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Comparative studies of the differences between flipped class and traditional class in orthopedic surgery education

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Objective: This study aims to compare the differences between traditional class teaching model and novel flipped class model in orthopedic surgery, and further clarify the potential merits.

Methods: Total 138 undergraduate fourth-year students from Shandong University who interned in the Orthopedics Department of Qilu Hospital from June 2022 to June 2023 were enrolled. They were randomly classified into traditional class group and flipped class group. At the end of the internship, all undergraduate students were evaluated in terms of orthopedic theoretical knowledge and practical operations. In addition, they also filled out subjective questionnaires related to satisfaction with related courses. All parameters involving two groups were compared.

Results: The theoretical assessment score of traditional class group was 75.10 ± 9.43 , while the theoretical assessment score of the flipped class group was 78.70 ± 10.71 , with a statistically significant difference ($p = 0.038$). Compared with the traditional class group (81.52 ± 8.50), the flipped class group showed a significant improvement in skill assessment scores (85.55 ± 8.29), with a statistically significant difference ($p = 0.006$). According to the weighted average score calculation, total score of students in the flipped class group (82.12 ± 6.69) was also higher than that in the traditional class group (78.31 ± 6.05), and the difference was statistically significant. Compared with the traditional class group, the satisfaction survey results of students in the flipped class group showed a significant improvement (except for reduce the learning burden), and the difference was statistically significant ($p < 0.05$).

Conclusion: The flipped class teaching mode significantly improves the learning interest and efficiency of internship students in orthopedic clinical teaching, and increases more communication and understanding between students and teachers. At the same time, it can tap into students' interests, hobbies, and self-learning abilities, effectively improving their mastery of theoretical knowledge and skill operations, which is worth promoting.

KEYWORDS

orthopedic surgery, traditional class, flipped class, undergraduate student, practical operation

Introduction

In recent years, with the continuous development and application of medical technology, as well as the increasing demand for student knowledge and clinical integration, the improvement of teaching models has gradually become a hot topic in the field of higher education at home and abroad. Orthopedic teaching mainly focuses on two aspects including basic theoretical knowledge and clinical practice. Its main characteristics are abstract and complex teaching content, complex knowledge points, strong logic, and limited learning hours. Meanwhile, it also involves various diseases. Therefore, it is difficult for undergraduate students to master this subject, leading to a lack of learning initiative. They are prone to rote learning of this subject, resulting in poor learning outcomes. Orthopedic surgery is a cutting-edge discipline that intersects with other basic and clinical medicine disciplines. In our hospital, the orthopedic department includes sub disciplines such as spinal surgery, joint surgery, trauma surgery, bone oncology, hand and foot surgery, and sports medicine. Orthopedics is a clinical science that studies human bones, muscles, and nerves. Therefore, medical students especially orthopedic students often require a comprehensive and thorough understanding of basic theoretical knowledge and clinical issues as much as possible.

At present, orthopedic education in China mainly targets undergraduate and graduate students in medical colleges and universities. This course is conducted in the form of theoretical knowledge in their fourth academic year. In the following year, which in fifth year, it is conducted in the form of clinical practice teaching in orthopedic surgery. In the current teaching of orthopedic surgery, whether it is theoretical teaching or clinical practice teaching, traditional classroom teaching still dominates. This traditional lecture-based teaching method is carried out according to the teaching syllabus. Some studies have shown that traditional clinical teaching courses suffer from insufficient teaching, leading to insufficient cultivation of critical reasoning thinking among graduate students in clinical teaching. At the same time, the traditional lecture-based teaching model cannot fully stimulate students' learning enthusiasm, and students' self-learning ability and cooperative learning ability cannot be improved. Self-learning, also known as self-directed learning, is defined as actively acquiring the necessary knowledge and build certain abilities through independent own learning (Charokar and Dulloo, 2022), which can fully mobilize students' motivation to learn, deepen their understanding of problems and mastery of knowledge, and develop the habit of lifelong learning. Self-directed learning is particularly important for medical education, which emphasizes the integration of theory and practice. An excellent doctor must have enough self-learning ability and cooperation ability to keep up with the rapid development of medicine and master more advanced theories and techniques. Meanwhile, it should be noted that critical thinking ability is necessary for clinical doctors (George et al., 2020; Batra et al., 2022), and active learning penetrates through medical education including orthopedic clinical practice education (Koo et al., 2022).

Numerous collaborative learning strategies applied to modern medical education have been reported, and flipped classroom is a new teaching model proposed in recent years, which is

problem oriented and allows students to independently explain and discuss the knowledge points of the course in class after consulting materials before class. Flipped classroom is defined as lecture time spending on applying knowledge obtained beforehand through preassigned readings and brief, introductory recorded lectures. Unlike traditional teaching methods based on repetition and memory, teaching is conducted by students, with teachers providing feedback and guiding undergraduate students in group discussions. Therefore, they can fully immerse themselves in the analysis of clinical cases and the application of knowledge, and the diagnostic and treatment environment can be well simulated. Understand and deepen knowledge while solving problems (Hew and Lo, 2018). On this basis, it can enhance the interest of undergraduate students, cultivate their clinical diagnosis and treatment abilities, and critical thinking (Dehghanzadeh and Jafaraghaee, 2018).

In recent years, most medical undergraduate students have been working in hospitals in prefecture level cities or counties. They engage in orthopedic surgery, with a focus on orthopedic trauma surgery on a daily basis. Due to the fact that the teaching syllabus only includes 2 weeks of orthopedic surgery, these medical students actually know very little about orthopedic surgery. Therefore, mastering orthopedic knowledge through short-term practice is a practical and important issue. This study will introduce the problem oriented flipped classroom teaching method into the teaching practice reform of orthopedics. On the basis of comparison with traditional teaching methods, this teaching method can achieve good teaching results (Bhavsar et al., 2022).

Research and methods

Study subjects

This study was approved by the Institutional Review Board (IRB) Committee of Qilu Hospital of Shandong University and all participants have signed informed consent forms. Total 138 undergraduate students from Shandong University who interned in the Orthopedics Department of Qilu Hospital from June 2022 to June 2023 were selected as the research subjects. All these undergraduate students (including 81 males and 57 females) voluntarily participated in this experimental study. With the help of a random number table, they were randomly divided into a traditional teaching group and a flipped classroom group, with 69 participants in each group. These undergraduate students did not systematically acquire theoretical knowledge related to orthopedic surgery in their previous studies, and did not receive flipped classroom teaching in previous courses. The flipped classroom group adopts a problem oriented self-learning teaching method, including 40 males and 29 females, aged (20.54 ± 1.04) years old; The traditional teaching group adopts traditional teaching methods, including 41 males and 28 females, aged (20.51 ± 1.22) years old. The basic information of the two groups of undergraduate students is shown in Table 1, and there is no significant difference in age, gender distribution, and class cadre proportion between the two groups ($p > 0.05$). At the end of the internship, all undergraduate students were evaluated in terms

TABLE 1 The basic details of two group students.

	Traditional class	Flipped class	<i>p</i> -value
Total	69	69	
Age	20.51 ± 1.22	20.54 ± 1.04	0.877
Gender			0.863
Male	41	40	
Female	28	29	
Class cadres	6	4	0.745

p < 0.05.

of orthopedic theoretical knowledge and practical operations. In addition, they also filled out questionnaires related to satisfaction with this course.

Teaching methodology

All undergraduate fourth-year students participating in this study were randomly divided into a traditional teaching group and a flipped classroom group, with 69 participants in each group. Students in two groups were given lessons in lecture classroom by the same teachers who at least with 5-year experience, while in different time.

The traditional teaching group adopts traditional teaching methods and explains the knowledge in the textbook according to the teaching outline.

The flipped classroom group adopts a problem oriented self-learning teaching method, and under the guidance of clinical teachers, adopts a problem oriented flipped classroom teaching method.

All undergraduate students have signed informed consent forms and voluntarily participated in relevant exams and surveys. Since the test papers and questionnaires are marked with their ID card numbers rather than their real names, the results of the test papers and questionnaires have no (positive or negative) impact on their course scores or grades. These undergraduate students independently completed relevant exams and surveys without the help of peers and mentors. The teaching process of the two groups is shown in [Figure 1](#).

Teaching effect evaluation

This study evaluated the clinical practice of undergraduate orthopedic students at Qilu Hospital of Shandong University and the clinical teaching guidance of teachers through basic theory exams, clinical practice skills exams, and satisfaction questionnaire surveys.

Theoretical knowledge test

The evaluation of clinical theoretical knowledge is conducted through test papers, mainly using Long Case Questions (LCQ), Structured Case Questions (SCQ), Modified Case Questions

(MCQ), and Short Answer Questions (SAQ). Theoretical exams are conducted in the form of closed book exams based on the teaching content. Objective questions are selected from relevant questions provided by physicians over the years, mainly focusing on students' mastery of knowledge items, systematic mastery and analysis of diseases, and ultimately scored by teachers who did not participate in the teaching.

Clinical practice skills test

The clinical practice skills test is scored using an improved Mini Cex evaluation system, with each score ranging from 1 to 10 points, including consultation, medical record writing, physical examination, surgery, doctor-patient communication, perioperative diagnosis and treatment. Finally, after converting practical skills to a percentage system, these two test scores are added together to obtain the total score.

Questionnaire survey

The evaluation questionnaires related to satisfaction include Overall satisfaction, Improve learning interest, Study independently, Expand knowledge, Solve problems independently, Critical thinking, Teamwork spirit, Learning efficiency, and Reduce the learning burden. These college students have been evaluated from the above aspects. The same anonymous questionnaire survey was conducted on two groups of students to evaluate their views and experiences.

Statistical analysis

All statistical analysis was conducted by SPSS 24.0 software. The measurement data were expressed by mean ± standard deviation (SD), and the significance was evaluated by the independent sample *t*-test. The enumeration data were subject to the *Chi-square* test to compare the teaching results between both groups. In this study, *p* < 0.05 indicated that the difference was statistically significant.

Results

Comparison of theoretical knowledge and skill assessment scores between two groups

The theoretical assessment score of traditional class group was 75.10 ± 9.43, while the theoretical assessment score of the flipped class group was 78.70 ± 10.71, with a statistically significant difference (*p* = 0.038). Compared with the traditional class group (81.52 ± 8.50), the flipped class group showed a significant improvement in skill assessment scores (85.55 ± 8.29), with a statistically significant difference (*p* = 0.006), as shown in [Table 2](#) and [Supplementary Figure S1](#). According to the weighted average score calculation, the total score of students in the flipped class group (82.12 ± 6.69) was also higher than that in the traditional class group (78.31 ± 6.05), and the difference was statistically significant (*p* < 0.001).

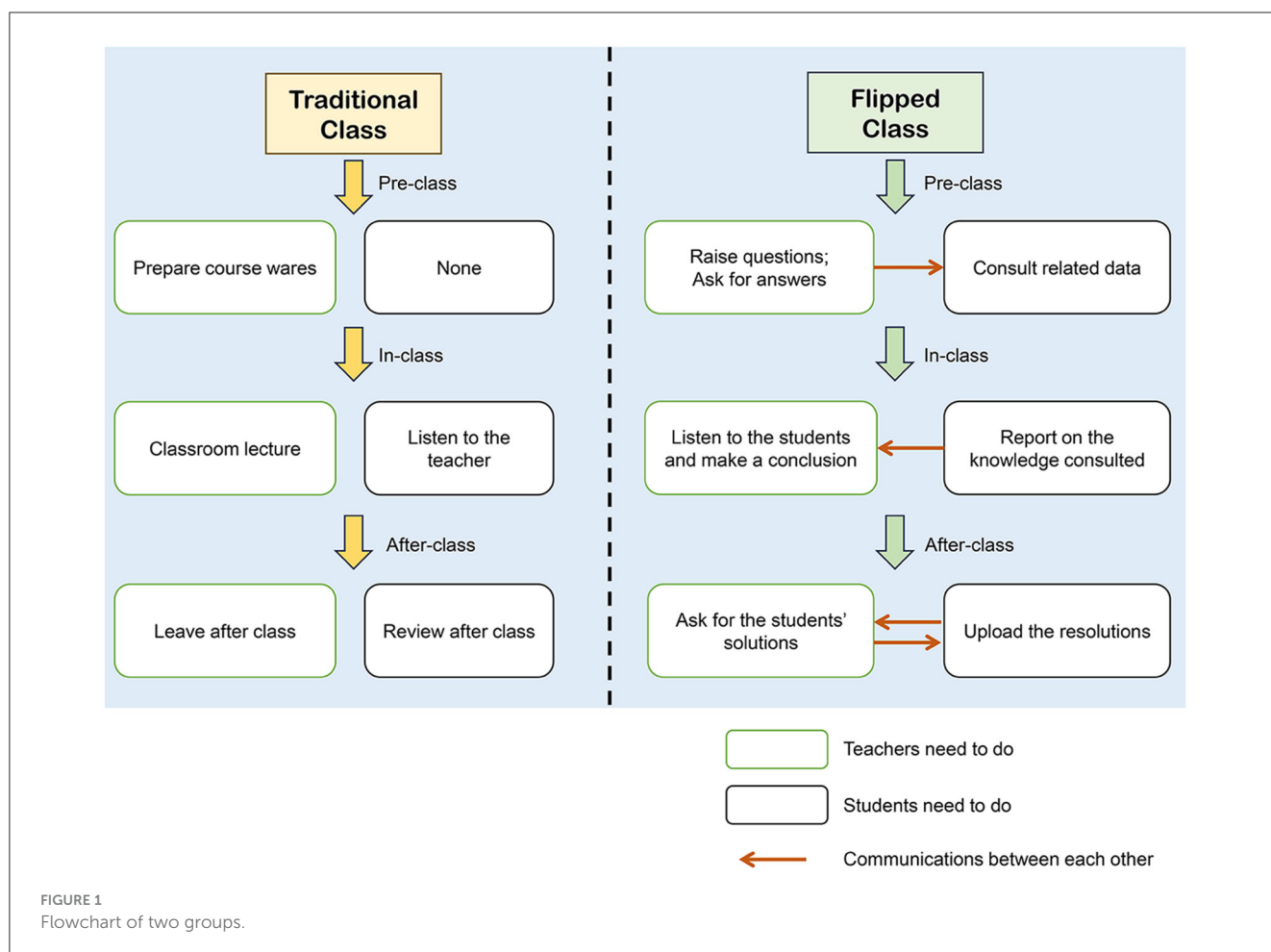


TABLE 2 Comparison of scores obtained between the two groups.

	Traditional class (n = 69)	Flipped class (n = 69)	t-score	p-value
Theoretical assessment score	75.10 ± 9.43	78.70 ± 10.71	2.096	0.038*
Skill assessment score	81.52 ± 8.50	85.55 ± 8.29	2.819	0.006*
Total weighted score	78.31 ± 6.05	82.12 ± 6.69	3.509	<0.001*

*p < 0.05.

Satisfaction questionnaire survey results

As listed in Table 3 and Supplementary Figure S1, compared with the traditional class group, the satisfaction survey results of students in the flipped classroom group showed a significant improvement (except for reduce the learning burden), and the difference was statistically significant ($p < 0.05$).

Discussion

Medical science is a complex discipline that combines scientific and practical aspects. In the current society, hospitals still mainly adopt traditional lecture teaching to cultivate medical students. However, clinical teaching has a wide range of knowledge, complex system, high learning difficulty, long time

span, and difficult integration of theory and practice, which brings great difficulties to teaching work (Mason and Strike, 2003). Moreover, senior medical students need to cultivate strong communication and clinical thinking abilities, which are also problems that traditional teaching cannot solve (Moberg and Whitcomb, 1999). The emergence of problem oriented flipped classroom teaching mode can significantly improve the above problems. Flipped classroom is a teaching model that reverses the process of knowledge transfer and internalization. It changes the traditional teacher imparting teaching method in the classroom, and instead provides learning materials before class, allowing students to self-study first. In the classroom, under the guidance of the teacher, discussions, communication, digestion and absorption are carried out, thereby improving the understanding and application ability of knowledge. At present, some practical application courses in domestic universities have

TABLE 3 Results of satisfactory questionnaire.

	Traditional class (<i>n</i> = 69)	Flipped class (<i>n</i> = 69)	<i>t</i> -score	<i>p</i> -value
Overall satisfaction	5.77 ± 1.88	7.19 ± 1.73	4.617	<0.001*
Improve learning interest	5.87 ± 2.02	6.86 ± 1.84	3.010	0.003*
Study independently	5.84 ± 1.80	6.91 ± 1.81	3.482	<0.001*
Expand knowledge	6.55 ± 1.72	7.28 ± 1.66	2.537	0.012*
Solve problems independently	6.03 ± 1.56	8.41 ± 1.17	10.140	<0.001*
Critical thinking	6.35 ± 1.62	7.49 ± 1.35	4.521	<0.001*
Teamwork spirit	6.39 ± 1.58	7.19 ± 1.40	3.137	0.002*
Learning efficiency	6.19 ± 1.45	6.74 ± 1.62	2.109	0.037*
Reduce the learning burden	5.17 ± 1.40	5.73 ± 2.31	1.694	0.093

**p* < 0.05.

conducted teaching explorations on flipped classrooms (Dong et al., 2021; Ji et al., 2022; Wu et al., 2022; Lu et al., 2023).

The model of traditional clinical medical education exists several questions, such as teacher led, student passive, low classroom efficiency, and limited practical opportunities. In recent years, a new teaching concept and method such as flipped class has attracted widespread attention and exploration in order to improve the clinical medical education model. Flipped class refers to moving the knowledge transmission part of traditional classrooms to pre class, providing online multimedia resources such as videos, audio, and text for students to preview independently, and moving activities such as exercises, discussions, and case studies that were originally homework to the classroom, guided and guided by teachers, to achieve the redistribution and optimization of time and space inside and outside the classroom (Bordes et al., 2021; Saeed et al., 2023; Sun et al., 2023). The flipped classroom has a natural fit and advantage in clinical medical education. It can fully utilize network technology and resources, improve students' self-learning ability and interest, increase classroom interaction and practice, and improve the teaching quality and level of teachers (Ji et al., 2023). Flipped classroom, as a novel and effective teaching model, has been widely applied and promoted in the field of clinical medical education both domestically and internationally. Different from the traditional classroom teaching model, the flipped classroom teaching model of this study realizes an organic positive cycle of guiding students to discover problems, solving problems, giving feedback and discovering problems again by themselves, in which the teacher acts as a mentor to guide students to solve specific clinical cases step by step instead of the traditional lecturer of knowledge, and at the same time, the students' own self-study ability and their ability to cooperate with each other will be fully improved (Tang et al., 2017; Li et al., 2023). Whereas the ability of self-learning and cooperation can enable doctors to master the most advanced medical theories and medical technology, enabling them to become lifelong learners and prompting them to discover deficiencies and solve specific clinical problems in communication and reflection, which is very important for becoming a qualified doctor (Charokar and Dulloo, 2022).

To compare the differences between traditional class teaching model and novel flipped class model in orthopedic surgery, and further clarify the potential merits, undergraduate students in this study were enrolled. They were randomly classified into traditional class group and flipped class group. At the end of the internship, all undergraduate students were evaluated in terms of orthopedic theoretical knowledge and practical operations. In addition, they also filled out questionnaires related to satisfaction with related course. Questionnaires on evaluation of students' satisfaction with teaching model are referred to previously published studies and associated criteria have been justified previously.

In terms of results, the theoretical knowledge assessment scores in this study indicate that the flipped classroom group has a significantly higher level of mastery of theoretical knowledge than the traditional teaching group. During the teaching process, students will take the initiative to find knowledge closely related to clinical practice, and will systematically learn the knowledge through problem orientation. Meanwhile, by encouraging students to extensively consult literature and share knowledge, teachers can increase the depth and breadth of their learning, which is beneficial for students to master relevant professional knowledge. At the same time, the skill operation assessment scores in this study indicate that students in the flipped class group have a significantly higher level of mastery of skill operations than those in the traditional teaching group. Among the students in the flipped classroom group, they can not only watch operation videos, but also self-check relevant knowledge on the Internet for further review, which greatly promotes their mastery of skill operations. According to the results of two satisfaction questionnaires, students in the flipped classroom group were more satisfied with the teaching method. In terms of learning interest, classroom atmosphere, level of classroom interaction, satisfaction with teacher-student communication, satisfaction with knowledge mastery, satisfaction with learning burden, and satisfaction with learning depth, the satisfaction of the flipped classroom group was higher than that of the traditional group (*p* < 0.05).

However, both two teaching model indeed have relevant advantages and disadvantages. Students who are in a flipped class, especially in medical education, must take up a lot of time to explain such difficult questions by themselves. They

commonly feel loss confidence during this period and require for assistance from outside. Fortunately, collaborations with each other may promote fast problem-solving. Meanwhile, students in traditional class are also hard to accept extensive knowledge in short time, even the aggregation of several key knowledge points may be lost. Whether it is theoretical knowledge or skill operations, flipped classroom teaching can simulate real medical scenarios, allowing students to independently solve problems like surgeons. At the same time, flipped classroom teaching encourages students to independently consult relevant materials in their spare time, expanding the breadth and depth of knowledge. Through the transition from passive acceptance to active acquisition of knowledge, students' interest in learning has significantly increased (El Sadik and Al Abdulmonem, 2021). As mentioned earlier, the flipped classroom can greatly develop students' self-learning and cooperative learning abilities and significantly improve their skill acquisition, which has been demonstrated in the training of dermatologists and ophthalmologists (Tang et al., 2017; Li et al., 2023). First of all, the teacher provides students with case studies, learning videos and other materials before class, guides students to discover problems through independent learning and actively collect relevant literature to form a holistic and perceptual understanding of knowledge, and students can also watch the materials before class repeatedly to achieve sufficient pre-course knowledge reserves for the next step of the discussion. Then, students use most of the knowledge and skills gained from self-learning to communicate with others in specific situations, and realize the collision of thinking and gain more knowledge in the process of cooperative problem solving, which enhances the students' sense of achievement and realizes the organic combination of independent learning and cooperative learning. Cooperative learning integrates the dispersed knowledge obtained from independent learning, and the strengths among different students will be magnified, while the weaknesses and shortcomings will be eliminated to the greatest extent possible. Finally, the teacher's guidance after the discussion further integrates the knowledge, and the teacher no longer plays the role of a knowledge transmitter but a guide in the whole process. The ideas of self-directed learning and cooperative learning run through the entire teaching activities of the flipped classroom, truly realizing the students' own acquisition and utilization of knowledge.

In addition, flipped classroom teaching will continue to provide content that students are interested in learning based on their personalized choices, allowing students to have a clear understanding of their own interests and independently explore deeper and more professional related knowledge, thereby improving the efficiency and quality of clinical medical education (Joseph et al., 2021).

Overall, this study compared the difference between flipped class and traditional class, and then discussed their specific advantages and disadvantages. However, this study also is given limitations such as small number subjects compared to other studies. Although this study evaluated these students by two distinct teaching models from both subjective and objective perspectives, they only presented the outcomes in the short

term. In the future, outcomes should be observed from long-term studies.

Conclusion

The flipped class teaching mode significantly improves the learning interest and efficiency of internship students in orthopedic clinical teaching, and increases more communication and understanding between students and teachers. At the same time, it can tap into students' interests, hobbies, and self-learning abilities, effectively improving their mastery of theoretical knowledge and skill operations, which is worth promoting.

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.

Ethics statement

The manuscript presents research on animals that do not require ethical approval for their study.

Author contributions

LW: Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Writing – original draft, Writing – review & editing. YX: Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Resources, Writing – original draft, Writing – review & editing. CQ: Data curation, Formal analysis, Investigation, Methodology, Resources, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. SY: Formal analysis, Investigation, Project administration, Resources, Supervision, Visualization, Writing – original draft, Writing – review & editing. XL: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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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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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/feduc.2024.1382948/full#supplementary-material>

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