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The impact of large-class flipped classrooms incorporating design thinking on self-awareness, team collaboration, learning efficiency, and comprehensive literacy of clinical medicine undergraduates

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Abstract

Context Jining Medical University has adopted the traditional large-class teaching mode in its Histology and Embryology course. In this mode, students' participation and learning outcomes are not satisfactory.

Objective To solve this problem, we integrated design thinking into the large-class flipped teaching.

Method A mixed methodology (qualitative and quantitative) was employed. Participants were from the university's Clinical Medicine Program, randomly assigned to the experimental and control groups. The experimental group received integrated flipped classroom instructions, whereas the control group received traditional large-class teaching. Data were collected using an empathy canvas, questionnaires, and classroom assessments.

Results Analysis of 24 empathy maps identified 32 learning gains and 18 pain points, categorized into four dimensions: self-awareness, teamwork, learning efficiency, and comprehensive competencies. Survey results showed 89.3% of students found this teaching model enhanced knowledge comprehension, 85.3% reported no increased learning burden, and 80% acknowledged improved comprehensive abilities. Significant gender differences emerged in resource preferences (males favored interactive resources while females preferred structured materials) and perceived learning burden ($p < 0.05$). Classroom assessments revealed no statistically significant difference between the experimental group (75.87 ± 12.06) and control group (74.25 ± 12.65) ($p > 0.05$).

Conclusion The large - class flipped classroom model integrated with design thinking has the potential to enhance learning outcomes and comprehensive literacy without imposing an additional burden. This model shows potential

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for application in the teaching of histology and embryology. However, further validation is needed to confirm its applicability across different content areas and learning environments.

Keywords Flipped classroom, Design thinking, Empathy canvas, Self-awareness, Team collaboration, Learning efficiency, Comprehensive abilities

Introduction

Histology and embryology study the microstructure, function, and processes of embryonic development in the normal human body [1]. As an introductory course for clinical medicine majors, it plays a significant role in providing professional guidance and lays a solid foundation for medical students to further study physiology, pathology, and other disciplines [2]. Given Jining Medical University's constraints of limited teaching staff and facilities, the course is presented as a large-class teaching model – for instance, the number of students could be as high as 160 in the combined class of 2022. Teaching challenges are mainly reflected in the following aspects of a large-scale classroom [3]. In large-class teaching, the lack of personalized guidance limits students' self-assessment and reflection, hindering their self-directed learning [4]. The absence of teamwork and interactive learning weakens collaboration and critical thinking [5]. Uniform teaching content restricts creativity and exploration [6, 7]. Long-term, it may hinder the full development of higher-order thinking and emotional intelligence, posing certain limitations on their future growth [8–10].

The application of the flipped classroom in medical education has garnered widespread attention. Research indicates that this teaching model can effectively enhance students' learning experiences and engagement. For example, students generally perceive the flipped classroom positively, believing it helps deepen understanding and improve self-directed learning abilities [11]. In the preclinical stage, the implementation of the flipped classroom is not only efficient but also time-saving, optimizing learning outcomes [12]. In graduate medical education, the flipped classroom has been shown to promote higher-order thinking and the development of clinical skills [13]. Additionally, studies suggest that the flipped classroom may become a new standard in medical education due to its support for personalized learning and interactive teaching [14]. In specialized fields such as podiatric medicine, the flipped classroom also demonstrates significant advantages [15]. Overall, the application of the flipped classroom in medical education holds broad prospects, but challenges remain with respect to long-term effectiveness evaluation, student engagement, and interdisciplinary collaboration [16].

The Teacher Standards issued by the International Society for Technology in Education (ISTE) point out that an important role for teachers in the future would be as "designers" [17]. Design thinking (DT) is a methodology for solving complex problems and provides a valuable tool for addressing challenging issues in medical education [18, 19]. The research on design thinking in the field of medical education shows a continuous and in-depth development trend. As mentioned in [20], design thinking is actively applied to address real-world medical problems and helps to solve practical difficulties. Many universities have carried out teaching and learning practices of design thinking [21, 22]. Design thinking has been integrated into the flipped online teaching of histology and embryology [3]. Through design thinking, the influence of evidence-based practice education has been expanded [23], and interdisciplinary courses have been co-created to cultivate medical students who are adaptable to the 21st century [24]. These practice and related studies have promoted the application and development of design thinking in medical education from different dimensions, providing new ideas and methods for the innovation of medical education.

In light of these circumstances, this research made improvements to the entrenched model of large-class teaching and innovatively embed design thinking deeply into the large-class flipped classroom. Emphasizing the promotion of students' autonomous learning outside the classroom, we encouraged them to actively explore knowledge by leveraging diverse resources. We meticulously organized in-depth classroom discussions to foster the exchange of students' ideas. Through the application of design thinking, we guided students through the process of problem identification, analysis, and resolution, thereby enhancing their capabilities in multiple dimensions. It is anticipated that the teaching quality be elevated and more students will be able to enjoy a superior educational experience despite limited educational resources. This study thus offers novel perspectives for the innovation of large-class teaching.

Research design and methods

Selection of teaching units

The subjects of histology and embryology total 76 credit hours in the undergraduate training program of clinical medicine at Jining Medical University. The course structure is rigorous and is divided into three teaching stages. The first stage (26 credit hours) explores the four basic tissues of the human body: epithelial tissue, connective tissue, muscle tissue, and nervous tissue. The second stage (32 credit hours) focuses on the study of vital systems such as circulation, immunity, and nervous system.

The third stage (18 credit hours) details the embryonic development process and mechanism from fertilization to the birth of a newborn individual. The content covered in the first stage lays the foundation for subsequent learning. This study specifically selected the final chapter of the first stage, “nervous tissue,” as the research content. Students had already gained a comprehensive understanding and experience of the content characteristics and learning methods of basic tissues and traditional teaching modes by the time they progress to this chapter. Therefore, they can better understand and experience the flipped classroom teaching model, which incorporates design thinking and is expected to provide more constructive feedback and suggestions.

Research subject selection and grouping

To ensure the scientific rigor, fairness, and transparency of the research, this study employed a random sampling method, selecting two of the six combined classes of the 2022 undergraduate clinical medicine program at Jining Medical University as research samples. The specific steps were as follows: First, the research population was defined as the six combined classes; second, a random sequence from one to six was generated using Excel; then, the classes corresponding to the first two numbers in the random sequence were chosen as the research samples.

This study strictly adhered to ethical review requirements and obtained approval from the Ethics Committee of Jining Medical University (Approval Number: JNMC-2020-JC-013). Prior to the commencement of the research, the research team provided all participants with a detailed explanation of the study’s purpose, procedures, potential risks, and benefits, ensuring their understanding of the voluntary nature of participation and their right to withdraw at any time. All participants signed a written informed consent form based on full comprehension. Throughout the study, participants’ personal information was kept strictly confidential, and data used solely for academic research purposes, ensuring full protection of their privacy.

The experimental group consisted of 150 students (75 male and 75 female students) who were randomly assigned to 24 activity groups using the group allocation method employed in the grouping teaching of the Wisdom Tree. The control group comprised 154 students. To ensure fairness and comparability of the study, both groups were provided with the same course duration, teaching resources, learning materials, and learning spaces.

The chapter on nerve tissue comprised six essential knowledge points: neuron structure, neuron classification, synapses, glial cells, nerve fibres and nerves, and nerve endings. Prior to the class, the presentation content of each group was determined by lottery. Each group was tasked with preparing one of these core topics for an in-class presentation. To ensure full coverage of the knowledge points, we set up four groups to prepare the same content. In class, one group was selected by random lottery to make a presentation, and the other three groups were responsible for commenting and asking questions.

Teaching design

This study applied Stanford University’s design thinking method [25, 26] to conduct teaching activities, which are divided into two phases. In the teaching plan design phase, the designer is the teacher, the product is the instructional design plan, and the users are the students in the experimental group. In the second phase, the implementation of the teaching plan, the designers are the students in the experimental group, the product is the display work of neural tissue knowledge points, and the users are both the students in the experimental group and the teachers.

During the instructional design phase, teachers engage in the process of design thinking with the participation of students. E (Empathy, Week 1): Three teachers are involved in the teaching activities, including one lead teacher and two teaching assistants. The teaching assistants and students participate fully in the teaching activities and complete learning tasks, using empathy maps to record students’ experiences, identifying pain points and gains. D (Define, Week 1): The team randomly selects three students from the participating group to discuss the aforementioned pain points and gains, and combines learning data from the Wisdom Tree platform to identify issues in large-class teaching: insufficient interaction, limitations on the development of students’ higher-order thinking and emotional abilities, and lack of personalized guidance. I (Ideate, Week 2): Organize brainstorming sessions with three teachers, three students, and two pathology experts, adhering to the principles of “no judgment, no negation,” to propose diverse solutions such as flipped classrooms, group discussions, and case-based teaching. All ideas are recorded on a whiteboard, categorized by theme, and ultimately filtered to select the most feasible solutions. P (Prototype, Weeks 3): Determine a teaching plan centred on “large-class flipped teaching” and outline the specific implementation process. T (Test, Weeks 4–6): Implement the teaching plan in the “Neural Tissue” chapter and evaluate its effectiveness through questionnaires, empathy canvases, and performance analysis.

During the implementation phase of the teaching activities, both teachers and students collaboratively advance the learning activities following the five steps of design thinking. The preparation period spans seven days. E (Empathy, Day 1): Teachers release learning resources and study guides to help students clarify learning objectives and tasks. Each group independently schedules a time for discussion to understand the learning tasks and identify any difficulties, then submits the discussion results to the teacher. D (Define, Day 2): Teachers guide students to identify the core issues within the tasks, helping them focus on key challenges. Under the guidance of the teachers, students further clarify and document the core problems in their learning tasks. I (Ideate, Days 3–4): Teachers provide personalized guidance, encourage students to conduct brainstorming sessions, and maintain ongoing communication with them. Each group engages in brainstorming to propose content presentation ideas and initially formulates a presentation plan. P (Prototype, Days 5–6): Teachers assist students in refining their presentation formats, offering feedback and suggestions to ensure their ideas can be translated into concrete works or plans. Based on the teachers' feedback, students prepare presentation materials and finalize their presentation plans. T (Test, Day 7): Teachers organize students to present their learning tasks, summarize the presentations of each group, and conduct a vote to select the winning group. Students present their learning tasks according to their plans, and through comments, questions, and voting, they discuss the effectiveness of the works and propose suggestions for improvement.

The experimental group adopted the teaching process in which team members sat in a circle during implementation to facilitate discussion, speaking, and filling out the empathy canvas. The content, activity format, implementer, and time allocation of each teaching segment are illustrated in Fig. 1. The control group adopted traditional large-class teaching methods.

Research methods

This study used a combination of qualitative and quantitative research methods to conduct an in-depth analysis of the learning experiences of clinical medical undergraduates in the flipped classroom teaching mode on the subject of nervous tissue.

In this study, the empathy map served as an important research tool. As one of the core tools in the design thinking methodology, the empathy map helped researchers understand and analyze the true needs, experiences, and emotions of the study participants [27]. The steps for using the empathy map were as follows: One week before the class, the leader of each group received materials for creating the empathy map, including an A1-sized paper, 100 sticky notes, and 10 coloured markers. The instructor introduced the use of the empathy map in detail to the experimental group students via Tencent Meeting, encouraging them to fully express their opinions and suggestions during the filling process. The instructor also provided necessary assistance and guidance to ensure the accuracy and validity of the results. The empathy map was divided into six dimensions: thinking, hearing, seeing, saying and doing, pain points, and gains, with each dimension having a corresponding area (Fig. 2). During the class, members of each group used sticky notes to record their learning experiences and attached them to the corresponding areas. Within three days after the class, the groups discussed and summarized their pain points and gains, and the group leader submitted the completed empathy map to the instructor. A total of 24 empathy maps were collected in this study, and qualitative analysis was conducted on these data, focusing on the students' experiences and feelings across the six dimensions to identify commonalities and differences.

The research team designed a survey questionnaire, the content of which covered students' basic situation, self-awareness, teamwork, learning efficiency, comprehensive ability, etc. Through this questionnaire, the team could systematically collect the views and experiences of each student in the experimental group on the teaching model, gaining a deeper understanding of whether this model enhances learning interest and cultivates students' comprehensive abilities.

Classroom quizzes are an effective way to assess students' mastery of knowledge [28]. To gain a deeper understanding of students' learning effectiveness, the research team designed a 100-point test targeting the six

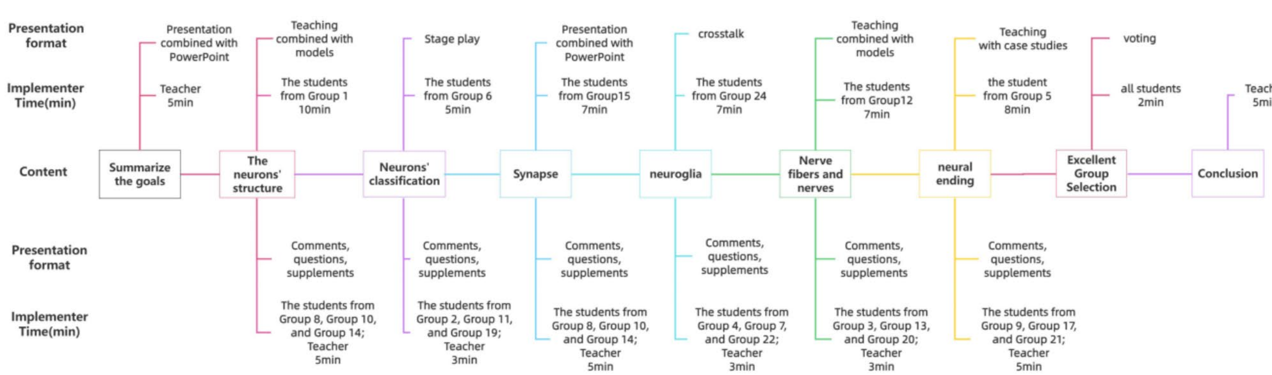

Fig. 1 Content, activity format, implementer, and time allocation for each segment of the flipped classroom incorporating design thinking

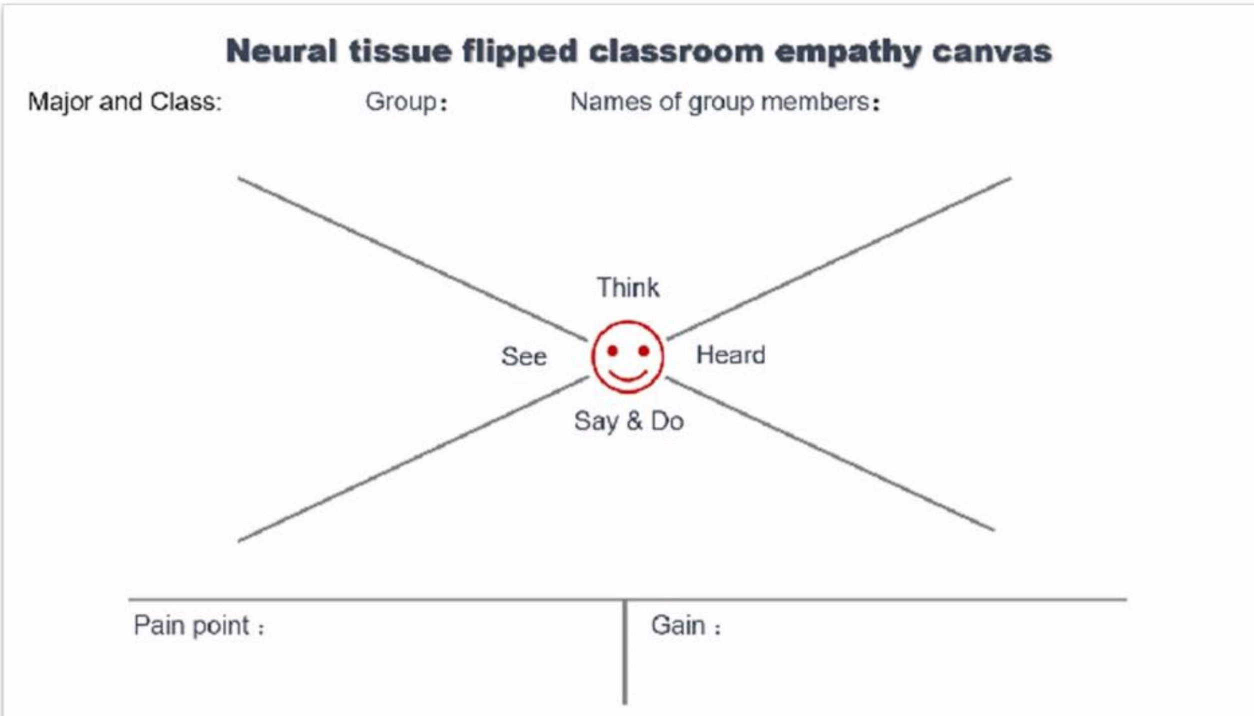

Fig. 2 The empathy canvas

core contents of this chapter, aiming to comprehensively evaluate students' understanding of the core knowledge points.

Data collection and analysis methodology

In this study, we employed WPS Office and Microsoft Excel for data entry and organization of empathy canvases, questionnaire survey responses, and classroom assessment scores. The statistical analysis was conducted by using SPSS® 21.0 software. For continuous variables, we utilized means and standard deviations as descriptive statistics and categorical variables were represented by frequencies (rates). T-tests and chi-square tests were performed to examine the associations and differences among various variables.

Results

Empathy canvas results

A total of 24 empathy canvases were submitted, one from each of the 24 groups. Using the inductive thematic analysis method, 32 key insights representing different gains and 18 pain points were identified. Based on the content, the specific information in the empathy canvases was quantified and classified. The results were organized into four main categories: self-awareness, teamwork, learning efficiency, and comprehensive ability. In terms of self-awareness, there were four gains and two pain points (Fig. 3): 12 groups (50%) recognized the gap between themselves and others, which stimulated their intrinsic motivation to learn; ten groups (41.7%) became aware of the importance of active learning; four groups (16.7%) expressed their preference for this innovative learning format; and two groups (8.3%) indicated an increase in self-confidence. There were fewer pain points in this aspect, with three groups (12.5%) feeling burdened by heavy coursework and only one group (4.2%) explicitly stating a lack of self-confidence.

In terms of teamwork, there were three gains and one pain point (Fig. 4): ten groups (41.7%) realized the importance of teamwork, four groups (16.7%) believed that intra-group cooperation and inter-group competition activated the classroom atmosphere, and only one group (4.2%) clearly mentioned the cultivation of a sense of competition. However, five groups (20.8%) said they could not communicate effectively with team members in class.

In terms of learning efficiency, there were seven gains and seven pain points (Fig. 5). It is worth noting that 13 groups (54.2%) realized that the combination of graphics and text improved the learning efficiency of this course, six groups (25%) understood the importance of previewing and reviewing, and four groups (16.7%) indicated that they would actively use multimedia to improve learning efficiency. The pain points in this aspect were mainly reflected in inadequate preparation, difficulty in remembering knowledge points, difficulty in understanding

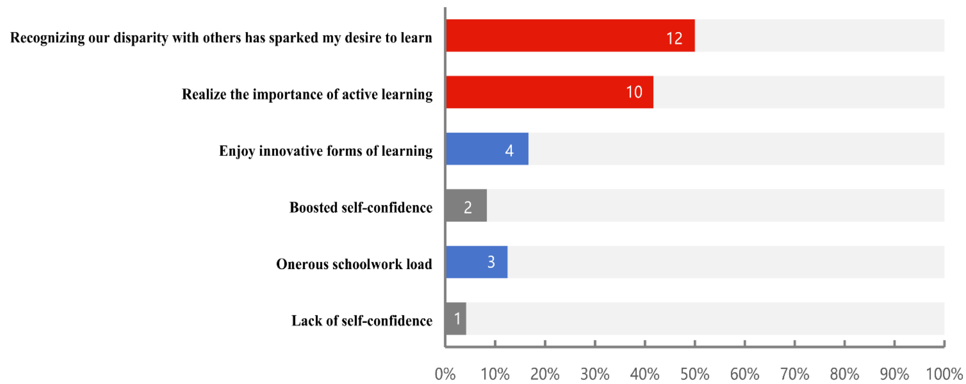

Fig. 3 Gains and pain points in self-awareness
Red represents data points of a relatively high level of criticality, indicating that interaction with others stimulates self-directed learning and the realization of the importance of active learning. Blue represents data points of a medium level of criticality, showing enjoyment of innovative learning forms and the onerous schoolwork load. Grey represents data points of a relatively low level of criticality

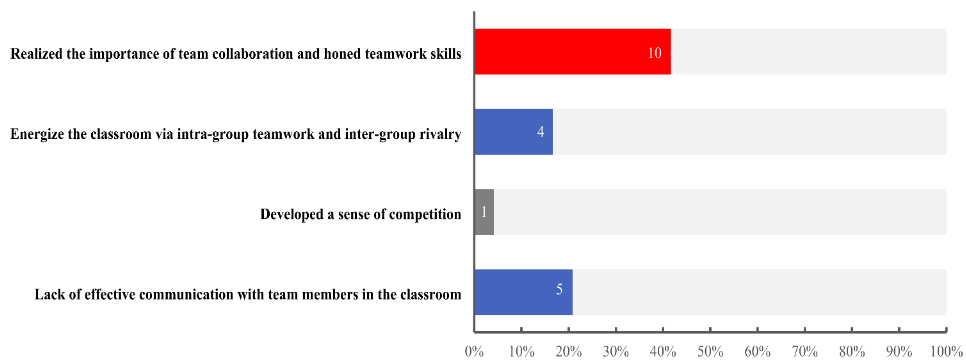

Fig. 4 Gains and pain points in teamwork
Red represents data points of a relatively high level of criticality, that is, realizing the importance of team collaboration and honing teamwork skills. Blue represents data points of a medium level of criticality, including energizing the classroom via intra-group teamwork and inter-group rivalry and the lack of effective communication with team members in the classroom. Grey represents data points of a relatively low level of criticality

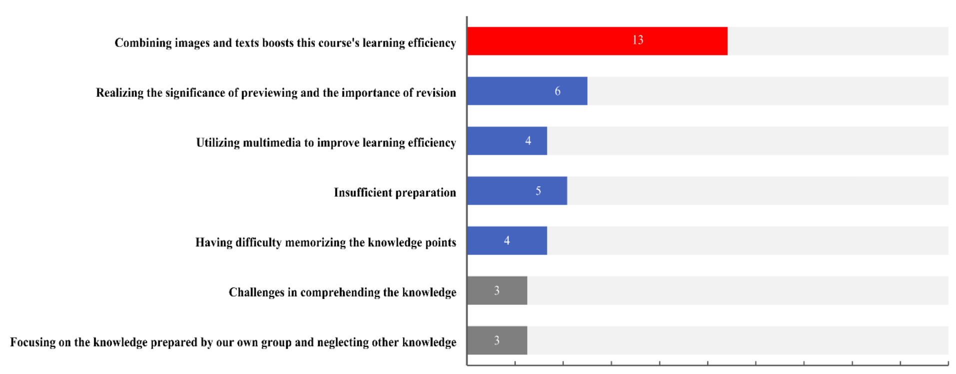

Fig. 5 Gains and pain points in learning efficiency
Red represents data points of a relatively high level of criticality, that is, combining images and texts boosts the learning efficiency of this course. Blue represents data points of a medium level of criticality, including realizing the significance of previewing and the importance of revision, utilizing multimedia to improve learning efficiency, insufficient preparation, having difficulty memorizing the knowledge points. Grey represents data points of a relatively low level of criticality

knowledge, or excessive focus on the content prepared by the group, while ignoring other knowledge.

In terms of comprehensive abilities, there were up to 17 gains and six pain points (Fig. 6): seven groups (29.2%) embraced the student-centred classroom environment, and six groups (25%) reported notable enhancements in their language proficiency, presentation skills, and communication abilities. Furthermore, a handful of groups demonstrated advancements in problem identification, analysis, and prioritization, deriving a sense

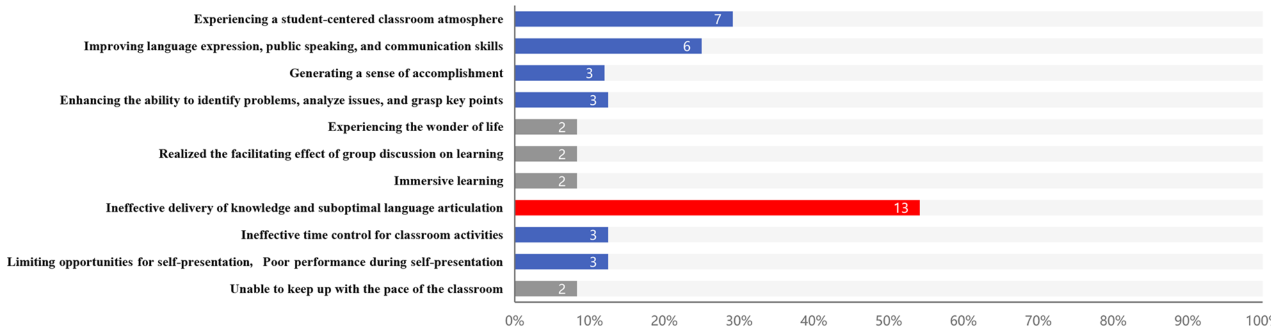

Fig. 6 Gains and pain points in comprehensive abilities
Red represents data points of a relatively high level of criticality, namely, ineffective delivery of knowledge and suboptimal language articulation. Blue represents data points of a medium level of criticality, including experiencing a student-centered classroom atmosphere, improving language expression, public speaking, and communication skills, generating a sense of accomplishment, enhancing the ability to identify problems, analyze issues, and grasp key points, ineffective time control for classroom activities, limiting opportunities for self-presentation and poor performance during self-presentation. Grey represents data points of a relatively low level of criticality

Table 1 Male and female students differ significantly in their use of pre-class learning resources (χ^2 = 8.887, $P<0.05$)

	Which resource aids pre-class self-study the most?				χ^2	P
	A. short videos	**B. e-book**	**C. textbook**	**D. online communication**		
male student	15(20.0%)	7(9.3%)	48(64.0%)	5(6.7%)	**8.887**	**0.031**
female student	31(41.3%)	7(9.3%)	35(46.7%)	2(2.7%)		

of accomplishment from the learning journey. While improvements in reflective thinking, innovativeness, and computer application skills were less frequently noted, some groups still exhibited progress in these areas. Among the pain points, the most prevalent issue was inadequate knowledge delivery and language expression – a point raised by 13 groups (54.2%). Three groups (12.5%) struggled with time management during classroom activities. Other challenges, albeit less frequently mentioned, included difficulties in keeping pace with classroom rhythms, limited presentation opportunities, the need for improved computer application skills, imbalances in teaching time allocation, and inadequate commentary abilities.

Survey questionnaire results

In the experimental class, the team distributed and collected 150 questionnaires, and the response rate of the survey was 100%. The responses to the relevant questions were as follows. “Do you think this teaching model increases the learning burden?” Some 85.3% of students said it had no effect or reduced their burden, while 24.7% believed it added to their learning burden. “Do you think group presentations and comment discussions help understand knowledge?” A total of 113 students (89.3%) thought that they were helpful. Regarding pre-class independent learning, students relied the most on textbooks, with 83 students choosing them (55.3%), followed by short videos, chosen by 46 students (30.7%). Regarding pre-class knowledge mastery, 68 students (45.3%) indicated that they could grasp the basic knowledge of this chapter before class, 37 students (24.7%) said they could not, and 45 (30.0%) were uncertain. In response to whether the learning resources released by the teacher before class were sufficient, 121 students (80.7%) gave a positive answer. During this learning process, 127 students (84.67%) experienced the “student-centred” subject status. Compared with traditional teaching, 120 students (80%) believed that this teaching model could better improve their comprehensive abilities and qualities. With this teaching model, students believed that their independent learning ability (128, accounting for 85.33%), self-confidence (89, or 59.33%), language expression ability (86, or 57.33%), communication skills (86, or 57.33%), and problem analysis and solving skills (59, or 39.33%) have significantly improved.

In the survey questionnaire, the team identified significant differences between male and female students in terms of pre-class learning resource preferences, ability to master basic knowledge, and perceptions of learning burden. Male students showed a stronger preference for interactive resources (e.g., videos, quizzes) and were more likely to perceive the teaching approach as reducing their learning burden (45.3%), while female students tended to favour structured resources (e.g., textbooks, articles) and mostly reported no change in their burden (49.3%). Additionally, male students demonstrated greater confidence in hands-on learning, whereas female students emphasized thorough preparation and repeated review. The details are listed in Tables 1 and 2, and 3.

Table 2 Male and female students differed significantly in their ability to Grasp basic knowledge before class ($\chi^2 = 10.214$, $P < 0.01$)

	Could you grasp the basic knowledge of this chapter before class?			χ^2	*P*
	A. Yes, I can	**B. No, I can't**	**C. Unsure**		
male student	42(56.0%)	19(25.3%)	14(18.7%)	10.214	0.006
female student	26(34.7%)	18(24.0%)	31(41.3%)		

Table 3 Male and female students differed significantly in their views on whether this teaching mode increased their learning burden ($\chi^2 = 7.539$, $P < 0.05$)

	Do you think this teaching mode increases the learning burden?			χ^2	*P*
	A. Increase	**B. Decrease**	**C. No effect**		
male student	18(24.0%)	34(45.3%)	23(30.7%)	7.539	0.023
female student	19(25.3%)	19(25.3%)	37(49.3%)		

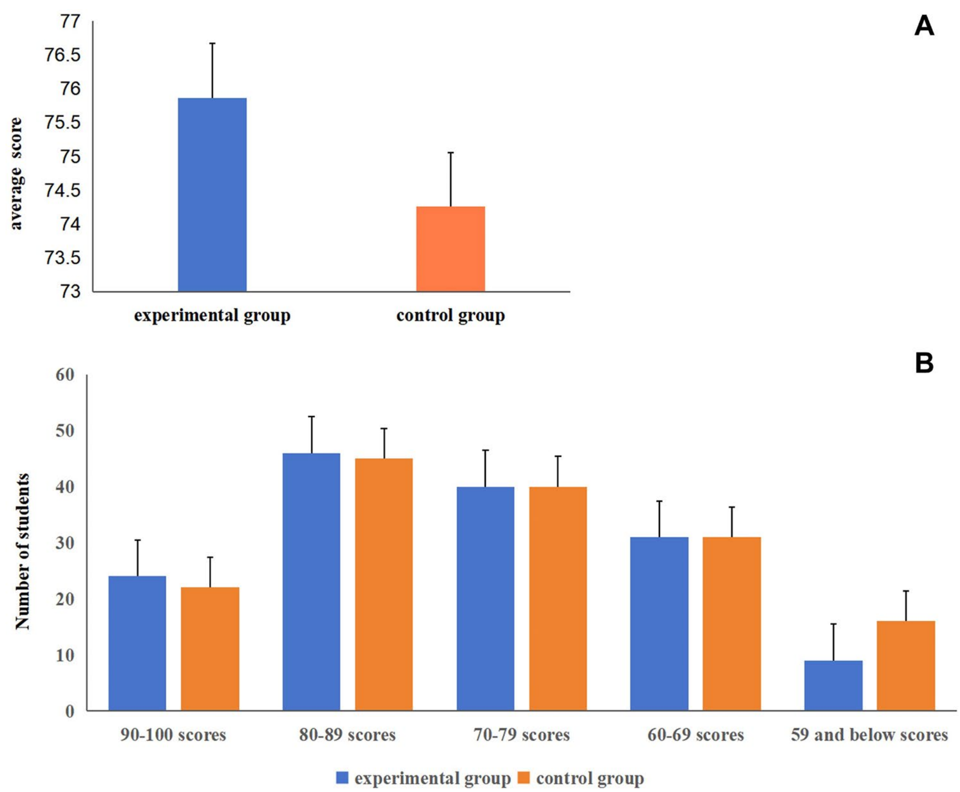

Fig. 7 Distribution of classroom quiz scores for the experimental group and the control group
Note. A: the average total score of the experimental group and the control group. B: the distribution of students across different score ranges. Statistical method: multiple t-tests, t = -1.137, $P = 0.256$

Results of classroom quizzes

The classroom test questions and scoring criteria were the same for both groups. The mean value of the actual scores in the experimental group was 75.87 ± 12.06, and the mean value of the actual scores in the control group was 74.25 ± 12.65. Although the average total score of the experimental group was slightly higher than that of the control group, this difference was not statistically significant. There was also no significant difference in the distribution of students across different score ranges (Fig. 7).

Discussion

This study examined the multifaceted impact of a flipped classroom model integrated with design thinking on students' learning outcomes. As evidenced by the experimental results, this teaching methodology exhibited unique advantages in terms of self-awareness, teamwork, learning efficiency, and overall competence.

Internal learning motivation refers to the driving force that students generate based on their internal factors to engage in learning. The results of the empathy canvas showed that self-awareness stimulated students' internal learning motivation, which is consistent with findings by

Ren [7]. Over 40% of the groups recognized the importance of active learning, indicating that the autonomous learning and interactive discussion components of this teaching model helped students clarify their learning goals. However, there is a divergence regarding the impact of flipped classrooms on student workload compared to previous research findings [28–30], which may be related to students' task-handling abilities.

Both the empathy canvas and questionnaire results indicate that students believed group presentations and peer evaluations significantly aided their understanding of knowledge and that intragroup cooperation and intergroup competition positively impacted the classroom atmosphere. This aligns with Peng's emphasis on the role of teamwork in stimulating learning enthusiasm and deepening knowledge comprehension [31]. However, effective communication among team members posed a challenge, which may be related to factors such as differences in cognitive levels among team members [32] and the communication atmosphere [33], as highlighted in previous studies.

In the "prototype" and "testing" phases of the teaching program implementation, the use of visual–textual resources and the integration of text and images in learning are essential. Research has found that students in flipped classrooms can more effectively grasp complex knowledge through this approach, and this effect is more pronounced compared to traditional teaching methods. The text-image integrated approach not only aligns with students' preference for using textbooks as pre-class resources but also closely matches the knowledge system of histology and embryology as a medical morphological discipline.

Research indicates that students intuitively experience a "student-centred" classroom atmosphere and perceive a significant improvement in their learning initiative and comprehensive abilities, which aligns with the findings of Ramnanan et al. [34]. However, the main pain point lay in the "ineffective knowledge delivery and suboptimal language expression" during the group presentation sessions. This may be attributed to two factors: intergroup competition leads students to focus more on the evaluation criteria of the presentation rather than the knowledge itself, or individual differences in expressive abilities and the unfamiliarity with novel teaching methods also impact performance. In the future, this issue could be addressed by optimizing evaluation mechanisms and enhancing training in expressive skills.

Notably, the questionnaire revealed gender differences in flipped classroom teaching. There were significant differences between male and female students in the selection of self-study resources before class, mastery of basic knowledge before class, and their views on a concomitant learning burden. These differences suggest that teaching practices should offer diverse resources (e.g., a combination of interactive and text-based materials), adopt flexible methods (e.g., integrating practical and structured learning), and provide continuous assessment and feedback support (e.g., offering exploratory task guidance for female students and structured plans for male students) to address gender-specific needs. By doing so, more inclusive teaching strategies can be designed to enhance overall learning outcomes.

Although the flipped classroom model did not significantly improve students' test scores in the short term, its advantages in enhancing student engagement and satisfaction are evident. Features such as self-directed learning before class, in-depth classroom interactions, and personalized support may positively impact students' long-term learning abilities, critical thinking, and independent learning habits. Limitations in traditional test design, the relatively short implementation period, and students' adaptability issues may explain the lack of significant differences in scores in the short term. In the future, optimizing assessment methods, strengthening student adaptability training, and conducting long-term follow-up studies will help more comprehensively uncover the educational value of the flipped classroom and promote its potential in cultivating students' comprehensive abilities.

This study has several limitations. First, while the empathy canvas effectively captures students' subjective experiences and perceptions in the flipped classroom, the findings rely on participant self-reports, which may introduce bias and lack supporting objective measurement data. It should be noted that conclusions regarding educational improvement and reduced learning burden are derived from students' subjective feedback. These data reflect self-perceived competency changes rather than actual ability enhancement measured through standardized tests or academic performance metrics, nor do they employ objective methods like time logs or physiological indicators to validate workload changes. Furthermore, factors including the small sample size, focus on a specific student population, and observed gender differences may affect the generalizability of the findings. Future research should adopt mixed methods combining qualitative and quantitative approaches, expand sample diversity, and incorporate longitudinal studies with objective measurement indicators to enhance result validity.

When adopting this teaching model, educators need to ensure the support of online platforms and multimedia tools as well as specialized training for teachers in design thinking and flipped classrooms. It is recommended to implement it first in a small scope of chapters or classes to reduce the difficulty for teachers and students to adapt. At the same time, teaching demonstrations and feedback mechanisms should be provided to help teachers optimize their teaching strategies and enhance students' sense of participation.

Conclusions

Students' self-perception indicates that the large-class flipped teaching model incorporating design thinking is believed to enhance learning outcomes and comprehensive literacy without increasing the learning burden. Although there is no significant difference in classroom test scores, students still feel an improvement in their comprehensive abilities. The study has found gender differences in the selection of pre-class resources, providing a basis for personalized teaching. This model has the potential for application in histology, embryology, and related morphology courses. However, when promoting it, challenges such as the diversity of teaching content, differences in teaching needs, and environmental adaptability need to be addressed.

Abbreviations

ISTE International Society for Technology in Education
DT Design thinking

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12909-025-07116-8.

Supplementary Material 1

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Author contributions

Hui Zhang, Yan Guo: Conceptualization, Methodology, Writing-original draft preparation. Xiuguo Li, Xiaomei Wang: Formal analysis, Writing-reviewing and editingXiaojin Li, Jinghua Zhai: Data curation, Formal AnalysisThe author(s) read and approved the final manuscript.

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Data availability

Availability of data and materialsThe authors declare that the data supporting the findings of this study are available within the paper and its Supplementary Information files. Should any raw data files be needed in another format they are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

Research involving human participants, human material, or human data was performed in accordance with the Declaration of Helsinki. All methods were carried out in accordance with relevant guidelines and regulations. All experimental protocols were approved by the Ethics Review Committee of Jining Medical University (No. JNMC-2020-JC-013). Written informed consent was obtained from all subjects and/or their legal guardians.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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