience the teacher's positive emotional display may report higher levels of pleasure, collaborative satisfaction, and stronger willingness to continue collaborating. H3: Compared with neutral emotional display, participants who experience a teacher's emotional display (positive or negative) may present a higher level of behavioral productivity in the group task.

METHODS AND MATERIALS

Participants and Design

Ninety Chinese university students were recruited through voluntary advertising (19 men, age: 21.28 ± 3.51 years). The teacher's emotional display was manipulated, and the participants were randomly assigned to either the positive emotional display condition ($n = 30$), the negative emotional display condition ($n = 30$), or the control condition ($n = 30$). We defined the sample size based on an earlier study that examined the emotional display effect on person perception (Saito et al., 2019). The volunteers were studying a wide range of disciplines in four universities in different cities. Regrettably, 16 participants dropped out of the experiment separately due to the problems of timing, connectivity, or other personal reasons. After deleting missing and invalid data, we obtained usable data from 74 participants: positive display condition ($n = 24$), negative display condition ($n = 24$), and control condition ($n = 26$). Informed consent was obtained from each participant prior to the experiment. Each participant was paid 10 ¥ for participation. The study protocol was approved by the local Academic Committee.

A between-subjects design was used in this study. The participants were randomly assigned to groups of four according to the existing group size research, referring to small-group problem solving (Gu et al., 2020). Although the participants were told that they would perform the task in fours with a teacher, they participated in the experiment collaborating with an experimental assistant who masqueraded as a teacher and all the information of the pretend teacher presented in the group was preprogrammed. The pretend teacher was a 27-year-old male student majoring in psychology, who was responsible for displaying different emotions during the group task. This was done to ensure that the quantity and quality of the information presented by the pretend teachers were comparable for each participant.

Materials

Manipulation of Emotional Display

Common emojis in interactive digital communication were used for the manipulation of teacher's display of emotions. This was done because there was an assumption that using emojis is a possible way to convey emotions in text-based online communication and compensate for the lack of nonverbal communicative cues (Chatzichristos et al., 2020). To select the

appropriate emojis to be used as different emotional display materials, we drew on one of the first and most well-known emoji sentiment lexicons that were created based on the context of 1.6 million tweets (Kralj Novak et al., 2015). More importantly, this type of emoji sentiment lexicon is commonly applied in China's daily communication software. According to the emojis sentiment valance and familiarity, three positive and three negative face emojis were preselected by two research assistants first. Then, 30 volunteers recruited randomly through an advertisement from the university were asked to evaluate the six emojis according to their emotional content using a questionnaire consisting of 12 items rated on a five-point scale. Examples of the items in the questionnaire were: "If a teacher sends an emoji like this, what emotion do you think the teacher is expressing? and "If you receive an emoji like this from a teacher, what emotion will you experience?" (1, very negative; 5, very positive). The first question was set to avoid misunderstanding of the emotional valance of the teacher among the participants, and the second question aimed to ensure that the participants' emotions were aroused by the emotional information.

Table 1 shows the emojis preselected by two research assistants and the mean score and SD reported by 30 Chinese students. The first two columns in **Table 1** show the emojis used and their descriptions. The third column includes the emotion scores of the teachers evaluated by the students when they used an emoji (Q1), while the last column shows the scores of students' emotions aroused by the emoji representing the teacher's emotional display (Q2). According to the data in **Table 1**, the "smiling face with a handclap" and the "sad face with the corners of the mouth turned downward" were chosen as the final experimental materials.

For the positive emotional display, the pretend teacher presented information in the group such as "Please continue expressing your ideas + a positive emoji (smiling face with a handclap)." For the negative emotional display, the pretend teacher presented information in the group such as "Please continue expressing your ideas + a negative emoji (sad face with corners of the mouth turned downward)." For the control condition, the pretend teacher only presented information in the group such as "Please continue expressing your ideas" without any emoji, and this was assessed as the sentence best representing the neutral emotion displayed by the 30 Chinese students.

The emotional display information was provided during the group discussions process 2, 4, 6, and 8 min after the experiment, which was constant among all groups. This was done to ensure that the teacher was involved in the entire process of the group task. Moreover, we decided to present the emotional display information at fixed times after the beginning of the experiment for several reasons. First, it would be difficult for the teacher to determine the moment to display the emotion. Second, it would be difficult for the teacher to evaluate the quality of ideas. Third, to exclude the potential effect of the frequency of emotional display, the emotion was displayed only four times.

Experimental Task

The study was conducted online through a software platform (QQ), which is widely used in educational settings and daily communication in China (Zhang et al., 2021). The users can send messages to other people in a QQ group, and there is an area used to display group membership information or messages posted by their group members. The participants were invited to participate in an online small-group study conducted by the research team. If the participants agreed to enroll in the online group study, a research assistant invited them to join the preset online chat room (QQ group), directing them to the experimental environment.

The instructions for the group task and rules were clarified in the online small group. Specifically, the group task was to discuss the following topic for 10 min: "How to improve college students' dormitory life satisfaction." This is a typical sample of the Realistic Presented Problems (RPP), which was of potential interest to the participants. Each group was required to generate as many novel ideas about the topic as possible, and all the ideas presented in the group were recorded for the next steps in the analysis. In the discussion process, the generation of ideas and feedback to each other often occur simultaneously. Hence, it is reasonable to speculate that the participants might also display emotions toward the feedback, especially if they pretend that the teachers display emotional information that looks like feedback during the group discussion. To avoid this, the participants were encouraged to improve on and combine the ideas generated by their group members but not to evaluate each other's ideas. Based on our observation, the participants did not evaluate each other's ideas. Therefore, in this study, the potential contaminant effect of the display of emotions from the participants was excluded.

Measurements

Basic Information Questionnaire

The basic information questionnaire was divided into two parts. The first part of the questionnaire captured the participants' demographic characteristics including gender, age, and major. The second part was aimed to measure the participants' positive and negative emotions within 2 weeks as the emotional baseline. A Chinese modified version of the Positive and Negative Affect Schedule (PANAS) developed by Watson et al. (1988) was adopted. The scale consists of eight items describing various emotions in terms of four positive (happy, excited, enthusiastic, and inspired) and four negatives (upset, irritable, afraid, and scared) affective descriptors (Dou et al., 2018). In this study, each question was scored on a seven-point Likert-type scale, and Cronbach's alpha reliabilities were all acceptable, 0.73 for positive items and 0.69 for negative items.

Manipulation Check Questionnaire

The participants were asked to respond to two manipulation check questions on a five-point Likert scale regarding the emotional display of the pretend teacher. The valence-arousal space is a typical two-dimensional scale used to characterize emotions (Russell, 1980). The first question asked the participants to estimate the emotional valence of the teacher's emotional display they experienced. The second question asked the participants to estimate the emotional arousal of the teacher's emotional display they experienced by responding to the item, "To what extent were you experiencing the emotion of the teacher during the group task."

TABLE 1 | Emotion scores of the different emojis used in this study.

Emoji	Description	Q1		Q2	
		M	*SD*	*M*	*SD*
	Smiling face with corners of mouth turned up	4.50	0.100	4.58	0.099
	Smiling face with open mouth	4.73	0.089	4.65	0.095
	Smiling face with handclap	**4.81**	0.096	**4.69**	0.108
	Sad face with frown	1.81	0.096	1.96	0.087
	Sad face with corners of mouth turned down	**1.35**	0.110	**1.42**	0.126
	Sad face with tear	1.69	0.133	1.96	0.152

Q1, Teacher's emotion evaluated by the students; Q2, Student's emotion aroused by the emoji. The values of emojis were chosen for the final experimental materials are bolded.

Questionnaire to Assess Participants' Perception of the Teacher

We used the items derived from prior research related to perceptions of competence to measure the participants' perception of the teacher who presented emotional information in the experiment (Fiske et al., 2002). The use of this measurement has previously been reported by Abele et al. (Abele and Wojciszke, 2014). There were 12 key trait words in the items of the scale, of which six were typical competence trait words (e.g., confident, intelligent, and competent). The participants indicated their degree of agreement or disagreement with each item on a five-point Likert scale ranging from 1 (strongly agree) to 5 (strongly disagree). The reliability coefficient (Cronbach's alpha) for the subscale used in this study was 0.95, which indicated satisfactory reliability.

Questionnaire Related to Participants' Feelings in the Collaboration

In this study, the participants' perceptions influenced by different teacher's emotional displays consisted of three parts: the participants' feeling of pleasure, collaborative satisfaction, and willingness to continue collaborating. First, to assess the effect of the teacher's display of emotions on participants' feelings in the collaboration, the participants were asked to recall the group process at the end of the experiment and rate the feeling of pleasure/displeasure they had experienced during the group task (Jones and Ekkekakis, 2019). The feeling of pleasure (displeasure–pleasure) was assessed using the modified Feeling Scale (FS) (Hardy and Rejeski, 1989). The FS is a single-item, five-point Likert-type scale, where 1 denotes "very bad" and 5 denotes "very good." Higher scores represent more positive emotion. Second, the three "collaborative satisfaction" items (slightly modified from previous studies) on a seven-point Likert-type scale were used to measure the participants' collaborative satisfaction (e.g., "I am very satisfied with the collaborative atmosphere/interactive process/group results") (Gladstein, 1984). Cronbach's alpha reliability was 0.95, and the mean score of the three items represented the degree of collaborative satisfaction. Finally, the willingness to continue collaborating was measured using a single item (with the question: To what extent are you willing to continue collaborating with this group in the future?). Response options for this item ranged from very unwilling to very willing on a seven-point Likert scale.

Productivity Measure

The evaluations proposed in online learning environments have been diverse in previous studies. Some studies have used basic behavioral data to reflect the participants' outcomes of online collaboration, such as time spent, the number of visits, or the ideas given by students (Palmer et al., 2008; Hamann et al., 2009). In this study, the number of effective ideas expressed in the group task within a given time by each participant was used as an indicator of the behavioral productivity of the group members. Effective ideas were expressed as ideas directly linked to problem-solving, that is, problem-irrelevant information (i.e., I am not satisfied with the dormitory in our school!) and duplicated ideas (two consecutive similar thoughts in a group) were eliminated. Two coders were trained to assess the number of effective ideas, and disagreements were resolved through discussion.

Procedure

Upon arriving on the QQ software platform, participants were told that they would be grouped with other participants and a teacher who had already been waiting for them online in the QQ group. Then, the experimenter introduced the group task to the group members as previously introduced. To appear real, everyone in the QQ group was asked to make a brief self-introduction. After the instruction section, the group worked on the task for 10 min, while the pretend teacher displayed different emotions during the process. This procedure was repeated under three different emotional display conditions. When the online small-group task was completed, a short self-report questionnaire was presented to each participant to measure the perception of the teacher and their collaboration perceptions. A diagram of the experimental design and procedure is shown in **Figure 1**.

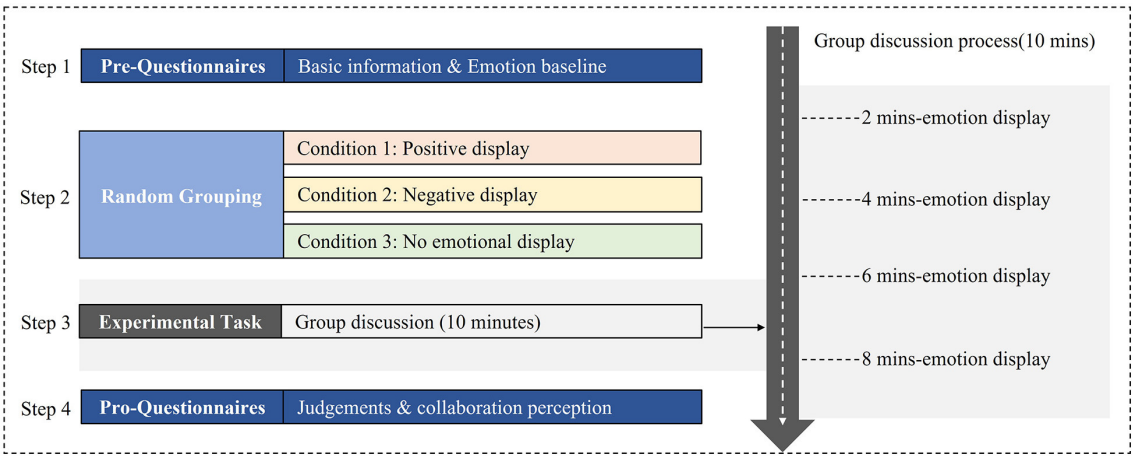

FIGURE 1 | Diagram of experiment design and procedure.

RESULTS

To compare the effect of teacher's emotional display on participants' outcomes in online small-group discussions, we conducted an ANOVA to test differences in judgments, perceptions, and behavioral productivity across the experimental groups under the three conditions. Descriptive statistics (means, *M*, and *SD*) of the participants in the experiment are shown in **Table 2**. Furthermore, linear regressions were conducted to examine the relationship between the judgments toward the teacher, students' collaborative perceptions, and behavioral productivity to further understand how the differences in the teacher's display of emotions influenced group members in the online small-group discussions. The correlation results for each variable are presented in **Table 3**.

Manipulation Check

We analyzed the manipulation of teacher's emotional displays. Univariate ANOVA using different emotional display conditions as the between-subjects factor was performed on participants' perceived teacher's emotional valence and arousal. The results showed a significant main effect of teacher's emotional displays on the teacher's perceived emotional valence [$F_{(2,71)} = 34.62$, $p < 0.001$, $\eta^2 = 0.49$], and no difference in teachers perceived emotional arousal [$F_{(2,71)} = 0.60$, $p > 0.05$, $\eta^2 = 0.02$]. The result confirmed that the manipulation was successful.

Participants' Perception of Teacher's Competence

A one-way ANOVA using different emotional display conditions as the between-subjects factor was performed on the participants' perception of the teacher's competence, and gender and age were added to the ANOVA model as covariates. The results showed that there was a significant main effect of different emotional displays on participants' perception of competence toward the teacher [$F_{(2,71)} = 7.63$, $p < 0.05$, $\eta^2 = 0.18$]. The *post-hoc* test showed that the participants' perception of the teacher's competence under the control condition ($M = 3.76$, $SD = 0.94$) was significantly higher than that under the negative emotional display condition ($M = 2.80$, $SD = 0.95$; $p < 0.01$), and there was no significant difference between the control and positive conditions ($M = 3.48$, $SD = 0.86$; $p > 0.05$). Thus, Hypothesis 1 was supported.

Participants' Feeling of Pleasure, Satisfaction, and Willingness to Continue Collaborating

An ANOVA with different emotional displays as the between-subjects factor was performed on students' feeling of pleasure in the collaboration, and emotional baselines of participants within 2 weeks as well as gender and age were added to the ANOVA model as covariates. As expected, the results showed a significant main effect of different emotional displays on the students' feeling of pleasure [$F_{(2,71)} = 11.66$, $p < 0.001$, $\eta^2 = 0.26$]. The *post-hoc* test showed that the students' feeling of pleasure under the positive emotional display condition ($M = 4.04$, $SD = 0.81$) was significantly higher than under the negative emotional display condition ($M = 3.04$, $SD = 0.69$; $p < 0.001$). There was no significant difference between the positive and control conditions ($M = 3.96$, $SD = 0.99$; $p > 0.05$). Thus, Hypothesis 2 was partially supported.

In addition, the participants' perceptions of collaborative satisfaction were analyzed using a one-way (between-subjects factor: different emotional display) ANOVA. There was a significant main effect of different emotional displays on the participants' perceptions of collaborative satisfaction [$F_{(2,71)} = 10.28$, $p < 0.001$, $\eta^2 = 0.23$]. The *post-hoc* test showed that the perceptions of collaborative satisfaction under the positive emotional display condition ($M = 5.35$, $SD = 1.01$) was significantly higher than under the negative emotional display condition ($M = 4.28$, $SD = 1.30$; $p < 0.001$). There was no significant difference between the positive and control conditions ($M = 5.71$, $SD = 0.99$; $p > 0.05$). To further explore the relationship between collaborative satisfaction and

TABLE 2 | Results of descriptive statistics and univariate ANOVAs on variables.

Dependent	Conditions	*N*	*M*	*SD*	*F*	η^2
Perceptions of teacher's competence	Positive	24	3.48	0.86	7.63*	0.18
	Negative	24	2.80	0.95		
	Neutral	26	3.76	0.94		
Feeling of pleasure	Positive	24	4.04	0.81	11.66**	0.26
	Negative	24	3.04	0.69		
	Neutral	26	3.96	0.99		
Collaborative satisfaction	Positive	24	5.35	1.01	10.28**	0.23
	Negative	24	4.28	1.30		
	Neutral	26	5.71	0.99		
Willingness to continue collaborating	Positive	24	5.63	0.92	4.10*	0.11
	Negative	24	5.00	1.53		
	Neutral	26	5.92	1.10		
Productivity in collaborative task	Positive	24	6.04	2.66	3.35*	0.09
	Negative	24	7.79	3.35		
	Neutral	26	5.65	3.19		

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

TABLE 3 | Correlation results of dependent variables in the experiment.

	Competence	Feeling of pleasure	Collaborative satisfaction	Willingness to continue collaborating	Behavioral productivity
Competence					
Feeling of pleasure	0.681**				
Collaborative satisfaction	0.553**	0.572**			
Willingness to continue collaborating	0.471**	0.675**	0.432**		
Productivity in collaborative task	−0.153	−0.128	−0.109	−0.073	

*$p < 0.01$.

other variables, a linear regression analysis was conducted. Only competence ($\beta = 0.38$, $B = 0.48$, $p = 0.029 < 0.05$, $R^2 = 0.529$) was significant. The results indicated that better perception of teacher's competence predicted higher perceptions of collaborative satisfaction with online small-group discussions.

Moreover, a one-way ANOVA using different emotional displays as the between-subjects factor was performed on the willingness to continue collaborating, and gender and age were added to the ANOVA model as covariates. The results showed a significant main effect of emotional display on willingness to continue collaborating [$F_{(2,71)} = 4.10$, $p < 0.05$, $\eta^2 = 0.11$]. The *post-hoc* test showed that the willingness to continue collaborating under the negative emotional display condition ($M = 5.00$, $SD = 1.53$) was significantly lower than under the control condition ($M = 5.92$, $SD = 1.10$; $p < 0.05$). There was no significant difference between the control and positive conditions ($M = 5.63$, $SD = 0.92$; $p > 0.05$). To further explore the relationship between the willingness to continue collaborating and other variables, a linear regression analysis was conducted. Only the perceptions of collaborative satisfaction ($\beta = 0.62$, $B = 0.63$, $p = 0.000 < 0.01$, $R^2 = 0.478$) were significant. The results indicated that students with higher satisfaction had a stronger willingness to continue collaborating with their group members.

Participants' Productivity in the Small-Group Discussion

A one-way ANOVA using the different emotional displays as the between-subjects factor was performed on the behavioral productivity of participants in the group task. The results showed a significant main effect of emotional display on the participants' collaborative behavioral productivity [$F_{(2,71)} = 3.35$, $p < 0.05$, $\eta^2 = 0.09$]. The *post- hoc* test showed that the behavioral productivity of the participants under the negative emotional display condition ($M = 7.79$, $SD = 3.35$) was significantly higher than under the control condition ($M = 5.65$, $SD = 3.19$; $p < 0.05$). However, there was no significant difference between the control and positive conditions ($M = 6.04$, $SD = 2.66$; $p > 0.05$). The result was contrary to Hypothesis 3 and indicated that those under the negative emotional display condition were more likely to present a higher level of behavioral productivity in the group task.

DISCUSSIONS AND LIMITATIONS

It is well-known that teacher's display of emotions influences various teaching–learning outcomes. However, there is limited research on the role of teacher's emotional display in small-group learning from the perspective of interaction, especially in text-based synchronous online learning environments. This study helps to close this gap in the literature. Thus, practitioners, researchers, and teachers will be provided with useful insights into how teacher's emotional displays influence students' perceptions and behavior productivity. In this study, we provided real-time adaptive emotional display as feedback to emotionally support interaction during small-group discussions. This study aimed to investigate how different teacher's emotional displays affect students' perceptions of the teacher, students' collaboration, and productivity in an online group. The participants were asked to discuss one realistic problem in four-member online groups, with a teacher as a member of each group.

Teacher's Display of Emotions and Students' Perception of the Teacher's Competence

The results regarding the participants' judgment of the teacher's competence revealed that students gave significantly higher scores on the teacher's competence under the neutral emotional display condition. This result confirms the conclusion that the emotion expressed by a teacher indeed affects the students' perception of the teacher's personality (Mendzheritskaya and Hansen, 2019). However, there exist some differences from previous studies on the relationship between specific emotional displays and students' perceptions. According to previous studies, a teacher's negative emotional displays mostly result in a more negative perception of the teacher's personality, and a teacher's positive emotional display is always connected with a more positive perception of the teacher's personality (e.g., more conscientious, more cautious, or more understanding). However, our results showed otherwise. Under the "control condition," when a neutral emotion was displayed by the teacher, students in the online group rated the teacher as being more competent in comparison to their counterparts under emotional display conditions, whether positive display or negative display.

Culture could be the reason for the result that teachers displaying neutral emotion in the group were rated higher in terms of competence (Hansen and Mendzheritskaya, 2017; Mendzheritskaya and Hansen, 2019). According to Markus and Kitayama (1991) theory of culture and self, people from independent cultures (e.g., American culture) tend to value free and open emotional displays. In contrast, those from Eastern cultures (e.g., Chinese culture) tend to value emotional self-control, emotional restraint, and emotional suppression in pursuit of interpersonal harmony (Markus and Kitayama, 1991). For example, a qualitative study of Chinese people found that they suppressed both negative and positive emotions for reasons such as controlling impulse rationally to prevent hurting others, allowing time to process what was going on, or avoiding showing off too much (Chiang, 2012). From the Chinese cultural perspective, emotional suppression may be appropriate for group harmony, and those who display neutral emotion in group activities may be regarded as having a high ability (Wei et al., 2013). Overall, the judgment of personality traits is influenced by culture-specific patterns and personal values within nations (Schmitt et al., 2007; Heine and Buchtel, 2009). The neutral emotional display of the teacher in teaching-learning activities may be more in line with students' expectations of an ideal teacher or a professional teacher in this study.

Teacher's Emotional Display and Students' Feeling of Pleasure, Satisfaction, and Willingness to Continue Collaborating

The results revealed that the students' feeling of pleasure under the positive emotional display condition was significantly higher than under the negative emotional display condition. The results extend the conclusions of previous studies, suggesting that emotional transmission occurs not only in face-to-face traditional communication (Frenzel et al., 2009) but also in online collaborative groups in the context of education. In addition, our results showed that the participants reported higher levels of collaborative satisfaction and stronger willingness to continue collaborating with their group under the neutral emotional display condition than under the other two emotional display conditions. The most likely reason for this result is the influence of students' perception of teacher's personality traits on students' interpersonal interactions. As mentioned above, the teacher's display of emotion influences students' perception of teachers, which is essential for interpersonal interaction in small-group learning. For example, when a person is judged to be dominant and aggressive, he or she is less likely to be chosen as a group member to work on a collaborative project; conversely, when a person is judged to be competent or trustworthy, we are more inclined to seek help from them when we are in trouble or collaborate with them (Krumhuber et al., 2007; Van Kleef et al., 2010; Cheng et al., 2013; Fang et al., 2018). The result of linear regression from this study that better perception of teacher's competence predicted higher perceptions of collaborative satisfaction confirms our reasoning. In short, the results regarding the influence of teacher's display of emotions on students' collaboration perception indicated that students tend to connect their teacher's emotions with their personality, which may consequently impact students' collaborative satisfaction and willingness to continue collaborating in teaching and learning activities (Mendzheritskaya and Hansen, 2019).

Teacher's Display of Emotions and Students' Productivity in the Small-Group Discussion

Moreover, we explored the effect of teacher's display of emotions on students' behavioral productivity in online small-group learning. The results showed that those under the negative emotional display condition showed significantly higher levels of behavioral productivity during the group task followed by students under the positive emotional display condition, and

finally, those under the neutral emotional display condition. Our findings are consistent with previous observations that emotional display or emotional reactions are powerful tools to keep students more motivated, remain engaged in the learning process, and facilitate better collaboration in education (Meyer and Turner, 2006; Maier et al., 2016; Sarsar, 2017). In other words, the teacher's emotional display improved students' levels of motivation, resulting in a high level of behavior productivity. However, it is noteworthy that the level of behavior productivity of students under the negative emotional display condition was significantly higher than that under the positive condition. A possible reason for this result could be that teacher's negative emotional display may result in students' unpleasant feelings, such as anxiety or stress, which is a complex emotional state. Appropriate anxiety is conducive to enhancing the response speed and alertness of the brain, thus improving the task behavioral productivity (Hordacre et al., 2016; Chen and Beck, 2019). In addition, this result that students under the negative emotional display condition generate the most ideas can also be interpreted in the context of the dual-process model of creativity proposed by De Dreu et al. (2008). The model suggests that positive emotional states enhance creativity through flexibility, while negative emotional states can enhance creativity because they stimulate emotional persistence. Namely, the teacher's negative emotional display connects with students' negative emotions, and this connection causes them to engage in more creative activities (generate more ideas and show a higher level of behavior productivity) by improving cognitive persistence.

Overall, the principal finding of this study is that teacher's emotional display influences students' perception of teachers, collaboration perceptions, and behavior productivity in online small-group learning, and researchers and teachers would provide useful insights regarding how to use them. These findings have practical implications. If the goal of the discussion activity is to bring students the experience of pleasure, then the teacher involved in the online small-group learning needs to present his/her positive emotions. If the activity's goal is to improve student participation in the discussion, then only the teacher's negative emotion is shown. Note that, if the teacher's aim is to establish well-functioning relationships among the group members, then the neutral emotional display is better for the teacher's competence evaluation, collaborative satisfaction, and willingness to continue collaborating in the Chinese cultural context.

LIMITATIONS

The present study has several limitations. First, the participants in the online group were unfamiliar with their group members prior to the experiment, which might not coincide with reality. In a real educational setting, students in a small-learning group are supposed to be acquainted with their teacher and group members. Therefore, the possible effects of familiarity on the relationship between teacher's emotional displays and students' perceptions and behavioral productivity should be further tested. Second, although the sample size was similar to other studies that examined the emotional display effect on person perception (Saito et al., 2019), a larger sample would help to better understand the effect of teacher's emotional display on the students' outcomes at the group level and better understand the possible interference of other variables (such as individual differences), thus achieving larger effect sizes. In addition, previous studies have shown that gender composition can influence group collaborative behavior (Liu et al., 2017). In this study, the number of male participants was very small. More male participants will need to be recruited to constitute more groups in terms of different gender compositions. In addition, the participants in this study were recruited from a wide range of disciplines; in other words, the students' different academic backgrounds and experiences might also have an impact on synthesis findings. Thus, some meaningful extensions can be made in the future to focus more on the discipline's students' characteristics and their impact on the outcomes related to the teacher's emotional display. Finally, presenting the emotional display information at fixed times irrespective of the actual ideas being raised at that time might lead to confusion (e.g., a positive emotional display to poor ideas and negative emotional display to good ideas). While the rationale for doing so was given in the text as mentioned before, a more appropriate way to present emotional display information should be adopted in future studies so that the potential effect of feelings of confusion could be ruled out.

CONCLUSIONS

By exploring how the display of teacher's emotions affects students' outcomes in online small-group discussions, the current study provides crucial findings for future studies and an understanding of the relationship between different teacher's emotional display and students' perception of the teacher's competence, students' collaborative perceptions, and behavior productivity in online small-group discussions. Using an empirical method, this study found that students who received a positive emotional display experienced a higher level of pleasure during the task. Notably, students who received the teacher's negative emotions showed a significantly higher level of behavioral productivity in the group task. In addition, the levels of students' judgment of the teacher's competence, as well as collaborative satisfaction and willingness to continue collaborating, were higher when they received neutral emotional display. Thus, the study offers some practical implications on whether teachers should display their emotions in a small-group discussion or how they display emotions according to the aim of the teaching activities.

DATA AVAILABILITY STATEMENT

All data included in this study are available upon request by contact with the first author XC (cxuejiaohappy@foxmail.com).

ETHICS STATEMENT

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

AUTHOR CONTRIBUTIONS

XC, HX, and JH contributed to the conception and design of the study. GB and ZL coordinated the data collection. HX performed the statistical analysis and XC wrote the first draft of the manuscript. All the authors contributed to manuscript revision and approved the submitted version.

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Emotional Intelligence, Emotional Regulation Strategies, and Subjective Well-Being Among University Teachers: A Moderated Mediation Analysis

*Jingrong Sha[1,2], Tianqi Tang[1], Hong Shu[1], Kejian He[3] and Sha Shen[1]**

[1] College of Educational Science and Technology, Northwest Minzu University, Lanzhou, China, [2] Key Laboratory of China's Ethnic Languages and Information Technology of Ministry of Education, Northwest Minzu University, Lanzhou, China, [3] Faculty of Law and Public Administration, College of Science and Technology, Guizhou University, Guiyang, China

This study aimed to explore the mediating role of emotional regulation strategies in the relationship between emotional intelligence (EI) and subjective well-being (SWB) among Chinese university teachers, and evaluate whether effort-reward imbalance moderated the mediating effect of emotional regulation strategies. A total of 308 Chinese university teachers were recruited for this study. The results showed that emotional regulation strategies played a partial mediating role in the relationship between EI and SWB. Moreover, an effort-reward imbalance moderated the relationship between emotional regulation strategies and SWB. For individuals with more balanced perceptions, EI had a significant effect on SWB *via* cognitive reappraisal, while for individuals with more imbalanced perceptions, EI did not have a significant effect on SWB *via* cognitive reappraisal. These findings provide a better understanding of the effects of EI and emotional regulation strategies on SWB, which could provide interventions for promoting SWB among teachers.

Keywords: emotional intelligence, emotional regulation strategies, subjective well-being, university teachers, effort-reward imbalance

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****Correspondence:***
Sha Shen
yilushen0104@163.com

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INTRODUCTION

Teachers at universities experience high levels of stress and job burnout owing to the challenging nature of their work (Teles et al., 2020), thus they have a significantly lower level of subjective well-being (SWB) than other professionals (Grenville-Cleave and Boniwell, 2012). SWB is regarded as "evaluation of life satisfaction and positive and negative affective reactions to one's life" (Busseri and Sadava, 2011; Chan, 2013), which is believed to play an important role in physical and mental health (Pressman and Cohen, 2005; Tsaousis et al., 2007). Many studies have shown that SWB is important for teachers. It is not only associated with their professional performance (Rahm and Heise, 2019) and mental health (Xin et al., 2021), but also influences students' cognitive outcomes (Pietarinen et al., 2014; Hung et al., 2016) and well-being (Xin et al., 2021).

Considering the importance of SWB, a great deal of research attention has been devoted to this field, with particular attention to identifying the factors and mechanisms that affect it (Koydemir and Schütz, 2012). Teachers can be regarded as emotional workers who need to be sensitive to their jobs (Yin, 2015), and there is no doubt that emotional intelligence (EI) is an

important factor that influences SWB. EI is defined as the ability to evaluate and express emotions, regulate emotions, and use emotional content in thinking and action (Mayer and Salovey, 1993). Previous studies have shown that one of the most reliable correlates of EI is SWB (Sánchez-Álvarez et al., 2016) and EI has been confirmed to be a strong predictor of SWB (Vergara et al., 2015; Lin et al., 2016). For example, Sánchez-Álvarez et al. (2016) conducted a meta-analysis of 25 studies with 8,520 participants, and the results showed that EI was positively correlated with SWB. Huang et al. (2018) used a structural equation model to conduct an empirical test on the survey data of 412 university students from two universities in South China and found that people with higher EI reported higher levels of SWB. In addition, studies have found that the improvement of teachers' EI can enhance their SWB (Vesely et al., 2013).

Although previous studies have indicated that EI is closely related to SWB, the relationship between EI and teachers' SWB is inconsistent (Lee et al., 2019). For example, Hassan (2019) explored the relationships between EI and SWB among university teachers and found a positive correlation between EI and SWB. However, some studies have found that EI has little influence on SWB. For example, Zeidner and Olnick-Shemesh (2010) found that EI had limitations in predicting SWB.

A possible explanation is that the relationship between EI and teachers' SWB is mediated or moderated by other factors. For example, previous studies have indicated that the relationships between EI and SWB may be influenced by emotion regulation strategies. Emotional regulation strategies include cognitive reappraisal and suppression of expression (Gross and John, 1998). Cognitive reappraisal is a form of cognitive change that involves construing a potentially emotion-eliciting situation in a way that changes its emotional impact (Lazarus and Alfert, 1964). Expressive suppression is a form of response regulation modulation that involves the suppression of persistent emotional expression behavior (Gross and John, 1998). Previous studies have shown a significant relationship between EI and emotional regulation strategies. For example, Quintana-Orts et al. (2020) confirmed there is a positive association between EI and emotion regulation strategies. Specifically, people with higher EI are more likely to choose effective emotional regulation strategies (Śmieja-Nęcka et al., 2011). In addition, studies have shown a significant relationship between emotion regulation strategies and SWB. For instance, Katana et al. (2019) discussed the influences of emotion regulation strategies on SWB, and the results showed that cognitive reappraisal aimed at increasing positive emotions was positively associated with higher SWB; suppression of positive emotion expression was negatively correlated with SWB. Therefore, do emotion regulation strategies mediate the relationships between EI and SWB among university teachers?

In addition, the relationship between EI, emotion regulation strategies, and SWB may be moderated by an effort-reward imbalance. Effort-reward imbalance is a source of work-related stress (Siegrist, 2010). According to affective events theory (Weiss and Cropanzano, 1996), the emotional experience accumulated in the work environment, together with other factors (including personality), shapes employees' work attitudes. In addition, affective event theory (Weiss and Cropanzano, 1996) proposed that the emotional state at work is a key carrier of the influence of personality and organization on job satisfaction and performance. Previous studies indicated that individuals with more positive affects at work are more likely to have higher EI (Lopes et al., 2006; Kafetsios and Zampetakis, 2008) and are prone to use more positive emotion regulation (Mérida-López and Extremera, 2017). Thus, effort-reward imbalance may be a potential moderator for the mediating effect of emotion regulation strategies between EI and SWB.

Based on previous studies and related literature, this study aimed to investigate the mediating role of emotional regulation strategies between EI and SWB and explored whether effort-reward imbalance moderated the mediating effect of emotional regulation strategies between EI and SWB among Chinese university teachers. Our hypotheses were as follows: (1) EI and emotional regulation strategies had positive effects on SWB; (2) emotional regulation strategies played a mediating role in the relationship between EI and SWB; and (3) effort-reward imbalance moderated the mediating effect of emotional regulation strategies between EI and SWB.

MATERIALS AND METHODS

Participants

We distributed 350 questionnaires to three universities in western China. The teachers ranged in age from 23 to 58 years, with a mean age of 38.4 (SD = 9.97). After excluding incomplete questionnaires, 308 participants' responses were used in this study. After completing the questionnaire, all participants received a gift as a reward. Please see **Table 1**.

Emotion Regulation Questionnaire

This study used an emotion regulation questionnaire (ERQ) based on the two-stage emotional regulation process model proposed by Gross (2003). A total of 10 items were divided into two dimensions: cognitive reappraisal (six items) and expression suppression (four items). Each item was answered on a seven-point scale (1 = very inconsistent, 7 = very consistent). In this study, the Cronbach's alpha coefficient of the cognitive reappraisal score was 0.85, and the Cronbach's alpha coefficient of the expression suppression score was 0.68.

TABLE 1 | Socio-demographic characteristics of the participants (n = 308).

		Groups	Frequency (%)
Gender	Female	142	46.1%
	Male	166	53.9%
Age	≤35	170	55.2%
	36–50	106	34.5%
	≥50	32	10.3%
Family background	Rural	55	17.9%
	Towns	253	82.1%
Only-child	Yes	132	42.9%
	No	176	57.1%

Emotional Intelligence Scale

Emotional intelligence was measured using the Emotional Intelligence Scale (EIS) developed by Law et al. (2004). It contains 16 items, each item is answered on a seven-point scale (1 = strongly disagree, 5 = strongly agree), and the total sum score based on the 16 items varies between 16 and 112. The higher the score that participants receive, the higher their EI. The Cronbach's alpha coefficient in this study was 0.94.

Effort-Reward Imbalance Questionnaire for Teachers

This study adopted the EFR questionnaire developed by Ren et al. (2019), which consists of two components (effort and reward). Effort contains 14 items, and the reward contains 14 items. Each item was answered on a five-point scale (1 = strongly disagree, 5 = strongly agree). According to Siegrist et al. (2004), the effort-reward ratio was computed for every respondent according to the formula e/(r × c) where "e" is the sum score of the effort scale, "r" is the sum score of the reward scale and "c" defines a correction factor for different numbers of items in the nominator and denominator, and the correlation factor of this study's questionnaire is 1 (14/14). The higher the ratio score participants get, the greater the imbalanced participants have, and the lower the ratio score participants get, the more balance participants have. The Cronbach's alpha coefficient of effort and reward in this study was 0.94 and 0.92, respectively.

Subjective Well-Being Scale

The study used the Chinese version of the SWB Scale (Duan, 1996), which consists of 18 items. Each item was answered on a five-point scale (1 = strongly disagree, 5 = strongly agree). The higher the total score, the more subjective the well-being of the participants. Cronbach's alpha coefficient in this study was 0.85.

Procedure

Data were collected using online questionnaires. First, we contacted the dean of academic affairs of the university, stated the purpose of the study, and received approval. Teachers were then invited to complete the questionnaire independently on weekdays.

Ethics

This study was approved by the Northwest Ethics Committee. Before participating in this study, all participants provided written informed consent to participate in the study.

Analytical Strategy

SPSS software (version 25.0) was used for data analysis. We first established the relationships among EI, effort-reward imbalance, emotional regulation strategies (cognitive reappraisal and expressive suppression), and SWB. Then, we used the SPSS macro PROCESS program to evaluate the mediating effect of emotional regulation strategies on EI and SWB and the moderating effect of effort-reward imbalance.

RESULTS

Correlation Analysis of Emotional Intelligence, Emotional Regulation Strategies, Effort-Reward Imbalance, and Subjective Well-Being

Pair correlation tests were conducted for each variable first, and the correlation coefficients among EI, emotional regulation strategies, effort-reward imbalance, and SWB are shown in **Table 2**.

The Relationships Between Emotional Intelligence, Emotional Regulation Strategies, and Subjective Well-Being

To analyze the influence of EI on SWB and the role of emotional regulation strategies, the SPSS macro PROCESS program was used to evaluate the mediating effect. Two regression equations were used to evaluate the following: first, the direct effect of EI on SWB; second, the mediating effects of cognitive reappraisal and expressive suppression between EI and SWB. The regression analysis results are listed in **Table 3**. The results showed that EI significantly predicted SWB (β = 0.39, t = 7.59, p = 0.000), cognitive reappraisal (β = 0.34, t = 6.37, p = 0.000), and expression suppression (β = −0.26, t = −4.65, p = 0.000). Also cognitive reappraisal significantly predicted SWB (β = 0.25, t = 4.63, p = 0.000), but expression suppression did not significantly predict SWB (β = −0.10, t = −1.93, p = 0.05). As shown in **Figure 1**, there was a mediating effect of cognitive reappraisal on the effect of EI on SWB.

Bias correction non-parametric percentage Bootstrap was further used to test the mediating effect, and the results are shown in **Table 4**. The direct effect value of EI on SWB was 0.17,

TABLE 2 | Statistical results of correlation analysis of main variables (n = =308).

Variable	*M* (SD)	1	2	3	4	5
EI	62.88(14.41)	1	0.34**	−0.26**	−0.16**	0.40**
Cognitive reappraisal	34.01(6.27)		1	0.05	0.01	0.35**
Expressive suppression	16.15(5.79)			1	0.10	−0.17**
Effort-reward imbalance	1.16(0.60)				1	−0.20**
SWB	78.47(9.01)					1

***p < <0.01.*

TABLE 3 | Mediation effect model test (n = 308).

Variable	Model 1			Model 2		
	SWB			SWB		
	Effect of value	SE	*t*	Effect of value	SE	*t*
EI	0.39	0.03	7.59***	0.29	0.04	5.06***
Cognitive reappraisal				0.25	0.08	4.63***
Expression suppression				−0.10	0.08	−1.93
R^2	0.15			0.22		
F	57.72**			28.26***		

***p < 0.01; ***p < 0.001.*

TABLE 4 | Bootstrap analysis of significance test of mediation effect (n = 308).

The path	Effect of value	Effect of the amount	Bootstrap 95% confidence interval down line	Bootstrap 95% confidence interval upper line
Direct effect (A→C)	0.17	85.71%	0.10	0.24
Indirect effect (A→B→C)	0.07	14.29%	0.02	0.13
Total effect	0.24	100%	0.18	0.31

A, EI; B, Cognitive Reappraisal; C, SWB.

accounting for 70.83% of the total effect, and the 95% interval was (0.10, 0.24), indicating that the direct effect was significant. The indirect effect value of cognitive reappraisal on EI and SWB was 0.07, accounting for 29.17% of the total effect, with a 95% interval of (0.02, 0.13), indicating a significant mediating effect.

The Moderated Mediation Analysis of Effort-Reward Imbalance

Table 5 shows the results of the moderated mediation analysis of effort-reward imbalance. In Model 59 (**Table 5**), the interaction term between EI and effort-reward imbalance was not significantly associated with cognitive reappraisal (β = −0.06, p = 0.06) and SWB (β = 0.07, p = 0.16), indicating that effort-reward imbalance did not moderate the relationship between EI and cognitive reappraisal, as well as the relationship between EI and health SWB. Moreover, the interaction term between cognitive reappraisal and effort-reward imbalance was significantly related to SWB (β = −0.35, p = 0.01), which showed that the effort-reward imbalance moderated the relationship between cognitive reappraisal and SWB.

To further examine the moderation mediation effect, we conducted Model 14 (**Table 5**).

The interaction term between cognitive reappraisal and effort-reward imbalance was significantly associated with SWB (β = −0.28, p = 0.04), as shown in **Figure 2**, the effort-reward imbalance moderated the effect of cognitive reappraisal on SWB. The index of moderated mediation was significant (β = −0.04, 95% CI = −0.083, −0.005). For individuals with more balanced perceptions, EI had a significant effect on SWB *via* cognitive reappraisal (β = 0.07, 95% CI = 0.039, 0.117). As for individuals with more imbalanced perceptions, EI had no significant effect on SWB *via* cognitive reappraisal (β = 0.02, 95% CI = −0.013, 0.065).

TABLE 5 | Results of the moderated mediation analysis.

Independent variables	Model 59		Model 14	
	Subjective well-being		Subjective well-being	
	Coefficient	t	Coefficient	t
Emotional intelligence	0.17	5.18***	0.17	5.16***
Cognitive reappraisal	0.33	4.25***	0.32	4.19***
Effort-reward imbalance	−2.33	−3.08**	−2.22	−2.95**
Emotional intelligence × effort-reward imbalance	0.07	1.40		
Cognitive reappraisal × effort-reward imbalance	−0.34	−2.44*	−0.27	−2.08*
R^2	0.24		0.24	
F	19.80***		24.18***	

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

DISCUSSION

This study evaluated the relationships between EI, emotional regulation strategies, effort-reward imbalance, and SWB among Chinese university teachers. The results showed that EI and emotional regulation strategies were significant predictors of SWB. In addition, this study also revealed that EI affects SWB through emotional regulation strategies. Moreover, an effort-reward imbalance moderated the relationship between emotional regulation strategies and SWB.

The results of this study show that EI positively predicted SWB, which was consistent with previous studies (e.g., Sánchez-Álvarez et al., 2016; Szczygieł and Mikolajczak, 2017). According to EI theory, as individuals with high EI are good at understanding and managing their emotions, they are more likely to cope better with the stresses and troubles of daily life (Zeidner et al., 2012). In addition, people with high EI are more likely to have good interpersonal relationships and prosocial behavior (Wood et al., 2007). Therefore, people with high EI are prone to have a higher level of SWB (Zeidner et al., 2009).

In addition, the results of this study indicate that emotional regulation strategies play a mediating role in the relationship between EI and SWB. Specifically, this study indicated that only cognitive reappraisal mediated the relationship between EI and SWB among Chinese university teachers. Previous studies have suggested that cognitive reappraisal and expression suppression are different aspects and have different neural mechanisms (Gross and John, 2003). Cognitive reappraisal exhibits preferential regulatory advantage, which occurs at an early stage of emotion generation. Therefore, the expression of emotion can change before the emotional response is fully generated (Schutte et al., 2009). In addition, instead of avoiding affective states, cognitive reappraisal deals with emotions by living with negative emotions. Specifically, in an embarrassing situation, they do their best to alter the circumstances and change the emotional consequences of the situation (Schutte et al., 2009). Moreover, studies have shown that cognitive reassessment not only reduces negative emotions and behavioral expression, but also requires relatively few cognitive resources, which can be used effectively in the social environment (Gross, 1999; Richards and Gross, 2000; John and Gross, 2004; Gross et al., 2006). Therefore, cognitive reevaluation,

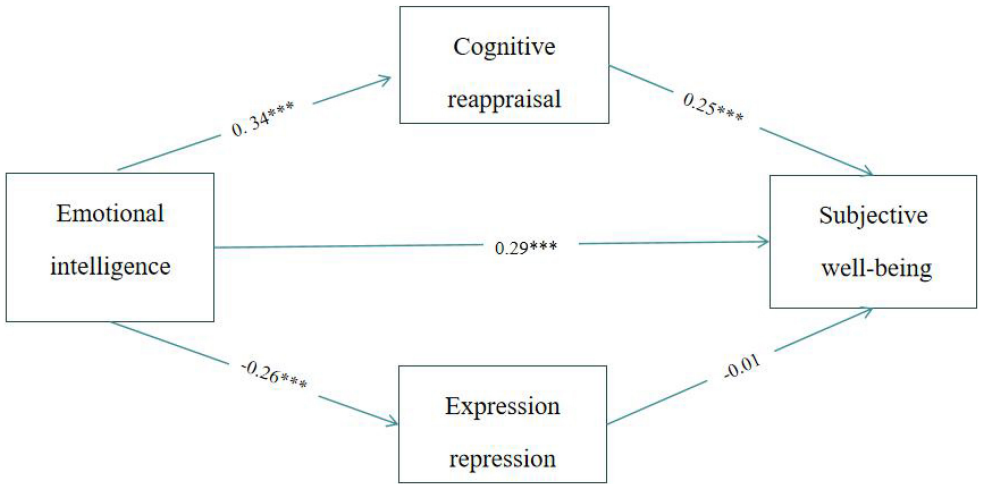

FIGURE 1 | The relationship models of EI, emotional regulation strategies, and SWB. ***$p < 0.001$.

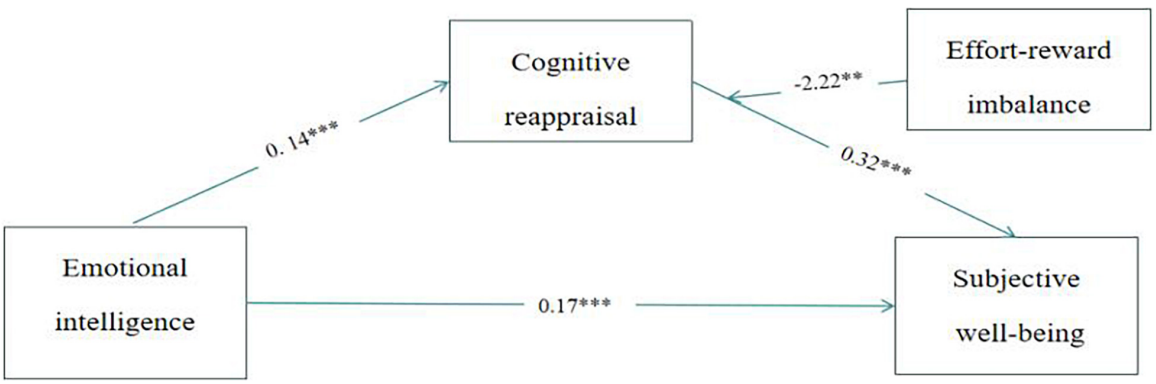

FIGURE 2 | The moderation mediate effect. **$p < 0.01$; ***$p < 0.001$.

as a healthy emotion regulation strategy, can better promote an individual's SWB (Haga et al., 2009).

More importantly, the study found that effort-reward imbalance moderated the relationship between emotional regulation strategies and SWB. For individuals with more balanced perceptions, EI had a significant effect on SWB *via* cognitive reappraisal, while for individuals with more imbalanced perceptions, EI had no significant effect on SWB *via* cognitive reappraisal. These results are in line with previous theories and studies. Affective events theory and affective event theory all proposed that the emotional experience accumulated in the work environment shapes employees' work attitudes. In addition, previous studies have shown that work affects are associated with EI and emotion regulation. More importantly, the results indicate that, compared with negative affect, the positive affect is stronger. This is an important finding that supports the growing evidence that positive affect takes precedence over negative affect as a predictor of work outcomes (Thoresen et al., 2003). As a source of human power (Isen, 2003) and positive affect promote the construction of personal and social resources (Fredrickson, 2001; Lyubomirsky et al., 2005). Therefore, the individuals with higher EI are more likely to adopt positive emotion regulation strategies which follow these "broadening and build" strategies, leading to higher a level of SWB.

This study had some limitations. First, the study used a cross-sectional design, which made it difficult to explore causal interpretations of these variables. A longitudinal study design is required in the future. Second, participants were recruited from the western cities of China, which may limit the generalization of the findings. Compared with the eastern coastal cities, the economy of northwest China is relatively backward, and previous studies have indicated that the economic level is closely related to SWB (Ngamaba et al., 2018; Ding et al., 2021) and EI (Shukla and Srivastava, 2016; Karapetyan, 2021). Future studies should expand the city of the participants.

These results provide a better understanding of the relationship between EI, emotional regulation strategies, and SWB, and expand the reports of potential causes of teachers' SWB from other studies. In addition, the present study has important theoretical significance for developing the theory of SWB, which expands the study of potential factors of university teachers' SWB and uncovers the mechanisms between EI and SWB. Although many studies have explored the relationships between EI and

SWB and tried to explore the potential mechanism between them, only a few studies have investigated the role of emotional regulation strategies. Thus, whether emotional regulation strategies mediate the relationship between EI and SWB remains unclear. This study provides evidence of the mediating role of emotional regulation strategies. More importantly, the study provides evidence for developing interventions to improve teachers' SWB. For example, educational institutions and government departments can improve teachers' intelligence through a series of activities, such as group psychological counseling and mental health lectures. In addition, for teachers with low EI, cognitive therapy can be used to improve their emotional regulation strategies to enhance SWB.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

This study was reviewed and approved by Ethics Committee of the College of Educational Science and Technology of Northwest Minzu University. Written informed consent was obtained from all participants for their participation in this study.

AUTHOR CONTRIBUTIONS

JS proposed the initial idea. TT and HS conducted the research, collected, and analyzed the data. SS has made significant contributions by redesigning and modifying the framework of the present study. All authors participated in writing the manuscript and approved the submitted version.

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To Be Expressive or Not: The Role of Teachers' Emotions in Students' Learning

*Yang Wang**

School of Educational Science, Nanjing Normal University, Nanjing, China

Understanding the role of teachers' facial expressions in students' learning is helpful to improve online teaching. Therefore, this study explored the effects of teacher's facial expressions on students' learning through analyzing three groups of video lectures. Participants were 78 students enrolled in three groups: one with an enhanced-expression teacher, one with a conventional-expression teacher, and one with the teacher's audio only. ANOVA was used to explore whether video lectures instructed by the enhanced-expression teacher were better than those instructed by the conventional-expression teacher and the audio-only teacher for facilitating students' learning, and what is the role of the teacher's emotions in students' perceived social presence, arousal level, cognitive load, and learning. The results showed that the video lecture by the enhanced-expression teacher was better than those with the conventional-expression teacher and with the audio-only for facilitating students' social presence, arousal level, and long-term learning. Interestingly, it was found that the teacher's emotions could relieve students' cognitive load. These results explained the inconsistency of existing studies by exploring the mechanism of teachers' emotions in students' learning. It also provides teachers with practical guidance for video lecture design.

Keywords: teacher's emotions, students' learning, enhanced-expression, social presence, arousal level, cognitive load

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Kun Yu,
University of Technology Sydney, Australia

***Correspondence:**
Yang Wang
wangyang@nnu.edu.cn
orcid.org/0000-0002-4125-9436

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INTRODUCTION

Video lectures are effective for delivering knowledge and have attracted much attention from practitioners and researchers. During the COVID-19 epidemic, video lecture-based learning has made it possible for students to learn at home without face-to-face interaction, avoiding the risk of virus transmission. However, how to minimize students' negative emotions, such as isolation, anxiety, and loneliness during online learning is one of the biggest challenges faced by teachers and researchers (Zembylas et al., 2008; Reupert et al., 2009; Regan et al., 2012; Xing et al., 2019). Studies support that teachers' emotions play a key role in students' learning. For example, Zembylas et al. (2008) found that teachers' emotional support is essential to relieve students' negative emotions. Reupert et al. (2009) examined the importance of teachers' presence and emotions for students' online learning. Fanselow (2018) found that teachers' emotions are associated with students' attention, memory, and motivation. Wang et al. (2019) supported that teachers' emotions had a positive effect on students' satisfaction and learning. Additionally, students' emotions depend heavily on the teacher's teaching design (Frenzel et al., 2018;

Mainhard et al., 2018). It is how teaching behaviors are interpreted by students that determines students' learning rather than the learning materials themselves (Marsh and Bailey, 1993). The Emotional Response Theory also supports that the connection between teacher communication and students' learning is regulated by the students' responses to the teacher's emotions (Mottet et al., 2006).

Although it is supported that teachers' emotions are essential to students' learning, teachers have not realized the role of their emotions in students' learning in video lectures. Some teachers tend to demonstrate relatively enhanced emotions, while others prefer to be conventional. Some teachers even feel that their expressions should be serious, as education itself is a serious matter (Wang et al., 2019). Hence, an understanding of the role of teachers' emotions in students' learning can provide teachers with practical guidance as to how to behave in video lectures.

The role of emotions in education has recently attracted researchers' attention, and it is now widely accepted that teachers' emotions are essential to students' learning. For example, Neill (1989) found that the teacher's emotions facilitated students' learning interest and performance. Similarly, Theonas et al. (2008) supported the belief that teachers' emotions expressed through facial expressions would improve students' learning. Wang et al. (2019) analyzed the role of teachers' facial expressions in students' learning and found that teachers' expressions improved students' learning. Keller and Becker (2020) explored the role of teachers' emotions in students' responses and found that teachers' emotions were related to students' emotions. Although studies support that teachers' emotions are essential to students' learning, there are still some studies which have found that the presence of the teacher had no significant effects on students' learning (Homer et al., 2008; Kizilcec et al., 2014). That is, the effects of teachers' presence and emotions on students' learning are still to be further explored. Exploring the role of teachers' presence and emotions in students' perceived social presence, emotions, cognitive load, and learning can improve our understanding of the internal mechanism of teachers' emotions in students' learning. It would also be helpful for effective video lecture design.

LITERATURE REVIEW

Emotions

Emotions are involved in every aspect of our lives, and they are key elements in education (Lacave et al., 2020). Emotion itself is difficult to define. It is an experience of a subject's attitude toward an object mediated by the central nervous system (Kleinginna and Kleinginna, 1981). Scherer (2009) proposed that emotions can be defined as cognitive, motivational, and physiological processes. They influence the way people think, behave, and process social information (Forgas and Eich, 2012). Despite the complex structure of emotions, currently emotions are often divided into two categories: positive and negative emotions (Watson et al., 1988). Positive emotions are often associated with optimism, happiness, and confidence, while negative emotions are associated with isolation, anxiety, and tension. It is supported that positive emotions are often associated with a better competence to pick relevant from irrelevant information, resulting in better performance in cognitive skills (Moridis and Economides, 2009). On the other hand, negative emotions are often associated with information analysis and judgment making (Isen et al., 1985). It is also supported that students' emotions affect their attention, cognition, and social behaviors (Isen et al., 1987; Chen and Sun, 2012). Lacave et al. (2020) also found that students' emotions are essential to their learning. Although emotions are essential to students' cognitive process, the internal mechanism of teachers' emotions in students' learning is still to be further explored. Kizilcec et al. (2015) supported that most students favor lectures with the teacher's presence, while some studies have proposed that teachers' emotions harmed students' learning (Homer et al., 2008). That is, there is no consensus on the role of teachers' emotions in students' learning. Hence, exploring the role of teachers' emotions in students' perceived social presence, arousal level, cognitive load, and learning can further explain the mechanism of emotions in students' learning. It is proposed that facial expressions can reflect a person's emotions in a natural state (Ekman et al., 1978; Keller and Becker, 2020). Thus, teachers' and students' emotions were analyzed through facial expressions in this study.

The Role of Teacher's Emotions in Students' Perceived Social Presence, Emotions, Cognitive Load, and Learning

Although teachers' emotions are essential to students' learning (Wang et al., 2019), the specific role of teachers' emotions in students' perceived social presence, arousal level, cognitive load, and learning have yet to be explored.

The Role of Teachers' Emotions in Students' Perceived Social Presence

Social presence refers to the extent to which a student is perceived as a "real person" in communications supported by media (Gunawardena, 1995). It is the extent to which a student authentically engages in learning interaction with others to reduce the distance between them. Social presence is determinant of students' online learning assessment (Edwards, 2021). Affective expressions, open communication, and group collaboration are the three factors that determine students' social presence. The affective expressions represent the extent to which participants share their personal details and emotions. Open communication refers to the extent to which group members trust in group communication and share ideas freely. Group coherence refers to the extent to which group members communicate frequently and effectively, and their readiness to influence and be influenced by others (Byrne, 2021). The perceived social presence determines students' perceived distance during online learning. Additionally, this perceived distance between students and teachers in the online environment is a considerable challenge for online learning (Barratt and Duran, 2021). The community of inquiry theory supports that teachers' expressions have effects on students' perceived presence and

online learning (Borup et al., 2012). The emotion expressed by the teacher's expressions in lectures could shorten this distance (Wang et al., 2019). However, Homer et al. (2008) found no significant differences between the social presence of students who learned in the video or no-video conditions. Thus, exploring the role of teachers' emotions in students' perceived social presence would be valuable for improving our understanding of online teaching.

The Role of Teachers' Emotions in Students' Arousal Level

Arousal level is a person's physiological and psychological awakening state. It is a measure of a person's perceived energy level, ranging from low (calming) to high (exciting). Arousal has been examined to be associated with cognition, psychology, and learning (Bjalkebring et al., 2015; Hoogerheide et al., 2019). Hence, exploring the effects of a teacher's emotions expressed by facial expressions could improve our understanding of the effects of teachers' emotions on students' learning in video lectures. Arousal levels can be assessed through the change of facial action units (Senechal et al., 2012). A two-dimensional space constructed by Ressel (1980) determined emotions according to two aspects: arousal (inactive-active) and valence (unpleasant-pleasant). The results were validated with facial expression stimuli (Calbi et al., 2017; Schneider et al., 2020).

Teachers' emotions have been shown to be associated with students' attention, memory, and motivation (Fanselow, 2018). It has even been found that emotions demonstrate stronger predictive power for students' learning performance than motivation and cognition (Ruiz et al., 2016; Iskrenovic-Momcilovic, 2018). Robinson (2013) found that teachers' emotions had a positive effect on students' satisfaction and learning. Pekrun (2014) also found that students' perceived emotions during computer-supported learning were essential to their learning performance. Furthermore, students' emotions greatly depend on the teacher's emotions (Frenzel et al., 2018; Mainhard et al., 2018). Although it is supported that teachers' emotions determine students' learning, the role of teachers' emotions in students' arousal level needs to be explored to explain the role of teachers' emotions in students' video-lecture-based learning.

The Role of Teacher's Emotions in Students' Cognitive Load

Intrinsic and extraneous load are two essential aspects of cognitive load (Sweller et al., 2019). Intrinsic cognitive load stems from the difficulty of the learning content, while extraneous cognitive load is generated from the poor design of the learning materials. Since a learner's cognitive resources in the information processing system are limited, Mayer and Moreno (2003) proposed that the cognitive load from the learning media is the biggest challenge of multimedia-supported education. Homer et al. (2008) proposed that, compared with students in the group without the teacher's video, those in the group with the teacher's video experienced a relatively higher cognitive load. Students may feel relaxed when teachers demonstrate positive emotions, while they may feel frustrated when the teacher seems negative. Students may have difficulty when they struggle to understand the teacher's emotions and the reasons behind those emotions (Schutz and DeCuir, 2002). That is, the teacher's emotions may improve students' cognitive load. However, Kizilcec et al. (2015) reported that most students tend to learn from lectures with the teacher's presence, and supported that the teacher's presence was essential to students' video-lecture learning. Wang et al. (2019) also supported that teachers' emotions have effects on students' learning and satisfaction. That is, the role of teachers' emotions in students' cognitive load is still to be further explored as exploring the role is essential to explain the mechanism of teachers' emotions in students' learning, and can provide practical guidance to improve students' video-lecture learning.

The Role of Teachers' Emotions in Students' Learning

Social learning theory proposes that learning is a process of observing, analyzing, and imitating others' emotions, attitudes, and behaviors (Bandura, 1997). This theory considers environmental and cognitive factors as two major elements that influence learning. It is proposed that emotions evoked in the learning can influence the learning process in turn. Robinson (2013) explored the interrelationship of emotion and cognition in online courses, and found that emotions can influence students' motivation and observation. Kay (2008) analyzed the relationship between emotions and students' learning and found that positive emotions can improve students' learning. However, Homer et al. (2008) and Kizilcec et al. (2014) found no significant difference between the learning performance of students who learned through lectures with and without the teacher's presence. That is, there is no consensus on the role of teachers' emotions in students' learning.

Research Questions

Although studies support that teachers' emotions are essential and can influence students' emotions, the internal mechanism of teachers' emotions in students' learning is still to be further explored. To fill this gap and to provide practical guidance for video-lecture teaching, the role of teachers' emotions in students' perceived social presence, arousal level, cognitive load, and learning were explored in this study with quasi-experimental research.

Specifically, this study aimed to explore the following research questions:

RQ1: What is the role of the teacher's emotions in students' perceived social presence?

RQ2: What is the role of the teacher's emotions in students' arousal level?

RQ3: What is the role of the teacher's emotions in students' cognitive load?

RQ4: What is the role of the teacher's emotions in students' learning?

MATERIALS AND METHODS

Study Design

A quasi-experiment was conducted to analyze the role of the teacher's emotions in students' perceived social presence, arousal level, cognitive load, and learning. Participants were randomly assigned into three groups and students of the three groups learned with video lectures instructed by a teacher with different levels of emotions. In the first group, students learned with the video lecture instructed by an enhanced-expression teacher; those in the second group learned with the video lecture instructed by the same teacher with conventional expression; and students in the third group learned with the teacher's audio of the lecture only. Then students' perceived social presence, emotions, cognitive load, and learning data were collected to analyze the mechanism of the teacher's emotions in the students' learning.

Participants and Materials

In this study, participants were students recruited from a Chinese university through the social network software, QQ. They were normal in terms of their social communication and had no previous learning experience of micro-course design. The fact that the learning process would be recorded was communicated to all participants before the experiment. Participants' background information including gender, age, and educational level was collected. The experiment schedules were defined during the enrollment. Of the 89 students who registered, 78 were available for the experiment. Participants' ages ranged from 18 to 24 years old (M = 20.4, SD = 1.93) with 15 males and 63 females.

Participants were randomly assigned to three learning groups. There were 26 students (5 males and 21 females) in each group. The teacher of the three video lectures was a female teacher with more than 4 years of online teaching experience.

The topic of the three video lectures was micro-course design. The content and teaching design of the three lectures were the same. In the conventional-expression video lecture the teacher was informed to teach in her usual way. In the enhanced-expression video lecture, she was encouraged to express her emotions as clearly as she could. The audio of the audio-only lecture was taken from the enhanced-expression lecture.

Measurements

Perceived Social Presence

To explore the role of the teacher's emotions in students' perceived social presence, students' perceived social presence was investigated after the learning session with a questionnaire adapted from Kim and Biocca (1997). Perceived social presence was assessed using six items (as shown in **Table 1**). Each question was assessed with a 5-point Likert scale (1 "*totally disagree,*" 5 "*totally agree*"). There was a reverse question in the social presence scale and its score was reversed before the data analysis. Hence, a higher score indicated a higher perceived social presence. The Cronbach's reliability (alpha) for perceived social presence was 0.89 which is considered acceptable (Nunnally, 1978).

TABLE 1 | The six-item questionnaire for the measurement of perceived social presence.

Dimension	Definition	Num	Item
Social presence	The sense that another person is "real" and "there" when using a communication medium	1	During the video-lecture learning, I feel like I am in a world constructed by the teacher.
		2	During the learning, I NEVER forgot that I was in the middle of an experiment.
		3	During the learning, my body was in the room, my mind was with the teacher.
		4	The lecture came to me and created a new world for me, and the world suddenly disappeared when the lecture ended.
		5	When the lecture finished, I felt like I came back to the "real world" after a journey.
		6	When the lecture finished, I could not come back to the real world in a short time.

Emotions and Arousal Level

Facial expressions analysis based on FaceReader is more reliable compared with traditional investigation and observation (Sun and Chen, 2016). FaceReader was constructed according to Ekman's basic emotion theory. In FaceReader, emotions and arousal levels are calculated based on movement analysis of 20 facial action units (Ekman et al., 1978). It has been found to be reliable and effective for assessing a person's emotions (Drozdova, 2014). Given the reliability of FaceReader, it was used in this study to assess the teacher's and students' emotions. The three video lectures were imported into FaceReader to explore the teacher's emotions. Students' learning processes were recorded with the camera in the computer, and FaceReader was used to analyze the recorded videos to determine the students' arousal levels.

Cognitive Load

To explore the role of the teacher's emotions in the students' cognitive load, students' perceived social presence and cognitive load were investigated after the learning session with a questionnaire adapted from Leppink et al. (2013). Cognitive load was assessed with six questions, including two on intrinsic load, two on extraneous load, and two on germane load (as shown in **Table 2**). Each question was assessed with a 5-point Likert scale (1-"*totally disagree,*" 5-"*totally agree*"). The Cronbach's reliability for the cognitive load scale was 0.90. The reliability for each sub-scale (intrinsic load, extraneous load, and germane load) was calculated to be 0.87, 0.91, and 0.85, respectively, which is considered to be acceptable (Nunnally, 1978).

Learning Performance

Before the learning, students' knowledge of this topic was assessed with a pre-test. After the learning, students' learning performance was assessed with short-term and long-term recall of the learning

TABLE 2 | The six-item questionnaire for the measurement of cognitive load.

Dimension	Definition	Num	Item
Cognitive load	Intrinsic load	1	What I just learned is very complex.
		2	The concepts or problems involved in the video lecture are very complex.
	Extraneous load	3	The instructions and/or explanations were very unclear.
		4	The teacher's expressions in the video lecture were difficult to understand.
	Germane load	5	The video lecture enhanced my understanding of concepts and definitions of micro-courses.
		6	The video lecture enhanced my knowledge of how to design micro-courses.

content. There were 10 questions on short-term and long-term recall which were different from the pre-test. The scores of the pre- and post-tests were between 0 and 10. Items such as "The advantages of micro-courses" and "How to design micro-courses" were included in the test. The pre- and post-tests were examined by two experts in educational technology to ensure their validity for assessing students' knowledge of micro-course design.

Procedure

There were three stages in this experiment. In the first stage, participants were taken into the classroom one by one. Researchers communicated with them to make sure that their social communication skills were normal, and they had not learned micro-course design before. At the same time, they were administered a pretest on micro-courses. In addition, they received training on how to operate the video lecture. In the second stage, they participated in learning. Students were randomly assigned to one of the video lectures. Each participant learned with the video lecture individually. To explore the effect of the teacher's emotions on the students' learning, participants' learning processes were recorded with the laptop camera. The experiment scene is shown in **Figure 1**. Each student viewed and tried to learn the content. In the third stage, there was a short-term recall posttest on the knowledge after students had finished learning. Their perceived social presence and cognitive load were also investigated. Finally, five participants in each group were interviewed about their learning experience. Two weeks later, a long-term recall posttest was administered to participants through emails. Those who finished the long-term recall posttest were rewarded with cash bonuses. All participants submitted the long-term recall posttest.

RESULTS

To explore the role of the teacher's emotions in students' learning, the two-way ANOVA was used to analyze students' perceived social presence, arousal level, cognitive load, and learning, using SPSS 19.0. The FaceReader analysis result indicated that there were six facial expressions in the enhanced-expression video lecture, three in the conventional-expression video lecture, and no expression result in the audio-only video lecture.

The Role of the Teacher's Emotions in Students' Perceived Social Presence

Students' perceived social presence was analyzed to explore the role of the teacher's emotions in students' perceived social presence. The Shapiro-Wilk test supported that we could not refuse the hypothesis that students' perceived social presence was normally distributed ($w_1 = 0.94$, $p_1 = 0.11$). The two-way ANOVA results indicated that the teacher's emotions had a significant effect on the students' perceived social presence [$F(2, 75) = 53.0$, MSE = 112.62, $p < 0.001$]. Specifically, the Bonferroni *post hoc* analysis showed that students' perceived social presence in the enhanced-expression teacher group was higher than that in the conventional-expression teacher group ($p < 0.001$) and the audio-only lecture group ($p < 0.001$) (as shown in **Figure 2**). Students in the conventional-expression teacher group demonstrated a higher perceived social presence than students in the audio-only lecture group ($p < 0.001$). RQ1 was thus answered. It was found that students in the enhanced-expression teacher group perceived higher social presence compared with those in the conventional-expression teacher group and the audio-only group. In addition, compared with students in the audio-only group, those in the conventional-expression teacher group perceived higher social presence. That is, the teacher's presence and emotions improved students' perceived social presence.

The Role of the Teacher's Emotions in Students' Arousal Level

Students' arousal level was analyzed to explore the role of the teacher's emotions in students' emotions. The Shapiro-Wilk test supported that students' arousal was normally distributed ($w_1 = 0.89$, $p_1 = 0.18$). The two-way ANOVA results indicated that the teacher's emotions had a significant effect on students' arousal level [$F(2, 75) = 103.1$, MSE = 0.682, $p < 0.001$]. Additionally, according to the Bonferroni multiple comparison tests, students' arousal in the enhanced-expression teacher group was significantly higher than that in the conventional-expression teacher group ($p < 0.001$). Also, students' arousal in the conventional-expression teacher group was significantly higher than that in the audio-only lecture group ($p < 0.001$). The result answered RQ2. It was found that the students in the enhanced-expression teacher group demonstrated higher arousal level compared with those in the conventional-expression teacher group and in the audio-only lecture group. That is, the teacher's presence and emotions improved the students' arousal levels.

The Role of the Teacher's Emotions in Students' Cognitive Load

The Shapiro-Wilk test supported that students' cognitive load was normally distributed ($w_1 = 0.95$, $p_1 = 0.19$). A significant difference in students' cognitive load among the three groups was found [$F(2, 75) = 3.29$, MSE = 13.94, $p = 0.04$] through

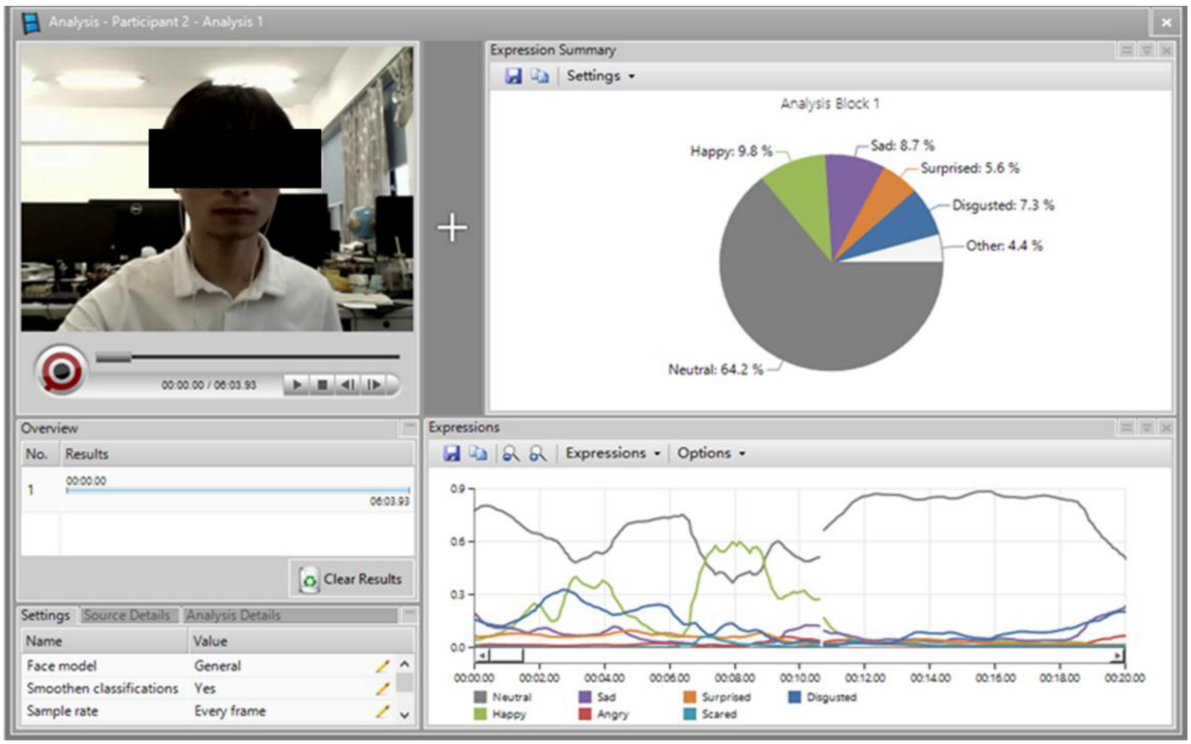

FIGURE 1 | Emotional analysis of a participant.

the two-way ANOVA result. Specifically, the Bonferroni multiple comparison tests indicated that students in the enhanced-expression teacher group ($p = 0.03$) and in the audio-only lecture group ($p = 0.04$) manifested significantly lower cognitive load compared with those in the conventional-expression teacher group. No significant difference was found in students' cognitive load in the enhanced-expression group or in the audio-only lecture group ($p = 0.71$). Additionally, there was no significant difference in students' intrinsic load and germane load among the three groups. Students in the enhanced-expression teacher group ($p = 0.04$) and audio-only lecture group ($p = 0.01$) reported significantly lower extraneous load compared with those in the conventional-expression teacher group. **Table 3** demonstrates the *post hoc* test result of the three groups' cognitive load. The result answered RQ3. Students in the enhanced-expression teacher group and the audio-only lecture group manifested lower cognitive load compared with those in the conventional-expression teacher group. That is, the teacher's presence improved students' cognitive load, but the teacher's emotions reduced students' cognitive load.

The Role of the Teacher's Emotions in Students' Learning

The Shapiro-Wilk test supported that we could not refuse the hypothesis that students' pre-test performance was normally distributed ($w_1 = 0.96$, $p_1 = 0.32$). Two-way ANOVA supported that no significant difference was found in the pretest knowledge of the three groups [$F(2, 75) = 0.08$, MSE = 0.12, $p = 0.93$]. The Shapiro-Wilk test supported that students' short-term and mid-term recall were distributed normally ($w_1 = 0.93$, $p_1 = 0.69$). No significant difference was found in the three groups' short-term recall according to the ANOVA result [$F(2, 75) = 0.13$, MSE = 0.17, $p = 0.74$].

While a significant difference was found in the long-term recall of the three groups [$F(2, 75) = 16.42$, MSE = 25.17, $p < 0.001$], specifically, students reported higher long-term

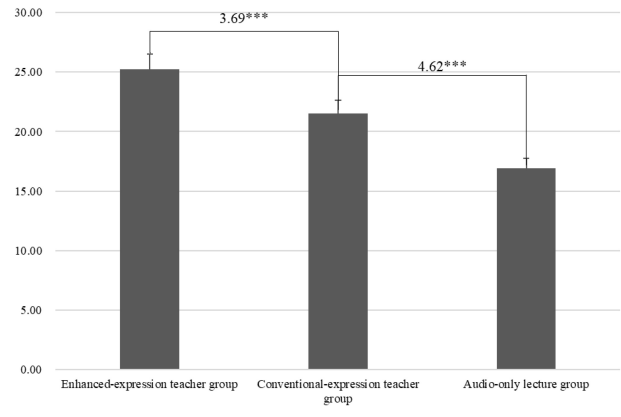

FIGURE 2 | Participants' perceived social presence in the three groups. The 3.69 and 4.62 represent the Mean difference, ***represents that the mean difference is significant at the 0.001 level.

TABLE 3 | *Post hoc* test of the three groups' cognitive load.

Cognitive load	Group (I)	Group (J)	Mean difference (I-J)	Std. error	*p*-value
Intrinsic load	1	2	0.31	0.27	0.57
		3	0.46	0.26	0.15
	2	3	0.15	0.22	0.77
Extraneous load	1	2	−1.42	0.23	0.04*
		3	0.38	0.32	0.32
	2	3	1.46	0.29	0.01*
Germane load	1	2	0.32	0.36	0.48
		3	0.15	0.34	0.76
	2	3	0.12	0.37	0.49

Group 1 means the "Enhanced-expression teacher group"; group 2 represents the "Conventional-expression teacher group"; group 3 represents the "Audio-only lecture group."
*$p < 0.05$.

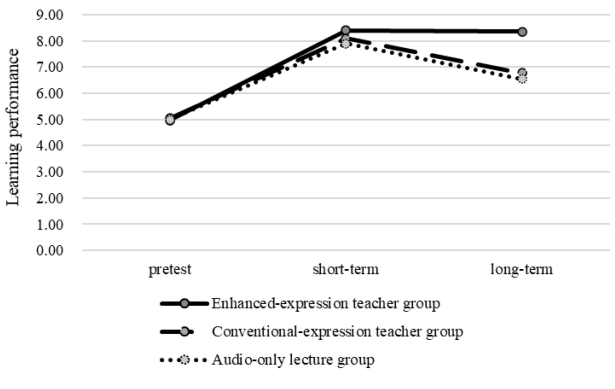

FIGURE 3 | Pretest and posttest outcomes of the three groups.

recall in the enhanced-expression teacher group than those in the conventional-expression teacher group ($p < 0.001$) and the audio-only lecture group ($p < 0.001$) through Bonferroni's multiple comparison test. No significant difference was found in the long-term recall of the conventional-expression teacher group and the audio-only lecture group ($p = 0.50$). The average scores of the three groups in the pre-test, short-term recall, and long-term recall are reported in **Figure 3**. RQ4 was therefore answered. That is, compared with students in the conventional-expression teacher group and the audio-only lecture group, those in the enhanced-expression teacher group reported higher long-term recall. It can therefore be stated that the teacher's presence and emotions improved students' learning.

DISCUSSION AND CONCLUSION

The role of a teacher's emotions in students' perceived social presence, arousal level, cognitive load, and learning performance was explored. The analysis results supported that the teacher's emotions facilitated students' perceived social presence, arousal level, and learning performance. Interestingly, it was found that the teacher's emotions could relieve students' cognitive load. Implications of this study are discussed as follows.

The Role of the Teacher's Emotions in Students' Perceived Social Presence

Students in the enhanced-expression teacher group reported a higher social presence than students in the conventional-expression teacher and audio-only groups. Compared with students in the audio-only lecture group, those in the conventional-expression teacher group demonstrated a significantly higher social presence. This finding is consistent with Wang et al. (2019) who found that teachers' emotions facilitated students' learning satisfaction. This result can also be explained by the transactional distance theory. This theory supported that students' perceived communication could influence their perceived distance with the learning community during online learning (Moore and Kearsley, 1996). The distance between students and the teacher is one of the biggest challenges of online learning. Thus, it is essential to shorten the distance between students and the teacher during online learning or video-lecture learning. It was found that the teacher's enhanced expressions could facilitate students' perceived social presence, which is essential to shorten the distance between students and the teacher. Hence, it is suggested that teachers could enhance their expressions during video lecture material production.

The Role of the Teacher's Emotions in Students' Arousal Level

It was found that the teacher's presence and emotions improved students' arousal level. This finding is supported by Baylor and Kim (2009) who showed that teachers' emotions expressed through expressions could improve students' perceptions and learning. It can also be explained by the emotion contagion theory in which the emotional contagion is an automatic, unconscious process of emotional transmission between individuals, an automatic tendency to imitate and synchronize facial expressions and movements, resulting in the production of the same emotion (Liu et al., 2019). The result is also supported by Becker et al. (2014) who found that the teacher's emotions were determinant of students' emotions, which could further improve their learning engagement. Thus, it is necessary for teachers to be expressive during video-lecture teaching.

The Role of the Teacher's Emotions in Students' Cognitive Load

The results indicated that the teacher's presence increased students' extraneous load, but the teacher's emotions reduced students' extraneous load. This result gives teachers practical suggestions for designing effective teaching materials. On one hand, it is consistent with Homer et al. (2008) who proposed that, compared with students in the no-video group, those in the video group experienced a higher cognitive load. On the other hand, it gives teachers practical suggestions to deal with this problem. The teacher's enhanced expressions during teaching acted as an assisting signal regarding the learning content which

could relieve students' cognitive load. The interview results also supported this finding. Several students proposed that the teacher's facial expressions during teaching could improve their understanding of the learning content and make it more impressive. This result explained the internal mechanism of why teachers' enhanced expressions facilitate students' learning engagement during video lecture learning.

The Role of the Teacher's Emotions in Students' Learning Performance

It was found that the teacher's presence and emotions had no significant effects on students' short-term recall. This may have resulted from the low difficulty level of the short-term recall and students' deep memory of knowledge as they had just finished learning. In contrast, the teacher's emotions improved the students' long-term recall. The interview data helped to explain this result. Several students proposed that the teacher's emotions during teaching acted as an indicator, meaning that the knowledge left a greater impression on them. This result is supported by Wang et al. (2019). Compared with Wang et al. (2019), the current study further explored the role of the teacher's emotions in students' social presence and cognitive load, which can explain the internal mechanism of the role of the teacher's emotions in students' learning. This result does not mean that the more expressive the teacher is the better, because the cognitive theory proposes that signals that are consistent with the learning content promote student learning (Mayer, 2005). That is, not all rich expressions are useful for students' learning. It is the emotional support improving students' understanding of the learning content that is useful for learning. Hence, we can conclude that the teacher's heightened level of facial expressions during teaching is helpful for students' content understanding.

This study gives researchers and practitioners practical guidance to improve video-lecture teaching. On one hand, teachers could heighten their facial expressions while teaching to improve students' learning, as teachers' improved expression of their emotions facilitates students' social presence, arousal level, and learning. On the other hand, although it is supported that teacher presence would improve students' cognitive load, the teacher's enhanced expressions could relieve students' cognitive load.

There are some limitations of this study that should be noted. The number of participants in this study was limited, which influences the generalizability of the results. Secondly, the teacher in this study is a teacher who is not so expressive in her natural state. Thus, the result may only apply to such teachers. In the future, more diverse methods can be considered during the analysis to further explore the role of teachers' emotions in students' learning.

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

The studies involving human participants were reviewed and approved by the Nanjing Normal University. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

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

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Benefits of Affective Pedagogical Agents in Multimedia Instruction

Yanqing Wang[1,2], Xiaowei Feng[3], Jiangnan Guo[1,2], Shaoying Gong[1,2], Yanan Wu[1,2] and Jing Wang[1,2]*

[1] Key Laboratory of Adolescent Cyberpsychology and Behavior, Central China Normal University, Ministry of Education, Wuhan, China, [2] School of Psychology, Central China Normal University, Wuhan, China, [3] Student Affairs Office, Shijiazhuang University, Shijiazhuang, China

The goal of the present study is to explore whether the affective states (happy or neutral) of a pedagogical agent (PA) in an online multimedia lesson yields different learning processes and outcomes, and whether the effects of affective PAs depend on the learners' emotion regulation strategies and their prior knowledge. In three experiments, undergraduates were asked to view a narrated animation about synaptic transmission that included either a happy PA (smiling expression and enthusiastic voice) or a neutral PA (neutral expression and calm voice) and subsequently took emotions, motivation, cognitive outcomes tests. Across three experiments, the happy PA group reported more positive emotions (*ds* = 0.70, 0.46, and 0.60) and higher level of motivation (*ds* = 0.76, 0.49, and 0.51) than the neutral PA group. Moreover, the happy PA prompted higher germane load (*d* = 0.41) than a neutral PA in Experiment 3. However, adding a happy PA to the screen did not improve learning performance. In addition, in Experiment 2, learners' usage of emotion regulation strategies moderated the effectiveness of affective PA on positive emotions in learners. Specifically, happy PAs increased the positive emotions of students who used expressive suppression strategy (*d* = 0.99) but not those who used cognitive reappraisal strategy (*d* = 0.13). In Experiment 3, the effectiveness of affective PAs was not moderated by learners' prior knowledge. Results support the cognitive affective theory of learning with media (CATLM) that students are happier and more motivated when they learn from happy PAs than from neutral PAs.

Keywords: affective pedagogical agents, multimedia learning, emotions, motivation, learning

Edited by:
Zhongling Pi,
Shaanxi Normal University, China

Reviewed by:
Lei Han,
Shandong Normal University, China
Yamin Wang,
Capital Normal University, China
Xue Wang,
Tianjin Normal University, China

***Correspondence:**
Shaoying Gong
gongsy@mail.ccnu.edu.cn

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INTRODUCTION

Objective and Framework

How to design video lectures to arouse learners' positive emotions, and will such positive emotions affect learning? Prior research has mostly focused on the question of how to design learning materials to foster affective processing in multimedia instruction (Um et al., 2012; Plass et al., 2014; Shangguan et al., 2019). In recent years, advances in computer technology and intelligent tutoring systems have enabled instructional designers to embed an animated pedagogical agent in computer-based learning environments. The pedagogical agent (PA) is a character that is presented on a screen to deliver instruction through verbal and non-verbal communication (Moreno, 2005; Veletsianos and Russell, 2014; Lin et al., 2020; Treal et al., 2020). In this case, researchers are increasingly concerned on how

to incorporate emotional design elements into PAs (e.g., affective pedagogical agents) to arouse learners' positive emotions and motivation, thus improving learning. Affective pedagogical agent (affective PA) is a type of agent that is designed to elicit certain affective experiences in learners through multiple modalities such as facial expressions, voices, and gestures (Guo and Goh, 2015). The goal of the present study is to explore the effects of affective PAs in a multimedia narrated video, and further identify the important boundary conditions that impact affective PAs.

Literature Review

Affective Pedagogical Agents in Multimedia Learning

During the past 10 years, research examining the influence of emotional design on multimedia learning has proliferated. Emotional design refers to the way of redesigning learning environments with the goal to increase learners' positive emotions and motivation to enhance learning performance (Um et al., 2012; Mayer and Estrella, 2014; Beege et al., 2020; Cheng et al., 2020; Wang X. et al., 2020). Emotional design includes two ways (Plass and Schwartz, 2014; Plass and Kaplan, 2016): One involves the emotional design of online learning materials and the other is the emotional design of interactive features in multimedia learning environments (e.g., the emotional stances of PAs).

Applying emotional design principles to learning materials pioneered first by Um et al. (2012). In their study, undergraduates were asked to learn a computer-based lesson covering the topic "how immunization works." In the positive emotional design (PED) lesson, the essential elements were rendered with warm colors, round shapes, and anthropomorphic eyes, while the control lesson was designed in monochromatic grayscale and rectangular shapes. The results found that college students in the PED group reported more positive emotions, lower task difficulty, higher level of motivation and performed better on comprehension and transfer tests than those in the neutral emotional design (NED) group. Subsequently, a growing number of studies found that PED could prime positive emotional response in learners, which in turn resulted in better learning outcomes (Plass et al., 2014; Gong et al., 2017; Uzun and Yıldırım, 2018; Shangguan et al., 2020). A recent meta-analysis by Wong and Adesope (2021) corroborated the findings from these studies, showing the positive effects of emotional design on learning outcomes ($g_{retention}$ = 0.35; $g_{transfer}$ = 0.27; $g_{comprehension}$ = 0.29). Builds on our understanding of PED in learning materials, the present study investigates the emotional design of PAs (affective PAs), which fits within the second way of emotional design.

There was also preliminary evidence showing that a positive affective PA including enthusiastic voices, smiling facial expressions and happy gestures could induce positive emotions in learners, improve motivation (Baylor and Kim, 2009; Liew et al., 2017; Wang et al., 2019; dos Santos Alencar and de Magalhães Netto, 2020; Schneider et al., 2022) and learning performance (Hernández et al., 2009; Beege et al., 2020). For example, Liew et al. (2017) applied the emotional design principle in an interactive learning environment by designing an enthusiastic PA to constantly smile, nod, and provide enthusiastic remarks. The results found that college students in the enthusiastic agent condition reported more positive emotions, higher intrinsic motivation and performed better on learning outcomes than learners in the neutral agent condition. Wang et al. (2019) asked college students to watch three different video lectures: the heightened level of expressiveness lecture (e.g., expressive facial expression), the conventional level of expressiveness lecture (e.g., neutral facial expression) and the audio-only lecture (no instructor' image). On subsequent tests, students in the video lectures with a heightened level of expressiveness instructor reported higher arousal level and learning satisfaction and scored higher in the medium-term recall test. The results again indicated the power of affective PAs on affective processing and cognitive outcomes. Similarly, Schneider et al. (2022) found that a PA who performed facial expressions led to higher perception of learning facilitation and better transfer performance compared with a PA who without facial expressions. Guo and Goh (2015) conducted a meta-analysis involving 30 experiments and found that the use of affective PAs had a moderate effect size of motivation (r = 0.35) and relatively smaller impacts on retention (r = 0.29) and comprehension (r = 0.26).

Two theories were used to explain the effectiveness of affective PAs in multimedia learning environments. The first is emotional response theory (Russell and Mehrabian, 1974), which emphasizes the relationship between students' perceptions of teacher immediacy behaviors and their emotional responses and cognitive learning. Based on this theory, Mottet et al. (2006) further explicated three components in instructional contexts: (1) instructors' verbal and non-verbal communications; (2) learners' emotional responses (3) learners' approach-avoidance behaviors. When the verbal and non-verbal messages of a PA increased positive emotions in learners, they would occur approach behaviors in terms of learning (Horan et al., 2012). From the perspective of emotional response theory, PAs with enthusiastic voices, smiling faces, and expressive gestures could elicit positive emotional responses in learners and promote them to engage in learning-related activities (Liew et al., 2017).

The second is the Cognitive Affective Theory of Learning with Media (CATLM, Moreno and Mayer, 2007), which extended the Cognitive Theory of Multimedia Learning (CTML; Mayer, 2021) by adding motivational and affective factors. CATLM proposes three assumptions: First, affective mediation hypothesis holds that motivation and affective factors may mediate learning by increasing or decreasing cognitive engagement; Second, metacognitive mediation hypothesis refers to individual meta-cognitive skills may influence learning by affecting cognitive and emotional processes; Third, individual differences hypothesis argues that individual characteristics may moderate the effectiveness of multimedia learning. According to the affective mediation hypothesis of CATLM, when PAs display positive emotions during online learning, learners may experience four key steps (Horovitz and Mayer, 2021; Lawson et al., 2021): (1) the learners first need to recognize the PA's positive emotions; (2) the learners respond to the PA's affective stances (such as feeling the same emotions as the affective PAs); (3) the learners' positive emotions improve the level of motivation to engage in deep

cognitive processing; (4) the motivational states lead to better learning outcomes.

Some studies have found the positive effects of affective PAs on arousing learners' positive emotions and motivation, but positive affective processing did not necessarily facilitate learning performance (Guo et al., 2014, 2015; Guo and Goh, 2016; Horovitz and Mayer, 2021). For instance, Horovitz and Mayer (2021) asked college students to watch an instructional video on the statistical topic of binomial probability, students in the happy instructor group could recognize the emotional state of the instructor and rated themselves as happier and more motivated than those in the bored instructor group. However, there were no significant differences in learning outcomes among different types of instructors. A series of studies by Guo et al. (2014, 2015) asked university students to interact with affective embodied agents that expressed positive affective through facial expression, body gesture and scripted feedback or neutral embodied agents. They found that affective embodied agents group reported more enjoyment and higher level of motivation than neutral embodied agents, but there was no difference in learning outcomes between the two groups.

In contrast to these findings, some studies demonstrated that affective PAs neither induced learners' positive emotions nor enhanced learning (Beege et al., 2020; Xie, 2020, Experiment 1). There are even research findings showed that the positive facial expression (e.g., smile) of PAs led to negative emotional and motivational responses in learners (Liew et al., 2016), or resulted in poorer comprehension test performance (Frechette and Moreno, 2010). The mixed findings indicated that additional factors may constrain the effectiveness of affective PA. Although there are some researchers tried to address the debates in the literature by identifying potential moderating variables, such as the types of affective PAs (Horovitz and Mayer, 2021) and the channel of emotional cues (Ba et al., 2021). They have still ignored the importance of learners' individual characteristics (e.g., learners' emotion regulation strategies and prior knowledge). According to the individual differences assumption of the CATML, individual characteristics may affect the efficacy of instructional design in multimedia learning. Therefore, it is necessary to examine whether learners' individual characteristics were important boundary conditions for the effectiveness of affective PAs.

Learners' Emotions Regulation Strategies

Emotion regulation is the set of controlled and automatic processes that individuals exert influence on how they experience or express their emotions and attempt to regulate or change the trajectory, duration, and intensity of emotions (Webb et al., 2012; Gross, 2015). The process model of emotion regulation (Gross, 1998) points out five emotion regulation strategies: situation selection, situation modification, attentional deployment, cognitive reappraisal, and expressive suppression. Cognitive reappraisal and expressive suppression are the two most commonly used emotion regulation strategies. The former is a form of cognitive change that refers to altering the emotional state by reformulating the meaning of a situation from other perspectives and reinterpreting the situational stimulus (Gross and Thompson, 2007). The latter is a form of response modulation that refers to the deliberate suppression of an impending or ongoing emotional expression, such as "putting a smile on" when angry. Studies have found that students using cognitive reappraisal strategy may be more confident in regulating their emotional experience, and thereby expressing more positive emotions but less negative emotions (Goldin et al., 2008). Compared to the cognitive reappraisal strategy, the expressive suppression strategy is mainly used to regulate the external emotional response rather than the internal emotional state. Therefore, learners who used expressive suppression strategy are more likely to experience more negative emotions and less positive emotions (Dryman and Heimberg, 2018). Similarly, research has shown that the cognitive consequences of different emotion regulation strategies may be different. For example, Strain and D'Mello (2015) found that students who used cognitive reappraisal strategy reported more affective engagement and achieved better learning outcomes than those who did not use any strategy. Dillon et al. (2007) reported that cognitive reappraisal strategy (cognitive up-regulation and cognitive down-regulation) rather than expressive suppression strategy promoted the memory of emotional materials. According to this line of research, learners who used cognitive reappraisal strategy can successfully regulate their emotional experience during learning. By contrast, the expressive suppression strategy is considered as a maladaptive emotion regulation strategy, which is usually associated with negative emotional experience and cognitive consequences, so students who used expressive suppression strategy may need more affective aid which provided by affective PAs. Therefore, we predict that affective PAs may be more beneficial to learners who used expressive suppression strategy than learners who used cognitive reappraisal strategy.

Learners' Prior Knowledge

Learners' prior knowledge refers to the level of their experience in a particular domain, which is regarded as one of the most important individual characteristics that affect learning (Kalyuga et al., 2003). Prior research has found that the level of prior knowledge may affect students' cognitive processing and learning outcomes (Kalyuga, 2007). A schema-based approach can be used to explain the differences between experienced and inexperienced learners. According to the experience dominance effect, learners with high prior knowledge possess a large number of relevant knowledge schemas stored in long-term memory. When new information is presented to learners, high-knowledge learners can quickly connect the input knowledge with existing schemas and avoid processing overwhelming amounts of information at once. By contrast, learners with low prior knowledge may lack sophisticated schemas associated with learning materials and have difficulty in processing relevant information in a timely manner, thus reducing the cognitive resources for organization and integration. In terms of learning performance, high-knowledge learners leave more available cognitive resources to process the central concepts, so perform better than low-knowledge learners. According to the expertise reversal effect (Kalyuga et al., 2003), instructional techniques that are effective

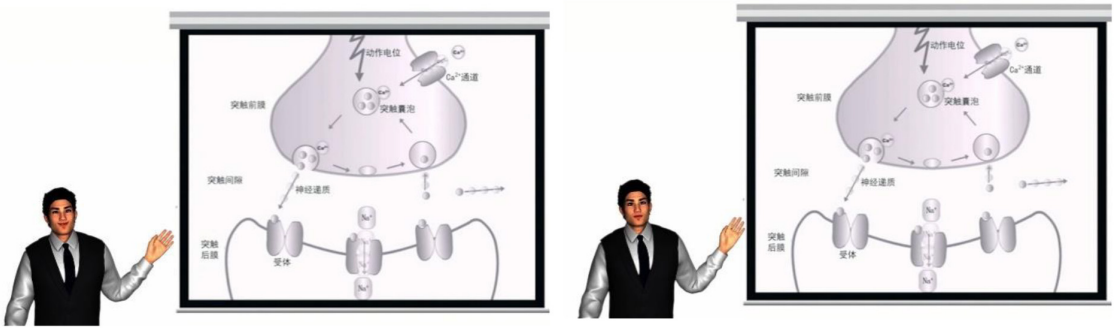

FIGURE 1 | Example frames from multimedia learning materials: Affective pedagogical agent (Left) and neutral pedagogical agent (Right).

for learners with low knowledge experience may be ineffective or even had negative consequences on those with high knowledge experience. When presented with a new learning material, low-knowledge learners are more likely to experience higher task difficulty due to lack of relevant schemas to guide cognitive processing, which may increase their negative emotions and decrease learning motivation (Efklides and Petkaki, 2005). Therefore, affective PAs may work as instructional supports to increase positive emotions and intrinsic motivation that stimulate and maintain generative processing. Instead, knowledgeable learners can apply schemas to knowledge construction on their own, so they may not need any instructional guidance (Shangguan et al., 2020; Wang F. et al., 2020). Therefore, the present study aims to explore the prediction that affective PAs may be more helpful for low prior knowledge learners than for high prior knowledge learners.

The Present Study

Previous studies have found the effectiveness of affective PAs with single emotional cue (smiling expression or enthusiastic voice) (Liew et al., 2016; Beege et al., 2020) or multilevel emotional cues (smiling expressions, enthusiastic voices, high level of head movements and gestures, and additional remarks) (Liew et al., 2017; Horovitz and Mayer, 2021). However, among various emotional cues, facial expression and vocal expression were the essential attributes that influenced learners' perceptions of the positive affection of agents (Liew et al., 2017). Domagk (2010) points out that the image and voice of PAs were the main factors priming the social interaction between learners and PAs. In light of this previous research, the affective PA in this study is designed with dual-channel emotional cues, including smiling facial expression and enthusiastic vocal expression. Thus, the first experiment of this study is conducted to explore whether affective PAs can affect learners' emotions, motivation, cognitive processing, and learning outcomes. According to emotional response theory and CATLM, the presentation of an affective PA can help arouse positive emotions and improve learning motivation, causing the learners to exert more effort to engage in deep cognitive processing, which is more likely to lead to meaningful learning outcomes. Based on the emotional response theory and CATLM, we predict that affective PAs with smile expressions and enthusiastic voices can enhance learning outcomes (retention test and transfer test). Additionally, those students will report more positive emotions and higher level of intrinsic motivation (hypothesis 1).

Furthermore, the present study seeks to investigate whether the effectiveness of affective PAs is moderated by some potential factors such as learners' emotion regulation strategies (Experiment 2) and prior knowledge (Experiment 3). According to the individual difference assumption of the CATLM, individual characteristics may affect the efficacy of instructional design in multimedia learning (Moreno, 2006). Based on the individual difference assumption of the CATLM and prior empirical studies, we hypothesize that compared to learners who used cognitive reappraisal strategy, learners who used expressive suppression strategy will report more positive emotions, higher level of intrinsic motivation, and achieve better learning outcomes when they receive an affective PA in contrast to a neutral PA (hypothesis 2). Besides, compared to learners with high prior knowledge, learners with low prior knowledge will report more positive emotions, higher level of intrinsic motivation, and achieve better learning outcomes when they receive an affective PA in contrast to a neutral PA (hypothesis 3).

EXPERIMENT 1

Method

Participants and Design

A priori power analysis was conducted using G*Power 3.1 with an estimated medium effect size $d = 0.62$, $\alpha = 0.05$, power = 0.8 (Faul et al., 2007). The medium effect size was based on a prior study by Liew et al. (2017). Based on the analysis, the suggested total sample size was 66. Therefore, 70 undergraduates from Central China Normal University were recruited to take part in this experiment. Four participants were excluded because they did not complete the posttests. The final sample consisted of 66 participants. The mean age of them was 19.8 ($SD = 1.23$) and 52 of them were women. In a one-factorial between subjects-design, 33 participants served in the affective PA group and 33 in the neutral PA group. There were no significant differences among the groups on prior knowledge, $t(64) = 0.90$, $p > 0.05$, positive

TABLE 1 | Means and standard deviations of all tests for two groups in Experiment 1.

Dependent variables	Affective PA		Neutral PA	
	M	*SD*	*M*	*SD*
Prior knowledge	14.61	5.4	15.88	6.11
The first positive emotions	3.39	0.53	3.38	0.53
The second positive emotions	3.63	0.56	2.98	0.33
Learning motivation	5.02	0.61	4.23	1.33
ICL	5.09	2.36	4.66	1.99
ECL	3.29	1.84	2.71	1.41
GCL	7.29	1.27	7.25	1.68
Retention test	14.17	4.82	13.64	4.60
Transfer test	3.01	1.64	3.11	1.42

Affective PA, affective pedagogical agent; Neutral PA, neutral pedagogical agent; ICL, intrinsic cognitive load; ECL, external cognitive load; GCL, germane cognitive load.

emotions, $t(64) = 0.07$, $p > 0.05$, mean age, $t(64) = 0.20$, $p > 0.05$, and proportion of men and women, $\chi^2(1) = 0$, $p > 0.05$.

Learning Materials

The materials were composed of two versions of computer-based instructional videos about the important process of synaptic transmission. The lesson focused on explaining how the chemical signals were transmitted across neurons in the nervous system, and the functions of action potentials, calcium ions, synaptic vesicles, and neurotransmitters in the transmission process. The same learning materials have been used in previous studies (Wang et al., 2018; Li et al., 2019; Wang F. et al., 2020), which proved to be moderately difficult. Both versions consisted of oral narration in a man voice and an illustration depicting the parts of neurons that are involved in synaptic transmission (as exemplified in **Figure 1**). For the affective PA condition, there was a middle-aged agent standing next to the illustration who displayed happy facial expressions and enthusiastic voices. In line with Liew et al. (2017, 2020), the enthusiastic agent was designed to constantly smile and the emotional tone of the voice was enthusiastic (i.e., a large dynamic pitch variation and a high pitch contour were used). In contrast, the neutral PA used neutral facial expressions and serious and calm voices (i.e., a low pitch level and small pitch variations were used). A professional male voice actor recorded the speech for the enthusiastic and neutral agent. The videos were created by Flash CS6 with the screen size is 1680 × 1050 pixels. Each video lasted 128 s.

Assessment Instruments

Pretest

The pretest consisted of a demographic survey (such as age, gender, educational level, and major), a knowledge questionnaire, and an emotional state scale. All materials were in Chinese.

The knowledge questionnaire was used to assess the level of prior knowledge concerning the chemical synaptic transmission, including 10 multiple-choice questions (e.g., "When the cell is in a resting state, what are the characteristics of the electric potential inside and outside the cell membrane?") and four self-evaluated questions (e.g., "How much do you know about chemical synapses?" "Have you taken any courses related to biological or neurophysiology"). There were four answers to each question on the multiple-choice questions and only one correct answer. Two points were awarded for each correct response. In terms of the subjective rating statements, participants were asked to mark a five-point scale ranging from 0 (very little) to 4 (very much) or a two-point scale marking 0 (No) or 2 (Yes). The total score of prior knowledge was computed by adding the number of points from all items, yielding the maximum points was 31. Similar prior knowledge questionnaires have been used in previous research (Wang et al., 2018; Wang F. et al., 2020).

The Positive Affective Scale (PAS) from the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988) was used to assess students' emotional baseline before formal learning. The PAS included 10 items: Enthusiastic, interested, determined, excited, inspired, alert, active, strong, proud, attentive, which were used to measure different feelings that learners experience in relation to positive affect. Participants were asked to rate emotions on a five-point Likert scale from 1 (not at all) to 5 (very much) before and after learning (coefficient $\alpha = 0.83$ for PAS1, 0.9 for PAS2).

Posttest

The posttest included the same emotional state scale as the pretest, a motivation questionnaire, a cognitive load questionnaire and learning outcome tests (a retention test and a transfer test). To measure learners' *intrinsic motivation*, participants completed a seven-point Likert-type Motivation Self-report Questionnaire developed by Isen and Reeve (2006). This questionnaire contains eight items, an example of the items was "The study materials aroused my desire to learn more." Each item was rated from 1 (completely disagree) to 7 (completely agree). The total motivation score was computed by averaging the scores of the seven responds ($\alpha = 0.93$).

Cognitive load experienced by learners was measured using the revised Cognitive Load Scale (Xiong et al., 2018). The scale consisted of 13 items, including three cognitive load subscales: internal cognitive load (ICL) (four items, Cronbach's $\alpha = 0.85$), external cognitive load (ECL) (four items, $\alpha = 0.81$) and germane cognitive load (GCL) (five items, $\alpha = 0.83$). Examples of the three subscales were "The explanation and description during the learning was very unclear" "The topics covered in the learning

materials were very complex." "The activity really enhanced my knowledge and understanding of synaptic transmission." Each item was rated on a 10-point scale from 1 (completely disagree) to 10 (completely agree). Each individual's score on cognitive load was computed by averaging their responses on each of subscales.

Learning performance was assessed using two learning outcome tests: retention test and transfer test. The retention test was comprised of seven fill-in-the-blank questions measuring the learners' memorizing of key information of the instructional video. For example, "The chemical synaptic transmission between neurons is mainly carried out among _____, _____ and _____." Participants received one point for each of information units (blanks), with a maximum of 22 points. The transfer test consisted of four open questions which required students to apply the newly learned knowledge to solve novel problems (e.g., "Cobra venom is rich in neurotoxins, so what do you think is the poisoning mechanism of being bitten by a cobra?"). One point was assigned for each acceptable statement regardless of wording, resulting in a total of 14 points. The measures used in this study are similar to those used in the previous studies by Wang F. et al. (2020). The test score was completed by two independent raters, and the average score of them was used as the learner's final score. Inter-rater reliability on the retention test and the transfer test were $r = 0.99$ ($p < 0.001$) and $r = 0.96$ ($p < 0.001$), respectively.

Apparatus

The videos were presented on Dell PC computers with 24-inch monitors, and all participants wore headphones while watching the video.

Procedure

The participants were randomly assigned to the affective PA group or the neutral PA group and tested individually. First, participants read and filled in the informed consent form. Next, they were asked to complete the demographic questionnaire, the prior knowledge test, and the emotional subjective report questionnaire. Then, participants were informed that they would view a lesson about synaptic transmission, and they needed to complete the corresponding tests after learning. After watching the video, participants worked on the emotions and motivation questionnaires and cognitive outcomes tests. The total duration of the experiment was approximately 30 min. This study was approved by the ethics committee of the university.

Results

Table 1 shows the mean scores and standard deviations on all variables for the affective PA group and the neutral PA group. We applied partial η^2 or Cohen's d as the effect size index. For the partial η^2, the value of 0.01, 0.06, and 0.14 were considered as small, medium, and large effect sizes; For the Cohen's d, the value of 0.20, 0.50, and 0.80 were considered as small, medium, and large effect size (Cohen, 1988), respectively.

Were Affective Pedagogical Agents Effective in Arousing Learners' Positive Emotions?

To check whether adding an affective PA in multimedia courses can arouse learners' positive emotions. we conducted a repeated measures analysis of variance (RM-ANCOVA) with the two measurement points of positive emotions as repeated measurement variables, the affective PA (affective PA and neutral PA) as between-subjects factor and prior knowledge score as a covariate. The analysis revealed a significant main effect for the affective PA, $F(1,63) = 3.89$, $p = 0.05$, $\eta_p^2 = 0.058$. The affective PA group ($M = 3.51$, $SD = 0.45$) reported more positive emotions than the neutral PA group ($M = 3.28$, $SD = 0.54$), and an interaction between the two measurement points of positive emotions and affective PA, $F(1,63) = 7.67$, $p = 0.007$, $\eta_p^2 = 0.109$. The simple effects analysis suggested that students reported more positive emotions at the second positive emotions measurement than the first positive emotions measurement in the affective PA group, $F(1,63) = 4.11$, $p = 0.047$, $d = 0.44$ (see **Figure 2**), but not in the neutral PA group, $F(1,63) = 3.61$, $p > 0.05$. However, there was no main effect for the measurement points of the positive emotions, $F < 1$.

Were Affective Pedagogical Agents Effective in Improving Learners' Intrinsic Motivation?

Next, in order to investigate whether affective PA could affect learners' intrinsic motivation, we performed a one-way ANCOVA with the two treatment groups as the between-subject factor and prior knowledge score as a covariate. As expected, analyses of the experimental result indicated that learners in the affective PA group reported higher intrinsic motivation than those in the neutral PA group, $F(1,63) = 11.06$, $p = 0.002$, $d = 0.58$.

Were Affective Pedagogical Agents Effective in Facilitating Cognitive Processing and Learning Outcomes?

To determine the effects of affective PA on cognitive processing and learning outcomes, we conducted one-way ANCOVAs using prior knowledge score as the covariate to compare the two groups on cognitive load, retention test, and transfer test.

With regard to the cognitive load, there was no significant difference between the affective PA group and the neutral PA group on ECL, $F < 1$, ICL, $F(1,63) = 1.49$, $p > 0.05$, and GCL, $F < 1$.

With regard to the learning outcomes, no statistically significant difference was found between the affective PA group and the neutral PA group on the retention test, $F(1,63) = 1.79$, $p > 0.05$, and transfer test, $F < 1$.

Discussion

The goal of Experiment 1 was to investigate whether affective PAs with smiling facial expressions and enthusiastic voices could arouse learners' positive emotions, increase intrinsic motivation and enhance learning performance from a narrated animation explaining the process of synaptic transmission. These results suggest that the affective PAs with smiling facial expressions and enthusiastic voices were effective in arousing the learners' positive emotions and improving intrinsic motivation, which partly supports hypothesis 1. According to the emotional response theory, instructor behavior (communications) may affect learners' emotional responses. Similarly, CATLM theory points that students are able to recognize the emotional states

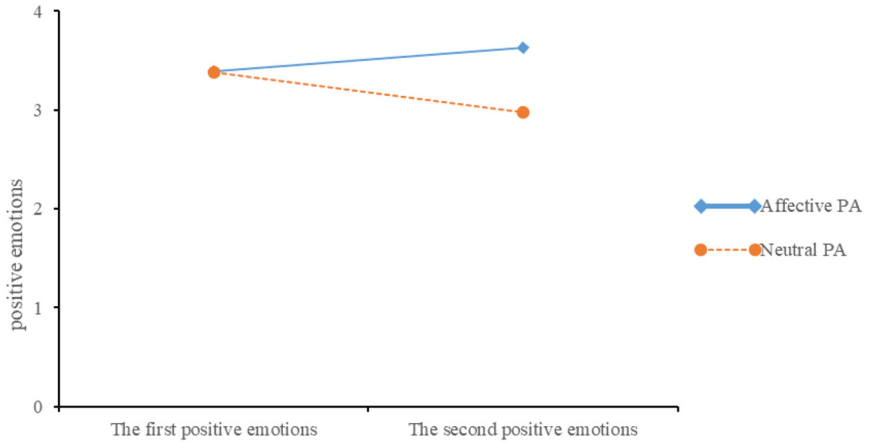

FIGURE 2 | The positive emotions on the first and second measurement point for the two groups in Experiment 1.

TABLE 2 | Means and standard deviations of all tests for four groups in Experiment 2.

Dependent variables	Affective PA				Neutral PA			
	CR strategy		ES strategy		CR strategy		ES strategy	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Prior knowledge	16.18	5.81	14.6	5.94	12.52	6.66	14.22	6.65
The first positive emotions	3.54	0.64	3.46	0.42	3.56	0.63	3.49	0.59
The second positive emotions	3.60	0.57	3.66	0.45	3.51	0.79	3.14	0.65
Learning motivation	4.88	1.00	4.29	1.13	4.16	1.35	3.89	1.12
ICL	3.32	2.40	4.23	2.12	4.65	2.39	4.44	2.44
ECL	1.79	1.73	2.87	1.71	2.15	1.63	2.12	1.79
GCL	7.54	1.12	6.50	2.06	7.14	2.02	6.60	2.08
Retention test	13.55	5.39	12.96	5.84	10.76	5.23	13.56	5.44
Transfer test	3.21	1.91	3.12	1.67	2.48	1.67	3.21	1.65

Affective PA, affective pedagogical agent; Neutral PA, neutral pedagogical agent; CR strategy, cognitive reappraisal strategy; ES strategy, expressive suppression strategy; ICL, intrinsic cognitive load; ECL, external cognitive load; GCL, germane cognitive load.

of the PAs, and feel the same emotions as the PAs, thereby triggering higher intrinsic motivation (Moreno and Mayer, 2007). Therefore, instructors' positive affective states (e.g., verbal and non-verbal emotional cues) could elicit the same kind of emotions among students, and positive emotions in turn led to positive changes in learning motivation.

However, we found no support for the effects of affective PAs on retention and transfer performances. The finding was consistent with several previous studies, which reported that presenting an affective PA on the computer screen didn't improve learning outcomes (Guo and Goh, 2016; Horovitz and Mayer, 2021). One possible reason may be that the learning outcomes tests utilized in the current study were immediate tests after learning. The effects of affective PAs on learning performance may be discerned on delay tests (Roediger and Karpicke, 2006). Another possibility may be that the duration of learning materials in our study was short and the influence of positive emotions on cognitive outcomes may be found in longer learning materials (Endres et al., 2020). It is of note that although the affective PAs did not increase the learners' GCL that is necessary for making sense of the learning material, the novelty of affective PAs did not cause learners to engage in more external cognitive processing. The result indicated that affective PAs did not serve as irrelevant information to impede learning.

EXPERIMENT 2

Experiment 1 found the positive effects of adding an affective PA on learners' positive emotions and intrinsic motivation. The goal of Experiment 2 is to test whether the positive effects of affective PAs depend on the emotion regulation strategies learners used, that is whether affective PAs are more beneficial for learners who used expressive suppression strategy than for those who used cognitive reappraisal strategy.

Method

Participants and Design

A total of 482 participants enrolled at a university in central China were recruited to complete an Emotion Regulation Questionnaire

(ERQ). Then, according to their scores on cognitive reappraisal dimension and expressive suppression dimension, the top 27% of the students in two strategies were, respectively, classified as cognitive reappraisal (CR) strategy group or expressive suppression (ES) strategy group. We eliminated data from students who studied biology (65), data from students who did not complete the questionnaire (9), and data from students who did not respond to the majority of survey questions (8). The final sample consisted of 111 participants. Among them, 59 used CR strategy and 52 used ES strategy. *A priori* power analysis was conducted using G*Power 3.1 with a medium effect size of $f = 0.30$, $\alpha = 0.05$, power = 0.8 (Faul et al., 2007). Based on the analysis, the suggested total sample size was 102. Paired sample *t*-tests showed that there was a significant difference between the two groups in CR strategy, $t_{\text{cognitive reappraisal}}(109) = 17.06$, $p < 0.001$, and ES strategy, $t_{\text{expressive suppression}}(109) = 14.09$, $p < 0.001$. The average age of the participants was 19.51 years ($SD = 0.94$), and 93 of them were women.

Participants were randomly assigned to one of the four conditions that resulted from a 2 × 2 between-factors design with affective PA (affective PA vs. neutral PA) and emotion regulation strategies (CR strategy vs. ES strategy) as factors. There were 28 in the affective PA/CR strategy group; 31 in the affective PA/ES strategy group; 25 in the neutral PA/CR strategy group; 27 in the neutral PA/ES strategy group. There were no significant differences among four groups on prior knowledge, $F(3,107) = 1.68$, $p > 0.05$, positive emotions, $F < 1$, and proportion of men and women, $\chi^2(3) = 5.66$, $p > 0.05$.

Materials and Apparatus

The learning materials, pretest (prior knowledge test and emotional state scale) and posttest (motivation questionnaire, cognitive load scale, retention test and transfer test) were the same as in Experiment 1. Inter-rater reliability was $r = 0.99$ ($p < 0.001$) for the retention test and $r = 0.97$ ($p < 0.001$) for the transfer test.

The Chinese version of ERQ revised by Wang et al. (2007) was used to measure learners' usage of two emotion regulation strategies: cognitive reappraisal and expressive suppression. It was originally developed by Gross and John (2003) and had since been translated into 33 languages. Separate scale scores were derived for these two emotion regulation strategies. The cognitive reappraisal scale consists of six items ($\alpha = 0.87$), for example, "When I want to feel more positive emotions (e.g., enjoyment), I change what I'm thinking about." The expressive suppression scale consists of four items ($\alpha = 0.60$), for example, "I control my emotions by not expressing them." All items use a seven-level rating scale ranging from 1 (completely disagree) to 7 (completely agree). The apparatus was the same as in Experiment 1.

Procedure

The procedure was the same as in Experiment 1. In addition, participants who commonly used each regulation strategy were randomly assigned to two conditions.

Results

Table 2 presents the means and standard deviations of the four groups on all variables. To explore the effects of affective PA and emotion regulation strategies on learners' positive emotions, intrinsic motivation, cognitive load and learning outcomes, we conducted a two-way ANCOVA with affective PA (affective PA vs. neutral PA) and emotion regulation strategies (CR strategy vs. ES strategy) as factors, and prior knowledge score as the covariate.

Were Affective Pedagogical Agents Effective in Arousing Learners' Positive Emotions?

For the second positive emotions measurement, there was a significant main effect of affective PA, $F(1,106) = 5.10$, $p = 0.026$, $\eta_p^2 = 0.046$, with the affective PA group reported more positive emotions ($M = 3.63$, $SD = 0.47$) than the neutral PA group ($M = 3.34$, $SD = 0.75$). There was no main effect for emotion regulation strategies, $F(1,106) = 1.78$, $p > 0.05$. The interaction between affective PA and emotion regulation strategies was significant, $F(1,106) = 4.16$, $p = 0.044$, $\eta_p^2 = 0.04$. The simple effects analysis found that there was a significant difference between conditions for learners who used ES strategy, $F(1,106) = 8.89$, $p < 0.001$, $d = 0.99$ (see **Figure 3**), with participants in the affective PA condition ($M = 3.66$, $SD = 0.35$) reported more positive emotions than those in the neutral PA condition ($M = 3.14$, $SD = 0.65$). Whereas there was no significant difference between two conditions for learners who used CR strategy, $F < 1$.

Were Affective Pedagogical Agents Effective in Improving Learners' Intrinsic Motivation?

For the intrinsic motivation, the two-way ANCOVA identified a significant main effect of affective PA, $F(1,106) = 4.02$, $p = 0.047$, $\eta_p^2 = 0.04$. Students in the affective PA group ($M = 4.60$, $SD = 1.09$) reported higher level of intrinsic motivation than those in the neutral PA group ($M = 4.03$, $SD = 1.25$). The main effect of emotion regulation strategies was also significant, $F(1,106) = 4.35$, $p = 0.04$, $\eta_p^2 = 0.04$, with learners who used CR strategy ($M = 4.50$, $SD = 1.24$) had higher level of intrinsic motivation than learners who use ES strategy ($M = 4.08$, $SD = 1.13$). The interaction between these two factors was not significant, $F < 1$.

Were Affective Pedagogical Agents Effective in Facilitating Cognitive Processing and Learning Outcomes?

Concerning the ICL, the two-way ANCOVA revealed that there was no significant main effect of affective PA, $F(1,106) = 1.21$, $p > 0.05$, no significant main effect of emotion regulation strategies, $F < 1$, and no significant interaction between affective PA and emotion regulation strategies, $F < 1$. Concerning the ECL, the two-way ANCOVA revealed that there was no significant main effect of affective PA, $F(1,106) = 1.42$, $p > 0.05$, no significant main effect of emotion regulation strategies, $F(1,106) = 2.96$, $p > 0.05$, and no significant interaction between affective PA and emotion regulation strategies, $F(1,106) = 1.74$, $p > 0.05$. Concerning the GCL, the two-way ANCOVA revealed that there was a significant main effect of emotion regulation strategies, $F(1,106) = 4.94$, $p = 0.028$, $\eta_p^2 = 0.05$. Learners who

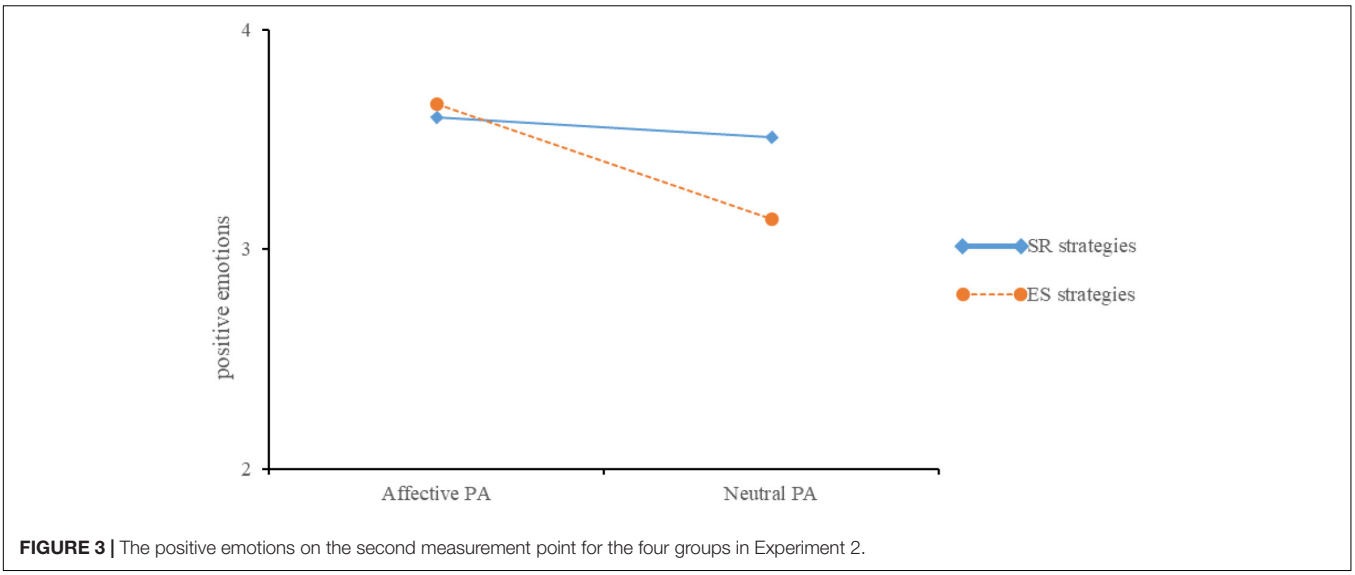

FIGURE 3 | The positive emotions on the second measurement point for the four groups in Experiment 2.

use CR strategy ($M = 7.33$, $SD = 1.65$) reported higher GCL than learners who used ES strategy ($M = 6.55$, $SD = 2.05$). However, there was no main effect of affective PA, $F < 1$, and interaction between affective PA and emotion regulation strategies, $F < 1$.

For the retention test, the two-way ANCOVA revealed that there was no significant main effect of affective PA, $F < 1$, no significant main effect of emotion regulation strategies, $F(1,106) = 1.83$, $p > 0.05$, and no significant interaction between affective PA and emotion regulation strategies, $F < 1$. For the transfer test, the two-way ANCOVA revealed that there was no significant main effect of affective PA, $F < 1$, no significant main effect of emotion regulation strategies, $F(1,106) = 1.10$, $p > 0.05$, and no significant interaction between affective PA and emotion regulation strategies, $F < 1$.

Discussion

These results of Experiment 2 replicate the findings of Experiment 1 and are partly consistent with hypothesis 1, indicating that there was a consistent pattern in which the affective PA group reported more positive emotions and higher level of motivation, but not performed better than the neutral PA group. In addition, consistent with hypothesis 2, affective PAs evoked positive emotions in learners who are accustomed to using expressive suppression strategy, but the positive effect disappeared for learners who used cognitive reappraisal strategy. Cognitive reappraisal strategy is related to expressing more positive emotions and less negative emotions, learners who used cognitive reappraisal strategy have confidence in managing and regulating their emotions to maintain positive emotional experience (Goldin et al., 2008). Expressive suppression is related to expressing more negative emotions and less positive emotions, learners who use expressive suppression strategy are more likely to feel intensity of negative emotions (Dryman and Heimberg, 2018). In comparison with learners who use cognitive reappraisal strategy, learners who use expressive suppression strategy have difficulty in regulating their emotions during learning. Therefore, direct instructional design such as adding an affective PA to the computer screen could provide affective support and help them to up-regulate positive emotions. Contrary to hypothesis 2, affective PAs improved intrinsic motivation of both learners who used cognitive reappraisal strategy and those who used expressive suppression strategy. The reason may be that learners under the affective PA condition experienced more positive emotions, while positive emotions can enhance learning motivation and interest (Um et al., 2012). Therefore, learners who used either emotion regulation strategy reported higher motivation in affective PA condition. In addition, affective PAs did not help improve the cognitive processing and learning outcomes of learners who used expressive suppression strategy. In the present study, affective PAs were more effective for learners' affective processing (e.g., emotions and motivation) but not for cognitive processing. The small effects of affective PAs on cognitive activities may not affect the cognitive outcomes of learners who use expressive suppression strategy.

In conclusion, Experiment 2 identified that the moderating effect of learners' emotion regulation strategies in the effectiveness of affective PAs. To clarify, affective PAs can better exert their positive influence on positive emotions when learners used expressive suppression strategy. The result showed that adopting cognitive reappraisal strategy may help learners to experience more positive emotions by changing the negative cognitions to regulate emotions experienced in learning.

EXPERIMENT 3

The results of Experiment 2 replicated the findings of Experiment 1 that affective PAs could increase learners' positive emotions and motivation. Moreover, Experiment 2 found the moderating effect of learners' emotion regulation strategies on positive emotions. In addition to the emotion regulation strategies learners used, learners' prior knowledge also plays an important role in learning. In Experiment 3, we aim at further exploring whether the effects

of affective PAs depend on learners' prior knowledge. Specifically, whether affective PAs are more helpful to students with low prior knowledge than those with high prior knowledge.

Method

Participants and Design

Three hundred and eighteen undergraduates were recruited to complete a prior knowledge test about synaptic transmission. Then, according to their scores on prior knowledge (M = 12.06, SD = 7.09), the top 27% and the bottom 27% of the students were, respectively, classified as high prior knowledge (HPK) group and low prior knowledge (LPK) group. The final sample consisted of 102 participants. A power analysis with G*Power 3.1 was conducted to calculate the number of participants with a medium effect size of f = 0.30 with power set at 0.80 and alpha set to 0.05 (Erdfelder et al., 2009). The recommended sample size was 102 participants. Among them, 52 were high knowledge learners and 50 were low knowledge learners. An independent sample t-test showed that the prior knowledge score of high knowledge learners was significantly higher than low knowledge learners, $t(100) = 32.99$, $p < 0.001$, $d = 6.54$. The average age of the participants was 19.75 years (SD = 1.21), and 80 of them were women.

The experiment used a 2 × 2 between-subjects design with affective PA (affective PA vs. neutral PA) and prior knowledge (HPK vs. LPK) as factors. The participants were randomly assigned to four groups: 25 in the affective PA/HPK; 27 in the neutral PA/HPK; 25 in the affective PA/LPK; 25 in the neutral PA/LPK. There were no significant differences among four group on positive emotions, $F(3,98) = 1.06$, $p > 0.05$, and proportion of men and women, $\chi^2(3) = 0.64$, $p > 0.05$.

Materials and Apparatus

The learning materials, pretest (prior knowledge test and emotional state scale) and posttest (motivation questionnaire, cognitive load scale, retention test and transfer test) were the same as that in Experiment 1. Inter-rater reliability was $r = 0.99$ ($p < 0.001$) for the retention test and $r = 0.96$ ($p < 0.001$) for the transfer test. The apparatus was the same as Experiment 1.

Procedure

The procedure was the same as in Experiment 1. In addition, participants with high/low prior knowledge were randomly assigned to two groups.

Results

Table 3 shows the means and standard deviations of each group for all variables. To explore the effects of affective PA and prior knowledge on learners' positive emotions, intrinsic motivation, cognitive load and learning outcomes, we conducted a two-way ANOVA with affective PA (affective PA vs. neutral PA) and prior knowledge (HPK vs. LPK) as factors.

Were Affective Pedagogical Agents Effective in Arousing Learners' Positive Emotions?

For the second positive emotions measurement, the analysis revealed a significant main effect for the affective PA, $F(3,98) = 9.91$, $p = 0.002$, $\eta_p^2 = 0.09$. Learners in the affective PA group reported more positive emotions (M = 3.69, SD = 0.50) than learners in the neutral PA group (M = 3.25, SD = 0.65). The main effect of prior knowledge was also significant, $F(1,98) = 8.79$, $p = 0.004$, $\eta_p^2 = 0.08$. Learners with high prior knowledge (M = 3.58, SD = 0.53) had more positive emotions than learners with low prior knowledge (M = 3.25, SD = 0.64). However, there was no interaction effect for the two factors, $F(1,98) < 1$, $p > 0.05$.

Were Affective Pedagogical Agents Effective in Improving Learners' Intrinsic Motivation?

The two-way ANOVA computed on intrinsic motivation scores revealed a main effect of affective PA, $F(1,98) = 7.84$, $p = 0.006$, $\eta_p^2 = 0.07$. Learners in the affective PA group (M = 4.71, SD = 0.77) reported higher level of intrinsic motivation than learners in the neutral PA group (M = 4.21, SD = 1.14). The main effect of prior knowledge was also significant, $F(1,98) = 11.98$, $p = 0.001$, $\eta_p^2 = 0.11$. Learners with high prior knowledge (M = 4.76, SD = 0.88) had higher level of intrinsic motivation than learners with low prior knowledge (M = 4.13, SD = 1.04). However, there was no interaction effect for the two factors, $F(1,98) = 1.08$, $p > 0.05$.

Were Affective Pedagogical Agents Effective in Facilitating Cognitive Processing and Learning Outcomes?

With regard to ICL, the two-way ANOVA revealed a main effect of prior knowledge, $F(1,98) = 63.07$, $p < 0.001$, $\eta_p^2 = 0.39$. Learners with high prior knowledge reported less ICL (M = 2.89, SD = 2.05) than learners with low prior knowledge (M = 5.94, SD = 1.87). There were neither a main effect of affective PA, $F(1,98) = 1.24$, $p > 0.05$, nor an interaction effect between these two factors, $F < 1$. For the ECL, the two-way ANOVA revealed a main effect of prior knowledge, $F(1,98) = 14.47$, $p < 0.001$, $\eta_p^2 = 0.13$. Learners with high prior knowledge reported less ECL (M = 2.10, SD = 1.27) than learners with low prior knowledge (M = 3.22, SD = 1.68). There were neither a main effect of affective PA, $F < 1$, nor an interaction effect between these two factors, $F < 1$. For the GCL, the two-way ANOVA revealed a main effect of affective PA, $F(1,98) = 4.26$, $p = 0.042$, $\eta_p^2 = 0.04$. Learners in the affective PA reported more GCL (M = 7.30, SD = 1.10) than learners in the neutral PA group (M = 6.64, SD = 1.99). There were neither a main effect of prior knowledge, $F < 1$, nor an interaction effect between these two factors, $F < 1$.

For the retention test, there was a significant main effect of prior knowledge, $F(1,98) = 139.63$, $p < 0.001$, $\eta_p^2 = 0.59$. Learners with high prior knowledge (M = 16.24, SD = 2.19) performed better than learners with low prior knowledge (M = 8.55, SD = 4.14). There were neither a significant effect of affective PA, $F < 1$, nor an interaction between affective PA and learners' prior knowledge, $F(1,98) = 1.52$, $p > 0.05$. For the transfer test, there was a significant main effect of prior knowledge, $F(1,98) = 57.64$, $p < 0.001$, $\eta_p^2 = 0.37$. Learners with high prior knowledge (M = 4.02, SD = 1.43) performed better than learners with low prior knowledge (M = 1.87, SD = 1.42). There were neither a significant effect of affective PA, $F(1,98) = 1.22$, $p > 0.05$, nor an

TABLE 3 | Means and standard deviations of all tests for four groups in Experiment 3.

Dependent variables	Affective PA				Neutral PA			
	HPK		LPK		HPK		LPK	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Prior knowledge	6.04	4.11	5.10	3.46	5.22	3.54	4.52	2.81
The first positive emotions	3.52	0.57	3.29	0.56	3.50	0.45	3.36	0.54
The second positive emotions	3.72	0.52	3.48	0.47	3.46	0.52	3.03	0.72
Learning motivation	4.93	0.81	4.49	0.69	4.61	0.93	3.78	1.61
ICL	2.72	2.18	5.67	1.84	3.05	1.94	6.20	1.77
ECL	2.03	1.19	3.37	1.96	2.16	1.36	3.07	1.37
GCL	7.46	1.14	7.14	1.07	6.68	1.88	6.59	1.14
Retention test	16.88	2.19	8.55	4.14	15.65	2.27	8.74	3.54
Transfer test	3.85	1.52	1.72	0.85	4.19	1.36	2.01	1.82

Affective PA, affective pedagogical agent; Neutral PA, neutral pedagogical agent; HPK, high knowledge learners; LPK, low knowledge learners; ICL, intrinsic cognitive load; ECL, external cognitive load; GCL, germane cognitive load.

interaction between affective PA and learners' prior knowledge, $F < 1$.

Discussion

Overall, as in Experiments 1 and 2, the results of Experiment 3 supported the idea that affective PAs could increase learners' positive emotions and intrinsic motivation, but did not result in higher retention and transfer test scores. The results are partly consistent with hypothesis 1. However, the results are not consistent with hypothesis 3 that affective PAs would be more beneficial for low knowledge learners but not for high knowledge learners because this pattern was not found for positive emotions, intrinsic motivation and learning outcomes. One possible reason may be that the emotional state of one person is automatically affected by another person's emotional expression (Hatfield et al., 1994, 2014), therefore, when provided with an affective PA, learners tend to mimic the emotions of instructor and synchronize their emotions with instructors' facial expressions and voices irrespective of their prior knowledge. The learning results can be explained by considering cognitive load. Although both low prior knowledge learners and high prior knowledge learners invested high GCL to comprehend information, high prior knowledge learners experienced lower ICL and ECL than low prior knowledge learners. Therefore, high prior knowledge learners may perceive the learning material easier, and thus performed better than low prior knowledge learners in both PA conditions. In addition, the range of prior knowledge may affect the interaction effects between affective PAs and learners' prior knowledge. More specifically, most of the participants were not complete novices or experts, thereby the levels of prior knowledge in synaptic transmission between the low and high group were not enough to span the entire continuum (Spanjers et al., 2011; Wang F. et al., 2020). In such cases, low prior knowledge learners may store some relevant knowledge structures in long-term memory, which might lead to that affective PA was not more beneficial to students with low prior knowledge.

In conclusion, Experiment 3 revealed that learners' prior knowledge did not moderate the effectiveness of affective PAs and identified a strong experience dominance effect that learners with high prior knowledge performed better than those with low prior knowledge.

GENERAL DISCUSSION

Empirical Contributions

In the present study, three experiments were conducted to investigate the effects of affective PAs on learners' positive emotions, intrinsic motivation, and learning outcomes. Across three experiments, students reported more positive emotions and higher level of intrinsic motivation when adding an affective PA to the multimedia lesson on synaptic transmission. The effective sizes for positive emotions and motivation were strong and consistent: $d_{\text{positive emotions}} = 0.70$, 0.46, and 0.60 in Experiment 1, 2, and 3; $d_{\text{intrinsic motivation}} = 0.76$, 0.49, and 0.51 in Experiment 1, 2, and 3. This is the major empirical contribution of this research, which provides powerful evidence for the effects of adding an affective PA to an online lesson.

In addition, in Experiment 2, the affective PAs were more beneficial for learners who used expressive suppression strategy ($d_{\text{positive emotions}} = 0.99$) but not for learners who used cognitive reappraisal strategy ($d_{\text{positive emotions}} = 0.13$). However, in Experiment 3, affective PAs aroused positive emotions and intrinsic motivation of both high knowledge learners and low knowledge learners. This is another primary contribution of this study, indicating that emotion regulation strategies but not prior knowledge was a boundary condition for the effectiveness of affective PAs.

Theoretical Implications

The pattern of results partially supports the emotional response theory (Horan et al., 2012) and the cognitive affective theory of learning with media (CATLM, Moreno and Mayer, 2007), which believes that students who study with affective PAs will have

more positive emotions, higher level of intrinsic motivation and learn better than those who learn with neutral PAs. Our results indicated that affective PAs with smiling faces and enthusiastic voices could affect learners' emotional and motivational states, but not learning performance.

Furthermore, the present study found that the beneficial effects of affective PAs on positive emotions were obtained for students who used expressive suppression strategy but not learners who used cognitive reappraisal strategy, which provided reliable empirical evidence for the individual difference assumption of the CATLM and expanded prior studies by identifying the important role of learners' characteristics in understanding the effects of affective PAs.

Practical Implications

Recent advances in computer technology have highlighted the important role of remote learning, online instruction, and learning with videos. In such cases, it is important for instructional practitioners to design video lessons as efficacious as possible. In the present study, we found that learners experienced more positive emotions and had a higher level of intrinsic motivation. Therefore, an important practical implication is that instructional designers should consider adding an affective PA who exhibited smiling facial expressions and enthusiastic voices when designing video lectures. In addition, it is important for instructors to display happy emotions either in traditional classrooms or in online courses to help increase students' positive emotions and motivation.

In addition, this study showed that affective PAs were partially helpful in arousing positive emotions in learners who used expressive suppression strategy but not those who used cognitive reappraisal strategy. Therefore, another practical consideration is that instructional designers should take the characteristics of learners into account when adding an affective PA to the computer screen.

Limitations and Future Directions

Notwithstanding these findings, this research has several limitations that should be addressed. First, participants were given the posttest immediately after the lesson. However, there are great differences in the learning outcomes of an immediate test and a delay test. The effects of affective PAs may be more pronounced in a delayed test (Horovitz and Mayer, 2021). Future research should add a delay test to explore the effects of affective PAs on learning.

Secondly, in this study, smiling facial expressions and enthusiastic voices were used to design the affective PAs. However, the current study did not distinguish the role of different emotional cues. Thus, an important issue for future research is to explore which emotional cues is most effective in learners' emotions, motivation, and learning.

Thirdly, this study focused on undergraduate students as participants. In addition, all of the three experiments used the same learning materials concerning synaptic transmission and animation duration was short. Accordingly, whether these findings can be generalized to different disciplines, groups and longer learning time remain to be further explored. What needs special attention is that learners' emotions are related to the perceived materials difficulty (Efklides and Petkaki, 2005). Therefore, it is also an interesting issue to examine whether the types and difficulty of learning materials moderate the effectiveness of affective PAs.

Finally, this study only used self-reported measures to explore the cognitive processing during learning. Further studies should use direct measurement techniques (e.g., eye tracking) to examine whether affective PAs serve as distractors or complements, thus elucidating the underlying mechanisms in learning with affective PAs.

CONCLUSION

The present study demonstrated the benefits of adding an affective PA to a multimedia lesson, as indicated by more positive emotions and higher level of intrinsic motivation. In addition, this study examined the boundary conditions of affective PA effects, and found that affective PAs could arouse positive emotions in learners who use expressive suppression strategy but not in those who use cognitive reappraisal strategy. However, learners' prior knowledge did not moderate the effects of affective PAs. These findings provide new perspectives for empirical research in the field of affective PAs, and also have important implications for educational practice.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

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

AUTHOR CONTRIBUTIONS

YQW contributed to the writing – original draft, data curation, visualization, interpretation, and methodology. XF contributed to the conceptualization, methodology, and data collecting. JG contributed to the analysis and writing. SG contributed to the conceptualization, interpretation, revising the work, supervision, funding acquisition, and validation. YNW and JW revised the draft. All authors have read and agreed to the published version of the manuscript.

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Research on the Impact of the Emotional Expression of Kindergarten Teachers on Children: From the Perspective of the Class Micro-Power Relationship

*Min Liu and Qiong Wang**

Graduate School of Education, Peking University, Beijing, China

During the preschool years, the socio-emotional responses children receive from interactions with teachers are incorporated into their own social behaviors. This is one of the key ways in which children acquire social and emotional skills. Based on field studies, it can be found that this learning process is not simple imitation of children, but of a more complex context of group interaction. To further clarify the impact of kindergarten teachers' emotion on the sociometric status and behavior of 3–5 year-old children in their classes, the researchers chose a Montessori mixed-age kindergarten in Beijing as the field site and observed five classes within the kindergarten over a 2-month period in this ethnographic case study. The study found that the power gap between teacher and pupil spreads rapidly to all children in the classroom as a result of the teacher's emotions, and even stimulates power stratification within the children. In addition, there are differences in the social behaviors between the children of different levels of power. As preschool children are in a critical developmental window when social knowledge is being accumulated and social skills are being acquired, using power relations within the kindergarten classroom as an entry point to analyze the impact of teachers' emotions on children's social behavior provides a new breakthrough for the professional development of early childhood education and the better achievement of educational goals.

Keywords: teacher emotions, children behavior, preschool education, micro-power theory, ethnography

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Zhongling Pi,
Shaanxi Normal University, China

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Chetan Sinha,
O.P. Jindal Global University, India
Weipeng Yang,
The Education University of Hong Kong, Hong Kong SAR, China

***Correspondence:**
Qiong Wang
wangqiong@pku.edu.cn

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INTRODUCTION

Hochschild (1979) classified the types of labor as "physical labor," "mental labor," and "emotional labor." Since then, more and more researchers have focused on the attributes of emotional labor in teachers' work and its relationship to teachers' professional development, particularly on the topics of teacher professionalism and burnout (Zhong, 2010; Liu et al., 2018). In addition to influences on their own professional lives, teachers' emotions can have an important impact on the growth and development of their students, especially in the preschool years. In this phase, the social-emotional responses and related knowledge children receive from interactions with teachers can be incorporated into their own social behaviors that is one of the important ways in which children in early childhood learn social and emotional skills (Denham and Bassett, 2019).

Furthermore, with the introduction of the theory of Emotional Intelligence in the 1990s, the close relationship between emotion and cognition in terms of the mechanisms of production and action was further clarified (Salovey and Mayer, 1990). Based on this, researchers and practitioners advocated the promotion of Social and Emotional Learning (SEL) to promote the holistic, healthy, and sustained development of children and young people through the cultivation of social and emotional knowledge and skills (Zins and Elias, 2007). Since the beginning of the twenty-first century, the practice of SEL has spread globally and its educational value has now been widely recognized by researchers and practitioners both nationally and internationally (Zins et al., 2007; Durlak et al., 2011). With the accumulation of relevant research, it has been found that the preschool stage is an important window for children's social and emotional development, a phase crucial for the development of children's future learning qualities, interpersonal relationship building, and sound personality formation (Torres et al., 2015). "Emotional Socialization" is a key learning approach for children in this stage to acquire social emotion. The social-emotion responses and knowledge gained through interactions with parents, teachers, and other adults are incorporated into their own social behaviors (Denham, 1997; Denham and Bassett, 2019). Therefore, there is both theoretical and practical value in exploring how teachers' emotions influence the development of children's social behavior and related competencies from the meso perspective of the classroom community and the micro perspective of teacher–student interaction.

In this study, the major question was how the kindergarten teacher's emotional expression affected the social behavior of children in class. This question is drawn not only from the existing studies mentioned above, but also from the researchers' extensive field practice in kindergartens. During the field research in kindergarten, the researchers found that teachers used language as a medium to convey their emotions toward particular children; children were very sensitive to the teacher's emotions, and thus imitating the teacher's emotional expressions, and permeated them in the establishment of social relationships. For example, if children noticed that a teacher was constantly regulating a child with emotions, such as anger, they would often blame the child socially or be reluctant to establish a friendly social relationship with that child. The children who are often disciplined became the "social pits" of the group. This phenomenon indicated the power gap between children within a kindergarten class. This has inspired the researchers to understand this phenomenon through the lens of power relations, where the teacher's emotions appear to accelerate the diffusion of power relations between teacher and pupil, and where other children are driven to emulate the behavior of the teacher, a person of higher power, which in turn affects the children's own social behavior. To further clarify this research phenomenon, the study hopes to build on existing research and field observations, adopting classroom power relations, and the psychology of emotions as a theoretical basis to explore in depth the relationship between kindergarten teachers' emotional expressions and children's social behavior.

LITERATURE REVIEW: DYNAMIC POWER RELATIONS IN KINDERGARTEN CLASSES

Power Relations Within Children: Leadership

Parten (1933) alluded to a definition of child leadership as action-based, involving the act of directing others, and more specifically, leadership is referred as "when a child gives direction, command, order, request, or persuasion, etc., to other children over whom he has influence and from whom he gets cooperation and submission" (Fu, 1977, p. 13). Researchers assert that some children acquire the higher position of power and show the leadership in social activities. For example, the latest synthesis research by Chen (2021) reviewed the existing observation-method based empirical research on preschool children's leadership at play, and found that the previous studies either dichotomized child leaders into "diplomat-bully," "successful-unsuccessful leadership," or labeling them as "dominator-director" according to their behaviors, and there are studies that categorized leadership styles specifically into dimensions and distinguished the types of children's leaders according to the attribute values of children on each dimension. In addition, Chen's reviewed the commonalities among preschool child leaders compared with their non-leader counterparts, including that child leaders were socially, linguistically, and cognitively more advanced, biologically older, more active in play participation, more likable by their peers, and socioeconomically more advantaged. Moreover, Chen suggested that child leadership may be attributable to the contextual influences, such as group dynamics and individual cultural experiences, which may be an important research direction but only a few studies have explored so far.

The power gap between preschool children observed by the researchers during fieldwork seems to show the presence of child leadership in the class: some children act as leaders, who occupy a commanding position in the class and direct their peers in the natural social activities. How dose these "little teacher" or "senior" appear? Based on field observations, the researchers found that their directing actions and higher ranking come out of imitation of their teachers, rather than fully influenced by factors, such as children's developmental level, age, popularity, and socioeconomic status. It inspires us to ponder how come they have the opportunity to gain more power and are able to direct other children, and why they the imitate teachers' behaviors. Distinct from the previous studies focusing on children's characteristics, this research highlights the influence of teacher emotion as a contextual factor on children's power ranking and corresponding social

behaviors, which we think better reflects the dynamics of power relation in classes.

Power Relations Under Negotiation Between Teachers and Children

The emergence of "little teachers" in the class means that teachers have transferred part of their power to children, actively or passively, allowing these children to acquire higher power status than the other peers. It reflects the transformation of power relations between teachers and children in the class. In a traditional class environment, the power relationship structure between teachers and students was top-down established, teacher-centered, and relatively stable. However, with the renewal of educational concepts and philosophy, child-centered pedagogy has been gradually prevailed, positioning children as active and competent agents in the present-day discourses of early childhood education (Wood, 2014; Nxumalo et al., 2018; Jobb, 2019). Under the child-centered pedagogy and educational philosophy, the power relations between teachers and children in the class shows a certain complexity and fluidity: Teachers and children dynamically negotiate and adjust their power relation, so that children have the opportunity to acquire part of the power that originally belongs to teachers in a traditional classroom.

The dynamic nature of power relations is one of the basic ideas of the micro-power theory of Michel Foucault (1926–1984). Foucault, as a leading contemporary philosopher, argued that wherever we are and whatever position we are in, we will be in a system of power constituted by the rules of reality. Foucault's view of power emphasizes that modern power is diffused in every corner of society, every group, and that power is diffused in relations, networks, and fields. It is a non-subjective, non-centralized "disciplinary" mechanism, in which everyone in the network of power is being controlled while remaining to be the source of power. The classroom is a typical field of power determined by various types of power in which the teacher and the children are inevitably influenced. In traditional teacher-centered classroom, the external manifestation of this field of power is the teacher's uninterrupted and continuous control over children's physical activities through techniques, such as rigorous space allocation, time division, activity planning, and power programming, or what Foucault calls "the making of individual by discipline" (Foucault, 1979). Take traditional teacher-centered classroom as field of power, the legitimacy of power is displayed through the teacher's authority, and the operation of power is mainly through discourse. This discursive power is formed by prescribing what each teacher and student should say, in what way, and how to say it. It can be argued that the operation of power in the classroom piggybacks on classroom discourse to control students, and that discourse is a way of releasing power and also a tool for its operation. While in modern child-centered classroom, teachers and students negotiate the power relationship through discourse. It is what Foucault calls "discourse as power" (Foucault, 1972).

According to the field observation in this research, due to the transformation of the current educational philosophy and the reconstruction of power relationship structure in the class, children as we called "little teacher" above have the opportunity to acquire additional power, resulting in the inequality of power status among children, and those in higher power status direct and instruct other children like what teachers do.

Children's Internal Pursuit of Power From the Perspective of Emotional Psychology

In addition to the external transformation of pedagogical philosophy and the changes of power relations, children's internal pursuit of higher power ranking drives them to imitate teachers' directing behavior and become leaders in the class. The emotional psychology from sociological perspective provides with the theory to explain how power relationship within a group influence the social behavior of its members. Theory of emotions on power-status, from Theodore Kemper, takes the changes in power status as the most common factor to trigger emotion. The members of different power status have different ways to express and experience emotion: Members in higher ranking are more likely to be angry and despise, while lower ranking are prone to be surprised and afraid (Kemper, 1990). In addition, the study from Lawler et al. (2000) shows that positive emotion ties people in the social relations. In other words, the urge and pursuits of each individual toward positive emotion naturally exists in social relations, which is an internal motivation to escalate power status.

Furthermore, given the principles of inter-group emotions and the inter-group assessment pathway in the formation mechanism, there may be a common consideration within the group based on shared interests rather than individual, resulting in a certain convergent emotion. Kenway and Fahy (2011) refer it as an "emotional resonance" (Emoscape). For instance, criticizing one child in a group activity may elicit anger from the whole class. This emotional communion in a particular spatial and temporal context may affect the social behavior and relationships of individuals in a particular group, e.g., blames or rejection toward the criticized child because of shared anger in a group. Therefore, there are often some followers around, who follow the child leaders to imitate teachers and direct other children.

Combined with the above literature review and our field work, this study makes a reasonable inference, that the kindergarten teachers' emotional expression through discourse is a tool to release power relations in the class and a catalyst to enhance the speed and efficiency of resonant power relations. Brought out by teachers' emotion embedded in discourse, children in the class quickly perceive the existence of power relations and adapt their social behaviors in response to their drive to pursue higher power status. Further, this research proposes the following questions: under the stimulative influence of teachers' emotional expression behavior, what are the outcomes of power stratification for children in kindergarten classes? What are the typical social behaviors of children at different power status?

RESEARCH METHOD

Research Field and Participants

The research data come from a larger qualitative study in which the researchers conducted extensive participant observations from May 2019 to July 2021 in a Montessori kindergarten in Beijing, China. This larger study aimed to refine the instructional design principles of situated teaching for promoting children's social and emotional knowledge and skills, and provide practical instructional guidance for the front-line teachers. An important work of the larger study is to observe and compare the children's natural emotional socialization during the interactions with teachers, and the SEL process in the classroom intervention conditions.

Among data collected in the larger study, the observation data and teacher in-depth interviews used in this study were collected from December 2019 to January 2020. The researchers observed 5 classes in the kindergarten in a participant position. On an average, there were 15 children in each class, and the average age of the children in the five classes was 52.5 months (46.7% are girls; 53.3% are boys). Since the kindergarten is a for-profit private kindergarten, children who enter the field kindergarten generally come from a considerably higher socioeconomic background and their parents received good education (the yearly cost of the field kindergarten is about 140,000 RMB, while that in public kindergarten in Beijing is about 10,000 RMB per year).[1] Each class has a foreign teacher, a Chinese AMS Montessori certified lead teacher (equivalent to the role of a homeroom teacher), an assistant teacher (responsible for assisting lead teacher, such as maintaining classroom orders and taking children to the toilet), and a life teacher (responsible for taking care of children's daily life, such as preparing lunch and bedding), which is a relatively ideal teacher-to-student ratio for providing support to children. All teachers in the five classes were women, except for two foreign teachers who were men.

Data Collection and Analysis

Specifically, the fieldwork process for this study included following steps. First, the researchers went to the kindergarten 1 day a week during the study period and entered the classroom to spend a day (from 8:00 to 15:00) in kindergarten with the children, such as breakfast in the morning when the children arrived, participation in Circle Time led by the foreign teacher, Montessori-style free work, as well as outdoor activities, lunch, naps, and afternoon teaching activities. Each day in the kindergarten classroom, the researchers videotaped the above activities with permission, and during observations, we recorded extensive fieldnotes by pen and paper. The researchers reviewed and collated the data collected on the same day and wrote a memo, thus ensuring that the field notes were abundant and authentic. In addition, the researcher interviewed the lead teacher of the class and observed to gain insight into the teachers' understanding of the relationships within the class group and to exchange views on key events in the class. After 2 months of observation, the researchers obtained a total of more than 50,000 words of classroom observation and over 40,000 words of teacher interviews transcripts.

During and after the data collecting process, we used qualitative Software Program NVivo to encode and analyze the data to enter and participate in the lives of the research subjects and present a detailed, dynamic, and contextualized picture of people under study, to see things from the perspective of local and discover the "meaning" hidden behind the concrete situations (Chen, 2000; Fetterman, 2007). The main codes conceptualized during the data analysis stage included emotional expression, power stratification, little teacher, supervision and discipline, power regulation, power ebb, social avoidance, neutral, etc.

Trustworthiness

Qualitative researchers should avoid the dangers to trustworthiness from multiple aspects, and the most helpful strategies include the following, that honestly introduce the research and build-up mutual trust with the participants, anonymize the field site and participants appearing in the to-be published research papers, provide reciprocal help to the participants as rewards, conduct field work rigorously in data collection and analysis, and etc. (Fetterman, 2007).

As mentioned above, the observation and interview data used in this research come from a larger qualitative study, and thus the researchers have already familiarized with the teachers and children in the field site and developed trust with them before entering the five classes. For example, the teachers are quite willing to consult us about problems they encounter in the teaching practice. As a result, the teachers agreed without hesitation for us to enter their classes and conduct observations after we introduced our research plan. Besides, as the kindergarten allows parents to attend classes and set up special observation seats in the classroom, we find no clear evidence that the children in the five classes were excessively affected by our presence. At the end of the 2-month observation, we shared our research findings and offered practical teaching suggestions for the teachers, with all private information were anonymized.

The data used in this research are collected from various sources, such as observation of the researchers, video recordings, and teachers' interpretations revealed in the interviews. Data from the above sources valid each other triangularly, which ensures the quality of both the data and research.

FINDINGS OF STUDY: POWER STRATIFICATION AND SOCIAL PERFORMANCE OF CHILDREN

In the chosen class, the teacher has the highest position of power within the class due to greater knowledge; so the disciplinary words or even reprimand from teacher can convey the disparity in power status between teacher and student. Moreover, the power relationship between the teacher and the reprimanded child is often accelerated by the expression of emotions, such as anger, prestige, and helplessness, which are transmitted to

[1]Data retrieved from: http://www.moe.gov.cn/jyb_xwfb/xw_zt/moe_357/jyzt_2019n/2019_zt4/bjx/mtjj/201905/t20190507_380923.html

all children in the class. Children in the class are sensitive to the power relationships reinforced by negative emotions. Some children, driven by an inherent instinct for positive emotions, imitate the teacher's behavior and take over some of the teacher's power, acting like a "little teacher" in the class to supervise other children. They become the higher power within the group of children in the class. Most children are influenced by the emotional resonance and perceive the negative emotions conveyed by the teacher when disciplining other children, so they are more likely to agree with or ignore the "little teacher" when they discipline their peers. Children who are frequently named and criticized by the teacher are at the bottom of the hierarchy of power within the kindergarten classroom, and in addition to receive criticism from the teacher, they are also monitored and disciplined by the "little teacher" or even the "little teacher's" supporters, i.e., children in the middle of the power hierarchy. When it comes to socializing with these children of lower hierarchy, other children may act the part or lack of interest to do so; thus over time, the lower-ranking children in the power relationship may become "socially deprived."

Higher Ranking Children: "Little Teacher" or "Senior"

In the kindergarten classroom, teachers actively or passively delegate some of their power to children. Active delegation includes teachers calling on children to monitor each other's behavior, and teachers explicitly asking children in the class to help monitor the behavior of particular children. The latter being less common in kindergartens nowadays because it hinders an egalitarian and friendly atmosphere in the classroom. Specifically, the teacher establishes a certain amount of peer supervision within the class through discursive behavior, for example, by first introducing the social rule of taking turns in using teaching materials within the class and informing children that if a peer breaks this rule and there is an argument, the child can correct the other child's behavior or raise hand to tell teacher. After the verbal introduction of the rule, the teacher reinforces the rule mainly through more physical behavior, for example, when a child acts out of line, the teacher immediately stops the child, and the emotions expressed by the teacher when stopping the child, such as anger, disappointment, and helplessness, magnify the power relationship between the teacher and the pupil, thus stimulating some children to imitate the social behavior of the teacher, a higher power, in pursuit of a positive emotional experience. As a result, the peer monitoring mechanism within the kindergarten classroom gives rise to children in the positions of power, such as the "little teacher" or "senior."

According to teacher interview, "Children know how to treat others accordingly. For example, the child in our class called King Kong sometimes thinks outside the box and cannot express himself clearly. He is used to imitating the behavior from cartoon or tale characters. When doing so, he cannot control himself properly, and others may get hurt. Teachers sometimes are relatively strict with him. For a while I would get angry and irritable and would stop King Kong's behavior very sternly. Soon, Tang Xin would often say, "King Kong, put this there" or " King Kong, you can't do that" and so on. This may be our understanding as adults, imposing our own ideas on Tang Xin; but what we see is that Tang Xin will only "instruct" a few children. This is also normal in Montessori kindergarten classes, where the child will imitate adult and can tell who the teacher likes and dislikes, and she will then condescend to instruct the children in the class who often don't follow the rules."

Another example is Hao Hao: "Hao Hao in my class is capable of imitation. Besides, he is the oldest in class, who often considers himself as a little teacher. I would often ask students, "Why are you doing that again?" "Didn't I tell you not to do that?" "I've called you several times, did you hear me?" Then, I found that Hao Hao repeating all these words, and even more fiercely. He would say to other children, "I've warned you, can't you hear me?" "Can't you see I'm here?" His tone is full of loathe like an adult. I found him a shadow of me: Every time I was impatient and irritated, he would be the same, quite explicitly. And Hao Hao doesn't say this to all the children. For example, there is a child in the class called Fan Shu, and when he is with other children, he will show kindness by jumping on someone's shoulder or patting them on the head, but other children may interpret this as Fan Shu hitting me. When there are more arguments like this, we sometimes feel helpless and say, "Why do you have to use such a move when you can behave?" Hao Hao would often criticize Fan Shu or come to me and say things like "Fan Shu is hitting someone again."

During the peer socialization process, Tang Xin and King Kong, Hao Hao and Fan Shu do not interact equally, as Tang Xin and Hao Hao often take on the role of "senior" or "little teacher," as the teachers say, to "instruct" or even "discipline" King Kong and Fan Shu. From the perspective of child developmental psychology, this social behavior of Tang Xin and Hao Hao is a social reference and imitation of the teacher's behavior; from the theories of classroom power systems and emotional psychology, a quest for a higher position of power. In the kindergarten classroom, there are often children who actively share some of power from teacher, such as Tang Xin, who uses teaching and instructive power of teacher's. This additional power gives children like "Tang Xin and Hao Hao" a higher and closer position of authority to the teacher than other children. In fulfilling the role of "little teacher" or "senior," these children often experience positive social experiences when exercising the power of their roles, as evidenced by the expressions of dislike and anger toward the inferior, and often display emotions of pride, smugness, satisfaction, and happiness when they "report" the inferior's rule-breaking behavior to the teacher.

It is important to note that within the class, there are children, such as Tang Xin and Hao Hao who actively share the teacher's authority, and teachers may also tacitly or actively relinquish some of their authority to these students. For example, in the story of Hao Hao and Fan Shu, the teacher initially behaves in a way that tacitly allows Hao Hao to be the "little teacher," but later, the teacher notices that Hao Hao is "abusing" the power, over-supervising and directing Fan Shu, and even involving attack-ish behavior in social performance, then teacher limits the power of Hao Hao.

As the headteacher said, "Four teachers in our class all disciplined Fan Shu. Hao Hao came to me every day to tell Fan Shu off, saying that Fan Shu hit him on the head again on the school bus and so on. I thought Hao Hao was a bit crossing the line, so I told him that he is already five years old and has to tell apart accidental touching and hit on purpose. I told him to tell the difference for several times, but you would find him smug every time he tells Fan Shu off."

In the kindergarten classroom, it can be inferred that whether the "little teacher" who is in a higher power ranking becomes a role model or a "prickly king" among the children, depends on the teacher's power regulation strategies. For example, if the homeroom teacher of Fan Shu and Hao Hao has acquiesced in the transfer of power to Hao Hao, Hao Hao may monitor within the children, contributing positively to the emergence of Hao Hao's sense of self and the effectiveness of classroom management. However, when power is abused, such healthy supervisory behavior has turned into social aggression, teachers need to adopt strategies to limit the power of the "little teacher" and rebalance power relations within the classroom.

Children in Lower-Ranking: "Self-Adjuster at the Ebb"

In the kindergarten classroom, the "little teachers" and their supporters who share some of the teacher's power may either monitor and discipline children, such as King Kong and Fan Shu, who are often criticized by the teacher, as Tang Xin and Hao Hao does, or they may avoid children, such as Yi Yi and Ruyi, described below, and "socially isolate" these children. In the power field of the kindergarten classroom, the "little teacher" and their advocates can discipline or isolate children, such as King Kong, Yi Yi, and Ru yi, while the latter are passive recipients despite their willingness. In this research, the latter are referred to as the low-power rankers within the kindergarten classroom, or "power pit." In the context of power relations, the low-power rankers are under pressure on social performance, as other children may be less inclined to socialize with the criticized child, reinforced by group emotions. In the long run, the lower-power rankers are likely to become the "social pits" of the kindergarten class. During the fieldwork, fortunately, the researchers found that even in power and social pits, kindergarten children have already developed certain social behavioral strategies to regulate the negative social experiences of being in a low power position.

During participating observation in the kindergarten class, the researchers found that the 4-year-old boy, Yi Yi, had adopted the social strategy of interacting more closely with the teacher, facing the pressure of his low power ranking and social puddle. According to in-depth interviews with teacher, Yi Yi's interests were very clear. He had a strong interest in books and words, and if the classroom activity was not in his interest, "Yi Yi would not sit down at all." For example, he always fails to put the finished picture books back on the shelf. To help him establish a behavioral code, the teacher will say to him, "If you don't put the books back on the shelf, you can't read them today" and sometimes if he keeps disobeying or refuses to communicate with the teacher, the teacher will scold him with anger. As the teacher said, "sometimes my facial expression has changed, but I won't do anything more than keep urging the child to do what he should do."

Ru Yi, a boy in another class, faces similar situation. Ru Yi is often behind schedule. His procrastination usually "ignites" teacher's negative emotion. Teacher needs to accomplish daily class activity as kindergarten requires, and takes care of every child in class, so it is hard for teacher to fully engage in helping these slow starters. Teacher may feel "anxious and a sense of inability" with Ru Yi. Other kids in class will not supervise and regulate Yi Yi and Ru Yi as "little teachers" do, but they show little willingness in interaction, "kind of avoiding him," as the teacher comments. From the perspective of the teacher, social avoidance is impairing to the development of children. "With the group avoidance, you do not develop awareness; without awareness, you will not be socializing; without socializing, nothing goes further." During class observation, the researchers found that these kids in social and power pits will adopt adjusting strategy to make up for the vulnerability.

As recorded during classroom observation, "After 9 a.m. Circle time, Yi Yi walked toward plants dial. The teaching material was occupied, so Yi Yi took out two planet balls. Instead of inviting Yi Yi together, the boy who was using that plants dial took Yi Yi's planet balls. As a result, Yi Yi tried to seek help. He turned to homeroom teacher first without saying anything but pointed at that dial. Teacher did not respond at once, so Yi Yi went back to the dial. There were two more boys by the dial that time and told Yi Yi to go away. Yi Yi had to go to the foreign teacher, but he did not get any assistance either. Yi Yi went on third strike. The homeroom teacher required Yi Yi to express his needs verbally, then took Yi Yi to join others at the dial and learnt about planets." ..... "At 9:13 a.m., Yi Yi would like to attend another table for plasticine activity. However, his participation was interrupted. Assistant tutor told him to put planet dial away before attending. Yi Yi returned to the dial, while new participant was playing the dial and prevented Yi Yi from organizing. Yi Yi turned to teacher for help by nuzzling up against the teacher without a word. Teacher then led children including Yi Yi to do the plasticine activity. After the activity, Yi Yi held teacher's hand and played the planet dial with teacher. With the assistant teacher gone, Yi Yi followed homeroom teacher to check out what the teacher was doing; then he checked on the foreign teacher. He was merely observing without participation."

During observation, other children in class do not interact with Yi Yi closely. On the contrary, Yi Yi is refused and rejected by fellow students. Yi Yi does not engage actively. This is an indirect evidence of his awareness toward his position in this power field—the power pit. Being in the power and social pit, Yi Yi and Ru Yi display similar social behavioral strategy: they take teacher as major social objects. To Yi Yi and Ru Yi, rather than being disciplined or isolated by peers and acknowledge their inferior position, it is a better choice to interact with the teacher. Teacher is the authoritative high ranker, which is more easily to accept than "little teacher." Teacher offers less negative emotion experiences. In addition, teachers in kindergarten often pay special attention to kids

with problem behaving. They even sit with those kids for better regulation. In a word, the reason that these kids prefer interaction with teacher is both internally and externally driven. Some kindergarten teachers think that lower rankers are not definitely inferior to high rankers in cognitive and socialization development. For example, Yi Yi and Ru Yi get more direct instruction when interacting with teachers. The intention of this study is not to encourage negative emotional expression from kindergarten teacher. In other words, students have the ability to understand teacher's negative emotion within a reasonable range. The negative emotional expression may not interfere with setting up quality interaction between teacher and student and the opportunity for students to acquire positive development.

Children in the Middle Power Ranking: "Supporter of Little Teacher," "Striker," and "Neutral"

During field trip in the kindergarten, the researchers found that attention was easily attracted to certain kids while failed to notice some other kids even for a whole day. In other words, the sense of "being" varies from kid to kid. "Little teacher," the higher power ranker, or lower ranker were more eye-catching to the observer. On the other hand, some kids participated all the class activities with mediocre performance, being hard to show their feature clearly. The researchers went over notes on class observation and teacher interview repeatedly but failed to find much material related to these kids with mediocre performance, both on their power ranking and social behavior. The field trip is not enough for the researchers to establish clear vision toward these kids. To enrich the resource, the researchers went back to the kindergarten. Combined with the existing class videos, researchers were able to take a closer look at the social behavior of these kids. The finding of this research is that these kids can be divided into three types: "supporter of little teacher," "striker," and "neutral."

First, with the impact of emotional resonance, the negative emotion given out by teacher to designated children would diffuse to the whole class. Every child within the class would sense it and thus forming the similar negative emotion like the teacher. As stated above, part of the class would sharply identify the power difference between teacher and students, which is signified by negative emotion. To pursue more positive emotional experience in the group, they would play a role of higher power ranking as "little teacher" and "senior." They are not only "little teacher" but individuals of more influence in the class. The rest of class react differently under the influence of "little teacher," and they will generate various psychological experience and social behavior, which are related to the characteristic of "little teacher." If a popular kid acts as the "little teacher," the others would tend to be attracted and impelled to agree with "little teacher"; otherwise, they would possibly ignore or even strike their position in a higher power ranking.

Besides, there is a group of "neutrals" exist in the middle ranking. For example, Meng Meng and Tian Tian are criticized frequently, because they almost always fail to concentrate in class and disturb the class discipline. Most kids are able to sense teacher's negative feeling toward Meng Meng and Tian Tian, and they choose to ignore them and avoid social interaction.

As recorded during classroom observation, "when the teacher was giving a lecture on Minor Cold, Meng Meng crawled under the desk, passing Xiao Jiu, Xiao Yi, and Kai Rui. The three of them all felt the disturbance, but they only took a glance and did nothing to stop him. Nor did they express specific feelings. Meanwhile, Tian Tian swiped his saliva onto the desk and said that his saliva smells as fragrant as his foot. Assistant teacher tried to stop him several times, however, Tian Tian stayed the same. Xiao Yi looked at Tian Tian without uttering a word."

In a kindergarten class, a large group of children are "neutral," such as Xiao Jiu and Xiao Yi. Although they feel the power relation under signified negative emotion, they are not voluntarily sharing teacher's power as Tang Xin and Hao Hao do—being the "little teacher" and higher power ranker. They face no social pressure, such as Fan Shu and Yi Yi in the power pit, either. These kids selectively ignore and avoid power stratification. They seldom socialize with "little teacher" and lower rankers. With most of teacher's attention going to those two roles, they have more chances to play with other similar "neutrals." They are in the middle of power relationship, and more stable in expression emotion.

CONCLUSION AND DISCUSSION

This study collected and analyzed rich ethnographical data to explore the influence of teachers' emotion on the preschool children's social behaviors. First, the research reviewed the literature about children leadership and power relations in class, to explain both the external and internal mechanism of how teachers' emotion influences children's power relation. Moreover, grounded by classroom observations and field work, we further clarify and elaborate the power stratification of children in kindergarten classes and the typical social behaviors of children in different power rankings.

Specifically, under the stimulation of teachers' emotional expression, three power levels, high, medium, and low, emerged within the children group. Among them, some children incline to imitate teachers' directing actions and become "little teacher" of a higher power position in the class, driven by their internal pursuit of better emotional experience and empowered in modern child-centered classrooms. Those children who are in a higher power ranking can either become a role model and leader with a sense of autonomy, or an annoying "prickly king," depending partly on the teachers' power regulation strategies. The children of higher ranking and their advocates tend to discipline children who are often criticized by the teacher, while the latter are passive recipients despite their willingness and they may even suffer from social avoidance under the effect of intragroup emotional resonance. But fortunately, the

children of lower ranking show certain initiative to compensate for their scarce social interactions with peers, such as seeking help and interacting with teachers more actively and frequently. Between children of higher and lower ranking, there are also "supporter of little teacher," "striker," and "neutral" children in the middle. Most of them frequently socialize with the similar middle, and their emotional experiences and expressions seem to be more stable.

IMPLICATIONS FOR PEDAGOGICAL PRACTICE

The finding of this study would enlighten teachers to transfer part of their power to student appropriately, to regulate power relationships in class strategically. It is beneficial to activate the children's autonomy and enhance ability to run the class by themselves. In conventional education concept, teacher holds almost all the power to teaching while students can only cooperate passively. But now this power field form has already changed. In modern educational context, with the popularity of ideological trend of humanism, "student-centered" had become the consensus of educational researchers and practitioners. In this study, even kindergarten children acquire willingness and ability to share the power, which relatively means that class manipulated by the teacher has transformed into semi-autonomous. The development of all students is led by themselves, while teachers are there for necessary guidance and assistance. Teachers need to be aware of how their emotion influence students in organizing the class. In class activities, they need to cultivate students' autonomy, interfere timely when the power stratification occurring within students as a result of power transfer. Teachers will need to adopt certain strategy to limit the power abuse of high ranker, help low ranker to adjust social relationship, and create loving, united atmosphere in class.

To further elaborate, although teacher's emotion affects the power relationship and social behavior of students, it is not necessary to require teachers to perfectly disguise their emotion, especially kindergarten teachers. According to previous research, depressing or disguising emotion are detrimental to teacher, which includes even more fierce emotional expression and lower satisfaction on interpersonal relationship (Rivers et al., 2007). The downward working satisfaction and happiness are particularly eye-catching, causing worse occupational burnout (Chang, 2009; Lechuga, 2012).

What we lose in hake we shall have in herring. In addition, the study finds that students in lower power rank develop their social regulatory strategy, such as enhancing interaction with teacher, which is also helpful for the development of children social ability. Additionally, moderate emotional expression from teacher works for establishing positive teacher-student relation and the cognitive development of students (Oplatka, 2011). In conclusion, teacher is encouraged to break the dilemma of "being the true self" and "faking themselves" (Li, 2018) from a perspective of effective teaching. The negative emotional expression may reinforce power relationship in class, and stimulate the power stratification within students. However, the cutting out natural and reasonable emotional expression of teacher is not a necessity. Offering scientific instruction on how to regulate power relationship within class and targeted intervention on children in different power rankings will be a more humanistic and effective way.

A class is the basic teaching unit in school, the daily context where teacher teaches and students study. Class could be regarded as a special social group, and the specialty lies in power classification and the transfer of its members will influence the realization of educational purpose in class activities. Children are in the critical development phase to accumulate social knowledge and master social skills, especially in preschool phase. The study takes internal power relationship in kindergarten class as a point to analyze how teachers' emotion affect children's social behavior. This study develops an in-depth understanding on the need of a class, contributes to the new break point in development of preschool profession, and better realization of educational aims.

IMPLICATIONS FOR RESEARCH DIRECTIONS

The research finding inspires future research to highlight the influence of contextual factors when exploring the forming mechanisms of children's leadership and power relations in classes.

As Chen (2021) mentioned in the synthesis research, 3–5 year-old children's leadership are considered to be partly attributable to the contextual factors, such as group dynamics. Inspired by existing literature and field observation, this study clarifies how teachers' emotional expressions and teacher-children power relations influence children's directing actions and social behaviors. To further expand the understanding of children's leadership, the influence of more micro and contextual factors, especially children's gender, and their functional mechanism should be explored in the future. In addition, both emotional expressions and power stratification in classes affected by social and cultural background to a certain extent (e.g., Wong, 2016; Ip et al., 2021), so it remains to be answered whether the research findings are still tenable after leaving the China's educational and cultural soil. It is worthy for researchers to conduct further research, and this may become a breakthrough for understanding specific educational phenomena from a cross-cultural perspective.

Teacher-student relationship and their interactions are dominant topics in education field, which is regarded as an important entry point to study children's cognitive, social, and emotional development (Meškauskienė, 2017; Wang, 2020; etc.). This study emphasizes the influence of teachers' emotional expressions on preschool children's social behaviors, and inspires future studies to focus on more profound and distal outcomes. As

mentioned in by a teacher interviewed in this study, for example, the children of lower ranking can take the initiative to interact with teachers to compensate for their scarce interactions with peers, and as a result they get more targeted guidance from the teacher. Besides, based on the teacher's observation, these children are likely to have a more positive cognitive development than other children. Surely, more subsequent empirical studies are needed to verify the hypothesized relation between children's power ranking and their cognitive development.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Peking University. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

ML conducted the participant observation and teacher interviews in the field Kindergarten, and through the field work, put forward the major idea of this study. QW directed ML in the entire conceptual framing and writing logic, and contributed to writing and editing this manuscript. Both authors contributed to the article and approved the submitted version.

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Effects of Teacher Enthusiasm and Type of Text on the Motivation and Achievement of Schoolchildren

Alberto Valentín, Pedro M. Mateos, Maria Mar González-Tablas and Estrella López*

Faculty of Psychology, University of Salamanca, Salamanca, Spain

This study aims to analyze the effects of teacher enthusiasm and type of text on student motivation and achievement. The participants were 369 elementary school students. We used four videos showing a teacher presenting two texts (narrative or descriptive) in two conditions of enthusiasm (high or neutral). A MANOVA revealed additive effects due to enthusiasm and text type on motivation and achievement, but no interaction. Mediation analyzes indicated that enthusiasm showed direct and indirect effects through motivation only for descriptive text. Therefore, the motivational mediation between teacher enthusiasm and student achievement could be especially important when the text is descriptive.

Keywords: teacher enthusiasm, type of text, intrinsic motivation, achievement, schoolchildren

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****Correspondence:***
Alberto Valentín
avc@usal.es

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INTRODUCTION

As education researchers, we have often asked ourselves why the comprehension or the memory of a movie, story, or theater performance is much stronger and more durable than the experience of attending a class. This may be attributable to, among other reasons, the structure of the information presented or the degree of enthusiasm with which the information is transmitted.

In the educational field, there is no commonly shared definition of teaching enthusiasm (Kunter et al., 2011; Keller et al., 2016). However, there is greater agreement that there are at least two ways to measure teacher enthusiasm (Keller et al., 2016). The first focuses on experienced enthusiasm, measured *via* the subjective feelings of the teacher (Taxer and Frenzel, 2018). The second focuses on displayed enthusiasm, measured through the observable behaviors of the teacher during the presentation of a class (Keller et al., 2014). Here, the enthusiasm displayed by the teacher can be considered their personal style of presenting information. That is, it constitutes the particular expressiveness with which the teacher transmits the educational contents. The displayed enthusiasm is usually operationalized according to Collins guidelines (Collins, 1978): fundamentally, through indicators of non-verbal behavior, such as voice intonation, facial expressions, etc.

Some empirical studies have tried to link the enthusiasm expressed by the teacher with the quality of the teaching they provide or with the students' results (for a review of these studies, see Keller et al. (2016)). With regard to student outcomes, past research has analyzed the effects of enthusiasm on both motivation and achievement. It has consistently been shown that teacher enthusiasm has a positive effect on student motivation, defined as intrinsic motivation (Patrick et al., 2000; Frenzel et al., 2010; Keller et al., 2014; Lazarides et al., 2019), or enjoyment (Frenzel et al., 2009, 2018; Kunter et al., 2013). However, the effects of teacher enthusiasm on student achievement have not been similarly demonstrated by past research. Most studies (Bettencourt et al., 1983; Burts et al., 1985) have not found a relationship between teacher enthusiasm and student grades. Thus,

Kunter et al. (2013) corroborated the effect of enthusiasm on motivation but found only some indirect effects on achievement. Hence, the relationship between teacher enthusiasm and student achievement is far from being a simple relationship.

The general theoretical framework guiding previous research on student enthusiasm and motivation has been social-cognitive learning theory (Bandura, 2001). According to this framework, the teacher acts as a model transmitting emotions and values to their students regarding the learning tasks (Frenzel et al., 2009). This is the main idea of the control-value theory of achievement emotions (Pekrun, 2006) by hypothesizing that teacher enthusiasm could generate positive emotions in the student about the subject and teaching. At the same time, teachers' enthusiasm could reduce negative emotions, such as students' class-related boredom, as shown in a series of studies by Cui et al. (2017, 2020, 2021).

There is, however, no clear theoretical framework to explain the direct influence of enthusiasm on performance. At the empirical level, the indirect influence of enthusiasm on achievement has been analyzed through variables such as the increase in student attention (Moè et al., 2021). An alternative that has been less explored in research is the analysis of contextual variables that might explain some conditions under which enthusiasm affects achievement.

Concerning this line of investigation, the precise relationship between teacher enthusiasm and student achievement could depend on other important variables in the educational environment. Enthusiasm could interact both with context variables (family, educational center, etc.) and with the characteristics of the study material. Concerning these characteristics, one that has proved to be important is the structure of the study material itself. There are a large number of different types of text but they can be reduced to a more parsimonious distinction between descriptive and narrative texts (Grabe, 2002), each with its own structure of discourse.

Narrative texts use chronological order as primary form of discourse organization (beginning, development, and end). This type of discourse helps the organization of knowledge and supports student progress in understanding the context through the reality reflected in its contents (Kintsch and Young, 1984). In contrast, descriptive texts use a wide variety of discourse organizers including, among others, the enumeration of the characteristics of a person or thing, cause/effect relationships, the presentation of a problem and its solution, and the comparison or contrast between alternatives. Therefore, the descriptive structure provides the information in its entirety, in addition to conveying ideas with accuracy. However, understanding a descriptive text requires prior knowledge (Larrañaga and Yubero, 2015; López and Fernández, 2016). Thus, we can speak of narrative texts and descriptive texts as a function of the type of structure prevailing within them. Furthermore, descriptive and narrative texts differ from each other in their objectives of informing and entertaining, respectively. In short, the first highlights "what is happening," while the second highlights "how it is happening."

These structural differences between narrative and descriptive text could have a special impact on comprehension or recall of information and, ultimately, on student achievement (Van Dijk, 1977; Graesser et al., 1994; Álvarez-Angulo, 1996; López-Escribano et al., 2013). Thus, the use of logical connectors in the language presented, such as "In this way," "First of all," etc., facilitates the understanding of descriptive-expository text (Graesser and Goodman, 1985; Sánchez and García, 2009), while the logic of the sequencing of narrated events facilitates the understanding of narrative texts. This narrative logic helps one to fill in the gaps that appear in the different sequences of the narrative and to make inferences about the representation of those events (Gárate, 1994).

One possible advantage of narrative texts is that they usually entertain, or are designed to entertain (Ministerio de Educación, Cultura y Deporte, 2013, 2017). That is, narrative texts aimed at children seem to generate enjoyment or motivation (Brewer and Lichtenstein, 1982). In this way, these texts can produce an additional, affective representation of the events, making them more memorable (Gernsbacher et al., 1992). Indeed, a narrative text is memorable if it manages to entertain (Dudukovic et al., 2004). Thus, narrative texts might increase both motivation and achievement (Pham and Sánchez, 2019) in schoolchildren.

Since both teacher enthusiasm and type of text seem to affect student motivation and achievement, it is possible that the two variables could combine their effects. To our knowledge, only Moè (2016) has considered the joint effect of these two variables; however, this study does not present statistical data on the interaction. Thus, the possible interaction between enthusiasm and text type remains unclear. The present study aims to explicitly analyze such an interaction. We consider that the effects of teacher enthusiasm on achievement could be more pronounced in narrative texts than in descriptive texts. That is, teacher enthusiasm could adapt well to the structure of a narrative text. Since the comprehension of a narrative text depends mainly on the continuity of its argument, the teacher's enthusiasm could highlight this. Conversely, we believe that teacher enthusiasm is less suited to descriptive texts. Understanding descriptive texts relies mainly on the use of logical connectors in the language, hence teacher enthusiasm could have a lower impact.

In sum, the aim of this paper is to analyze the effects of teacher enthusiasm and text type on student motivation and achievement. Specifically, our hypotheses are: (a) the high-enthusiasm condition will have a more beneficial effect on intrinsic motivation and achievement than the neutral enthusiasm condition; (b) the narrative text will have a more beneficial effect on intrinsic motivation and achievement than the descriptive text; and (c) we expect the beneficial effect of high teacher enthusiasm on intrinsic motivation and achievement to be more pronounced for the narrative text than for the descriptive text.

MATERIALS AND METHODS

Design

Our research used an analytical, prospective, cross-sectional, and mixed factorial design, in which the enthusiasm displayed by the teacher was the between factor, and the type of text used was the within factor. Displayed enthusiasm was operationalized in two categories: high enthusiasm and neutral enthusiasm. Low enthusiasm was not incorporated into the design because, in

daily teaching practice, it is not a condition opposite to high enthusiasm. For its part, type of text was operationalized into two categories (narrative and descriptive), chosen for being the most used textual modalities in teaching practice.

Participants

The participants were 369 children, of whom 185 were males, aged between 9 and 12 years (M = 10.94, SD = 0.80). The children came from 32 primary education centers: public (68.9%), subsidized (21.8%), and private (9.3%). These centers were located in the autonomous communities of Castilla y León and Extremadura (Spain). The number of children from each center ranged from a minimum of 8 to a maximum of 26.

Instruments

Description of the Independent Variables

We selected two texts representing the narrative and descriptive modalities. As a narrative text, the story "The Lion and the Puppy" by León Tolstoy was selected, taken from The Best Stories for Children, and translated from Russian by Bibicharifa Jakimzianova and Jorge Saura (2015). The descriptive text selected was "Bees," taken from Hum Sweet Hum (OECD, 2009). A more detailed description of the texts used can be found in **Appendix**.

We made a total of 16 video recordings that showed the same teacher reading the narrative text or the descriptive text. For half of the recordings of each type of text, the teacher showed high enthusiasm, and for the other half she showed neutral enthusiasm. We selected, by agreement among judges (five expert researchers in emotional expression), the four recordings in which the teacher best reflected these levels of enthusiasm. The judgments for both levels of enthusiasm were made on the basis of the displayed enthusiasm criteria described by Collins (1978) and Murray (1983): intonation, expressivity of the eyes, gesticulation, body mobility, facial expression, and dynamism. The videos selected in this way operationally define our conditions of high and neutral enthusiasm.

We controlled several indicators of both the texts and their recordings. As regards the texts, they were similar in terms of length after eliminating articles, prepositions, conjunctions, adverbs, and repeated words. There were 106 words in the descriptive text and 121 words in the narrative text. In addition, according to the indexes collected in LexEsp (Sebastián et al., 2000), the two texts were similar in terms of the frequency of word usage [$t(205) = -0.23$, $p > 0.819$]. Other lexical indices revealed that the words in the narrative text presented greater familiarity [$t(213) = 3.82$, $p < 0.001$], concreteness [$t(216) = 3.67$, $p < 0.001$], and imaginativeness [$t(218) = 4.09$, $p < 0.001$] than the words in the descriptive text. The recordings of the descriptive text last for 2.51 min (high enthusiasm) and 2.45 min (neutral enthusiasm), whereas the narrative text has a duration of 2.49 min in both enthusiasm conditions.

Measurement of Dependent Variables

We measured intrinsic motivation using four questions related to the following dimensions: enjoyment, interest, pleasure, and curiosity. We constructed the questions from the wording used by Moè (2016). A 5-point Likert-type scale was used. The total score on intrinsic motivation was obtained from the average of the scores on the four questions.

In addition, we consider the estimated duration of the recording as an indirect indicator of intrinsic motivation insofar as a time estimation less than the actual time would reflect less boredom and/or greater intrinsic motivation. As such, we asked the participants to judge the time duration of each presentation using a Visual Analog Scale (0–5 min). In order to compare the time estimates attributed to each type of text, we transformed all of the scores into a single scale.

We measured achievement in terms of reading competencies (strategies and skills), as defined in the PISA Evaluation Report (2007) (OCDE/MEC, 2007). So, for each text, we evaluated: broad understanding (identifying the main idea of the text), retrieval (locating one or more fragments of information), induction (the ability to make inferences), and interpretation (the ability to extract explicit information from the text). Furthermore, we add an item to evaluate free recall (unassisted retrieval of words). A description of the items used to measure achievement, as well as how they are scored, can be found in **Appendix**. The score for each competency was transformed into a ratio scale. The overall achievement score was the sum of these ratio scales (with a range from 0 to 5).

To confirm the effectiveness of the teacher enthusiasm manipulation, we included a question in which the participants were asked about the degree of enthusiasm they perceived in the teacher. The response scale ranged from 0 to 5. The response of the participants constitutes our measure of the perceived enthusiasm variable.

Procedure

A total of 32 primary education centers agreed to collaborate in the study. Prior informed consent of the parents was required in order for students to participate. In each center, two groups were selected at random, with the only condition being that in each group there was the same number of boys as girls. The information was collected during school hours, in classrooms facilitated by the centers.

The participants were informed about the task, and instructions emphasized that they should pay close attention because they would later be asked questions related to the task. Each child saw two recordings: one for the descriptive text and one for the narrative text. The order in which the recordings were presented was randomized among the participants. In addition, a perceptual judgment distracting task was used to separate the two recordings. Half of the children saw the recordings in the high-enthusiasm condition and the other half saw the recordings in the neutral-enthusiasm condition.

RESULTS

Preliminary Analyses

The means and standard deviations of the main variables are shown in **Table 1**.

TABLE 1 | Descriptive data of the variables.

		Type of text						
		Narrative		Descriptive		Global		
Measures	**Enthusiasm**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	***N***
Intrinsic motivation	Neutral	2.89	1.04	2.30	0.88	2.59	0.80	183
	High	3.39	0.88	2.83	0.88	3.11	0.71	186
	Total	3.14	1.00	2.57	0.91	2.85	0.80	369
Estimated time	Neutral	2.98	1.19	3.36	1.14	3.20	0.96	183
	High	2.31	1.03	2.81	0.94	2.55	0.79	186
	Total	2.64	1.16	3.08	1.08	2.87	0.93	369
Achievement	Neutral	1.55	0.93	1.31	1.01	1.42	0.82	183
	High	2.07	0.96	1.88	1.03	1.99	0.90	186
	Total	1.81	0.98	1.60	1.06	1.71	0.91	369

We conducted a reliability analysis of the indicators of intrinsic motivation (Cronbach's alpha = 0.85) and achievement (Cronbach's alpha = 0.72), with both measures showing good internal consistency. In addition, to check the effectiveness of the enthusiasm manipulation we carried out a *t*-test for the means difference on the perceived enthusiasm variable (t = 15.39, df = 357.58, $p < 0.001$). The result confirms that the high enthusiasm group (M = 3.51, SD = 0.72) perceived greater enthusiasm in the teacher's presentation than the neutral enthusiasm group (M = 2.26, SD = 0.84).

Data Analysis

To test our hypothesis, a 2 × 2 multivariate analysis was carried out, with a within factor (type of text) and a between factor (teacher enthusiasm), using intrinsic motivation, estimated time, and achievement as dependent variables. The multivariate tests were significant for both teacher enthusiasm $F(3, 365) = 31.75$, $p < 0.001$, partial $\eta^2 = 0.21$, and type of text $F(3, 365) = 46.44$, $p < 0.001$, partial $\eta^2 = 0.28$. No significant interaction effects were found, $F(3, 365) = 0.40$, $p > 0.756$, partial $\eta^2 = 0.003$.

When we analyzed the effect of enthusiasm on the direct measure of intrinsic motivation (**Figure 1A**), the result was significant, $F(1, 367) = 42.48$, $p < 0.001$, partial $\eta^2 = 0.10$. Scores were higher in the high enthusiasm group than the neutral enthusiasm group. Additionally, in respect of intrinsic motivation scale scores, type of text effects were found, $F(1, 367) = 108.95$, $p < 0.001$, partial $\eta^2 = 0.23$. The narrative text scores were higher than the descriptive text scores. There were no interaction effects.

In analyzing estimated time (**Figure 1B**) as an indirect measure of intrinsic motivation, effects were found due to teacher enthusiasm, $F(1, 367) = 44.68$, $p < 0.001$, partial $\eta^2 = 0.11$. The estimated time was less in the high enthusiasm group than in the neutral enthusiasm group. In addition, effects due to type of text were found, $F(1, 367) = 44.37$, $p < 0.001$, partial $\eta^2 = 0.11$. The estimated time scores were lower for narrative text than those for the descriptive text. No interaction effects were found.

Finally, in analyzing the measure of achievement (**Figure 2**), we found that the enthusiasm effects were significant $F(1, 367) = 37.86$, $p < 0.001$, partial $\eta^2 = 0.09$. The achievement scores were higher in the high-enthusiasm group than in the neutral enthusiasm group. In addition, effects due to type of text were found, $F(1, 367) = 17.80$, $p < 0.001$, partial $\eta^2 = 0.05$. The achievement scores were higher for the narrative text than the descriptive text. There were no interaction effects.

Mediational Analysis

We carried out further analyses, in addition to those directly related to the hypotheses, in order to check for possible mediating effects between our study variables, using the PROCESS macro (version 2.15) for SPSS (model 4) (Hayes, 2017). We tested three multiple mediation models, in which the independent variable was teaching enthusiasm (X), the dependent variable was achievement (Y), and the mediating variables were intrinsic motivation (M1) and estimated time (M2). In the first model we used the global scores for these variables, while in the second and third models we used the scores relative to the descriptive and narrative texts, respectively.

In the first model (**Figure 3**), the results showed statistically significant total effects for teacher enthusiasm on student achievement (c). Similarly, the direct effects of teacher enthusiasm on intrinsic motivation (a1), on estimated time (a2), and on achievement (c′) were significant. The direct effect of intrinsic motivation on achievement was also significant (b1). However, the direct effect of estimated time on achievement was not significant (b2). Regarding the indirect effects of teacher enthusiasm on student achievement, the mediation of intrinsic motivation (a1b1) was significant, but not the mediation of estimated time (a2b2).

In the second model (**Figure 4A**), we obtained results similar to those found in the first model, that is, significant direct (a1, a2, b1, and c′) and indirect (a1b1) effects. However, in the third model (**Figure 4B**), only the direct effects of enthusiasm on intrinsic motivation (a1), on estimated time (a2), and on achievement (c′), were significant. Thus, in this model, we do not find intrinsic motivation mediating effects on achievement.

DISCUSSION

Research on the effects of teacher enthusiasm on student outcomes has a long tradition. This research has consistently shown that teacher enthusiasm affects motivation, although its effects on achievement have been less clear. One way to clarify the effects of enthusiasm on achievement is to consider enthusiasm jointly with other educational context variables. In the present study, we choose a variable that we consider particularly relevant: the type of text used by the teacher.

Consistent with the results obtained in the literature (Patrick et al., 2000; Frenzel et al., 2009, 2010, 2018; Kunter et al., 2013; Keller et al., 2014; Lazarides et al., 2019), our results confirm the effect of teacher enthusiasm on the intrinsic motivation of the student. Thus, when the teacher speaks with enthusiasm, the students show greater interest in the text and the presentation time seems shorter.

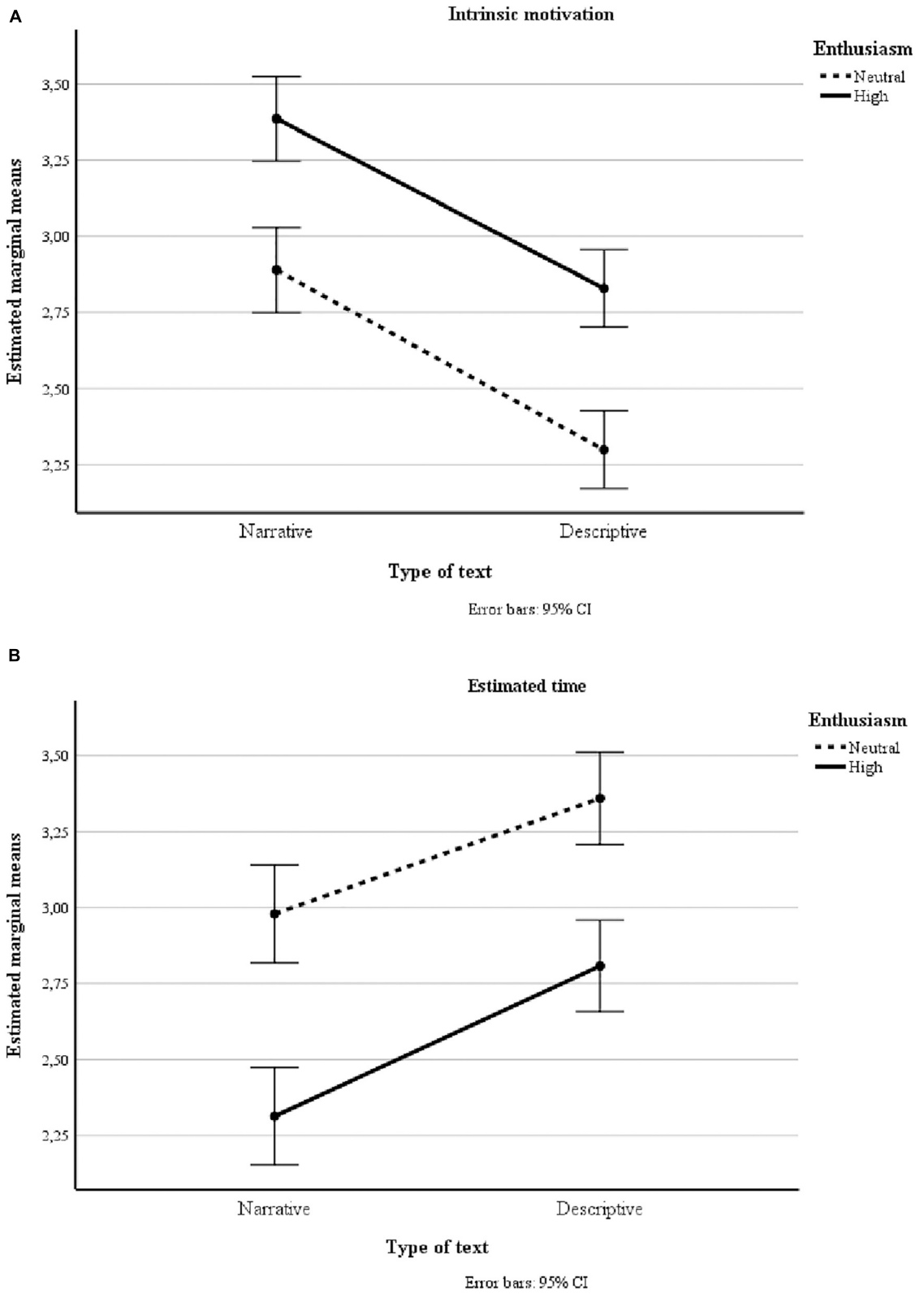

FIGURE 1 | Estimated marginal means for intrinsic motivation **(A)** and estimated time **(B)** by teacher enthusiasm and type of text.

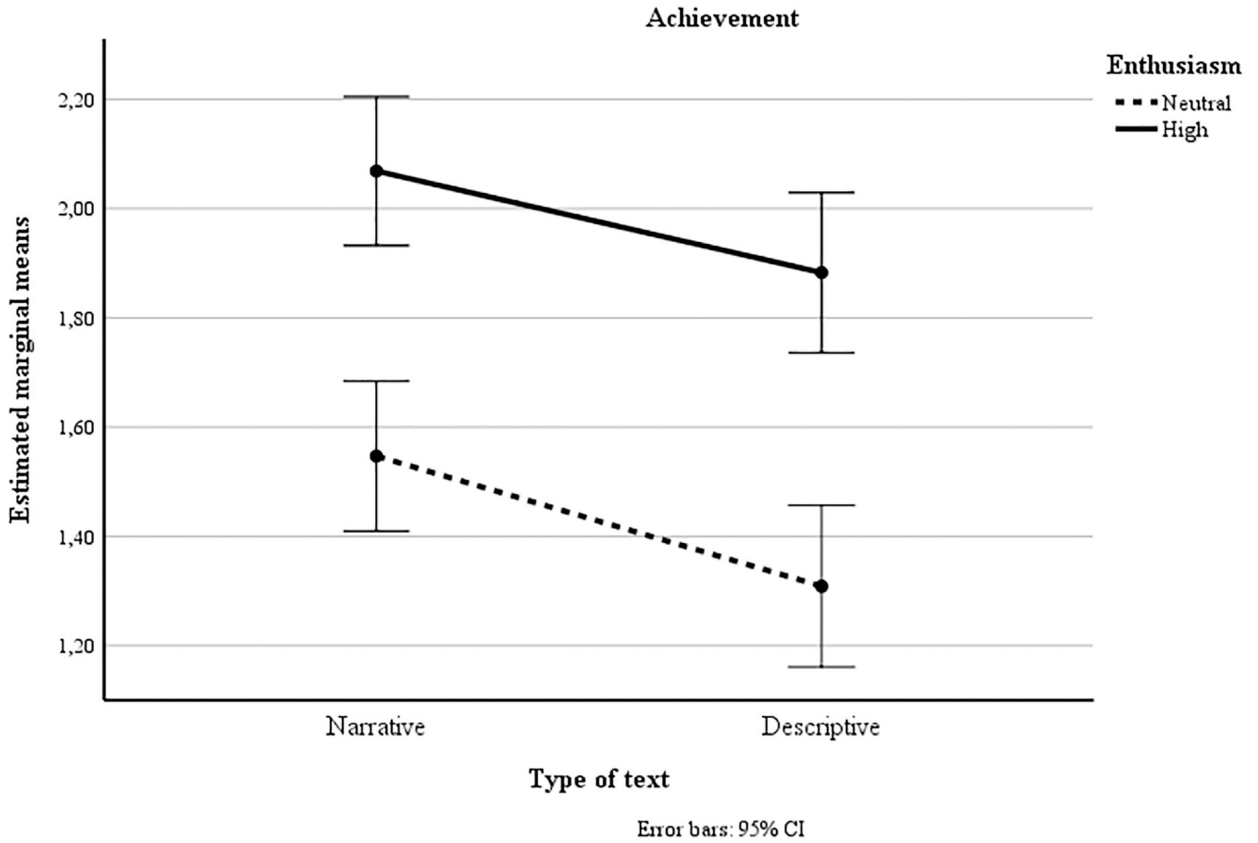

FIGURE 2 | Estimated marginal means for achievement, by teacher enthusiasm and type of text.

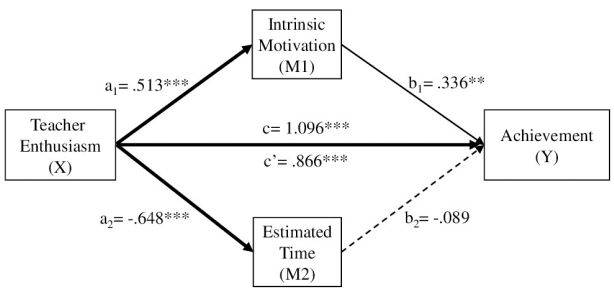

FIGURE 3 | Analysis of mediation through intrinsic motivation and estimated time as a function of teacher enthusiasm over achievement. a_1, a_2, b_1, b_2, c' = path coefficient (unstandardized coefficient). *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$. Direct effects B = 0.866, SE = 0.194, $t = 4.475$, $p < 0.0000$, 95% CI [0.485, 1.246]. Indirect effects B = 0.230, SE = 0.084, 95% CI [0.070, 0. 401]. Total effects B = 1.096, SE = 0.178, $t = 6.153$, $p < 0.0000$, 95% CI [0.746, 1.446].

Furthermore, we also found that teacher enthusiasm has beneficial effects on student achievement. This result is consistent with studies that have found an association between enthusiasm and achievement (Evertson et al., 1980; Kunter et al., 2013; Mahler et al., 2018). However, some experimental studies have failed to show that teacher enthusiasm has an effect on student achievement. These failures have led some researchers (Motz et al., 2017) to conclude that teacher enthusiasm influences student motivation, but not student achievement.

The fact that we have obtained results that differ from those of other researchers could be attributed to a bad manipulation of enthusiasm and/or an inadequate achievement measurement on our part. However, we do not believe that this was the case. On the one hand, our enthusiasm manipulation was effective. That is, the students unequivocally perceived when the teacher was expressing herself enthusiastically. In addition, to measure achievement we used the PISA Report evaluation criteria (OCDE/MEC, 2007). That is, we used an institutionally standardized procedure to measure achievement.

This discrepancy between our results and those of other researchers could be attributed to the age of the participants in our study. It is possible that enthusiasm expressed by the teacher influences learning/achievement only at the primary education stage. Perhaps the supposed effect of *emotional contagion* from the teacher (Mahler et al., 2018) only translates into greater achievement in the case of primary-age children. Like us, other authors have found effects from teacher enthusiasm on achievement in samples of primary-age children (Moè, 2016). However, contrary to this argument, McKinney and colleagues, in a wide range of studies with children of different ages (Larkins and McKinney, 1982; McKinney et al., 1984; Burts et al., 1985) found no differences attributable to age.

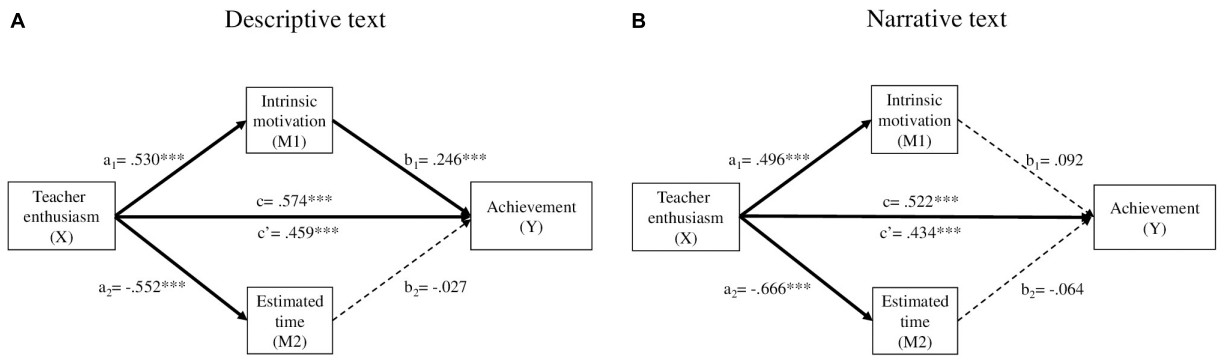

FIGURE 4 | Analysis of mediation through intrinsic motivation and estimated time as a function of teacher enthusiasm over achievement: descriptive text model **(A)** and narrative text model **(B)**. a_1, a_2, b_1, b_2, c' = path coefficient (unstandardized coefficient). $^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$. **(A)** Descriptive text: Direct effects B = 0.459, SE = 0.111, $t = 4.151$, $p \leq 0.000$, 95% CI [0.242, 0.676]. Indirect effects B = 0.115, SE = 0.043, 95% CI [0.035, 0.204]. Total effects B = 0.574, SE = 0.106, $t = 5.418$, $p \leq 0.000$, 95% CI [0.366, 0.782]. **(B)** Narrative text: Direct effects B = 0.434, SE = 0.104, $t = 4.164$, $p \leq 0.000$, 95% CI [0.229, 0.638]. Indirect effects B = 0.088, SE = 0.036, 95% CI [0.022, 0.163]. Total effects B = 0.522, SE = 0.098, $t = 5.303$, $p \leq 0.000$, 95% CI [0.328, 0.715].

With regard to the type of text, we found that it affects the intrinsic motivation of the student. The narrative texts generated more intrinsic motivation than the descriptive texts, both in terms of interest and estimated time. This result was expected since narrative texts, unlike descriptive texts, are usually constructed to entertain. The narrative text that we used in this research is intended to entertain, as it is a fictitious narrative text, more than an informative narrative text (Dudukovic et al., 2004; Ministerio de Educación, Cultura y Deporte, 2013, 2017).

Similarly, we found that the type of text affects student achievement. The children obtained higher achievement on the narrative text than on the descriptive text. This may be because narrative texts, unlike descriptive texts, can add additional emotional representation to the content, making it more memorable (Gernsbacher et al., 1992; Dudukovic et al., 2004). This is in accordance with the fact that, as we point out above, the narrative text generated more motivation than the descriptive one. The superiority of the narrative text could also be due to the structure of this type of text. In this regard, the chronological presentation of events, typical of the narrative structure, might be more understandable for schoolchildren than a presentation supported by logical connectors, typical of the descriptive structure. Finally, narrative texts do not require the prior knowledge that is required for descriptive texts (Larrañaga and Yubero, 2015; López and Fernández, 2016), and this could also have contributed to the participants' higher achievement on the narrative text.

Beyond the described effects of each variable, a central objective of our research was to analyze whether enthusiasm interacts with text type in its effects on student outcomes. With regard to achievement, contrary to our hypothesis, we were unable to confirm interaction between the degree of enthusiasm and type of text. In other words, we did not confirm that the beneficial effect of teacher enthusiasm on achievement was more pronounced in relation to narrative text than it was in relation to descriptive text. Our results suggest that both the adaptation of study material to narrative-type structures and the enthusiasm of the teacher's presentation positively but independently affect the achievement of primary school students.

As regards motivation, we were also unable to confirm our hypothesis of an interaction between enthusiasm and type of text. That is, high motivation caused by high teacher enthusiasm was not more pronounced for the narrative text than for the descriptive one. This result was similar for the two intrinsic motivation indicators that we used: the scale of intrinsic motivation and the estimation of the time duration for each type of text. In short, we have not been able to clarify the type of text for which teacher enthusiasm exerts the most beneficial effect on student outcomes. In the present study, enthusiasm and the type of text jointly effect achievement and motivation.

The influence of teacher enthusiasm on both motivation and achievement, found in this study, leaves open the possibility that motivation acts as a mediating variable between teacher enthusiasm and student achievement. The mediation between these variables would seem to be implicit in how many educators understand the educational process. In this regard, the specialized literature suggests that one of the mechanisms by which enthusiasm influences academic achievement is precisely by fostering student motivation (Babad, 2007; Keller et al., 2013). Consequently, many authors have expressly stressed the need to empirically prove such influence (Kunter et al., 2011; Keller et al., 2016). However, some researchers claim to have shown that enthusiasm affects motivation but not achievement (Motz et al., 2017), leading them to question the mediating role of motivation. In the present research, we have attempted to demonstrate empirically, through a mediational analysis, both the direct and indirect effects of enthusiasm on achievement.

This mediational analysis provides support for the mediating role of motivation between teacher enthusiasm and student achievement. Our results suggest that when the teacher acts enthusiastically, it promotes intrinsic motivation in students and this, in turn, boosts their achievement. At the same time, the teacher's enthusiasm makes the student's experience of time seem shorter. However, this other form of motivation does not produce higher student achievement. Estimated time duration, as an indirect measure of motivation, is probably too generic and too distal to predict achievement.

The sequence enthusiasm–motivation–achievement, suggested by the above analysis, becomes more complex when taking into consideration the type of text. When the text is descriptive, the enthusiastic teacher encourages the students' motivation, which, in turn, increases their achievement. When the text is narrative, the enthusiastic teacher also encourages the student's motivation toward that text, but this motivation does not increase achievement. Therefore, motivation acts as a mediator only when the text is descriptive. That is, the characteristics of each type of text determine the mediating role of motivation. Paradoxically, narrative texts are the ones designed to entertain and, indeed, in this study the narrative text generated more intrinsic motivation than the descriptive one. Thus, the lower motivation that is associated with the descriptive text, compared to that associated with the narrative text, turns out to have a greater explanatory power in student achievement.

In conclusion, the relationship between enthusiasm–motivation–achievement suggested by our results reveals high complexity. Motivation may have more impact on achievement in less intrinsically motivating subjects. That is, teacher enthusiasm could maximize its effect on achievement when said enthusiasm is able to increase students' interest in contents that are intrinsically less attractive.

Finally, it should be noted that we have used two different texts to operationalize the text type variable. Given the close relationship between the content of the text and its structure, it is difficult to determine the contribution of each in the effects that we have found. Future research should explore whether teacher enthusiasm might interact with textual modality when using a single text produced in two versions: one narrative and one descriptive. Similarly, it would be interesting to confirm whether our results might be generalizable among students of other ages.

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 Comité de Bioética from the University of Salamanca. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

AV: conceptualization, project administration, funding acquisition, investigation, and writing – original draft, review, and editing. PM: conceptualization, writing – review and editing, and investigation. EL: conceptualization, visualization, and resources. MG-T: conceptualization, methodology, formal analysis, and writing – original draft. All authors contributed to the article and approved the submitted version.

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APPENDIX

Achievement assessment

Two texts and a set of questions were used to measure achievement.

Texts

We used a descriptive text and a narrative text. The selected descriptive text is one of the texts used by PISA to assess the reading literacy of students. It is a descriptive-explanatory text called "Bees" (see https://www.oecd.org/pisa/pisaproducts/Take%20the%20test%20e%20book.pdf; pp. 56–57). Specifically, we use the adaptation of this text made for its application to Spanish schoolchildren. Regarding the narrative text, we reject the text proposed by PISA (the story by León Tolstoy "A just judge"), as it is longer and more complex than the descriptive text "Bees." We selected instead a story, also by Leon Tolstoy, entitled "The Lion and the Puppy." This story is a narrative text of similar length and complexity to the descriptive text. The English-speaking reader can find several editions of this story. For example, "The lion and the puppy: and other stories for children" (https://cmc.marmot.org/Hoopla/MWT12358619).

Questions

We evaluated the achievement of the students by means of five questions relating to each of the texts. For the descriptive text, four of these questions correspond to those used as sample questions in the PISA tests (see https://www.oecd.org/pisa/pisaproducts/Take%20the%20test%20e%20book.pdf; p. 57). We also used the scoring criteria of the PISA tests to evaluate the answers to these questions (see pp. 94–96). For the narrative text, we developed four original questions. These questions were designed to be comparable to those of the descriptive text in terms of the cognitive aspects assessed, the formats, and the order of item presentation. An English translation of the questions used for the narrative text is presented below.

Question 1

What is the purpose of providing dogs and cats to zoo animals?

A. To feed the wild animals.

B. To make friends with the wild animals.

C. To keep the dogs and cats until their owner comes to pick them up.

D. To go inside to see the wild animals.

Score 1: Choice D.

Score 0: Other options.

To answer this question correctly, students had to identify the main idea of the text.

Question 2

List three actions by the lion when the puppy turned on its back and started wagging its tail.

1. _____
2. _____
3. _____

Score 1: Three of the following actions in any order: "The lion touched him with his claw"; "The lion examined him"; "The lion moved his head"; "The lion did not hurt him"; "The lion walked away."

Score 0: Other actions.

To answer this question correctly students had to find one or more fragments of information.

Question 3

What is the main difference between the first puppy and the second one?

A. The second puppy was eaten by the lion.

B. The first puppy was eaten by the lion.

C. The first puppy died of grief.

D. The second puppy got sick.

Score 1: Choice A.

Score 0: Other options.

To answer this question correctly students had to make inferences.

Question 4

¿Why did the lion become sad, sniff the puppy and lick it?

_____
_____
_____

Score 2: Answers that indicate both the friendship between the puppy and the lion and the lion's grief. For example: "Because the puppy was his friend and he was sorry that the puppy died."

Score 1: Answers that mention only one of the options. For example: "Because the puppy was his friend" or "Because he was sorry that the puppy died."

Score 0: Irrelevant, inaccurate, incomplete, or vague responses. For example: "Because he was hungry," "Because he wanted to play," etc.

To answer this question correctly, students had to extract explicit information from the text.

To complete the evaluation of student achievement, we developed the following free recall question. This fifth question was applied to both texts.

Question 5

Write down everything you remember from the text. Please be as accurate as possible. If you are able to write the same words as you have heard, then that is even better.

_____
_____
_____
_____
_____
_____
_____
_____
_____

Scoring: for the free recall score, we use the ratio of the number of valid recovered words to the total number of valid words in each text. We rate as valid words: nouns, adjectives, verbs, and numerical expressions. We do not rate: repetitions, variations of the noun (male/female, singular/plural), verb forms, and grammatical determiners such as pronouns, articles, etc.

To answer this question correctly the students had to recall the information without clues.

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The Impact of Emotional Feedback and Elaborated Feedback of a Pedagogical Agent on Multimedia Learning

Yueru Lang[1,2], *Ke Xie*[1,3], *Shaoying Gong*[1,2]*, *Yanqing Wang*[1,2] *and Yang Cao*[1,2]

[1] School of Psychology, Central China Normal University, Wuhan, China, [2] Key Laboratory of Adolescent Cyberpsychology and Behavior (CCNU), Ministry of Education, Wuhan, China, [3] No. 4 Junior Middle School of Wuhan Optics Valley, Wuhan, China

This study aimed to explore the impact of emotional feedback and elaborated feedback provided by a pedagogical agent (PA) on learners' emotions, intrinsic motivation, agent perception, cognitive load, and transfer performance in multimedia learning. The experiment was conducted based on an actual undergraduate course. Undergraduate students (N = 117) were randomly assigned to one of the four conditions, where PA's feedback differed by emotional feedback (with vs. without) and elaborated feedback (elaborated feedback vs. knowledge of results). Results revealed that emotional feedback reduced learners' confusion, activated intrinsic motivation, and enhanced agent perception. In addition, elaborated feedback improved intrinsic motivation, agent perception, and transfer performance but reduced germane cognitive load. Surprisingly, there was no significant interaction between emotional feedback and elaborated feedback. These findings had implications for designing a PA with a feedback fulfilling learners' emotional and cognitive needs to maximize multimedia learning.

Keywords: emotional feedback, elaborated feedback, pedagogical agent, multimedia learning, learning processes, learning performance

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***Correspondence:**
Shaoying Gong
gongsy@ccnu.edu.cn

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INTRODUCTION

With the advance of educational technology, implementing a pedagogical agent (PA) to interact with learners in real time becomes a trend in computer-based learning environment. Providing feedback is an important function of PA, which keeps learners' motivation high and benefits performance (Dennis et al., 2015). Feedback can be classified by content into emotional feedback and cognitive feedback (Economides, 2005). Some studies have found the positive effects of emotional feedback provided by PA on emotions (Klein et al., 2002; Arroyo et al., 2011), learning motivation (Lin et al., 2014), agent perception (Woolf et al., 2010), but uncertain facilitation on cognitive processes or performance (Guo et al., 2014; Kim et al., 2017). Other studies indicated that elaborated feedback, one type of cognitive feedback, could promote academic achievement (Moreno, 2004; Lin et al., 2013; Law and Chen, 2016), while the impact on learning processes was ambiguous. The following questions need to be further solved: Can emotional feedback of PA have an impact on learning performance? What kind of cognitive feedback is more conducive to learning? Can PA incorporated with emotional feedback and elaborated feedback at the same time facilitate not only learning processes but also learning performance? On the basis of previous

studies, this study aims to explore the impact of emotional feedback and elaborated feedback provided by PA on learning processes and performance and investigates whether emotional feedback and elaborated feedback can produce a mutual effect on learning.

PA and Learning

Pedagogical agents are animated anthropomorphic characters employed in the digital learning environment to convey information and enhance motivation by simulating social interaction with learners (Kim et al., 2007; Castro-Alonso et al., 2021). There are two propositions of theories to explain how PA affects multimedia learning. One proposition was based on Social Presence Theory and Social Agency Theory. The other was based on the Interference Theory of Social Agency.

Both the Social Presence Theory and the Social Agency Theory posit that PA might be beneficial for learning processes and performance. According to Social Presence Theory, the social presence of a PA contributes to the level of intimacy that depends on factors such as smiling, dialogue, and eye contact. Therefore, learners tend to perceive the PA as a "real person" and have a more positive emotional experience, stronger learning willingness, and greater satisfaction, and then achieve better academic performance than those who do not study with PA (Gunawardena and Zittle, 1997). Another theoretical framework to explain the effect of PA on learning is Social Agency Theory. It supposes that social cues exhibited by PA make learners perceive a computer–human interaction as a human–human interaction, which primes the social interaction schema (Mayer et al., 2003; Atkinson et al., 2005). When learners interpret the learning environment as a social one, they might invest more mental efforts in processing information conveyed by PA, which in turn might improve transfer performance (Mayer and DaPra, 2012; Fiorella and Mayer, 2021).

However, the prediction of Interference Theory of Social Agency is different. It posits that PA, as a seductive detail, may hinder learners with retention and transfer performance of core materials because PA may occupy limited working-memory capacity at the selecting, organizing, or integrating stage (Paas et al., 2003; Lehman et al., 2007). Following this rationale, presenting a PA in a multimedia environment may be counterproductive.

Up to now, there is empirical evidence for Social Presence Theory and Social Agency Theory (Wang et al., 2020; Castro-Alonso and Sweller, 2021; Schneider et al., 2022). However, there is also some evidence for Interference Theory of Social Agency (Lin et al., 2020). Lin et al. (2013) and Lawson et al. (2021) pointed out that specific characteristics of agents, such as how to convey information, could affect the effectiveness of PA. Hereby, instead of generally discussing whether PA can promote learning, we should focus more on specific characteristics of PA. The necessity of a finer-grained analysis of PA's characteristics also has been suggested by Schroeder and Adesope (2014). This study investigated the effect of feedback, one of the internal PA's characteristics, on learning processes and performance.

PA's Emotional Feedback and Learning

Feedback is one of the most important elements of instructional guidance (Panadero and Lipnevich, 2022). When a test-like event is launched, learners are encouraged to generate an answer on the basis of prior knowledge and evaluate their own current performance. Feedback is a powerful tool to help learners evaluate their learning so as to bridge the gap between current performance and the target (Hattie and Timperley, 2007).

A study by Shute (2008) revealed that feedback could not only regulate motivation and emotions, but also supply personalized scaffolding through cognitive information. In this vein, PA's feedback can be classified by content into emotional feedback and cognitive feedback. Emotional feedback aims to ameliorate learners' emotional states (Terzis et al., 2012; Tung, 2013), which can support learners through conveying inspiration, entertainment, empathy, praise, criticism, and so on (Economides, 2005). Parallel empathy and reactive empathy are the two most important forms of emotional feedback. In parallel empathy, the PA identifies and reproduces learners' emotions. In reactive empathy, the PA helps learners to regulate emotional states after identifying their emotions (Burleson and Picard, 2007; Economides, 2009; Terzis et al., 2012).

Some researchers stressed that emotions are inherently interconnected with cognition. For example, Moreno and Mayer (2007) Cognitive Affective Theory of Learning with Media makes the case that the emotional interaction between learners and computers is a motivational factor, which influences the cognitive processing of multimedia information, including selection, organization, and integration. Plass and Kaplan (2016) later proposed the Integrated Cognitive Affective Model of Learning with the Multimedia (ICALM), which proposed that emotional processes are intertwined with, and inseparable from, cognitive processes. In cognitive-emotional processing of multimedia stimuli, emotional processes make demands on cognitive resources, and cognitive activities are affected by emotional factors to some extent. Given that PA's emotional feedback is a form of human–computer emotional interaction, it may affect not only emotional processes but also cognitive processing. In this vein, a study by Schneider et al. (2022) confirmed that a PA merely with facial expressions contributed to happy and successful learning, and emotional feedback to provide learners with support was more likely to improve emotions, motivation, and performance (Kim et al., 2007).

There is mounting evidence for PA's emotional feedback that facilitates learning processes. Emotional feedback can improve learning processes by triggering positive emotions, reducing negative emotions, enhancing motivation, and bringing better agent perception. For emotions, a PA with parallel empathy or reactive empathy reduced boredom and frustration among young adults (Hone, 2006; Arroyo et al., 2011). A similar result can be found in a study with children. In Burleson (2013) study, an effective PA with parallel and reactive empathy increased positive emotions alongside a decreased sense of stuck when children solved a Tower of Hanoi problem. Regarding motivation, PA with parallel empathy enhanced university students' motivation in course of academic

information seeking and course of accounting (Guo et al., 2014; Lin et al., 2014). Concerning agent perception, a study with high school students learning mathematics showed agent perception to be better when PA was featured with reactive-empathic behaviors as opposed to PA with neutral behaviors (Woolf et al., 2010). Terzidou et al. (2018) also found similar results among college students in educational virtual environment courses. For cognitive load, to our knowledge, previous studies have barely explored whether emotional feedback can affect cognitive load. Nevertheless, based on Social Presence Theory (Gunawardena and Zittle, 1997) and Social Agency Theory (Mayer and DaPra, 2012; Fiorella and Mayer, 2021), PA with emotional feedback can foster the social connection and create a human-to-human interaction atmosphere, which in turn encourages learners to invest more mental efforts in learning tasks.

In terms of learning performance, previous studies have not been able to convincingly determine whether PA with emotional feedback can promote learning achievement. Although Lin et al. (2014) and Shen (2009) have found that a PA featured with parallel and reactive empathy helped college students improve transfer performance in both accounting and mathematics, the majority of studies have revealed no significant impact on learning performance (Burleson and Picard, 2007; Kim et al., 2007, 2017; Arroyo et al., 2009; Guo et al., 2014; Terzidou et al., 2018). For instance, Kim et al. (2007) found that PA's parallel empathy did not promote pre-service teachers' retention or transfer performance in pre-service training. Guo and Goh (2016) also examined whether using an affective PA could facilitate learning. The affective PA was designed to show reactive empathy when learners get answers. The result revealed that students in affective PA condition did not perform better than those with neutral PA or No-PA in retention performance. Some researchers suggested two opposite possible reasons for these results: first, emotional feedback may not be sufficient to affect the cognition of complex learning because it does not involve supportive information for cognitive processing (Kim et al., 2007). Second, PA's emotional feedback may affect cognition, but the impact on cognitive processes is double-edged. On the one hand, emotional feedback can make the learning experience better and further expand working memory to help learners allocate cognitive resources. Learners are willing to invest more mental efforts in learning tasks (Frechette and Moreno, 2010; Plass and Kalyuga, 2019). On the other hand, emotional feedback may occupy cognitive resources, increase extraneous cognitive load, and distract attention (Li et al., 2013; Guo et al., 2014), then interfere with learning (Cabestrero et al., 2018). In order to better understand the impact of PA's emotional feedback on cognitive processing, cognitive load is necessary to be taken into consideration. Moreover, it is important to highlight that the manipulation check of emotional feedback has barely been addressed in previous studies. As a premise, the manipulation of PA's emotional feedback should be proved to be effective in this study, and then we will investigate whether emotional feedback can affect learning processes and performance.

PA's Elaborated Feedback and Learning

Cognitive feedback serves learners with cognitive-related information targeting to support comprehension, problem-solving, and the elimination of misconceptions (Economides, 2006; Kim et al., 2007; Narciss, 2008). Further, cognitive feedback can be classified by complexity into simple feedback and elaborated feedback (Shute, 2008). Simple feedback is defined as either merely verifying whether the answer is correct called knowledge of results (KR), or showing the correct answer called knowledge of correct response (Lin et al., 2013). Elaborated feedback can provide instructional information additionally including hints, problem-solving cues, supplementary materials, etc.

As a form of cognitive feedback, elaborated feedback contains problem-solving cues and error-correcting information for knowledge construction, and so might it be able to improve outcomes of high-order learning (Moreno, 2004; Moreno and Mayer, 2005; Lin et al., 2013; Law and Chen, 2016). For instance, Moreno (2004) found that learners in the elaborated feedback group performed better in retention and transfer tests than the KR group when learning plant discovery topics. Subsequent study by Lin et al. (2013) revealed that college learners in the elaborated feedback group outperformed their counterparts in the KR group when learning physics with a PA in a computer-based environment. A meta-analysis also demonstrated that elaborated feedback was more effective in boosting high-order learning than simple feedback (Van der Kleij et al., 2014).

Furthermore, elaborated feedback is closely related to learning processes. According to the Five-Stage Model of Computer-Based Formative Assessment, learners' emotions, motivation, or cognitive aspects can be adjusted by processing and self-evaluation based on feedback (Timmers et al., 2015). Some studies have provided empirical evidence for the facilitation of elaborated feedback on motivation, agent perception, and germane cognitive load, as well as a decline in extraneous cognitive load (Moreno, 2004; Xu, 2018; Wang et al., 2019). For example, Wang et al. (2019) found that more detailed feedback resulted in lower extraneous cognitive load, more positive feedback perception, higher germane cognitive load, and stronger intrinsic motivation in psychological statistics. Nevertheless, some studies showed no significance in learning processes between students who received elaborated feedback and those who received simple feedback. One such example is reported by Lin et al. (2013), in which KR and elaborated feedback groups showed similar motivation and cognitive load during the learning of thermodynamics materials among college students.

In sum, although elaborated feedback in most previous studies could improve performance, its effect on learning processes is still uncertain. In particular, the effect of elaborated feedback on emotions seems to be a black-box. According to the Control-Value Theory of Academic Emotions (Pekrun et al., 2007), as part of a pedagogical environment, PA's elaborated feedback is posited to be antecedents of emotions, then emotions are assumed to affect motivation, cognitive resources, and achievement. With that in mind, we developed a learning system and investigated whether elaborated feedback could affect learners' emotions,

motivation, agent perception, cognitive load, and learning performance in the psychological statistics course.

The Current Study

Previous studies have revealed that PA's emotional feedback may improve learning processes, but emotional feedback alone has little effect on learning performance due to the lack of necessary cognitive support (Arroyo et al., 2011; Guo et al., 2014). Considering directly related to cognitive processing, PA's elaborated feedback is beneficial for learning performance but has uncertain impact on emotions, motivation, or cognitive load. Since emotional feedback and elaborated feedback have their own superiorities, it is necessary to further investigate whether presenting these two forms of feedback simultaneously can promote both learning processes and performance.

In the present study, we go beyond previous work by considering a manipulation check of emotional feedback to make sure the emotional feedback design was reasonable and valid. Then, we explore the impact of PA's emotional feedback and elaborated feedback on undergraduate students' learning processes and performance. Specifically, the current study explores the following question: Can PA's emotional feedback and elaborated feedback affect learners' emotions, intrinsic motivation, agent perception, cognitive load, and transfer performance? Can emotional feedback and elaborated feedback interact to influence emotions, intrinsic motivation, agent perception, cognitive load, and transfer performance?

In line with Social Presence Theory (Gunawardena and Zittle, 1997) and Social Agency Theory (Mayer and DaPra, 2012; Fiorella and Mayer, 2021), PA with emotional feedback provides a social connection that fosters social interaction schema, which in turn results in more positive emotions, stronger learning motivation, more positive agent perception, and more mental efforts invested in learning tasks (Frechette and Moreno, 2010; Plass and Kalyuga, 2019). Since cognitive activities are affected by emotional factors (Plass and Kaplan, 2016), it is hypothesized that similar results will occur in this study and the emotional feedback can facilitate learning performance.

Hypothesis 1

Compared to learners studying with neutral PA (PA without emotional feedback), learners who are shown PA with emotional feedback have more positive emotions, less negative emotions (H1a), stronger intrinsic motivation (H1b), better agent perception (H1c), higher germane cognitive load (H1d), and better transfer performance (H1e).

Since several previous studies have proven the learning-beneficial effects of PA's elaborated feedback (Moreno, 2004; Lin et al., 2013; Van der Kleij et al., 2014), it is assumed that a similar result will occur in this study. According to the Five-Stage Model of Computer- Based Formative Assessment (Timmers et al., 2015) and Control-Value Theory of Academic Emotions (Pekrun et al., 2007), implementing a PA with elaborated feedback leads to an increase in positive emotions, motivation, learner's perception of agent, germane cognitive load, and decrease in extraneous cognitive load (Lin et al., 2013; Xu, 2018; Wang et al., 2019). Therefore, the following hypothesis is formulated:

Hypothesis 2

Compared to learners receiving the knowledge of results from PA, learners receiving elaborated feedback have more positive emotions, less negative emotions (H2a), stronger intrinsic motivation (H2b), better agent perception (H2c), higher germane cognitive load (H2d), and better transfer performance (H2e).

Until now, to our knowledge no study has simultaneously investigated the intertwining influence of PA's emotional feedback and elaborated feedback. From the above literature review, PA's emotional feedback benefits learning processes, and elaborated feedback facilitates learning performance. Based on ICALM, showing these two kinds of feedback should achieve better effects on both learning processes and results. For this, the present study looks at this supposed interaction exploratory:

Hypothesis 3

There are interaction effects of PA's emotional feedback and elaborated feedback in terms of emotions, intrinsic motivation, agent perception, cognitive load, and transfer performance. There is an advantage of PA with emotional feedback and elaborated feedback simultaneously over other conditions in all dependent variables (H3).

METHOD

This experiment investigated the impact of PA's emotional feedback (with vs. without) and elaborated feedback (elaborated feedback vs. KR) on learning, as determined by five measures: learners' emotions, intrinsic motivation, agent perception, cognitive load, and transfer performance.

Participants

Participants were 117 undergraduate students who had finished a psychological statistics course. The average age of the participants was 19.79 ($SD = 0.89$). Of these participants, 89 were females and 28 were males. Participants were randomly assigned to one of four conditions: PA with emotional and elaborated feedback, PA with emotional feedback and KR, neutral PA with elaborated feedback, and neutral PA with KR (cf. **Table 1**).

Design of PA and Feedback

The PA in this study was developed using MAYA, a 3D-animation-design tool. It was designed as a male teacher with pleasant, distressed, and neutral dynamic facial expression (cf. **Figure 1**). The PA could nod or shake his head.

Given that confusion, boredom, frustration, enjoyment, and satisfaction were the most common emotions during online learning (D'Mello and Graesser, 2012; D'Mello, 2013), PA provided emotional feedback according to one of these five emotions every time reported by learners. In PA with emotional feedback condition, referring to a previous study (Terzis et al., 2012), PA presented parallel empathy and reactive empathy through facial expression and text feedback. The facial expression of PA was the same-valence as emotions reported by participants. That is, PA showed a pleasant expression when the participant reported a positive emotion, or a distress expression when the participant reported a negative emotion. In terms of text

TABLE 1 | Distribution of participants.

	PA with emotional feedback		PA without emotional feedback		Total
	PA with KR	PA with elaborated feedback	PA with KR	PA with elaborated feedback	
Male	7	7	7	7	28
Female	23	22	22	22	89
Total	30	29	29	29	117

PA, pedagogical agent; KR, knowledge of results.

FIGURE 1 | Facial expressions of PA: **(A)** pleasure; **(B)** neutral; **(C)** distress.

feedback, PA reproduced participants' emotions and provided additional supportive texts, which was referred to as Attribution Theory in previous studies (Chen et al., 2012; Cabestrero et al., 2018) to encourage participants (cf. **Table 2**). In PA without emotional feedback (neutral PA) condition, PA kept neutral expression all the time and did not support participants by text.

Concerning elaborated feedback manipulation, PA with elaborated feedback provided information about the correctness of the answer (e.g., "the answer is wrong"), correct answer (e.g., "The correct answer is D"), formula (e.g., "the calculation formula of the harmonic mean is $M_N = \frac{N}{\sum \frac{1}{X_i}}$"), and problem-solving steps (e.g., "according to information of the question, N=3, $\frac{1}{X_1} = \frac{0.8}{10} = \frac{2}{25}$, $\frac{1}{X_2} = \frac{1}{10}$, $\frac{1}{X_3} = \frac{1.2}{10} = \frac{3}{25}$. Thus, $\sum \frac{1}{X_i} = \frac{3}{10}$, substituting into formula yields:$M_N = 10s$"). As for PA with KR condition, PA only stated the correctness of the answer (e.g., "the answer is correct" or "the answer is wrong"). All feedback provided by PA was in Chinese (cf. **Figure 2**).

Materials and Measures

Learning Materials and Transfer Test

The learning materials and transfer test in this study were adopted from a previous study of Wang et al. (2019), which covered psychological statistics knowledge, such as descriptive statistics, hypotheses testing, ANOVA, and probability distribution. Ten multiple-choice items were contained in the learning materials and transfer test, respectively. Each item in initial learning had a homogeneous item in the transfer test. The difficulty coefficient of items ranged from 0.4 to 0.6.

Manipulation Check on Emotional Feedback

Manipulation check was conducted to ensure that the manipulation of emotional feedback was effective. Participants completed a 5-point item "PA understood my emotions and provided support for me" ranging from 1 (strongly disagree) to 5 (strongly agree) (Guo and Goh, 2016).

Emotions

Three negative emotions (confusion, boredom, and frustration) and two positive emotions (enjoyment and satisfaction), which are mostly experienced during learning (D'Mello and Graesser, 2012; D'Mello, 2013) were measured in this study. During learning, participants reported their emotions by clicking one of the five emotion buttons after answering each item. Immediately, PA presented emotional feedback based on these self-reported emotions. Before learning, participants reported their emotions in psychological statistics classes (Münchow and Bannert, 2019). Post-test emotion questionnaire was used to measure participants' overall emotional states during learning. Participants rated 5 items (confusion, boredom, frustration, enjoyment, and satisfaction) on a 5-point scale ranging from 1 (not at all) to 5 (extremely strong) in a pre-test and post-test emotion questionnaire.

Intrinsic Motivation

Intrinsic motivation was measured with a 11-item scale questionnaire adapted from Instructional Materials Motivation Scale (Keller, 1983) (e.g., "I like using this system to learn"). Participants rated items on a scale of 1 (strongly disagree) to 5 (strongly agree). Cronbach's alpha for the scale in this study was 0.87.

Agent Perception

Participants' agent perception was measured with the Agent Persona Instrument developed by Ryu and Baylor (2003). The scale consisted of 20 items, including four dimensions: facilitating learning (10 items) (e.g., "Agent focused me on

TABLE 2 | Rules of emotional feedback.

	Correct answer	Wrong answer
Confusion	Text: I am sad to see you confused. This question is really difficult! Facial expression: distress	Text: I am sad to see you confused. Cheer up, never give up! Facial expression: distress
Boredom	Text: I am sad to see you boring. Let us try some challenging tasks! Facial expression: distress	Text: I am sad to see you boring. Please pay attention. Facial expression: distress
Frustration	Text: I am sad to see you frustrated. Keep going, you can make it! Facial expression: distress	Text: I am sad to see you frustrated. This question is really difficult, let's try some other tasks. Facial expression: distress
Enjoyment	Text: I am glad to see you so pleasant. I am so happy for you! Facial expression: pleasure	Text: I am glad to see you so pleasant. Keep up the good work! Facial expression: pleasure
Satisfaction	Text: I am glad to see you so satisfied. I am so happy for you! Facial expression: pleasure	Text: I am glad to see you so satisfied. Keep up the good work! Facial expression: pleasure

the relevant information"), credible (5 items) (e.g., "Agent was knowledgeable"), human-like (5 items) (e.g., "Agent was human-like"), and engaging (5 items) (e.g., "Agent was friendly"). All items were translated into Chinese and then back-translated to ensure equivalent meaning and double-checked by a psychological professor. Items were rated on a scale from 1 (strongly disagree) to 5 (strongly agree). Cronbach's alpha of the four dimensions and combined scale were 0.81, 0.71, 0.76, 0.85, and 0.90, respectively.

Cognitive Load

Perceived learning system availability, task difficulty, and mental effort were used to assess participants' extraneous cognitive load, intrinsic cognitive load, and germane cognitive load, respectively (Paas et al., 1994; Gerjets et al., 2009). Participants rated how convenient to work with the learning system ranging from 1 (extremely convenient) to 9 (extremely inconvenient), how difficult to learn psychological statistics a moment ago ranging from 1 (extremely easy) to 9 (extremely difficult), and how much effort exerted in learning ranging from 1 (extremely low) to 9 (extremely high).

Procedures

The learning environment was programmed with Scala + Java mixed language on JVM platform, which supported the following three phases of this experiment. In the preparation phase, after completing informed consent, participants were randomly assigned to one of four conditions. Then, participants inputted demographic information and completed the emotion questionnaire. Before starting learning, participants were given two irrelevant exercises to become familiarized with the learning system. During the learning phase, after each item, participants were required to report their emotional state at that time by choosing one from five buttons representing confusion, boredom, frustration, enjoyment, and satisfaction. Immediately, PA presented emotional feedback through facial expressions and text feedback according to emotions reported by participants. The learning task lasted for 15–20 min. In the post-test phase, participants completed the emotion questionnaire, manipulation check, questionnaires on agent perception, intrinsic motivation, cognitive load, and transfer test in sequence. The experiment lasted ∼30 min.

Research Design

This study employed a 2 × 2 between-subjects design, in which independent variables included PA's emotional feedback (with vs. without) and elaborated feedback (elaborated feedback vs. KR). The dependent variables were emotions, intrinsic motivation, agent perception, cognitive load, and transfer performance.

RESULTS

SPSS 24.0 was used to perform the two-way multivariate analysis of covariance (MANCOVA) for emotions, prior knowledge, manipulation check, intrinsic motivation, agent perception, cognitive load, and transfer performance. Scores in the learning phase (a measure of prior knowledge) and five pretest emotions were included as covariates for manipulation check, post-test emotions, intrinsic motivation, agent perception, cognitive load, and transfer performance. The result of means and standard deviations of all variables was shown in **Table 3**.

Manipulation Check

MANCOVA revealed that there was a significant difference on the manipulation of emotional feedback [$F_{(1, 107)} = 16.76$, $p < 0.001$, $\eta_p{}^2 = 0.135$]. Participants reported that PA with emotional feedback identified their emotions better and provided more support for them than neutral PA. There was no significant main effect of cognitive feedback [$F_{(1, 107)} = 1.495$, $p = 0.22$, $\eta_p{}^2 = 0.014$] or interaction [$F_{(1, 107)} = 2.89$, $p = 0.09$, $\eta_p^2 = 0.026$].

Post-test Emotions

Significant main effect was only found for emotional feedback on confusion. It could be shown that PA performing emotional feedback led to less confusion than neutral PA [$F_{(1, 107)} = 6.66$, $p = 0.01$, $\eta_p^2 = 0.059$]. However, the main effects of emotional feedback on boredom [$F_{(1, 107)} = 1.28$ $p = 0.26$, $\eta_p^2 = 0.012$], frustration [$F_{(1, 107)} = 3.27$, $p = 0.08$, $\eta_p^2 = 0.030$], enjoyment [$F_{(1, 107)} = 1.15$, $p = 0.29$, $\eta_p^2 = 0.011$], and

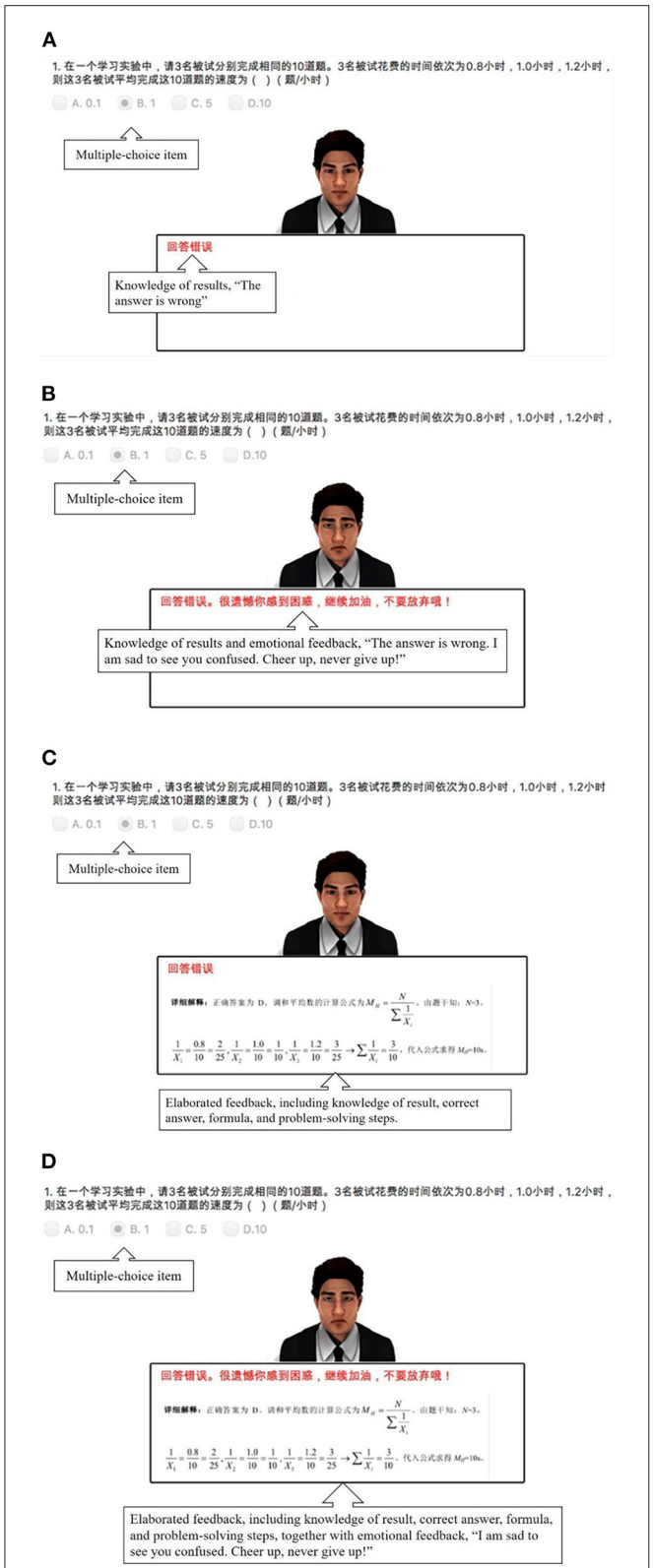

FIGURE 2 | Examples for feedback presentation in the four conditions: **(A)** without emotional feedback + with knowledge of results; **(B)** with emotional feedback + with knowledge of results; **(C)** without emotional feedback + with elaborated feedback; **(D)** with emotional feedback + with elaborated feedback.

satisfaction [$F_{(1, 107)} = 1.77$, $p = 0.19$, $\eta_p^2 = 0.016$] were not significant. The main effects of elaborated feedback on emotions [confusion $F_{(1, 107)} < 1$; boredom $F_{(1, 107)} < 1$; frustration $F_{(1, 107)} < 1$; enjoyment $F_{(1, 107)} < 1$; satisfaction $F_{(1, 107)} < 1$] and interactions between emotional feedback and elaborated feedback on emotions [confusion $F_{(1, 107)} < 1$; boredom $F_{(1, 107)} < 1$; frustration $F_{(1, 107)} = 1.03$, $p = 0.31$, $\eta_p^2 = 0.010$; enjoyment $F_{(1, 107)} = 1.77$, $p = 0.19$, $\eta_p^2 = 0.016$; satisfaction $F_{(1, 107)} < 1$] were not significant.

Intrinsic Motivation

MANCOVA found significant main effects of emotional feedback and elaborated feedback on intrinsic motivation. Compared with the neutral PA, PA with emotional feedback led to higher intrinsic motivation (marginally significant) [$F_{(1, 107)} = 3.72$, $p = 0.06$, $\eta_p^2 = 0.034$]. In a similar way, PA with elaborated feedback resulted in stronger intrinsic motivation than PA with knowledge of results (KR) [$F_{(1, 107)} = 14.76$, $p < 0.001$, $\eta_p^2 = 0.121$]. However, the interaction failed to reach significance [$F_{(1, 107)} < 1$].

Agent Perception

Significant main effects were found on agent perception in MANCOVA for both emotional feedback and elaborated feedback. The PA with emotional feedback group perceived PA better than the neutral PA group [$F_{(1, 107)} = 4.58$, $p = 0.04$, $\eta_p^2 = 0.041$]. The same main effect occurred when PA provided an elaborated feedback while showing cognitive feedback [$F_{(1, 107)} = 5.22$, $p = 0.02$, $\eta_p^2 = 0.046$]. The interaction between these two factors was not significant [$F_{(1, 107)} < 1$].

Cognitive Load

Only the main effect of elaborated feedback on germane cognitive load was revealed, indicating that learners reported lower germane cognitive load when they received elaborated feedback from PA [$F_{(1, 107)} = 3.87$, $p = 0.05$, $\eta_p^2 = 0.035$], but emotional feedback had no significant main effect on germane cognitive load [$F_{(1, 107)} < 1$]. In terms of extraneous cognitive load and intrinsic cognitive load, main effects of neither emotional feedback [extraneous cognitive load $F_{(1, 107)} < 1$; intrinsic cognitive load $F_{(1, 107)} < 1$] nor elaborated feedback [extraneous cognitive load $F_{(1, 107)} < 1$; intrinsic cognitive load $F_{(1, 107)} = 2.65$, $p = 0.11$, $\eta_p^2 = 0.024$] reached significance. Moreover, the interaction failed to reach significance [extraneous cognitive load $F_{(1, 107)} < 1$; intrinsic cognitive load $F_{(1, 107)} < 1$; germane cognitive load $F_{(1, 107)} < 1$].

Transfer Performance

For transfer performance, MANCOVA only found a significant main effect of elaborated feedback. On Comparing PA with the KR group, learners in PA with an elaborated feedback condition performed better in transfer performance [$F_{(1, 107)} = 34.79$, $p < 0.001$, $\eta_p^2 = 0.046$]. Learners who received emotional feedback from PA performed similarly to those studying with neutral PA in transfer test [$F_{(1, 107)} = 1.38$, $p = 0.24$, $\eta_p^2 = 0.013$], and the interaction between emotional feedback and elaborated feedback was not significant [$F_{(1, 107)} < 1$].

TABLE 3 | Means and standard deviations of all variables.

	PA with emotional feedback ($M \pm SD$)		PA without emotional feedback ($M \pm SD$)	
	PA with KR	**PA with elaborated feedback**	**PA with KR**	**PA with elaborated feedback**
Pretest confusion	4.30 ± 0.99	4.45 ± 1.02	4.07 ± 0.92	4.55 ± 1.02
Pretest boredom	3.37 ± 0.96	3.31 ± 0.89	3.17 ± 0.85	3.45 ± 0.87
Pretest frustration	3.43 ± 0.90	3.62 ± 0.94	3.07 ± 0.84	3.59 ± 1.09
Pretest enjoyment	3.83 ± 1.02	3.83 ± 0.66	4.28 ± 0.84	3.86 ± 0.92
Pretest satisfaction	3.93 ± 1.05	3.83 ± 0.89	4.21 ± 0.86	4.14 ± 1.13
Prior knowledge	4.40 ± 1.87	3.38 ± 1.70	4.52 ± 2.01	3.41 ± 1.66
Manipulation check	4.37 ± 1.10	4.28 ± 1.03	3.17 ± 0.76	3.79 ± 1.26
Posttest confusion	4.57 ± 1.10	4.79 ± 1.15	5.07 ± 0.53	5.14 ± 0.79
Posttest boredom	2.70 ± 0.95	2.83 ± 0.97	3.00 ± 0.96	2.90 ± 1.11
Posttest frustration	4.13 ± 1.20	4.48 ± 1.21	4.59 ± 1.02	4.66 ± 1.17
Posttest enjoyment	3.53 ± 0.97	3.14 ± 0.95	3.24 ± 0.91	3.31 ± 1.04
Posttest satisfaction	3.23 ± 1.01	3.14 ± 1.13	3.14 ± 0.92	3.03 ± 0.98
Intrinsic motivation	4.00 ± 0.60	4.29 ± 0.59	3.79 ± 0.60	4.16 ± 0.72
Agent perception	3.91 ± 0.64	4.24 ± 0.51	3.72 ± 0.54	3.96 ± 0.55
Extraneous cognitive load	5.57 ± 2.01	5.14 ± 1.96	5.24 ± 1.79	5.21 ± 2.35
Intrinsic cognitive load	7.13 ± 1.14	7.07 ± 1.28	6.93 ± 1.69	7.07 ± 1.96
Germane cognitive load	7.63 ± 1.10	7.14 ± 1.64	7.86 ± 1.06	7.28 ± 1.71
Transfer performance	5.53 ± 1.96	7.24 ± 2.13	6.14 ± 2.26	7.41 ± 2.06

PA, pedagogical agent; KR, knowledge of results.

DISCUSSION

The Role of PA's Emotional Feedback in Learning

The present study found that PA's emotional feedback affected learning processes, such as emotions, motivation, and agent perception, whereas it had no significant effect on cognitive load or transfer performance.

Firstly, PA's emotional feedback reduced learners' confusion, which was in line with past studies (Klein et al., 2002; Prendinger et al., 2003; Hone, 2006; Shen, 2009; Woolf et al., 2010), whereas it did not increase positive emotions. H1a was partially supported. In line with Social Presence Theory, our results showed to some extent the beneficial nature of PA's emotional feedback in improving learners' emotional experience by enhancing proximity between PA and learners. In the present study, learners made 1,170 emotional reports during the learning phase, including 45% confusion, 22% enjoyment, 14% satisfaction, 14% frustration, and 5% boredom. Confusion was most reported by learners, so emotional feedback that learner received mainly targeted to reduce confusion. Other emotions appeared too infrequent to be further affected by PA's emotional feedback.

Secondly, as expected in H1b and H1c, learners' intrinsic motivation and agent perception were higher in PA with emotional feedback condition than in neutral PA condition. Consistent with Social Presence Theory and Social Agency Theory, PA's empathic behaviors created supportive atmosphere and minimized the communication barriers in human–computer interaction (Lin et al., 2013). As a result, learners perceived PA to be more intimate and were motivated to engage in learning (Guo and Goh, 2016).

However, inconsistent with H1d and H1e, PA's emotional feedback influenced neither cognitive load nor transfer performance. According to previous studies, the lack of direct useful information for cognitive processing kept learners far from constructing knowledge (Kim et al., 2007). PA's emotional feedback in this study only reproduced learners' emotions and provided emotional support so that it regulated emotional or motivational factors rather than cognitive factors. The good news was that PA's emotional feedback did not increase extraneous cognitive load or hinder learning. That is, PA's emotional feedback did not occupy learners' mental resources or act as distracting elements that drew learners' attention away from the learning content.

The Role of PA's Elaborated Feedback in Learning

In terms of learning processes, our findings supported H2b and H2c, showing that elaborated feedback enhanced intrinsic motivation and positive agent perception. The Five-Stage Model of Computer-Based Formative Assessment suggests that learners adjust their motivational and cognitive states according to feedback received in a test-like task (Timmers et al., 2015). Elaborated feedback contained more useful information that helped learners narrow the knowledge gap between the current state and the target state. From this, learners perceived PA as a facilitator for learning, believed that they had control over their own studying, and engaged themselves in learning tasks (Pekrun and Perry, 2014; Wang et al., 2019). These results also provided supportive evidence for ICALM, where cognitive factors and motivation interweave so that elaborated feedback can support

cognitive processing and motivational adjustment. Nevertheless, elaborated feedback had no impact on learners' post-test emotions, and H2a was not verified. An explanation might be that different attribution styles have opposite effects on emotions (Sixte et al., 2020). For example, when receiving elaborated feedback for correcting a wrong answer, learners with internal attribution style experience negative emotions on account of attributing failures to insufficient capability. Conversely, learners with external style attribute failure to high difficulty, so they hold the view that elaborated feedback can help them learn new things better, thereby experiencing more positive emotions and less negative emotions. For this reason, we wonder if the valences of effects of attribution styles on emotions are converse so that the total effect is not significant. Future research can bring learners' attribution style into consideration as a moderator. Besides, contrary to H2d, learners in PA with elaborated feedback group reported lower germane cognitive load compared to those in PA with KR group. It might be that since learners in PA with elaborated feedback condition were provided with detailed information for knowledge construction, they cut down on cognitive resources to process materials, i.e., they proactively reduced mental effort (Zhao, 2014) so that germane cognitive load was decreased. Given that KR only contained information about whether the answer was correct, cognitive resources were still highly required when learners needed to invest mental effort a lot in analyzing errors and correcting misunderstandings (Johnson and Priest, 2014). Although there was a significant difference between the two groups, the germane cognitive load of all learners was maintained at a high level ($M > 7.28$ on a 9-point scale).

As for learning performance, participants performed better in the transfer test when they received elaborated feedback than KR. The finding supported that H2e and was in line with previous studies (Lin et al., 2013; Law and Chen, 2016). In the present study, elaborated feedback not only verified whether the answer was correct, but also showed the correct answer, formula, and cues for the solution. Such cognitive information helped learners bridge the gap between old and new knowledge easier and promoted knowledge construction to the improve transfer performance (Gong et al., 2019; Wang et al., 2019).

The Mutual Effect of PA's Emotional Feedback and Elaborated Feedback

This study did not find any significant interaction between emotional feedback and elaborated feedback on learning processes or performance. As a result, H3 was not supported. No matter which kind of cognitive feedback learners received, emotional feedback could improve learners' emotions and motivation. Containing detailed cognitive information, elaborated feedback successfully supported cognitive processing. Both emotional feedback and elaborated feedback provided means to activate learners' intrinsic motivation and had their own distinctive advantages, so their effects may be relatively stable and could not substitute for each other.

Limitations and Future Directions

By exploring the impact of emotional feedback and elaborated feedback on multimedia learning, this study provided empirical evidence for Social Presence Theory, Social Agency Theory and ICALM. This study found that PA's emotional feedback facilitated learning processes, including better emotional experience, stronger intrinsic motivation, and enhanced agent perception; PA's elaborated feedback improved learning processes by affecting intrinsic motivation, agent perception, and finally improved transfer performance. What stands out in this study leads to strong recommendations for PA's emotional design and feedback optimization.

Three features of this work limited the conclusions we can draw about PA's emotional and elaborated feedback on multimedia learning.

First, PA's emotional feedback was not diverse enough to fully improve emotions, where emotional feedback reduced confusion but did neither reduce other negative emotions nor increase positive emotions. In this study, confusion was mostly triggered by moderately difficult tasks, and it was easiest to be affected by emotional feedback than other emotions. Nevertheless, a textual library is needed to present more personalized feedback for better experience in future studies, in which emotional feedback can be customized on learners' characteristics, current emotional states, and task performance. Besides, according to the modality principle for managing essential processing in multimedia learning (Castro-Alonso and Sweller, 2021), emotional feedback can be delivered by both auditory and visual channels (e.g., voice and facial expressions) to reduce the redundancy effect as much as possible in future studies.

Second, self-report of emotions after each item may interrupt learning. In spite of accurate identification of emotions, self-report in learning sessions scattered cognitive resources into cognitive processing of core materials and emotional awareness. Future studies can introduce artificial intelligence technology, biofeedback technology, and observation method to automate the identification of emotions. In addition, we only used self-report measures to assess learning processes. To gain more objective evidence and holistic understanding, future work should use multimodal data (the fusion of information extracted from multiple data sources, such as eye-tracking, EEG, facial data streams, physiological indexes, etc.). For example, data sources from self-report-scale and eye-tracking during learners' interaction with a learning system can be integrated and used to measure cognitive load (Sharma et al., 2022).

Third, this study was conducted with learning materials on undergraduate psychological statistics. Therefore, conclusions should be treated with prudence when generalized to other groups or courses. It will be worthwhile to repeat the experiment with learners from different grades and diverse learning materials, as well as explore whether learners' characteristics moderate the effects of feedback on learning processes and performance.

CONCLUSIONS

This study examined the impact of PA's emotional feedback and elaborated feedback on learning. Results showed that emotional feedback decreased confusion, triggered intrinsic motivation, and enhanced agent perception, but had no impact on cognitive variables such as cognitive load and learning performance. Elaborated feedback improved intrinsic motivation, agent perception, and transfer performance but reduced germane cognitive load compared to KR. This study confirms that either emotional feedback or elaborated feedback has an essential function in multimedia learning.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

Ethical 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

YL contributed to data collection, data analysis, and paper writing. KX contributed to experimental design and data collection. SG contributed to experimental design and paper writing. YW and YC contributed to paper writing. All authors contributed to the article and approved the submitted version.

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EDITED BY
Harrison Yang,
State University of New York at Oswego, United States

REVIEWED BY
Jianzhong Janne Hong,
Central China Normal University, China
Jingxiu Huang,
South China Normal University, China

*CORRESPONDENCE
Zengzhao Chen
llczz@163.com

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Instructors' expressive nonverbal behavior hinders learning when learners' prior knowledge is low

Mengke Wang, Zengzhao Chen*, Yawen Shi, Zhuo Wang and Chengguan Xiang

Faculty of Artificial Intelligence in Education, Central China Normal University, Wuhan, China

This study investigated the influence of instructors' expressive nonverbal behavior and nonexpressive nonverbal behavior in video lectures on students' learning performance and affective experience. We conducted two rounds of experiments using the same materials and procedures, the only difference being the participants. In each round of experiments, participants were randomly assigned to expressive condition or nonexpressive condition. 227 rural primary school sixth-graders took part in experiment 1, participants in expressive condition had better affective experiences and perceived tasks as less difficult, but had lower learning performance than participants in nonexpressive condition. 175 sixth-graders from urban primary schools participated in experiment 2. The results showed that instructors' expressive nonverbal behavior also improved students' affective experience and reduced students' perception of task difficulty, but there was no significant difference in learning performance between the two groups. Comparing the pretest scores of students in the two experiments, it was found that the pretest scores of participants in experiment 2 were higher than those in experiment 1. Overall, instructors' expressive nonverbal behavior can improve students' affective experience and reduce their perception of task difficulty. However, when students' prior knowledge is relatively low, instructors' expressive nonverbal behavior hinders students' learning performance. We suggest that teachers adopt expressive nonverbal behavior when lecturing because it is beneficial to maintain students' long-term interest in learning. However, it should be noted that the difficulty of learning material should be determined by students' prior knowledge.

KEYWORDS

nonverbal behavior, learning performance, affective experience, video lectures, multimedia learning, nonverbal expressiveness, prior knowledge

Introduction

Under the global COVID-19 pandemic, video lectures become more widely used in school education than ever (Gouëdard et al., 2020; Wang et al., 2021). In the video lectures with instructor presence, the eye gaze, facial expression, gestures, and paralinguistic speech characteristics of instructors could have different degrees of expression. For example, some

instructors smile in the video, use pointing gestures to guide learners' attention, and speak in cadence. While there are also some instructors who have no facial expressions, do not use gestures, and speak in a single tone. The former instructors used expressive nonverbal behaviors, while the latter instructors used nonexpressive nonverbal behaviors. Nonverbal expressiveness describes the nonverbal behaviors with different levels of expression and is conceptualized as the manifestation of those nonverbal behaviors which communicate animation, enthusiasm, interest, and overall expressiveness (Roter et al., 2006). Instructors with expressive nonverbal behaviors are often considered as warm, intimate, and approachable, while instructors with nonexpressive nonverbal behaviors are often considered as cold, remote, and unapproachable.

Instructors' nonverbal expressiveness affects learners' emotions, motivation, interest, and affective experience. Learners who learn from instructors with expressive nonverbal behavior tend to report more positive emotional experiences. However, liking does not always lead to learning (Wilson et al., 2018). According to previous studies on teaching videos with instructors' presence, although teaching videos with instructors present were more favored by learners than those with texts or audio alone, learners also believed that they paid more attention when watching videos with instructors present. However, the results of comprehension tests showed that videos of instructors present did not improve learners' scores on comprehension tests, and learners paid more attention to the teacher than to the material. In addition, other studies have shown that instructors' visual cues and motor characteristics also attract learners' attention, depleting attention resources that should be used to process learning material (Kizilcec et al., 2014). Compared with nonexpressive nonverbal behaviors, expressive nonverbal behaviors of instructors have more motor characteristics. Therefore, empirical research is needed to confirm whether expressive nonverbal behaviors of instructors can distract learners' attention and decrease their learning performance.

Furthermore, studies in multimedia learning mainly focused on adult learners (e.g., Stull et al., 2018; Beege et al., 2020; Horovitz and Mayer, 2021) and the impact of video lectures on younger learners have not been fully studied. Compared to adult learners, younger learners, especially primary learners, have relatively little knowledge and shorter attention spans. Thus, it is more difficult for them to establish connections with new knowledge from self-directed video learning. These difficulties may lead to increased cognitive load and boredom emotion. More research is needed to investigate the influence of video lectures on younger learners' learning performance and affective experience. Research on this issue will facilitate video design for younger learners. Therefore, this study aims to explore the influence of instructors' nonverbal expressiveness on primary school learners' learning performance and affective experience (including learning experience and learning satisfaction).

Literature review

In empirical studies, researchers have linked instructors' nonverbal behavior with classroom outcomes, forming varying labels such as enthusiasm (Brophy and Good, 1986; Marsh, 1994; Jackson et al., 1999; Patrick et al., 2003; Kunter et al., 2008, 2011), immediacy (Mehrabian, 1969; Andersen, 1979; Velez and Cano, 2008; Liu, 2021), and communication style (Norton, 1978; Sallinen-Kuparinen, 1992). Although the frameworks of these terms mentioned above are not identical, they all share a common variable, namely nonverbal expressiveness. Its core is the application of nonverbal behavior. Expressive instructors are those very expressive in their faces, hands, voices, and body orientation toward their audience. Normally, they make use of demonstrative gestures, vivid facial expressions, meaningful body movements, and varying voice tones (Keller et al., 2016). While nonexpressive instructors are those who have not mobilized nonverbal behavior. They present an emotionless facial expression, avoid eye contact, and rarely employ gestures, their intonation does not change and body posture remains stiff.

The positive impact of instructors' expressive nonverbal behavior on learning

It seems to be an intuitive common sense that instructors who smile, gesticulate, and express enthusiasm are viewed by students as being more student-oriented, organized, stimulating, and knowledgeable and as having more rapport than nonexpressive instructors. A multitude of studies confirmed that instructors' expressive behavior contributes to preventing boredom, increasing interest, improving satisfaction, and motivating students to pursue their studies by continuous shifts in the various channels of their nonverbal behavior (Liu, 2021; Moè et al., 2021).

Emotional response theory and emotional contagion theory both provide valuable insight into how instructors' expressive nonverbal behavior promotes students' learning. According to the emotional response theory, instructors' expressive nonverbal behavior will induce an emotional response in learners (McCroskey et al., 2006; Mottet and Beebe, 2006). When an instructor shows a direct gaze and a happy face, it may prime students' positive response and interpret it as 'the instructor is happy to teach me.' Once an instructor's nonverbal behavior stimulates students' emotional responses, it could further motivate students to engage in activities and facilitate learning (Mayer, 2014; Liew et al., 2017; Pi et al., 2020). Besides, smiling expressions, open body posture, and passionate tone, all suggest a high valence of positive emotion which could affect learners' emotions through the process of emotional contagion (Pekrun et al., 2002). Becker et al. (2014) believed that emotions conveyed through instructors' nonverbal behavior are as important as the knowledge itself.

What's more, studies found that without external incentives audiences are more strongly influenced by delivery style than by

content. Instructors' nonverbal cues could affect students' judgment of instructors' professional ability. Smiles, positive voice tone, head nods, eye contact, and gestures could encourage students' positive attitudes (Goldberg and Mayerberg, 1973; Kaufman 1975, unpublished doctoral dissertation[1]; Woolfolk et al., 1977; Chaikin et al., 1978; Guyer et al., 2019; Lawson et al., 2021a). When instructor expressiveness overrides the effect of lecture content on student evaluations, the "Dr. Fox Effect" happens, this is also known as the educational seduction phenomenon. Students' evaluation of instructors' professional ability, in turn, affects students' cognitive engagement, and ultimately affects the learning result. Although "Dr. Fox Effect" causes researchers' concern about the validity of students' evaluation of teaching, it is sufficient to illustrate the importance of instructors' nonverbal expressiveness in teaching (Peer and Babad, 2014).

The negative impact of instructors' expressive nonverbal behavior on learning

Although instructors' expressive nonverbal behavior enhances students' emotional experience, they do not definitely promote students' cognitive performance. Andersen and Withrow (1981) recorded three different levels of nonverbal expressiveness videotapes to different audiences and found that nonverbal expressiveness predicted 22% of the variance in students' affect learning, but it was not a significant predictor for behavioral commitment or cognitive learning. Chaikin et al. (1978) conducted an exploratory study, on the condition that the instructor behaved with eye contact, leaning forward, smiling, and head nods produced more positive ratings from fifth-grade students than on the other condition that the instructor behaved with little eye contact, leaning away, frowning, and shake head. But there was no significance in learning performance between the two conditions. What's more, some studies have documented the negative effect of instructors' expressive nonverbal behavior on students' learning outcomes. Basow and Distenfeld (1985) claimed that although the expressive instructor received the highest student evaluations, students who watched a nonexpressive female instructor had the highest achievement. Besides, McKinney et al. (1984) reported that instructors' high level of expressive nonverbal behavior increases classroom management problems in primary school.

Expressive nonverbal behavior contains more dynamic elements (e.g., making gestures, walking, showing different facial expressions) than nonexpressive nonverbal behavior. This dynamic information attracts students' attention (Shaddy and Colombo, 2010). The limited-capacity assumption reminds us that each channel in the human information processing system has a limited capacity. Instructors' nonverbal behavior is needed to be processed and integrated with the learning materials. They may compete with the learning materials for limited capacity, thereby affecting the processing of learning materials. As Ayres and Sweller (2005) demonstrated when learning from video lectures presenting an instructor and learning materials, students are required to integrate disparate information, and they have to split their attention to process information from more than one source. Instructors' nonverbal behavior may add extraneous cognitive load on students, which imposes an additional processing burden on a learner's mind (extra processing in the brain) and negatively affects cognitive outcomes.

The present study

The current study aimed to explore the influence of instructors' different levels of nonverbal expressiveness in video lectures on elementary students' learning performance and affective experience (including learning experience and learning satisfaction). We conducted two experiments with the same experimental materials and procedures but different samples. In experiment 1, participants were from a rural primary school. In experiment 2, participants were from an urban primary school.

Experiment 1

Research questions and hypothesis

Based on emotional response theory and emotional contagion theory, the expressive instructor may improve students' affective experience (including learning experience and learning satisfaction) more than the nonexpressive instructor. Thus, we formulated the following hypothesis:

> *H1*: Compared with the nonexpressive condition, students who learn from the instructor with expressive nonverbal behavior will have a better learning experience.
>
> *H2*: Compared with the nonexpressive condition, students who learn from the instructor with expressive nonverbal behavior will report higher learning satisfaction.

As for learning performance, existing studies presented contradictory results. On the one hand, instructors' expressive nonverbal behavior has advantages in maintaining students' interest and motivation in learning, leading to high learning performance. On the other hand, instructors' expressive nonverbal behavior competes with learning materials for students' attention and limited working memory, resulting in poor learning performance. Therefore, our research question was: What is the effect of instructors' nonverbal expressiveness on students' learning performance?

1 Kaufman, P. (1975). *The effects of nonverbal behavior on performance and attitudes in a college classroom*. Unpublished doctoral dissertation, Oklahoma State University.

Method

Participants and design

Participants in the present study were students from a township elementary school located in Guizhou, China. A total of 227 students in sixth grade responded to the survey. The sample consisted of 114 males and 113 females. All participants were randomly assigned to two groups: 115 (male = 54, female = 61)students grouped in the expressive condition and watched the video lecture with an expressive instructor. 112 (male = 60, female = 52) students grouped in the nonexpressive condition and watched video lectures with a nonexpressive instructor. The data were collected through questionnaires that were administered in the school classes by a research assistant and six school instructors. The study protocol was approved by the ethics committee of Central China Normal University.

Material

We created two learning videos with different nonverbal expressiveness. To reduce the influence of the emotional attributes of the learning content on students' emotions, the classification of vertebrates was chosen as teaching content. Within the videos, a female on-screen instructor was implemented, while the learning content was presented via slides. The authors prepared a list of body movements, facial expressions, and tone of voice, which should be performed in the respective condition. Before the videos were recorded, the instructor received concrete instructions from the authors of this study. The instructor was trained to perform targeted nonverbal behavior as flawlessly as possible before the final videos were recorded.

The illustration of the experimental manipulation is presented in Table 1. In the expressive condition, the instructor smiled, looked directly at the camera and her body faced the camera. When she pointed to the teaching material, her eyes were directed towards the teaching material and her body was sideways towards the teaching material. She used a positive tone when lecturing and varied the voice speed and intonation with the content. The learning time was limited to 522 s.

In the nonexpressive condition, the instructor's face was serious. She looked down or toward the camera, and her body was facing forward. She did do not use hand gestures or change body orientation. She used a monotone tone in the whole lecture. The learning time was limited to 455 s. Screenshots are shown in Figure 1, and the waveforms are shown in Figure 2. Taking into account the ecological validity of the experiment, both experimental treatments were relatively mild and not very exaggerated.

Measurements

Prior knowledge test

The prior knowledge test was an 8.5 × 11 inch sheet of paper that asked participants to provide their gender and class. This test also included (1) three true or false items(e.g., Snails are not vertebrates,1 point each, 3 points in total), (2) two single-choice items (e.g., Which reptiles are listed? (A) gecko; (B) frog; (C) earthworm; and (D) snail) in which every item had four choices and only one correct answer (1 point each, 2 points in total), and (3) one multiple-choice question (Which of the following descriptions of the characteristics of the tortoise are correct? (A) Turtles can live in water or on land, so they are amphibians. (B) The tortoise is a vertebrate. (C) The tortoise is a reptile. Two points). All the items in the test were developed by the researchers and examined by a biology professor to ensure expert validity. The total possible score was 7 points. The higher the score on this test indicated a higher degree of prior knowledge.

Learning performance test

Under the guidance of a biology professor, the researcher who was familiar with the learning content developed the learning performance test. It included (1) five fill-in-blank items (e.g., The definition of a vertebrate is _____.); (2) three true or false items, (e.g., Birds are warm-blooded); and (3) four short-answer items (e.g., Which category of vertebrates does the tortoise belong to?). The total possible score was 18 points. The higher the score indicated a higher degree of learning performance.

Learning experience questionnaire

The learning experience questionnaire (Stull et al., 2018) was used to measure participants' learning experience for the two video lectures. Students were asked to rate their experience on the following 9 items: "I felt that the subject matter was difficult," which was reverse coded in the analysis, and "I enjoyed learning this way," "I would like to learn this way in the future," "I feel like I have a good understanding of the material," "After this lesson, I would be interested in learning more about the material," "I found the lesson to be useful to me," "I felt like the instructor was

TABLE 1 Illustration of the experimental manipulation.

Nonverbal behavior	Expressive condition (behavior, second)	Nonexpressive condition (behavior, second)
Facial expression	Smile, 51 s	No facial expression all the time
Eye gaze	Direct gaze(looked straight to the camera), 371 s	Direct gaze (looked straight to the camera), 93 s
	Guided gaze (used guided gaze to direct attention to the slides), 151 s	Averted gaze (looked down), 362 s
Gesture	Pointing gestures (pointed to the slides), 268 s	No gestures all the time
Body orientation	Frontal body,157 s;lateral body, 365 s	Frontal body all the time
Voice tone	Positive voice tone, voice speed and intonation change with the content	Monotone all the time

FIGURE 1
Screenshots of the two versions in the experiment (after privacy treatment). **(A)** The expressive version and **(B)** the nonexpressive version.

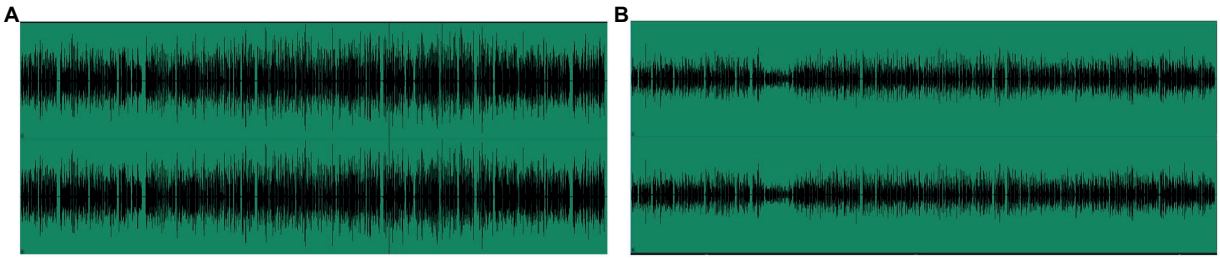

FIGURE 2
Waveforms of the two versions in the experiment. **(A)** The expressive version and **(B)** the nonexpressive version.

working with me to help me understand the material," "I found the instructor's teaching style engaging," and "I felt motivated to try to understand the material." The items could be rated on a 7-point Likert scale ranging from 1 ("strongly disagree") to 7 ("strongly agree"). In the current study, Cronbach's alpha for the learning experience questionnaire was 0.822.

Learning satisfaction questionnaire

This questionnaire was based on the Video Course Learning Satisfaction Questionnaire. The original 20 items scale was modified such that items that did not fit the context of the current study were deleted (e.g., items about instructor-student interaction). The modified scale had three 5-point Likert-scale items (1 = absolutely disagree, 5 = absolutely agree): instructor teaching had one item, teaching content had one item, and learning environment and equipment had one item. Higher scores indicated higher learning satisfaction. Cronbach's alpha for the learning satisfaction questionnaire was 0.786.

Procedure

The study was carried out in six multimedia classrooms, with six naturally occurring classes. Each condition was randomly assigned to three classes. 115 students (male = 54, female = 61)watched the instructor with expressive nonverbal behavior video lecture, and 112 (male = 60, female = 52) students watched the instructor with nonexpressive nonverbal behavior video lecture. The procedure was as follows: firstly, participants filled in demographic information and took the prior knowledge test. Secondly, they viewed one of two system-paced video lecture. Thirdly, they filled out the learning experience questionnaire and the learning satisfaction questionnaire. Finally, they took the learning performance test. It tooks approximately 30 min to complete the experiment.

Results

Four independent sample *t*-tests were conducted with experiment conditions (expressive vs. nonexpressive) as the between-subject factor, prior knowledge, and the following three measures as dependent measures: learning performance, learning experience, and learning satisfaction. There was no significant difference in prior knowledge between the two groups ($p = 0.053 > 0.05$, Cohen's $d = 0.054$), prior knowledge score for expressive condition $M = 3.47$, SD = 1.003 and for nonexpressive condition $M = 3.52$, SD = 0.849. Descriptive statistics for all dependent variables are shown in Table 2.

Learning performance

The independent sample *t*-test showed that there was a significant difference in learning performance between the two

TABLE 2 The descriptive statistics for dependent variables in experiment 1.

Dependent variable	Expressive ($N = 115$)		Nonexpressive ($N = 112$)		t	d	Sig.
	M	SD	M	SD			
Learning performance	12.60	3.612	16.04	2.421	−8.459	1.118	<0.001** (2-tailed)
Learning experience	40.16	15.119	40.16	13.174	−0.002	0	0.499 (1-tailed)
Learning satisfaction	12.04	2.252	11.03	2.183	3.171	0.455	0.001* (1-tailed)

*$p < 0.05$; **$p < 0.001$.

groups ($t = -8.459$, $p < 0.001$). Students in the nonexpressive condition performed much better than students in the expressive condition (Cohen's $d = 1.118$).

Learning experience

The independent sample t-test showed that there was no significant difference in learning experience ($t = -0.002$ $p = 0.499$) between the two groups. To compare differences, we performed 9 independent sample t-tests with each sub-item in the learning experience as the dependent variable and experiment conditions (expressive vs. nonexpressive) as the between-subject factor. Descriptive statistics are shown in Table 3. A significant difference in perceived difficulty between the two groups ($t = 0.971$, $p = 0.010$) was found. The mean values in brackets in the row of perceived task difficulty in Table 3 are the results of reverse scoring, which was used to calculate the overall learning experience. Students in expressive condition thought the content was less difficult. Additionally, instructors with expressive nonverbal cues could be significantly more effective in facilitating participants' enjoyment ($t = 3.275$, $p = 0.007 < 0.05$) and desire to learn more knowledge about the material ($t = 1.552$, $p = 0.012 < 0.05$). The calculation results of the effect size indicator Cohen's d show that the three items E1, E2, and E5 all were low effects[d(E1) = 0.136, d(E2) = 0.455 d(E5) = 0.219]. No other significant differences were found ($p > 0.05$) on the left 6 sub-items. Overall, our results partly support hypothesis 1.

Learning satisfaction

Students in the expressive group were more satisfied than those in the nonexpressive group. There was a significant difference in learning satisfaction between the two groups ($t = 3.171$, $p = 0.001$, Cohen's $d = 0.455$). Overall, the result supported hypothesis 2.

Discussion

Students performed better in the learning performance test when the instructor with nonexpressive nonverbal cues. This was an interesting and counterintuitive finding. Intuitively, the instructor with expressive nonverbal behavior worked "harder" and students "should" learn more from her. However, it was not the case. Previous studies (McKinney and Larkins, 1982) have shown that students had the highest achievement scores when they were in the medium enthusiastic-teacher condition rather than in the high enthusiastic-teacher condition. Two reasons may contribute to the results. Firstly, when instructors with expressive nonverbal behavior, they attract more attention from students, resulting in reduced student attention to learning materials. According to Mayer's selecting-organizing-integrating theory of active learning, attention, which occurs in the stage of information selection, is the basis of information organization and integration (Mayer and Moreno, 2003). When students spent less time paying attention to materials, it will harm the organization and integration of learning material information. Secondly, elementary students with limited working memory. Instructors' nonverbal information occupies learners' limited working memory, which affects the processing of learning material. The simultaneous processing of nonverbal information and learning material information and the integration of the two put forward high requirements for learners' cognitive processing.

Although there was no significant difference in the overall learning experience between the two groups, there were significant differences in three sub-items. Students who watched the instructor with expressive nonverbal behavior found the content easier (e.g., "I felt that the subject matter was difficult," the less the score, the easier), more preferred the instructional video (e.g., "I enjoyed learning this way"), and were more interested in learning (e.g., "After this lesson, I would be interested in learning more about the material"). It was consistent with a previous study. Lawson et al. (2021b) proved that positive instructors promoted the enjoyment of the lesson. This can be explained from both emotional contagion and emotional response theory. From the emotional contagion perspective, the instructor's smiling expression and changing intonation conveyed positive emotional information to students, making students' emotions more positive. From the emotional response perspective, due to the beneficial social cues provided by the expressive instructor, the connection between students and the instructional video was strengthened, leading to a higher emotional evaluation of the video. The reason for interest difference may be that students are more interested in the content they are not familiar with and have not mastered, which can be proved by students' learning performance scores. In addition, from the perspective of emotion, students are easy to be interested in the content they like. As we already know, students in the expressive condition enjoyed the course more, which may have led to a higher interest in future learning. Concerning learning satisfaction, instructors' expressive nonverbal behavior enhanced students' satisfaction which is consistent with the previous study (Wang et al., 2019). This may be because the positive nonverbal

TABLE 3 Results of independent sample *t*-test of learning experience sub-items in experiment 1.

Source of variation	Expressive condition ($N = 115$)		Nonexpressive condition ($N = 112$)		*t*	*d*	Sig. (1-tailed)
	M	SD	*M*	SD			
E1. I felt that the subject matter was difficult.	1.93(5.07)	1.464	2.15(4.85)	1.750	0.971	0.136	0.010*
E2. I enjoyed learning this way.	5.50	1.360	4.80	1.698	3.275	0.455	0.007*
E3. I would like to learn this way in the future.	4.56	1.791	4.40	1.814	0.669	0.089	0.494
E4. I feel like I have a good understanding of the material.	4.91	1.621	4.99	1.683	−0.346	−0.048	0.499
E5. After this lesson, I would be interested in learning more about the material.	5.83	1.273	5.51	1.626	1.552	0.219	0.012*
E6. I found the lesson to be useful to me.	5.25	1.569	5.04	1.695	0.934	0.129	0.168
E7. I felt like the instructor was working with me to help me understand the material.	4.63	1.654	4.91	1.713	−1.177	−0.166	0.474
E8. I found the instructor's teaching style engaging.	4.39	1.836	4.05	1.811	1.318	0.186	0.211
E9. I felt motivated to try to understand the material.	5.11	1.581	4.73	1.789	1.610	0.225	0.055

*$p < 0.05$.

cues of instructors won the favor of students, which can be proved by the degree of students' enjoyment of the course.

In sum, instructors' expressive nonverbal behavior had an opposite effect on students' learning performance and affective experience. Expressive nonverbal behavior promoted students' affective experience but hindered their learning performance. The instructor with nonexpressive nonverbal behavior was more conducive to elementary students' performance in the post-test. Concerning affective experience, the instructor with expressive nonverbal behavior improved students' enjoyment and learning interests. What's more, students were more satisfied in the expressive condition than those in the nonexpressive condition.

Experiment 2

Aim and hypothesis

The purpose of experiment 2 was to verify the conclusions of experiment 1, so we chose a different sample to conduct the experiment. Based on the findings of experiment 1, the following hypotheses were formulated:

> *H3*: Compared with the expressive condition, students who learn from the instructor with nonexpressive nonverbal behavior will perform better in learning performance test.
>
> *H4*: Compared with the nonexpressive condition, students who learn from the instructor with expressive nonverbal behavior will have a better learning experience.
>
> *H5*: Compared with the nonexpressive condition, students who learn from the instructor with expressive nonverbal behavior will report higher learning satisfaction.

Method

Participants and design

Participants in the present study were students from an urban elementary school located in Wuhan, China. A total of 175 students in sixth grade responded to the survey. The sample consisted of 87 males and 88 females. All participants were randomly assigned to two groups: 87 students (male = 41, female = 46) watched the video lecture with an expressive instructor and 88 (male = 46, female = 42) students watched video lecture with a nonexpressive instructor. The data were collected through questionnaires that were administered in the school classes by a research assistant and four school instructors. The study protocol was approved by the ethics committee of Central China Normal University.

Material

The two versions of the video lectures were the same as experiment 1.

Measurements

The pre-test, post-test, and post-questionnaires were the same as in experiment 1.

Procedure

The study was carried out in four multimedia classrooms, with four naturally occurring classes. Each condition was randomly assigned to two classes. 87 students (male = 44, female = 43) watched the instructor with expressive nonverbal behavior video lecture, and 86 (male = 42, female = 44) students watched the instructor with nonexpressive nonverbal behavior video lecture. The procedure was as follows: firstly, participants filled in demographic information and took the prior knowledge test. Secondly, they viewed one of two system-paced video lectures. Thirdly, they filled out the learning experience questionnaire and

learning satisfaction questionnaire. Finally, they took the post-test. It took approximately 30 min to complete the experiment.

Results

Four independent sample *t*-tests were conducted with experiment conditions (expressive vs. nonexpressive) as the between-subjects factor, prior knowledge, and the following three measures as dependent measures: learning performance, learning experience, and learning satisfaction. There was no significant difference in the prior knowledge between the two groups ($t = 1.08$, $p = 0.281 > 0.05$). The mean and standard deviation for the expressive condition were $M = 4.08$ and SD = 1.081, and for the nonexpressive condition were $M = 3.90$ and SD = 1.155. Descriptive statistics for all dependent variables are shown in Table 4.

Learning performance

We did not find a significant difference in learning performance between the two groups ($t = -0.135$, $p = 0.447 > 0.05$). The nonexpressive group ($M = 17.57$, SD = 2.986) performed slightly but not significantly ($p = 0.447 < 0.05$) higher than the expressive group ($M = 17.51$, SD = 3.121). Hypothesis 3 was violated.

Learning experience

The independent sample *t*-test result showed that there was a significant difference in learning experience between the two groups ($t = 2.658$, $p = 0.005 < 0.05$, Cohen's $d = 0.410$). To compare differences, we performed 9 independent sample *t*-tests with each sub-item in the learning experience as the dependent variable and experiment conditions (expressive vs. nonexpressive) as the grouping variable. Descriptive statistics are shown in Table 5. Specifically, there was significant difference on perceived difficulty ($t = 2.286$, $p = 0.003 < 0.050$, Cohen's $d = 0.432$), learning interest ($t = 2.342$, $p = 0.010 < 0.050$, Cohen's $d = 0.359$), and usefulness ($t = 1.864$, $p = 0.032 < 0.050$, Cohen's $d = 0.286$). It was consistent with experiment 1 that students in the expressive condition perceived the content as less difficult. And they became more interested in the learning topic. The result supported hypothesis 4.

Learning satisfaction

There was a significant difference in learning satisfaction between the two groups ($t = 1.774$, $p = 0.039 < 0.050$, Cohen's $d = 0.279$). Descriptive statistics are shown in Table 4. It was found that students in expressive condition were more satisfied than students in nonexpressive condition. Hypothesis 5 was supported.

Discussion

Experiment 2 aimed to find out if students who watched the expressive video had a better affective experience but worse learning performance than those who watched the nonexpressive video. In experiment 2, the same procedure was conducted but a sample from a different city was selected. Results showed that students who watched the expressive videos did report a higher learning experience, but there was no significant difference in learning performance between the two groups. By comparing the pretest scores of students in the two experiments in detail, we found that the pre-test scores of students in experiment 2 were higher than those in experiment 1($M = 3.50$ in experiment 1, $M = 3.99$ in experiment 2). In experiment 2, students in urban areas scored slightly better on the prior knowledge test than those in rural areas. For participants in experiment 2, instructors' nonexpressive nonverbal behavior had no significant effect on their learning performance may because they had relatively higher prior knowledge. The phenomenon that approaches and instructional design that work well for individuals with low knowledge experience may not work well for individuals with high knowledge experience is called the expertise reversal effect (Kalyuga et al., 2003). In the field of multimedia learning, learners' previous knowledge is an important factor affecting learning results (Kalyuga, 2007).

Students in experiment 2 reported significant differences in learning experience, while students in experiment 1 did not report significant differences in the overall learning experience. It is possible that there is a correlation between the learning experience and the learning performance: low learning performance put a negative effect on the learning experience, while high learning performance put a positive effect on the learning experience. In experiment 1, the learning performance of students in the expressive group was significantly lower than those of the nonexpressive condition, which offset the good learning experience of instructors' expressive nonverbal behavior. The opposite was true for the nonexpressive condition. Thus, there was no significant difference in the learning experience of

TABLE 4 The descriptive statistics for dependent variables in experiment 2.

Dependent variable	Expressive condition		Nonexpressive condition		*t*	*d*	Sig. (1-tailed)
	M	SD	*M*	SD			
Learning performance	17.51	3.121	17.57	2.986	−0.135	−0.020	0.447
Learning experience	48.39	10.01	43.79	12.33	2.658	0.410	0.005*
Learning satisfaction	11.33	2.38	10.57	3.03	1.774	0.279	0.039*

*$p < 0.05$.

TABLE 5 Results of independent sample *t*-test of learning experience sub-items in experiment 2.

Source of variation	Expressive condition		Non-expressive condition		*t*	*d*	Sig. (1-tailed)
	M	SD	*M*	SD			
E1. I felt that the subject matter was difficult.	1.15 (5.85)	1.393	1.81 (5.19)	1.653	2.286	0.432	0.003*
E2. I enjoyed learning this way.	5.40	1.466	4.99	1.801	1.630	0.250	0.053
E3. I would like to learn this way in the future.	4.83	1.543	4.58	1.818	0.963	0.148	0.169
E4. I feel like I have a good understanding of the material.	5.84	4.647	5.01	1.719	1.561	0.237	0.060
E5. After this lesson, I would be interested in learning more about the material.	5.76	1.478	5.18	1.742	2.342	0.359	0.010*
E6. I found the lesson to be useful to me.	5.33	1.459	4.86	1.814	1.864	0.286	0.032*
E7. I felt like the instructor was working with me to help me understand the material.	5.41	1.560	5.01	1.771	1.562	0.240	0.060
E8. I found the instructor's teaching style engaging.	4.47	1.868	4.14	1.955	1.149	0.173	0.126
E9. I felt motivated to try to understand the material.	5.08	1.723	4.75	1.827	1.230	0.186	0.110

*$p < 0.05$.

the two groups. There's another possibility, rural students with low prior knowledge find the learning content difficult ($M = 1.84$ in experiment 1, $M = 1.48$ in experiment 2, the less scores, the easier). To understand the learning content, they pay more attention to the learning material and do not pay much attention to the expression of instructors' nonverbal behavior. Students with high prior knowledge have less pressure to master the learning content and pay more attention to the instructors' nonverbal behavior. Therefore, the learning experience was not significantly different in Experiment 1 and significantly different in Experiment 2.

Conclusion

This study conducted two rounds of experiments to explore the effects of instructors' nonverbal expressiveness in video lectures on primary school students' learning performance and affective experience (including learning experience, and learning satisfaction). Counterintuitively, both experiments showed that instructors' expressive nonverbal behavior decreased students' perception of the learning difficulty, that is, students who watched the expressive nonverbal behavior video thought the teaching content was less difficult than those who watched the nonexpressive video. Interestingly, we also found an expertise reversal effect, that is, methods that work for learners with low prior knowledge do not work for those with high prior knowledge. Students from urban areas in experiment 2 performed better on prior knowledge test than students from rural areas in experiment 1. As a result, unlike in experiment 1, nonexpressive instructors promoted students' learning performance, in experiment 2, no significant difference in learning performance was found. In terms of learning experience and satisfaction, both experiments showed that instructors' expressive nonverbal behavior improved students' learning experience (for experiment 1, it improved the learning experience of individual sub-items, and for experiment 2, it improved the overall learning experience) and satisfaction.

Contribution and implication

This paper adds important information to the multimedia learning literature regarding instructors' nonverbal expressiveness on elementary students' learning performance and affective experience. Instructors' expressive nonverbal behavior enhances students' affective experience but hinders students' learning performance when students' prior knowledge is low. Besides, it further supports the limited-capacity assumption that each channel in the human information processing system has a limited capacity. Instructors' expressive nonverbal cues may increase the amount of information processing, which led to the decline of students' learning performance when students with low prior knowledge.

The implications of this research for teaching are that instruction should be based on learners' prior knowledge. Facing learners with different prior knowledge, instructors' expressive nonverbal behavior will have different effects. For learners with low prior knowledge, instructors' expressive nonverbal behavior hindered learners' learning performance. While for learners with high prior knowledge, instructors' expressive nonverbal behavior did not hinder learners' learning performance. Considering the long-term development of learners, we do not advise instructors to adopt nonexpressive nonverbal behavior even facing learners with low prior knowledge. Because compared to expressive instructors, nonexpressive instructors were less efficient in improving learners' affective experience. For learners with low prior knowledge, instructors should adopt expressive nonverbal behavior, but reduce the difficulty of learning content or provide learners with more scaffolds, so as to help students achieve good learning performance, meanwhile obtaining a good affective experience and maintaining interest in learning.

Limitations and future research

Despite the meaningful and interesting findings, this study has three aspects of limitations that need to be further considered. First, we did not use eye trackers to track students' attention due to the large sample size and equipment shortage. This makes it lack evidence for us to compare whether there are differences in learners' attention distribution on instructors and learning content. In future research, we recommend using eye trackers to record the attention distribution of learners with different prior knowledge when watching video lectures with different nonverbal expressiveness instructors. Second, we did not measure learners' perceptions of the instructor's professional level and emotional state. Instructors' nonverbal behavior is more than cognitive information for learners, it is essential emotional information and social cues. Learners might perform differently when learning from a perceived expert than a perceived novice (Beege et al., 2019). What's more, when learners perceive the instructor's emotion as positive, learners may be more willing to engage in learning activities. The third limitation of the study is that the findings are not generalizable across cultures. This study was conducted in China, and its conclusions are more applicable to Chinese students. We know that nonverbal expressiveness is closely related to culture. What is considered expressive nonverbal behavior in the context of Chinese culture may not be expressive enough in the context of Western culture. Future research should explore the impact of different levels of nonverbal expressiveness of instructors on young learners in different countries and cultural backgrounds.

Data availability statement

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

Ethics statement

The studies involving human participants were reviewed and approved by the Central China Normal University. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements. Written informed consent was obtained from the individual(s) for the publication of any identifiable images or data included in this article.

Author contributions

MW and ZC conceived the study. ZC contributed to the supervision. MW, YS, and CX conducted the experiment and collected the data. YS and ZW analyzed and interpreted the data. MW contributed to the writing of the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Publisher's note

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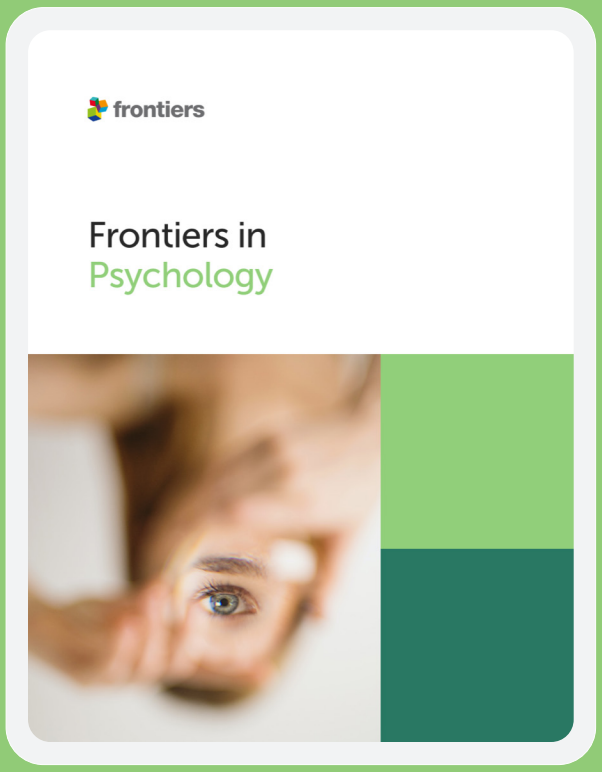

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