



# Efficacy of Flipped Classroom and Game Teaching in Experimental Teaching of Histology and Embryology

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**Background:** Histology and Embryology (HE) are important basic medical courses, with complex, abstract content and difficult memorization of knowledge points, which leads to a decrease in students' interest in learning. Therefore, how to improve students' learning interest is worth serious consideration by teachers. This study aims to investigate the promoting effect of interesting teaching based on flipped classrooms and game teaching on the experimental teaching of HE.

**Methods:** Implementing flipped classrooms and gamified teaching methods for the class of 2023 in clinical medicine. Before class, the teaching videos were uploaded to Moso Teach to guide students in self-directed learning. In class, each group discussed the experimental content on the digital platform, and the teacher supervised the classroom to guide and address queries. Later, some students were randomly selected to explain the morphological characteristics of the main structure on the podium, and the teacher recapitulated and assessed the performance of each group. Finally, the knowledge points of HE were carefully designed into classroom games to make the learning experience more engaging. The effectiveness of the flipped classroom and game-based teaching methods was assessed through surveys and comparisons of grades with those of students in the 2022 class who were taught using traditional methods.

**Results:** In this study, 93.62% of the students reported an enhanced teaching effect after altering the experimental teaching method. Meanwhile, the proportion of students who did not understand the observation slices declined from 12.77% to 1.06%, while those who were not very active or passive declined from 43.62% to 21.28%. Importantly, the scores of experimental and final exams for the 2023 grade of students taught by interesting teaching method were significantly higher than those of the 2022 grade of students taught by traditional teaching method ( $P < 0.05$ ).

**Conclusion:** The application of flipped classroom and game teaching, piqued students' curiosity, kindled their interest in learning, and amplified their learning enthusiasm and self-learning ability.

**Keywords:** flipped classroom, game teaching, histology and embryology, experimental teaching

## Introduction

One of the first professional courses that medical students are exposed to is HE—a crucial basic course in medical science that teaches the microstructure and function of the human body.<sup>1</sup> Although the relatively abstract and boring theoretical knowledge makes the course difficult for freshmen to adapt and learn, mastering it exerts a crucial promoting effect on their ensuing professional learning and stable professional acumen.<sup>2,3</sup> Experimental teaching is vital in the entire teaching process, serving students to integrate and expand their theoretical knowledge, as well as stimulate their interest in learning. Currently, the conventional experimental teaching mode follows the approach of teacher-led presentation, student observation, teacher question and answer (Q&A), and classroom summary. This entire process is led by the teacher and students learn passively. The teacher cannot ascertain the learning acumen of each student, lacks constructive supervision and assessment, and the teaching quality cannot be guaranteed.<sup>4</sup> Moreover, students generally

lack interest in learning. Therefore, how to stimulate students' interest in learning is an issue that teachers must pay attention to.

Fronting the impact of diversified and ever-evolving information technologies in the context of "Internet plus education," society and parents have set forth higher expectations and requirements for teachers. Meanwhile, the popularization and application of technology have also posed increased challenges to teachers' teaching methodology. The popularity of smartphones has created opportunities for the "Internet plus Education" initiative.<sup>5</sup> As mobile learning based on smartphones is not limited by time and space, it has emerged as a new way for college students to acquire personalized and diversified learning. In today's era of assorted education and tailored learning, research on smartphone-based mobile learning for college students is of utmost significance and representativeness.<sup>6</sup>

A mobile teaching assistance app called Moso Teach, which utilizes smartphones, has effectively enhanced classroom interaction and provided real-time feedback. Through the App, teachers can easily manage their classes, send notifications, upload resources, assign schoolwork, organize discussions, address queries, and perform other teaching activities. Offering students services like course subscription, schoolwork completion, message push, courseware download, video browsing, and resource learning on mobile devices aids effective assessment of students' learning progress and grades, eventually providing a new mobile teaching experience of online learning for students. Furthermore, the advent of information technology has introduced digital teaching platforms to the experimental teaching of HE. The platform resources comprise multiple panoramic digital slices of histology, enabling students to observe slices anytime and anywhere, without the restriction of time, space, or number of people. This provides college students with a new way to access personalized and diverse learning resources.

It is evident that digital morphological teaching platforms, as well as Moso Teach, facilitate online learning for students prior to class, which is conducive to the implementation of flipped classrooms. Multiple studies have shown that flipped classrooms can enhance student satisfaction, reduce their cognitive burden, and improve their ability to learn independently.<sup>7-9</sup> However, at present, the application of flipped classrooms in medical education, particularly in the fields of HE, is limited,<sup>8</sup> and it relies heavily on the students' self-motivation; as a result, the pre-class learning experience can be quite solitary. Therefore, incorporating game-based interactive elements into the teaching process can enhance teamwork skills and significantly increase students' interest in learning. It has been confirmed that gaming software and platforms such as Kahoot, HistoRM, and Quizlet have been used in the teaching of HE.<sup>10-15</sup> However, there have been no reports on the use of games adapted from television entertainment shows in these teaching contexts. Thus, this study utilizes digital morphological teaching platforms and Moso Teach to investigate the role of flipped classrooms and games adapted from television entertainment shows in stimulating students' interest in learning and improving their academic performance.

## Materials and Methods

### Participants and Statistical Analysis Methods

The interesting teaching conducted in 2023 grade comprised 96 medical students at Jiujiang University. The scores of experiment exam and final exam obtained in 2023 grade were mainly compared with those from the traditional teaching methods in 2022 grade (The number of students participating in the traditional teaching programs was 94). Moreover, the teacher in both 2022 grade and 2023 grade was the same person, and the difficulty level of the exam remained consistent in both years. In addition, the questionnaires at the beginning and end of the 2023 semester were identical.

GraphPad Prism version 8 was employed to analyze data. Percentages and Fisher's exact test were used for qualitative data obtained from the questionnaires conducted at the beginning and end of the semester. Meanwhile, mean  $\pm$  standard deviation and *t*-test were used for quantitative data came from the scores of exam. A *p*-value of  $< 0.05$  was set as significant.

### Teaching Preparation

Pertinent literature was reviewed to comprehend the prevailing use of Moso Teach in other courses at school, followed by developing a detailed work plan per the requirements and teaching attributes of the undergraduate clinical medicine

curriculum. Before commencing the course, the teacher logged into the Moso Teach App and created a Moso Teach about “Histology and Embryology.” Per the teaching syllabus, filled in the course introduction and teaching progress, guided 2023 grade of students to download the Moso Teach App on their mobile phones, and used the invitation code to join the corresponding class. Every time, based on the teaching schedule, courseware was pushed in advance on Moso Teach before class, and self-test questions were pushed after class, enabling students to preview and review anytime and anywhere. After the release of teaching resources, all students’ mobile phones received instant message notifications. If students browsed or downloaded the resources, learning progress could be monitored in real time.

Schoolwork was assigned on Moso Teach, students answered questions on their mobile phones or took photos to upload, and teachers graded or had students assess each other on Moso Teach. Quizzes were conducted regularly in the classroom through Moso Teach to grasp the efficacy of students’ learning stages. Next, group learning was conducted on Moso Teach to harness students’ teamwork spirit. Then, a discussion and Q&A window was opened throughout the semester, students’ queries were addressed, and students were encouraged to discuss and answer each other, promoting mutual enhancement.

To conveniently manage and familiarize students, all students had to enter their student ID and real avatar when joining the class, view the average attendance rate, attendance frequency, and attendance trend chart of their classmates, along with the attendance, tardiness, early departure, sick leave, personal leave, and other data of each student. Moso Teach can automatically track students’ learning progress, and teachers can view them through mobile Apps and the Internet.

## Teaching Design (Figure 1)

The first four experimental classes were still primarily led by the teacher, with the teacher regularly illustrating the experimental content, followed by students’ independent observation and the teacher’s review and addressing queries. From the fifth class onwards, the conventional teacher-led experimental teaching mode was transitioned to a student-centered experimental teaching mode per the educational concepts like the flipped classroom.

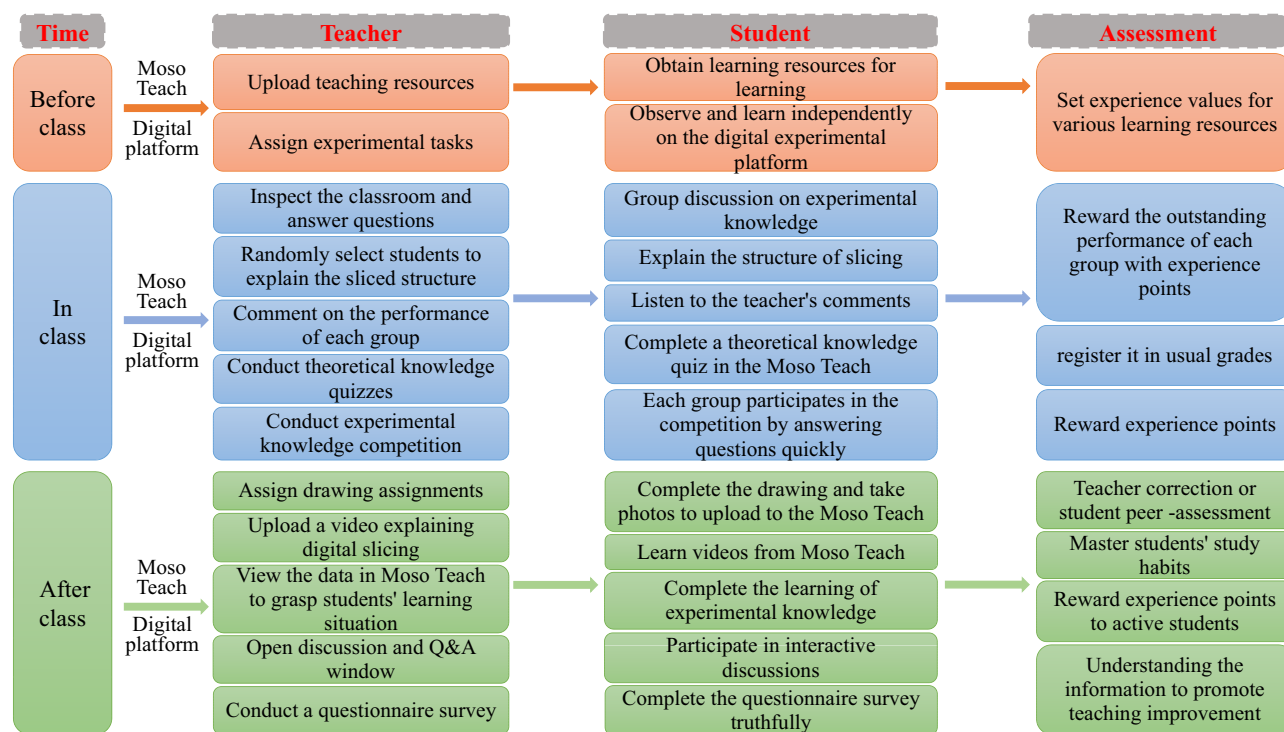


Figure 1 Design of digital experimental teaching for HE based on Moso Teach.

*Before class:* Based on the teaching progress, notifications were published in advance on Moso Teach and digital slice explanations of micro-lesson videos were sent to help students learn independently, furthering their understanding and assimilation of theoretical knowledge. Concurrently, the digital slices and pertinent knowledge points were assigned that warranted observation in the experimental class. Each group leader supervised the team members to observe and preview the digital platform.

*In class:* Each class ran for 90 min. In the first 40 min, each group leader organized team members to discuss the experimental content on the digital platform, comprehend the preview situation, raise queries, and discuss with each other. The teacher inspected the classroom and offered guidance and explanation to each group. In the next 25 min, per the number of observed slices, 2–4 groups were randomly selected from Moso Teach to send team members to the podium to deliver lectures on digital slicing, elucidating the key knowledge points and related structures, and taking queries from other groups. In the last 25 min, the teacher summarized and evaluated each group's performance, highlighted issues, and conducted occasional quizzes through Moso Teach to understand the learning stage effects on students. Alternatively, small games were organized irregularly through Moso Teach to encourage intergroup competition and collaboration. Besides, students could also check in their class through Moso Teach, making it convenient and quick to grasp their attendance situation. Meanwhile, the “shake” function could be used to randomly select students to partake in question-asking and preemptive answering, thereby raising the fun quotient of the class.

The design of the game competition aimed at transforming the learned content into some simple and exciting games, enabling students to review pertinent facts in a relaxed and enjoyable state. The game segment denoted variety shows, including the Chinese Idiom Competition, involving target timing, where contestants have to guess target nouns as quickly as possible, and the one with the shortest time wins. The game offers an opportunity for “passing” and one violation. In the “same question confrontation” segment, both contestants shared a multiple-choice graphic question, and the one who answered correctly started describing. Each contestant had to explain the selected noun in no more than three words, and the two sides took turns swapping until one contestant correctly guessed. Regarding the “noun-guessing limit,” within a specified time, the narrator continued to describe, and both parties took turns guessing words until they guessed correctly. Here, no opportunities were provided for “passing” or violating regulations. Regarding “time-limited guessing,” within the specified time, contestants had to answer as many graphic-choice questions as possible and explain to their peers to guess the answer. There was just one chance to “pass” and two opportunities to violate regulations. About “drawing guessing,” participants had to draw the structure designated by the teacher on site within the specified time, and their peers had to guess it accurately.

*After class:* Drawing assignments were allocated while advising students to continue watching digital slicing instructional videos and pertinent teaching materials, practice self-test questions, and prudently review after class. Then, opened a discussion and Q&A window throughout the semester, where students took screenshots of structures they did not recognize in digital slicing and sent them to the window to guide and motivate students to discuss and address queries with each other, helping mutual development.

## Teaching Evaluation System

In Moso Teach, students were rewarded with experience points for viewing several resources and engaging in activities. Students who participated in classroom activities, discussions, and Q&A windows were also rewarded with experience points to enhance their learning interest and enthusiasm, as well as to assess their learning status and aptitude through experience points. A questionnaire survey was conducted before and after the class through Moso Teach to measure changes in students' understanding and interest in the course. Soliciting students' views, opinions, and suggestions on the experimental teaching process at the start, middle, and end of the semester, and providing timely feedback to help students resolve multiple issues in a targeted manner, along with fine-tuning teaching methods, are beneficial to a more enjoyable and competent teaching and learning process. Assessed students' expertise of pertinent knowledge points per the results of multiple irregular classroom quizzes. Experimental teaching was primarily based on group learning, encouraging unity and teamwork. Nominated or randomly selected groups or members explained the slices to comprehend students' learning state. Meanwhile, regular classroom competitions were organized through Moso Teach to augment learning interest and increase learning enthusiasm. Smartphone-based Moso Teach is fully engaged in

organizing digital experimental teaching of HE, recording data of students' learning processes and habits, and assessing the efficacy of experimental teaching through experience points, stage quizzes, questionnaire surveys, and other methods, rendering the assessment system of experimental teaching more reasonable.

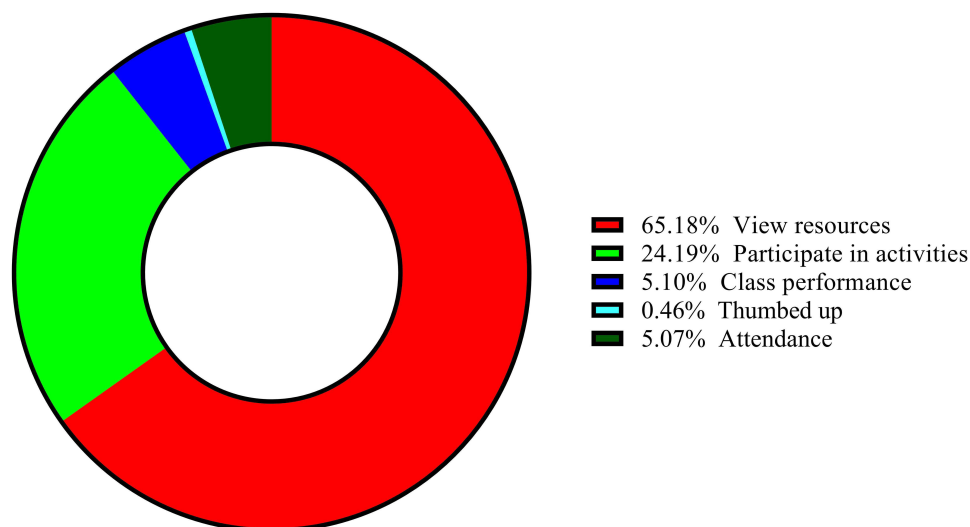
## Results

We first attempted to apply Moso Teach to the teaching of HE in nursing undergraduate programs. After constant upgrading and summarization, it was then slowly applied to other professional courses associated with HE, including clinical medicine, oral medicine, and medical laboratory technology, attaining satisfactory teaching results and unanimous praise from teachers and students. Given below is a demonstration of the efficacy of the digital experimental teaching reform of HE based on Moso Teach applied in clinical medicine majors.

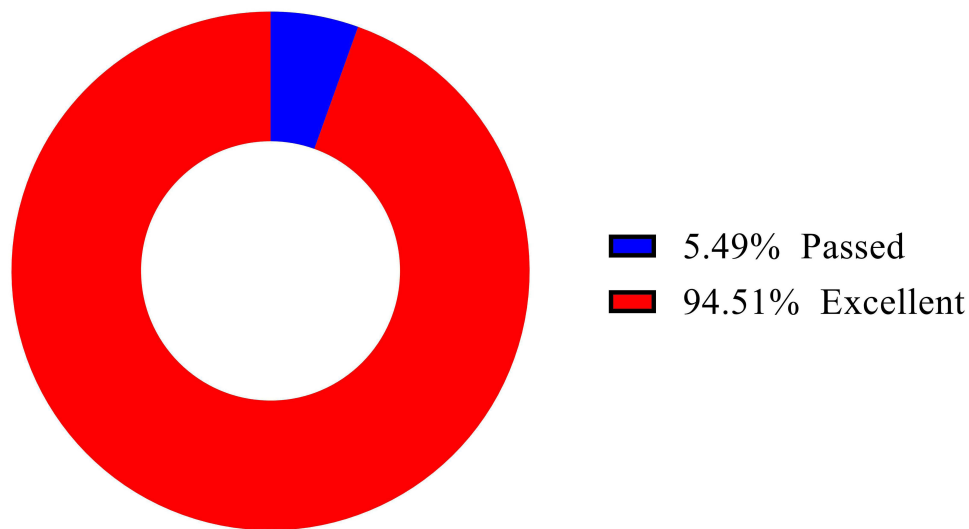
## Experience Value Statistics

By the end of the semester, 63 courseware, videos, and other resources were available on Moso Teach, comprising 22 teaching courseware, 21 review courseware, 11 experimental teaching videos, and 5 extracurricular materials. In addition, self-testing questions were pushed 18 times, along with 5 regular tests, 1 mid-term examination, 1 laboratory exam, 3 voting questionnaires, and 1 teaching feedback survey. Except for mid-term examinations, laboratory examinations, and regular quizzes, corresponding experience points were set for resource viewing and activity participation (Figure 2), with a cumulative expected experience point of 149. Besides, extra experience points were awarded to students who answered questions in class, discussed and answered questions in class, asked creative questions, participated in project games and competitions, prudently completed teaching feedback surveys, or provided feasible suggestions. Notably, 1–5 experience points were awarded per students' performance. The highest experience value reached 173, whereas the lowest was 129.

According to the experience value statistics table, 47 students (50%) obtained an experience value of 149, with the lowest being 120. The average expected experience value was 147, signifying that the vast majority of students meticulously completed the learning and activity participation of several resources in class (Figure 3), indirectly portraying students' acknowledgment of the way they participated in learning through Moso Teach. Furthermore, 3 students with an additional experience value of 0 demonstrated that some students did not actively engage in classroom activities, discussions, Q&A, and teaching feedback surveys.



**Figure 2** Method of obtaining experience points.

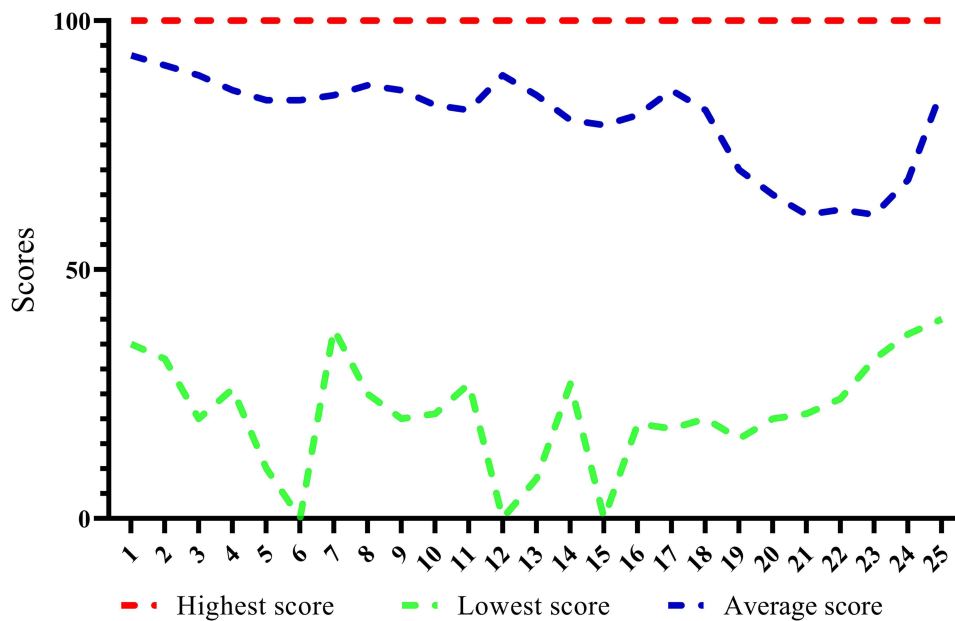


**Figure 3** Distribution of experience points.

**Note:** Based on the highest experience value (The value is 173) among students, those with >80% are considered excellent, those with 60–80% are considered passing.

### Test Results

A total of 18-chapter self-test questions were pushed in one semester, with 615 choice questions overall. Students could complete them without any restriction on the number of times and integrate textbook knowledge through continuous practice. Besides, classroom tests were conducted five times, with 10–20 choice questions quickly finished each time. Meanwhile, a mid-term examination was conducted, with 50 choice questions overall, along with an experimental examination with 20 graphic choice questions. [Figure 4](#) demonstrates that the average scores of self-test questions were higher than those of classroom tests, suggesting that most students could practice self-test exercises seriously outside of class. Nevertheless, the average score exhibited a minor downward trend, depicting a decline in students’ interest and eagerness to practice questions from the beginning to the end of the course. Furthermore, irregular classroom quizzes truly reflected students’ learning condition, whereas the results of mid-term and experimental examinations were



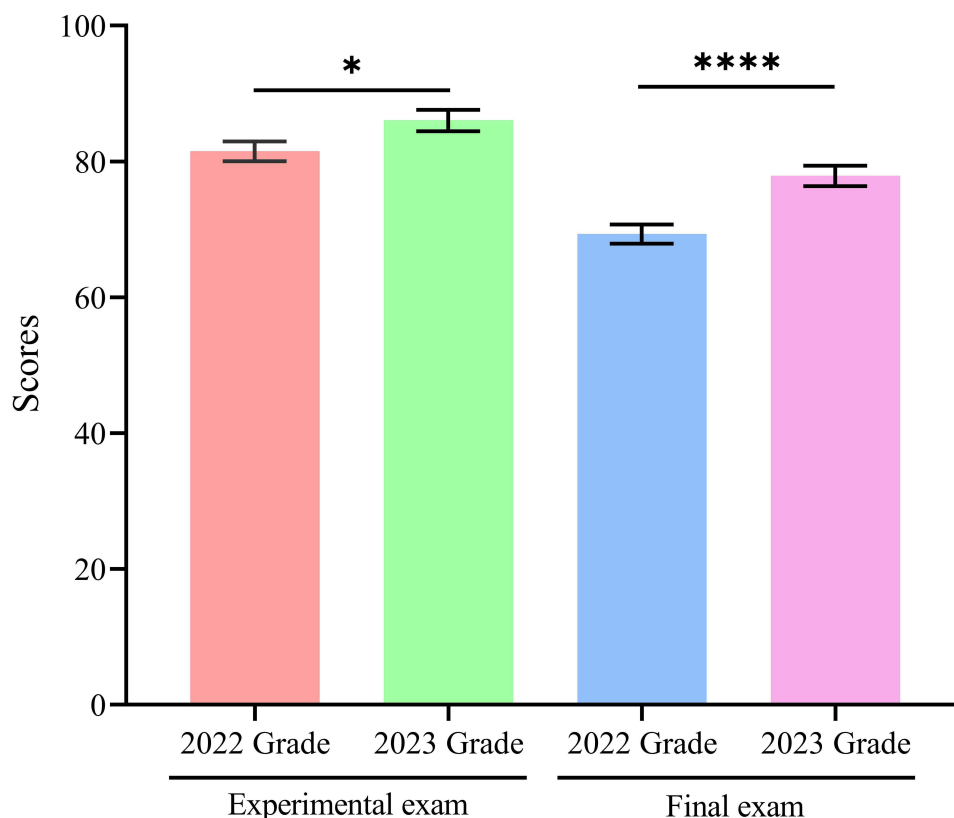
**Figure 4** Test score situation for 2023 grade of students. 1–18, chapter self-test; 19–23, classroom test; 24, mid-term exam; 25, experimental exam.

comparatively ideal, suggesting that students recognized the significance of these two examinations, took them seriously, and prepared satisfactorily. Importantly, the scores of experimental exam for 2023 grade of students were significantly higher than those of 2022 grade of students taught by traditional teaching method ( $P < 0.05$ ), and the same phenomenon occurred in the final exams ( $P < 0.0001$ ) (Table S1 and Figure 5).

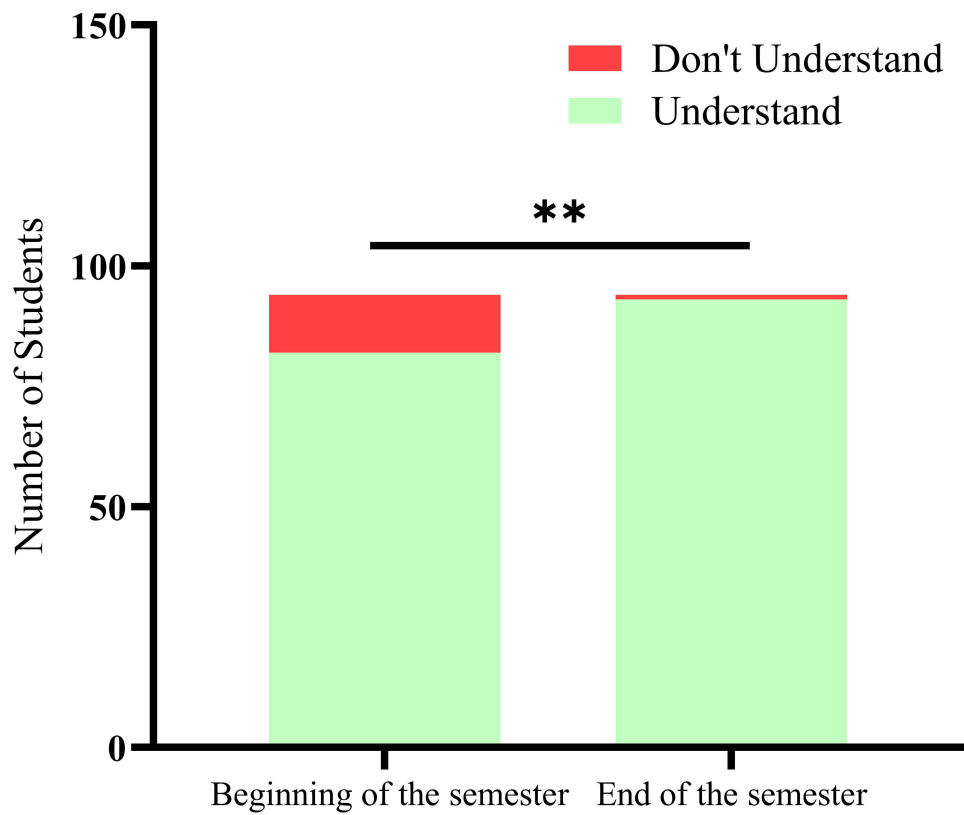
## Voting Questionnaire Results

A voting questionnaire was conducted through Moso Teach to comprehend students' opinions on the utility of this App in HE teaching. The final teaching questionnaire survey (Table S2) revealed that the majority of students favored the use of Moso Teach and carefully reviewed the resources available on it. Regarding regular quizzes on Moso Teach, students took them seriously and claimed that this testing method promoted their daily learning. Most students were interested in the HE course, recognized the course significance, acknowledged the teaching process, and adapted to such teaching methods.

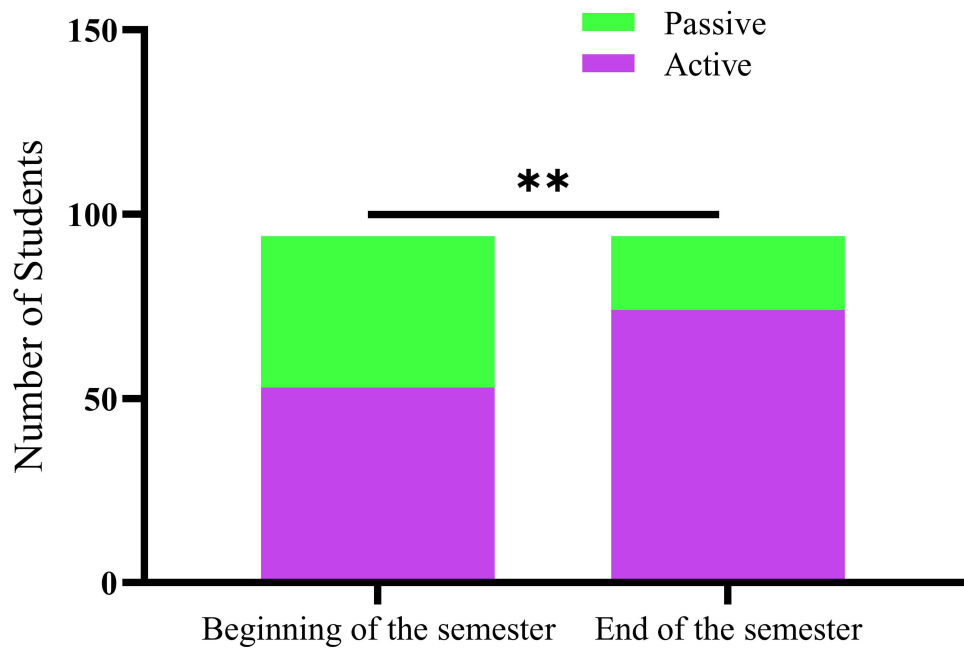
The questionnaire survey on experimental teaching at the beginning and end of the semester (Tables S3 and S4) demonstrated that 50% and 43.62% of students testified a substantial or marginal enhancement in teaching efficacy after modifying the teaching method of experimental classes. Meanwhile, 84% of students considered experimental teaching to be more effective in integrating theoretical knowledge points. The proportion of students who did not understand the observation slices declined from 12.77% to 1.06% (Figure 6), while that of students who felt less active or passive in class declined from 43.62% to 21.28% (Figure 7). Moreover, 94.68% of students approved group discussions for joint learning, 80.85% approved on-stage slicing explanation, and >90% claimed that the game competition segment enhanced course interest and harnessed knowledge proficiency. Meanwhile, most students also recognized the significance of learning through observing digital slices on morphological digital platforms. While 60.64% of students reported that



**Figure 5** The scores of experimental and final exam. The results were presented as the mean ± SEM. \* $P < 0.05$ , the scores of experimental exam for 2022 grade ( $81.49 \pm 1.48$ ) vs the scores of experimental exam for 2023 grade ( $86.04 \pm 1.57$ ); \*\*\*\* $P < 0.0001$ , the scores of final exam for 2022 grade ( $69.32 \pm 1.42$ ) vs the scores of final exam for 2023 grade ( $77.89 \pm 1.51$ ).



**Figure 6** The proportion of students who fully understand the observed slices under Traditional Teaching or Interesting Teaching.  $**P<0.01$ , the proportion of students fully understanding the observed slices at the end of the semester (98.94%) VS the proportion of students fully understanding the observed slices at the beginning of the semester (87.23%).



**Figure 7** The proportion of students actively learning under Traditional Teaching or Interesting Teaching.  $**P<0.01$ , the proportion of students actively learning at the end of the semester (78.72%) vs the proportion of students actively learning at the beginning of the semester (56.38%).

observing digital slices enabled better uptake of related knowledge, only 4.26% of students preferred conventional slices. Overall, these findings suggested that the modification of experimental teaching methods markedly enhanced teaching quality, harnessed students' self-learning ability, and stimulated learning interest in students.

Nevertheless, after modifying the experimental teaching method, the proportion of students who were very satisfied or relatively satisfied with the teaching process declined from 98.93% to 93.62%, while those who were not very satisfied or very dissatisfied surged from 1.06% to 6.38%, and those who were not very suitable or adapted to the teaching method surged from 2.13% to 8.51%. These findings could be attributed to the fact that students learn passively and have less pressure under the conventional teaching method at the beginning of the semester. While the modification of the experimental teaching method warrants students to be more proactive, the learning pressure before and after class is bigger. Besides, there are pressures of random on-stage slicing explanation and participation in game competitions—all of which complicate students' complete adaptation to the new teaching methods.

In this study, initial and final questionnaire surveys elucidated students' opinions on the teaching process. The initial survey clarified students' feelings about the curriculum and teaching when they first encountered HE; based on this, the teaching process was adjusted appropriately to help them adapt as soon as possible. The final survey summarized students' teaching and learning situation over the past semester, providing useful accretion for future teaching improvement.

## Teaching Feedback Survey

The final teaching feedback survey probed students' feelings about this course and their opinions and recommendations on the teaching situation. Most students affirmed teachers' teaching ability and methods, as well as recognized the reform of digital experimental teaching methods for HE based on Moso Teach. For example, one student stated,

The most impressive part for me is probably the game part of the experimental class. In order to perform stably after going up, we need to review the relevant knowledge points several days in advance. The first time we play the game, it is indeed a bit nervous, but when the game starts, we answer the first question correctly. At that moment, a sense of pride surged from the bottom of my heart, and it was from then on that I began to love this course.

Another student stated,

Online video materials are one of the highlights of teaching, and watching videos helps me observe slices in the next day's lab class. The offline experimental class adopts a group teaching mode, which allows us all to participate. The most noteworthy aspect is the game segment, which greatly enhances the classroom atmosphere.

Meanwhile, some students reported that group learning enhanced their self-learning ability, enabled them to identify their problems, and increased efficiency through group discussions—all of which were very helpful for learning. Of note, teaching slicing in laboratory classes is both a challenge and a display of learning outcomes. The game segment is highly distinctive and can kindle students' fighting spirit. Furthermore, occasional small tests act as a check and reminder of regular grades.

Nevertheless, some students put forth some opinions and recommendations regarding the experimental classroom. Some stated that during the group discussion stage, the leader has to always explain the slices, putting immense psychological pressure and responsibilities on him/her. Consequently, the leader usually understands the related knowledge, although the team members might not fully understand it. Thus, we recommend that each group take turns serving as the leader for a week. Another student reported that when a student goes on the podium to explain the structure of an organ, others are a little preoccupied, either watching their own slices or watching teaching videos. Only a few listen carefully, which utterly wastes the precious time of experimental classes. Hence, better planning the pace of experimental classes and mobilizing students' enthusiasm is an issue that warrants careful consideration.

## Discussion

With the "Internet plus" action in full swing, the informatization reform of education has garnered considerable attention.<sup>8–10</sup> This study successfully integrated smartphone-based information technology with a morphological digital

experiment platform, as well as “flipped classroom” and game-based teaching methods. Additionally, a comprehensive formative assessment system was established. As a result, not only was students’ interest in learning significantly enhanced<sup>16–18</sup>(Figure 7 and Table S4) but their academic performance also improved markedly (Figure 5).

The results of this study indicate that Moso Teach and the digital experiment platform are extremely convenient to use. Through the Moso Teach, profuse teaching resources, such as experimental teaching videos, were pushed, enabling students to accomplish mobile learning through their smartphones anytime and anywhere. Notably, Moso Teach and digital experimental platforms were utilized fully to execute diverse teaching tasks at different periods before, during, and after class. Meanwhile, drawing on the flipped classroom model in the classroom, numerous forms of online classroom activities were organized to gamify the teaching process, thereby stimulating students’ interest in learning and improving their participation.<sup>19</sup> Cloud teaching can accomplish data-driven teaching processes, and real-time feedback assists in teaching diagnosis, making teaching controllable and forward-looking, constantly improving the teaching process.

In this study, we also made innovations in the teaching assessment system. A new teaching evaluation system was established that covered different periods before, during, and after class, along with online and offline processes, to complete multidimensional process and formative student evaluation. Meanwhile, teachers could use the big data in the Moso Teach backend to examine the differences in students’ learning processes, their learning attitudes, skills, and expertise of different knowledge points, thereby enabling tailored modifications of teaching progress and methods, and even facilitating personalized guidance for students.

It is evident that Moso Teach and the morphological digitization platform facilitate the implementation of flipped classrooms in a more efficient and convenient manner. The concept of flipped classrooms is gaining attention in medical education as it aligns with the digital age’s demand for more interactive and accessible learning experiences. By shifting the delivery of instructional content outside of the classroom, a flipped classroom allows students to engage with materials at their own pace, thereby maximizing in-class time for discussions, problem-solving, and other active learning activities. Compared to traditional medical education methods, the flipped classrooms enable students to acquire a richer knowledge base while enhancing their satisfaction with the learning process. The results of this study are in line with those found in the literature.<sup>10–15,20–23</sup> In addition to the flipped classroom approach, this study also incorporates game-based teaching methods, inspired by the television entertainment programs that young students enjoy so much. We adapted the concepts of HE into games, and the results showed that students found this interactive approach to be very enjoyable. As is well known, interest is a powerful driving force for learning, and game-based teaching is more effective than other methods in stimulating students’ interest;<sup>23</sup> this is directly reflected in the significant improvement in their academic performance. Furthermore, the game-based teaching method used in this study does not rely on traditional online gaming platforms or game software. Instead, the face-to-face interactions in the classroom add an element of entertainment, making the learning experience more engaging and attractive. It also helps to avoid the distractions that can arise from prolonged use of electronic devices.<sup>12</sup>

Despite the satisfactory results of this study, there are also the following limitations: Firstly, a randomized controlled trial could not be conducted. Jiujiang University enrolls 8 classes of clinical medicine undergraduates each year, and dividing them into an experimental group and a control group might lead to unfairness. Differences in teaching methods between the two groups could result in significant variations in academic performance, potentially leading to a bias in the distribution of scholarships between the experimental and control groups. In the future, we plan to implement a randomized controlled trial by enrolling students separately and revising the scholarship evaluation criteria. Secondly, both the flipped classroom approach and game-based interactions have the question of limited coverage. In subsequent studies, we need to design more targeted approaches to reach a larger number of students. Lastly, the applicability of our teaching method needs to be improved. Currently, many universities in China use the Moso Teach platform, and similar teaching aids exist in other countries as well; the flipped classroom is also a commonly used teaching method. However, the game-based teaching method used in this study is a unique design. We have already conducted extensive promotion, which has attracted the attention of many teachers. Moreover, since our games are designed to mimic Chinese television entertainment programs, they are very popular among young students. Since television entertainment programs exist in different countries, teachers can easily adapt professional knowledge points into games. From this perspective, our teaching method has considerable applicability.

## Conclusions

The research results indicate that this smartphone-based mobile teaching aid, when combined with flipped classrooms and gamified learning methods, is indeed worth further promotion. This teaching approach makes the entire experimental learning process more complete, enjoyable, and less stressful, thereby alleviating the tension between teaching and learning that often arises due to the dullness of the material and the excessive number of knowledge points. This innovative teaching method not only stimulates students' interest in learning and enhances their enthusiasm for learning but it also strengthens the interaction between teachers and students, contributing to the improvement of teaching quality and making the learning process more efficient and smooth. Furthermore, it represents an effective attempt to modernize traditional experimental teaching methods through the use of information technology. However, future research should focus on enhancing the rigor of the design, improving the practicality of the teaching methods, and conducting longitudinal studies to observe the long-term effects of this approach.

## Ethics Approval and Informed Consent

The study aligns with Ethical Review Measures for Life Sciences and Medical Research Involving Human Subjects (2023, article 32) and the regulations on Exemption from Ethical Review of the Association for the Accreditation of Human Research Protection Programs (*Tip Sheet 8. Exemptions: criteria for Making Determinations*), which permit educational innovation projects to proceed without additional ethics approval when using routine teaching methods and data-anonymized assessments.

All participants (medical undergraduates, age over 18) provided oral informed consent (*Raise hands in agreement*) prior to enrollment. The consent process specifies the purpose of the research, voluntary participation, confidentiality (data anonymization).

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## Disclosure

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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