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Revitalizing established teaching and assessment methods in oncological rehabilitation comprehensive laboratory course

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In the reform of medical laboratory courses, innovative teaching methods and the development of a teaching assessment system are crucial. However, in past practices, assessments have encountered some issues: a greater emphasis on recording outcomes, neglecting supervision of the process; a focus on summarizing writing, overlooking the importance of analysis and improvement. In the teaching process of Jilin University's Oncological Rehabilitation Experimental Teaching Demonstration Center, the Peer-Assisted Learning (PAL) model is employed to enhance students' learning approaches. The innovative incorporation of Direct Observation of Procedural Skills (DOPS) and Mini-Clinical Evaluation Exercise (Mini-CEX) facilitates effective assessment and feedback. The combination of these reform measures not only addresses issues in experimental teaching but also enhances the internalization of students' knowledge and skills. In this study, we applied the evaluation systems of Direct Observation of Procedural Skills and Mini-Clinical Evaluation Exercise (Mini-CEX) to the comprehensive laboratory course in oncological rehabilitation. We utilized questionnaires to assess the impact of these reforms on students, aiming to evaluate the effectiveness of the course modifications. Statistical analysis of the data revealed a high level of student approval and a strong willingness to learn under the new evaluation system. Compared to traditional teaching methods, the introduction of DOPS and Mini-CEX significantly enhanced students' overall competencies and improved the quality of the oncological rehabilitation course. Our approach represents an innovative reform, suggesting that incorporating DOPS and Mini-CEX into teaching could provide a widely applicable and promising new educational method. This paper explores and systematically elaborates on the reform and practice of the teaching model and formative assessment in the comprehensive laboratory course of oncological rehabilitation.

KEYWORDS

oncological rehabilitation, experimental teaching, teaching evaluation, formative assessment, teaching reform

1 Introduction

In the context of the new medical education landscape, innovative teaching models and the assessment of learning objectives have become central to the reform of the Cancer Rehabilitation Science experimental course. In 2018, our university introduced a comprehensive experimental course in Cancer Rehabilitation Science. This course, which

integrates rehabilitation medicine with clinical oncology, constitutes a sub-discipline of rehabilitation medicine. It is characterized by its strong comprehensiveness and wide interdisciplinary knowledge base. The curriculum not only encompasses fundamental laboratory techniques but also includes the distinctive features of advanced clinical rehabilitation procedures. Students are expected to repeatedly internalize knowledge and operational skills through practical experience. However, under the constraints of traditional teaching models, limited by class hours, space, and assessment methods, experimental courses often struggle to achieve effective teaching and learning. Addressing these challenges, we have innovatively introduced two approaches: Peer-Assisted Learning (PAL) and the combined assessment method involving Direct Observation of Procedural Skills and Mini-Clinical Evaluation Exercise (Mini-CEX). These innovations focus on classroom teaching and feedback on outcomes, aiming to enhance the overall effectiveness of the teaching and learning process. PAL is a well-established undergraduate medical education model, known for capitalizing on the interaction among students to foster a proactive learning environment. The combined use of DOPS and Mini-CEX involves setting detailed scoring criteria for each experimental component on the scale. After teachers score each part of the student's operation, the students receive feedback for reference and correction, aiming to enhance their mastery of experimental operational skills. This paper explores and summarizes the reforms and practices in the teaching model and formative assessment of Cancer Rehabilitation Science experimental courses. The goal is to provide valuable insights for the reform of the medical experimental teaching and evaluation system.

2 Research background

Medical education has always focused on the design and implementation of teaching models for medical courses. With the continuous changes and developments in the field of medicine, there is an increasing emphasis on optimizing and innovating teaching models. The teaching model of medical courses plays a crucial role in influencing students' academic proficiency, professional competence, and clinical practical abilities. This holds significant importance in cultivating outstanding medical talents. In the design and implementation of medical course teaching models, it is essential to integrate the advancements in modern medicine with the distinctive features of traditional medical courses, thus constructing a comprehensive medical education system. This implies the need for tailored teaching approaches, designing forward-looking and practical curriculum structures for different medical specialties and disciplinary fields. Simultaneously, the innovation of teaching models should align with students' learning characteristics and needs, incorporating various teaching methods and resources. These may include traditional lectures, laboratory demonstrations, as well as modern technological approaches such as multimedia instruction and online teaching. This multi-faceted approach aims to enhance students' interest and effectiveness in learning. Peer Assisted Learning is an instructional approach based on students assisting each other through collaborative learning. In the PAL model, students are divided into small groups, engaging in mutual communication and cooperation to learn and solve problems collectively. In the field of medical education, a meta-analysis has provided evidence for the effectiveness of the PAL model (Zhang and Maconochie, 2022). PAL has become a recognized and effective teaching method, contributing positively to the creation of a more active and collaborative learning atmosphere (Bergeron et al., 2018). PAL not only has a positive impact on students' personal beliefs and confidence (Bugaj et al., 2019), but also research suggests that students express a much higher level of preference for PAL as a learning method compared to traditional teaching approaches (Jawhari et al., 2021).

Educational assessment is a quantitative and experiential evaluation of students' learning outcomes, beneficial for transforming the teaching process into a controllable system with constant feedback adjustments, progressively aligning instructional effectiveness with expected goals. Process assessment, as a form of temporary, dynamic, and recurrent evaluation, comprehensively assesses students' performance and progress throughout the teaching process. In recent years, this assessment approach has garnered significant attention and widespread application in medical education. In medical education, process assessment is particularly emphasized due to the highly practical and complex nature of the medical field, imposing elevated demands on students' practical skills and professional competence. Through process assessment, teachers can more accurately evaluate students' performance in practice, offer timely feedback and guidance, aiding them in continuously enhancing their professional skills and strengthening clinical operational abilities. The emergence of the integrated experimental teaching model can be traced back to the 1990s, representing a significant reform in medical education. It deviates from the traditional pattern where experimental courses are reliant on theoretical ones and instead integrates multidisciplinary knowledge into practical teaching. The aim is to cultivate students' comprehensive abilities and exploratory thinking. The Cancer Rehabilitation Science comprehensive experimental course, as a result of this reform, encompasses integrated experimental projects from various disciplines, including clinical oncology and rehabilitation therapy. These experiments involve complex principles and operations, posing challenges for both teaching and learning, demanding students to continuously consolidate their acquired knowledge and skills through practical operations. In the training of practical examination, communication, and reasoning skills, students apply foundational scientific knowledge to clinical scenarios. In the modern information-oriented teaching environment, the development and introduction of learning strategies that enhance learning outcomes will to some extent improve the accessibility of learning resources in pre-clinical education (Keenan et al., 2023). Exploring a new teaching model in the reform involves paying attention to various aspects, including the design of instructional content, diversification of teaching methods, variations in the difficulty of the curriculum, and the supervision and assessment of students' learning outcomes (Zhang et al., 2022).

In the traditional teaching evaluation system, the primary assessment method revolves around writing laboratory reports. Despite post-lab report writing being considered an effective method for fostering students' scientific spirit and evaluating the effectiveness of experimental teaching over the years, this approach has its drawbacks. It tends to prioritize the completion of teaching and learning in a single instance, emphasize outcome recording over process supervision, and focus more on summarizing writing while neglecting analysis and improvement. Firstly, writing laboratory reports may lead students to focus solely on recording the experimental process and results, neglecting the cultivation of skills

in experimental design, analysis, and reasoning. Secondly, the act of writing experiment reports could encourage a mechanistic approach to writing, rather than fostering a genuine understanding and application of experimental methods and outcomes. Additionally, the writing of experiment reports may limit students' flexibility, failing to adequately reflect their innovative capabilities and practical problem-solving skills. If these issues are not addressed and resolved, they may result in students approaching classroom experimental operations with a lack of seriousness, displaying a perfunctory attitude. There is a prevalent tendency towards disregarding the significance of writing experiment reports, with a leaning towards a dismissive attitude and a propensity for plagiarism. This leads to limitations in the effectiveness of experiment reports, almost rendering them meaningless. Furthermore, poor mastery of the principles and skills involved in experimental operations contributes to rapid knowledge forgetting among students, further diminishing the effectiveness of experimental teaching. In relevant studies, some students have reported a decline in their learning enthusiasm as the course progresses, which may be associated with the extended duration of the course and a decrease in student interest. Addressing this phenomenon, teachers need to be attentive to changes in students' learning enthusiasm and take measures to boost their engagement. It is crucial to promptly identify issues among students and intervene, make timely adjustments to teaching methods, and consistently ensure the maintenance of students' enthusiasm for learning (Zhang et al., 2022). Therefore, there is an urgent need for profound reforms to address these issues. We aim to explore new assessment approaches in the Cancer Rehabilitation Science comprehensive experimental course. The goal is to enhance students' enthusiasm and active participation in experimental operations, increase their emphasis on writing experiment reports, ensure their ability to comprehend experimental principles, and facilitate the lasting retention and practical application of knowledge and skills gained from experiments. An improved evaluation system and effective real-time feedback are crucial methods for students to achieve self-awareness and adjustments in their learning status and depth of learning. This enhances students' understanding of knowledge and learning methods, aids teachers in timely adjustments to teaching methods, and further promotes the effectiveness of classroom teaching (Rong et al., 2022).

According to the changing international trends in competency-based medical education, teaching assessment is gradually incorporating workplace-based assessment (WPBA) methods that evaluate procedural skills in the spirit of the competency-based medical curriculum (Kamat et al., 2022). Two commonly used WPBA tools introduced are the Mini-Clinical Evaluation Exercise (Mini-CEX) in 1995 and the Direct Observation of Procedural Skills in 2003 (Saeed et al., 2023). The aforementioned assessment methods have seen increasing utilization worldwide in the evaluation of clinical skills and teaching courses. For instance, in India, a short-term educational research initiative was conducted as part of the Medical Council of India's Medical Education Advanced Course (ACME) innovation project. The objective was to integrate Direct Observation of Procedural Skills as a formative assessment and learning tool to refine the ENT surgical skills of E.N.T. residents and interns (Bansal, 2019). In a medical education reform initiative for undergraduate students in Germany, additional learning content related to ultrasound skills was introduced to meet professional demands. Students' capabilities in this area would be formatively assessed through Direct Observation of Procedural Skills (Teichgräber et al., 2022). Furthermore, the effectiveness and positive impact of DOPS as an assessment tool have been further confirmed (Lörwald et al., 2018).

From another perspective, studies have demonstrated a close relationship between university teaching methods and the development of student competencies (López-Novoa et al., 2021). Effective teaching methods can stimulate students' interest in learning and enhance learning outcomes. A teacher's abilities, encompassing teaching skills, communication abilities, and knowledge level, directly impact the effectiveness of teaching. Therefore, the design of university teaching methods must consider the competency level of teachers to ensure compatibility. Additionally, to improve teachers' abilities, universities can continuously enhance their professional levels through training and academic exchanges, thereby better leveraging teaching methods to improve teaching quality. Hence, universities should emphasize the development and enhancement of teachers' professional abilities by providing ongoing education, training, and development opportunities to improve overall teaching quality and students' academic performance. A study analyzed the educational impact and perceptions of lecturers at Catalonian universities before and after the pandemic. Professors made efforts to apply the knowledge they gained, but faced challenges such as insufficient time to adjust teaching practices and the complexities of online assessments. The study concluded that there is a need for continuous training programs to establish support networks and collaboration to improve teaching quality (Ramos-Pla et al., 2021). Conversely, from the students' perspective, a quantitative study aimed to understand the relationship between university students' perceptions of online teaching quality during the SARS-CoV-2 pandemic and factors such as teaching plans, material resources, interaction processes, and emotional components. The findings revealed that students' perceptions of online teaching quality were directly related to the resources provided by professors and the interaction between students and professors. The study concluded that universities need to implement support and guidance models, especially for first-year students, to foster their autonomy, digital skills, and self-regulation abilities, and to adjust methods for both students and professors according to the new normal (del Arco et al., 2021). The aforementioned studies strongly demonstrate that university teaching reforms need to enhance teaching methods and improve teachers' professional abilities to elevate overall teaching quality and provide better academic development and career planning support for students. This requires a concerted effort from educational institutions and administrators to formulate relevant policies and provide resource support, adapting to the ever-changing teaching demands while continuously optimizing teaching methods and teacher development mechanisms. Such efforts ensure the alignment between teaching methods and teacher capabilities, enhancing teaching quality and promoting students' holistic development. Therefore, innovative teaching reforms are not only aimed at improving students' learning outcomes and academic performance but also at fostering teachers' professional growth and elevating overall teaching quality. This approach drives substantial progress in teaching reforms, advancing towards the goal of high-quality education.

3 Implementation of peer-assisted learning model

The traditional teaching model has exhibited several drawbacks, including low student engagement, an overly one-way delivery approach, leading to diminished student interest, lack of personalized instruction, and insufficient cultivation of independent learning skills. In the context of educational reform, it is imperative for educators to contemplate how to break away from the traditional teacher-centric lecture format. Instead, innovative approaches should be explored to inspire students' interest in learning and enhance teaching effectiveness. Jilin University's Cancer Rehabilitation Science Experimental Teaching Demonstration Center has shifted its teaching model by incorporating a peer-assisted learning approach, where students take on both the roles of learners and teachers. PAL typically includes several variants, such as near-peer tutoring (NPT), where mentors receive training ahead of trainees (usually at least 1 year); reciprocal peer tutoring (RPT), where students rotate between being mentors and mentees within the same training and learning course; and in peer-to-peer tutoring, higher-skilled students are designated as mentors to assist lower-skilled students, as both simultaneously participate in the course (Shenoy and Petersen, 2020). Considering the characteristics of the Cancer Rehabilitation Science curriculum and the students' proficiency levels, we have chosen the Reciprocal Peer Tutoring (RPT) model for instruction. The implementation of the PAL model typically follows these steps: firstly, students are divided into small groups, often composed of classmates with relatively balanced abilities. Secondly, under the supervision of the teacher, these groups engage in learning activities such as collaborative reading, discussions, problem-solving, etc. In the PAL model, students bear certain responsibilities, showcasing collaborative and leadership skills while also taking on independent learning responsibilities. PAL is instrumental in fostering teamwork and cooperation among students. It shifts the focus of learning from the teacher to the students themselves, aiding in the development of students' autonomous learning and self-management skills. PAL is conducive to promoting communication and collaboration among students, cultivating positive interpersonal relationships, communication skills, and emotional management abilities. The introduction of PAL contributes to educational innovation and enhances teaching effectiveness (Table 1).

3.1 Sociality

In the role of knowledge recipients, students exhibit a high level of understanding towards individuals who share their social roles. This dynamic provides a strong motivation for certain students to take on the role of student mentors. Research indicates that students aspiring to become mentors display a strong enthusiasm and motivation for teaching, which is a crucial factor driving their active engagement in the teaching role (Bugaj et al., 2019).

Cognitive and social congruence refer to educators actively seeking to understand students' cognitive and social needs and adjusting their teaching methods and styles accordingly. This congruence implies that educators' teaching approaches and interactions with students align and coincide with students' cognitive and social needs. Throughout the educational process, cognitive and social congruence require educators to adapt to students' cognitive abilities and developmental stages, responding positively to social contexts. This ensures that the teaching environment and methods align with students' cognitive and social characteristics, making instruction more meaningful and effective. Factors such as students' social backgrounds, cultural differences, language abilities, among others, need to be considered in teaching to ensure that instructional methods and content are accepted and understood by students on both cognitive and social levels. Therefore, the PAL mode involves student mentors and students sharing a similar and common knowledge base, which represents cognitive congruence. Simultaneously, student mentors and students share similar social roles, indicating social congruence (Lockspeiser et al., 2008). In a study by Loda et al. (2020) a questionnaire survey was conducted to explore the potential mechanisms of effective PAL, utilizing factor analysis to delve into these concepts.

3.2 Effectiveness

In various medical courses, Peer Assisted Learning has been integrated into education in multiple ways, positioning itself as a method to enrich classroom content and enhance the value of teaching within the established context, rather than serving as a mere alternative to traditional teaching methods. Recent research indicates that PAL is not only an effective pedagogical strategy contributing to improved student learning but also has the potential to enhance their academic performance at an underlying level (Guraya and Abdalla, 2020). Particularly noteworthy is the substantial benefit that student tutors themselves derive from participating in PAL, a aspect supported by relevant studies (Burgess et al., 2014). Furthermore, the academic community is delving deeper into the study of PAL, aiming to unveil its precise impact and mechanisms within medical education. PAL, being a potent teaching strategy, not only facilitates students' better understanding and mastery of course content but also provides them with opportunities for mutual growth and academic exchange. This collaborative learning model sparks students' academic interests, with the potential to cultivate medical professionals who are not only proficient but also innovative and possess strong teamwork skills. Therefore, PAL emerges not just as a teaching tool but as a crucial pathway for fostering academic development and personal growth.

3.3 Inclusiveness

The student body exhibits rich diversity, allowing teachers to implement personalized teaching strategies based on differences in various aspects among individuals, thereby enhancing overall teaching quality. The PAL model perfectly caters to this need as it can provide personalized support for students with varying learning levels. In the PAL model, academically proficient students can consolidate and deepen their knowledge by instructing others, simultaneously improving their teaching skills. On the other hand, students with weaker academic abilities can engage in peer-assisted learning to compensate for their learning deficiencies. The core philosophy of this model revolves around mutual assistance and support among students, extending beyond academic aspects to encompass emotional support and social interaction. The mode of

TABLE 1 A study related to the effectiveness of PAL in medical teaching (Aljahany et al., 2021; Christensen et al., 2023; Han et al., 2015; Khan et al., 2021; Pelloux et al., 2017; Schaffer et al., 2021; Zentz et al., 2014).

Publication date/country	Research content	Conclusion	References
United States	Evaluating the effectiveness of PAL in clinical settings and determining students' perceptions of fulfilling the professional nursing role	PAL effectively reduces student anxiety and boosts confidence, serving as an impactful teaching strategy for learning professional skills	Zentz et al. (2014)
Saudi Arabia	Evaluate the perceived advantages of simulation-based PAL among healthcare professional students and interns, as well as their acceptance of this novel concept of student-led learning from peers	Aids in understanding the perceived process by research participants. All students expressed their willingness and enthusiasm to use simulation as PAL	Aljahany et al. (2021)
United Kingdom	Validate the use of PAL in teaching basic laparoscopic skills to medical students on a low-cost simulator and compare the effectiveness of PAL training between preclinical and clinical medical students	PAL simulation is a proven and effective training method, demonstrating significant training outcomes at both preclinical and clinical levels	Schaffer et al. (2021)
South Korea	Evaluating anatomy teaching under the PAL model and comparing the impact of PAL-modeled anatomy versus teacher-led anatomy on students' self-assessment and academic performance	Anatomy courses under the PAL model enhance students' self-awareness and their ability to retain and interpret anatomical knowledge	Han et al. (2015)
France	Evaluating the Effectiveness of PAL Compared to Teacher-Guided Instruction in Peripheral Venous Catheter Insertion Training	Students in the PAL group demonstrate significantly higher confidence levels, highlighting the effectiveness of PAL in peripheral venous catheter insertion training	Pelloux et al. (2017)
Pakistan	Evaluating the effectiveness of PAL and expert-assisted learning based on scores achieved by medical students and investigating student perceptions of PAL	PAL is a valuable tool that can be integrated into the curriculum	Khan et al. (2021)
Norway	Designed to gain insights into the PAL learning group experiences from the perspective of physical therapy students	The study findings support the integration of PAL learning groups as a supplement to formal instruction, recognizing PAL's contribution to students' transition to the university environment	Christensen et al. (2023)

mutual learning and assistance fosters the establishment of friendly relationships, thereby promoting inclusivity and teamwork among students. The PAL model aims to create a learning atmosphere characterized by mutual respect and trust, allowing students to freely express their viewpoints, opinions, and confusions. Consequently, the collaboration and interaction among students in this model not only facilitate the transfer and mastery of knowledge but also contribute to the development of a conducive learning environment. In comparison to traditional one-way teaching, this collaborative learning approach stimulates positive thinking and discussions among students, making knowledge more easily absorbed and understood.

4 Construction of formative assessment reform plan

Since 2018, the Jilin University Cancer Rehabilitation Experimental Teaching Demonstration Center has been fully implementing the educational policies of the new era, aligning with the requirements of medical education in the information age. In addition to the traditional experimental report assessment, innovative cancer rehabilitation comprehensive experimental evaluation tools, namely DOPS (Direct Observation of Procedural Skills) and Mini-CEX (Mini-Clinical Evaluation Exercise), have been introduced. These tools are utilized together to achieve a procedural assessment of skill operations across various environments.

In the practical skills operation section, teachers conduct a comprehensive assessment of students based on the DOPS (Direct Observation of Procedural Skills) evaluation form. This assessment includes grading on various aspects such as mastering the basic principles of the experiment, preparation of equipment and materials before the operation, accuracy in key operational steps, degree of teamwork and collaboration, handling of emergency situations, post-experimental item disposal, and ethical considerations. The advantages of the DOPS evaluation method lie in its ability to provide performance assessments in real-world settings, aiding in the identification and correction of deficiencies in operational skills. Through direct observation, teachers can gain a thorough understanding of students' skill levels in practical operations, offering targeted feedback, necessary guidance, and suggestions. This assessment method contributes to the enhancement of students'

professional skills, provides a clear understanding of their strengths and areas for improvement, and ensures the safety and quality of operations.

In the clinical practice component, teachers utilize the Mini-CEX (Mini Clinical Evaluation Exercise) to assess students' professional capabilities. The Mini-CEX scale consists of three main sections: basic information, scoring items, and feedback records. The primary scoring items encompass physical examination, humanistic/professional qualities, clinical diagnosis, organizational efficiency, overall clinical competence, and others, each with detailed scoring criteria. The assessment process unfolds as follows: under the teacher's observation, students perform clinical skill operations, and the teacher records comments on the Mini-CEX scale, providing immediate feedback to make students aware of shortcomings and facilitate timely improvements. Throughout the assessment process, both teachers and students gain a clear understanding of students' existing knowledge levels, identified deficiencies, and areas for future improvement. This enhances the guidance provided by teachers and the learning experience for students, offering a more targeted direction for development.

The establishment of a combined assessment method using DOPS (Direct Observation of Procedural Skills) and Mini-CEX (Mini Clinical Evaluation Exercise) allows teachers to better understand students' individualized learning needs. It enables teachers to provide precise feedback and guidance tailored to students' specific situations, thereby facilitating more effective support for individual student development. Moreover, through this assessment system, teachers gain a comprehensive understanding of students' performance in laboratory skill operations and clinical skill practices. This insight enables them to adjust teaching methods and content more effectively, enhancing the overall quality of education. It ensures a holistic improvement in students' skill development and professional competence, elevating their ability to solve practical problems. This, in turn, lays a solid foundation for students to become qualified clinical technicians or laboratory professionals in the future.

The application of this innovative assessment system extends the scope of comprehensive evaluation and teaching effectiveness in a multi-environment experimental course, offering a fresh perspective and approach to enhancing students' practical skills and academic performance. Through this open-ended assessment system, students not only receive feedback and guidance from teachers and assessors but also engage in self-assessment and reflection. This allows them to better understand their skill levels and learning objectives, facilitating more targeted learning planning and self-improvement. Therefore, this innovative assessment approach provides new pathways and insights for promoting comprehensive evaluation and the development of practical skills in students.

4.1 Interactivity

Process assessment emphasizes timely interaction and adjustments during the teaching process. However, experimental teaching, due to its temporal and spatial constraints imposed by laboratory and equipment conditions, confines teaching and learning to a one-time completion. This limitation results in insufficient internalization of students' practical skills. To address this issue, we have established a teaching process and timeline in our curriculum planning that includes operation, assessment, real-time feedback, adjustments (improvements), and debriefing (summary). This process encompasses several key steps. First, there is the implementation of specific operations or skills, followed by an assessment of student performance. After evaluation, personalized feedback is promptly provided to help students understand their strengths and areas for improvement. Based on the feedback, students can make adjustments and improvements to demonstrate better performance in the next operation. Finally, we conduct a summary and debriefing, emphasizing key points and encouraging continuous progress. These steps complement each other, ensuring that students continuously improve and enhance their skills in practice, while also providing them with comprehensive guidance and support. DOPS and Mini-CEX are considered complementary tools, forming an innovative supervisory evaluation mechanism. In actual teaching, feedback and adjustments in core steps mainly manifest in two modes: immediate feedback and course-wide feedback. For immediate feedback and adjustments, we employ two modes: first, through demonstration operations and online resources, promptly adjusting surgical techniques; second, the systematic use of formative assessment by teachers to evaluate students' achievement of learning objectives and adjusting teaching strategies and methods based on the assessment results. Particularly in relatively independent experimental segments, such as suturing in the establishment of gastric ulcer models or ventricular intubation in the preparation of isolated frog hearts, as well as in clinical postoperative speech rehabilitation for brain tumor patients, we use formative assessment to adjust classroom teaching, aiming to achieve teaching goals and enhance surgical skills. The feedback and adjustments throughout the course cover the entire learning process of the comprehensive experimental study in tumor rehabilitation. During lesson planning and discussions, teachers repeatedly review teaching objectives and students' current learning status through formative assessment forms, reflect on and adjust teaching strategies, and devise methods to address gaps. In classroom teaching, adjustments to the content can be made based on the effectiveness of different sessions, especially in demonstrating and providing focused explanations on challenging operations and key surgical techniques. This comprehensive adjustment throughout the course contributes to effectively driving the learning process and improving teaching outcomes. It helps students better understand their learning progress, gain in-depth knowledge and skills, and provides guidance and recommendations for the next stage of learning. Through these two feedback modes, we ensure that students receive timely guidance and support during the learning process, continually enhancing and optimizing their learning outcomes.

4.2 Effectiveness

The indicators for formative assessment should be clear and specific, aiding in the effective achievement of teaching objectives. In the field of tumor rehabilitation experiments, formative assessment goes beyond merely setting evaluation criteria and incorporating them into the final grades. It involves the implementation of assessment through experimental operations, evaluation, real-time feedback, improvement, and summarization. Establishing accurate and effective indicators for formative assessment scales is the primary step in this process. Formative

assessment is primarily conducted autonomously by teachers and students during classroom teaching, but this does not imply that the assessment can be arbitrary. Teachers engage in collaborative lesson planning, discuss and refine specific grading criteria for key experiments in the course, and provide detailed descriptions of critical operations to ensure the effectiveness of the assessment structure and content. This includes requirements related to animal welfare protection, cleanliness, and orderliness of the surgical operating table, guiding students to gradually establish comprehensive and standardized practical abilities in tumor rehabilitation. These standardized requirements aim to guide students in progressively developing comprehensive and standardized practical abilities in the field of tumor rehabilitation, covering aspects such as animal welfare protection and the neatness and orderliness of the surgical operating table. Not only does this approach allow students to learn through practical interactions with animals and surgical operating tables, but it also contributes to fostering their sense of responsibility and attention to detail. Simultaneously, these comprehensive and standardized requirements help create a positive campus learning environment and professional ethical standards, enhancing students' professional and vocational competencies. Furthermore, these standardized requirements aid students in accumulating richer and more comprehensive experiences in practice, preparing them adequately for future employment and academic research. Beyond the confines of the laboratory, in clinical practices, formative assessment enables students to immediately correct errors, thereby improving learning efficiency. It also enhances students' proactiveness and self-reflective capabilities, contributing to the cultivation of their interest and enthusiasm for clinical practices.

4.3 Integration

In the past several years of teaching practice, given the comprehensive and challenging nature of the comprehensive experimental course in cancer rehabilitation, we have placed significant emphasis on the incorporation of formative assessment into the course evaluation methods. This has resulted in the development of a multifaceted assessment system comprising modules such as comprehensive experimental reports, literature review and retrieval, exploratory experimental design, experimental implementation, and paper writing. These modules are structured to be completed in stages corresponding to the course progression. The composition of the experimental reports encompasses a comprehensive assessment of students' fundamental abilities, including their experimental operations, observation records, and analytical thinking regarding experimental research. Additionally, through tasks such as literature review and retrieval, as well as exploratory experimental design, we evaluate students' introductory capabilities in innovative research. Leveraging student innovation laboratories and experiment proposals designed by students themselves, we enable capable students to engage in innovative experimental research and paper writing under the guidance of teachers. This approach addresses the issue of experimental teaching being overly focused on confirmatory experiments and lacking innovative exploratory experiments. Within the teaching evaluation system, the combined use of DOPS and Mini-CEX serves as a newly incorporated module within the formative assessment system. This significantly enhances comprehensive supervision in teaching and learning, aligning with students' cognitive patterns. This embedded formative assessment module robustly complements and enhances our existing evaluation system, making it more closely aligned with students' learning realities. It enables a more comprehensive assessment of students' learning situations, identifies potential issues, and facilitates timely adjustments in teaching strategies. Simultaneously, this assessment module can inspire students' learning motivation, enhance their self-awareness and initiative, encouraging them to engage more deeply in both classroom and independent post-class learning. Through a comprehensive evaluation and tracking of students' learning processes, we can better meet individualized needs, aiding each student in achieving their academic development and growth. Overall, we have constructed a unique formative assessment scheme within the Jilin University Rehabilitation Therapy Experimental Teaching Demonstration Center, successfully applying and practicing it in teaching from 2018 to 2022.

5 Evaluation of practical effectiveness

5.1 Facilitating teaching, guiding adjustments in teaching activities

Renowned contemporary American psychologist and educator, Benjamin Bloom, employed a thought-provoking metaphor to underscore the necessity of formative assessment for continuous guidance and adjustment in students' learning processes. He emphasized that formative assessment should function more like a thermostat, dynamically adjusting based on circumstances, rather than a simple thermometer (or a basic "weather vane") that only indicates the current temperature. Formative assessment should be a timely, ongoing, and comprehensive evaluation process, providing practical feedback on students' performance in learning and facilitating adjustments and guidance throughout the learning process. The analogy of a "thermostat" implies that the assessment process should adapt, much like controlling a thermostat, continuously adjusting based on students' evolving performances, and consistently maintaining an appropriate state, similar to how a thermostat automatically regulates room temperature to ensure it stays within a comfortable range. This also emphasizes that the assessment process needs to be more dynamic and flexible, capable of adjusting and providing feedback as students progress through different developmental stages.

Therefore, formative assessment should not merely serve as a "scorebook" but should involve an analysis and reflection on data indicators, objectively evaluating the achievement of students' learning objectives, and adjusting the teaching and learning process based on the analysis results. Our qualitative research, consisting of interviews and surveys, indicates that teachers widely acknowledge the significant assistance provided by the formative assessment system in achieving teaching objectives. Further analysis reveals that the formative assessment system substantially contributes to enhancing learning outcomes, manifested primarily in the following aspects: Firstly, it provides guidance. Before the teacher-student introductory meeting and in the student handbook, we clearly defined the methods and approaches of formative assessment. Detailed grading criteria were

established in the formative assessment workbook. This enables students to have a clear understanding of the objectives before the lab session, allowing them to consider their operational key points based on the criteria. Next is the evaluation feedback. During the course, instructors provide immediate feedback adjustments or summaries based on evaluation data and make overall adjustments to the course throughout its duration. In practice, we have successfully established a beneficial cycle of evaluation, feedback, and improvement. Lastly, there is reinforcement of motivation. In the implementation of formative assessment, teachers strategically focus on and motivate students with moderate or challenging mastery levels. By reinforcing positive feedback, they attract attention and encourage these students to achieve their learning objectives. With the design and application of DOPS and Mini-CEX scales, the Comprehensive Experimental Course in Tumor Rehabilitation has not only been selected as a first-class undergraduate course in virtual simulation but has also been included in the category of first-class undergraduate courses in Jilin Province's blended online and offline courses. This demonstrates the effectiveness of the assessment system and its significant impact on enhancing the course.

5.2 Enhancing abilities, facilitating the achievement of quality goals

We conducted a questionnaire survey in 2021 with 89 undergraduate students from the Rehabilitation Therapy program who participated in the oncological rehabilitation course. All surveyed students successfully completed the course and the questionnaire. The participants, with an equal male to female ratio, were aged between 20 and 21 years. The results (see Figure 1) indicate that the majority of students reported improvement in analytical and synthetic abilities (85.4%), interpersonal relationships and collaborative skills (89.9%), and creative problem-solving abilities (92.1%). Additionally, there were notable enhancements in decision-making skills (83.2%), critical thinking abilities (80.4%), communication and expression skills (75.8%), leadership skills (72.9%), and logical thinking and rigor (68.5%). Importantly, following the implementation of the formative assessment system, the students achieved a remarkable success rate of 93.3% in their initial practical experiments, with an average reduction of 7.6 min in the completion time (see Figure 2). Figure 3 illustrates the evaluation of the three methods (PAL, DOPS, and Mini-CEX) from both student and faculty perspectives. Student feedback indicates high approval for the implementation of PAL and DOPS (Figures 3A,B), particularly in direct observation. Similarly, PAL and DOPS received positive evaluations (Figures 3A,B), highlighting its effectiveness in assessing clinical skills. Faculty feedback also shows strong support for Mini-CEX (Figure 3C), emphasizing its practicality in direct observation and skill assessment, and positive responses in enhancing teaching quality and student competency. This figure enhances the comprehensiveness of our data, demonstrating the effectiveness and feasibility of these methods in the oncological rehabilitation laboratory course. Students provided positive evaluations in terms of overall interest and collaborative spirit in the teaching. In their comments, some suggested "increasing the weight of regular grades and strengthening formative assessments; formative assessments can better reflect students' comprehensive abilities," demonstrating students' acceptance of the formative assessment system and their enthusiastic learning intentions towards the comprehensive experimental course. These results indicate that the students' multifaceted skills and qualities have been cultivated and enhanced through the learning experiences in this course.

6 Reflection and prospects

6.1 Dynamic optimization of evaluation indicators should be considered

The teaching activities possess the characteristics of continuous development and change. Students from different majors and with different educational objectives require tailored teaching methods and assessment criteria. During the collaborative lesson planning phase, teachers should engage in in-depth discussions on how to optimize and improve the formative assessment rubric based on an analysis of student performance. Teachers need to consider both the course requirements and the actual learning situations of students, collectively exploring how to establish more comprehensive and accurate assessment criteria to better evaluate students' learning processes and achievements. This process should follow the convenient criteria for setting assessment indicators while ensuring dynamic optimization of assessment content to enhance the credibility and validity of the assessment rubric. Simultaneously, there is a continuous need to refine the content and format of the assessment rubric to improve its credibility and validity. This involves incorporating the latest trends in teaching practices and disciplinary developments, dynamically revising and updating assessment indicators to ensure alignment with teaching objectives and the accuracy of assessment outcomes. Such efforts will further enhance the optimizing role of formative assessment in achieving teaching objectives, promoting a more scientific and effective evaluation of students' learning processes, better guiding teaching practices, and advancing the improvement of teaching quality. Therefore, teachers should continuously explore and refine the formative assessment system to meet the teaching demands of different majors and student development goals, driving ongoing improvements and advancements in teaching practices.

6.2 Leveraging smart labs to enhance teaching and learning efficiency is essential

Currently, our center has established six smart laboratories equipped with integrated functional machines. These classrooms incorporate devices such as operating tables, ventilators, thermometers, and cameras, enabling the execution of various experimental procedures. These devices not only support experimental operations but also facilitate functions such as attendance tracking, monitoring, explanation, interaction, and testing. Teachers make full use of the hardware capabilities of the smart laboratories, seamlessly integrating the "soft" formative assessment into the process. For instance, during practical sessions, students can utilize real-time feedback evaluations to access virtual simulation projects within the integrated machines. They can refer to instructional materials and engage in virtual operations, enhancing the success rate of procedures and reducing the time required to complete experiments. In addition, teachers can utilize the functional

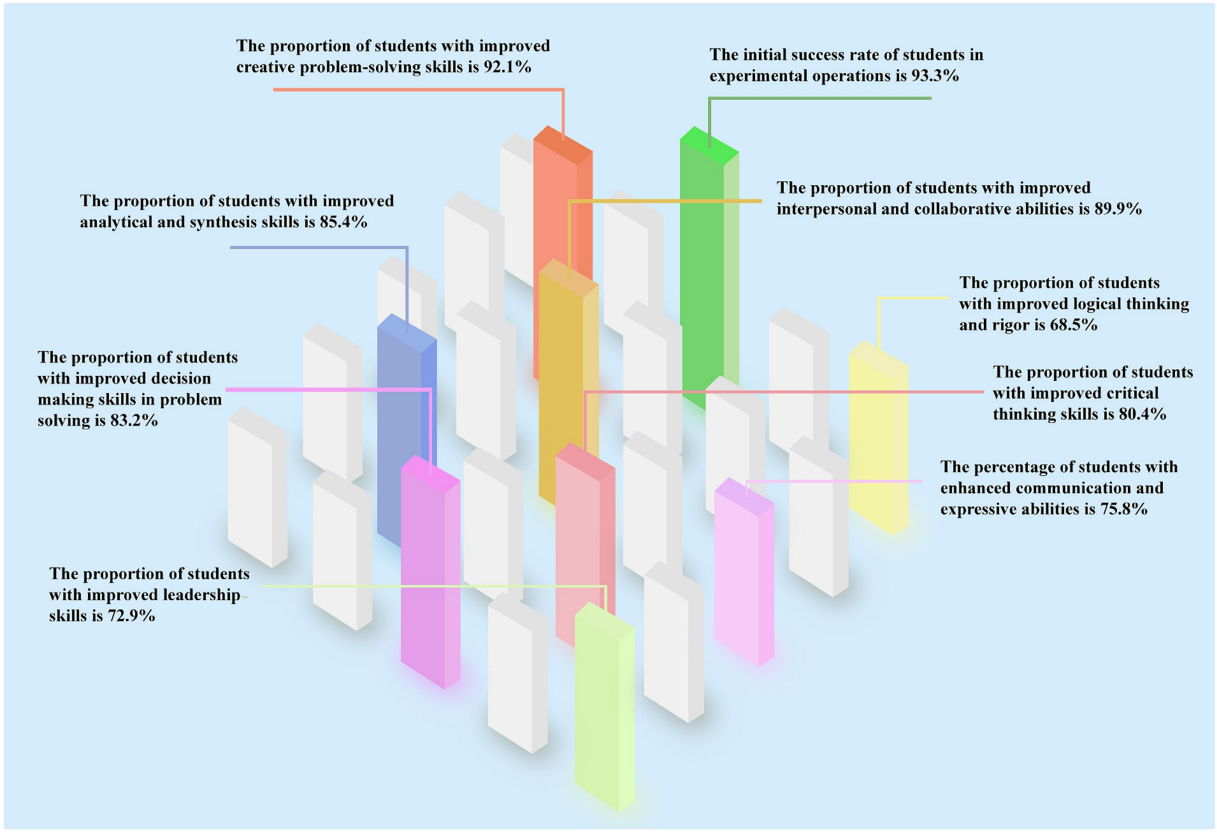

FIGURE 1
Improved self-assessment feedback on student capabilities.

teaching screen to project their demonstrations and students' typical operations onto the large screen. By analyzing specific experimental steps, teachers can evaluate students' understanding of the experimental process and the accuracy of their experimental operations, providing timely feedback and guidance. Through this approach, students can gain a more intuitive understanding of their performance in experiments, while teachers can conduct assessments and guidance more scientifically, promoting the comprehensive development of students. The integration of "soft" formative assessment with the hardware equipment of the smart laboratory in this way enhances the interactivity and real-time nature of teaching, contributing to the improvement of teaching quality.

6.3 Utilizing information technology to enhance assessment efficiency is imperative

In the process of using the formative assessment forms, we leverage information technology to enhance the efficiency and accuracy of evaluations. Building upon existing DOPS and Mini-CEX evaluation systems, teachers further optimize and streamline the assessment content. Through the use of information technology, this content is integrated into the smart laboratory system. The use of this technology allows evaluation procedures to be conducted within the software of intelligent tablets. Importing student information in advance reduces the need for repetitive form filling. Consequently, teaching instructors can focus more on critical teaching actions such as observation, assessment, feedback, and discussion. Additionally, using software to input assessment information facilitates the rapid generation of quantitative data charts, aiding timely feedback interaction and summarizing classroom discussions. The Jilin University Oncological Rehabilitation Experimental Teaching Demonstration Center, through its exploration of formative assessment reform, has optimized the comprehensive teaching evaluation system. This reform promotes the linkage between teaching evaluation and feedback improvement, achieving comprehensive supervision of students' experimental operations. It effectively addresses the challenge of the "one-time completion" issue in oncological rehabilitation experimental teaching, significantly enhancing the effectiveness of teaching practical skills. Looking ahead, we will focus on the dynamic optimization of evaluation system indicators and their integration with information technology. By continuously collecting and analyzing student learning data, we aim to gain in-depth insights into the unique characteristics and needs of different students. This will enable us to provide personalized teaching guidance and assessments. Leveraging advanced information technology, we plan to establish a comprehensive data management system capable of real-time collection, storage, and analysis of evaluation data. This system will better support teaching decisions and the assessment of student growth. Simultaneously, we will strive to

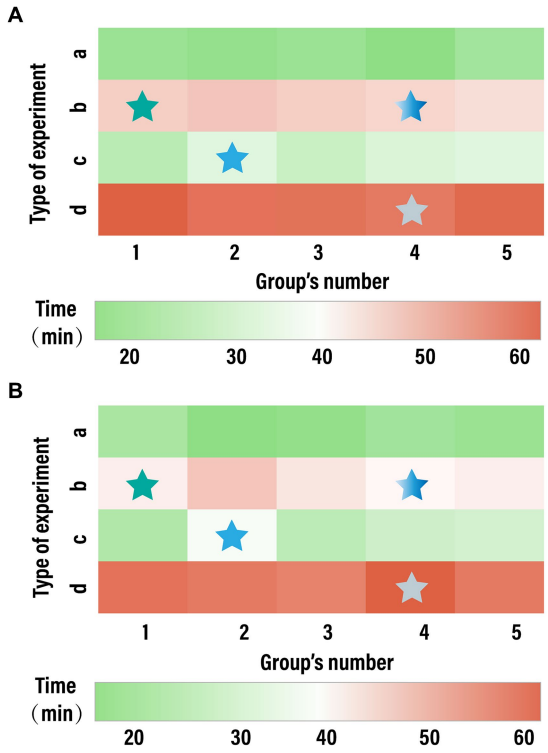

FIGURE 2
Heatmap of time spent by students on different types of experiments before **(A)** and after **(B)** curriculum reform. This heatmap illustrates the time durations spent by students on four common types of experiments, labeled as a, b, c, and d (e.g., rehabilitation training for precise hand grasping functions in postoperative brain tumor patients), before and after the curriculum reform. The time scale at the bottom transitions from green to red, indicating durations from 20 to 60 min, with greener colors representing shorter durations and redder colors longer durations. Experiments marked with asterisks indicate a significant reduction in time spent, by over 10 min, demonstrating the effectiveness of the curriculum reform.

enhance the interactivity of evaluations. By introducing open-ended evaluation formats and diverse assessment methods, we aim to encourage students to actively participate in the teaching assessment process, fostering their autonomy in learning and development. Through these initiatives, our goal is to further improve the effectiveness and interactivity of evaluations, better supporting the enhancement of practical teaching standards, and driving continuous improvement and development in teaching quality.

7 Summary

Globally, Direct Observation of Procedural Skills and Mini-Clinical Evaluation Exercise have been widely adopted in medical education across many countries. For instance, in the United Kingdom, these assessment methods are extensively used in the training of medical undergraduates, postgraduates, and interns, and have been shown to significantly enhance students' clinical skills and reflective abilities (Al-Jundi et al., 2017; Cohen et al., 2009; Mitchell et al., 2013; Tricio et al., 2016). Similarly, in Australia and Canada, DOPS and Mini-CEX are integral to medical education evaluation systems, aiding students in adapting to clinical practice more effectively (Castanelli et al., 2016; Hatala et al., 2006; Khan et al., 2022; Oldfield et al., 2013; Stritzke et al., 2023). However, the application of these methods varies across different countries and regions. In resource-rich nations, these assessment tools have been fully implemented and have received positive feedback. Conversely, in some developing countries, limited educational resources pose significant challenges to the implementation of these methods (Behere, 2014; Soemantri et al., 2018). Although DOPS and Mini-CEX have been successful in many countries, their global implementation faces several challenges. Cultural differences may affect the acceptance of these methods; in some countries, students and educators may not be accustomed to frequent direct observation and feedback, necessitating cultural adaptations during implementation (Kundra and Singh, 2014; Shafqat et al., 2022). Additionally, resource limitations pose significant barriers. In developing countries, a lack of sufficient teaching staff and educational equipment can hinder the effectiveness of these methods. Furthermore, educators require specialized training to effectively utilize these assessment tools, which is challenging in regions with limited educational resources (Alomar, 2022; Sivaraman et al., 2024). To address these limitations, the following measures are recommended: (1) Adapt methods to local cultural contexts for better acceptance; (2) Increase educational resources in limited areas through government and international support; (3) Develop comprehensive teacher training programs for proficiency in DOPS and Mini-CEX. These strategies can enhance the global adoption and effectiveness of DOPS and Mini-CEX, improving medical education quality and clinical skills. Peer-Assisted Learning has been applied in medical education in the United States and Australia, enhancing cooperative learning and improving educational outcomes (Bone et al., 2019; Zentz et al., 2014). While students generally view PAL positively, its implementation faces cultural and resource challenges. In individual-focused systems, students may resist peer assistance. Effective PAL implementation requires cultural adaptations, enhanced resources through government and international support, and systematic training programs. These measures can globally improve medical education quality and student learning outcomes.

Against the backdrop of medical education reform, there is an urgent need for innovation and improvement in teaching methods and assessment systems. The new teaching model should place greater emphasis on students' actual needs and personalized learning. In a problem-oriented learning approach, it aims to enhance students' interest and initiative in learning. The establishment of an assessment system should consider evaluating students' comprehensive qualities and practical abilities. It should not only focus on knowledge mastery but also prioritize the cultivation of students' innovative thinking, clinical application skills, and professional ethics. Oncological rehabilitation, being a comprehensive course that integrates multidisciplinary knowledge in diverse environments, demands high teaching standards. Coordination of content from multiple disciplines is necessary to ensure students achieve a comprehensive understanding of the entire subject area. In response to the aforementioned needs, we innovatively implemented the PAL teaching model and the joint assessment system of DOPS and Mini-CEX. Through the implementation of these measures, the teaching quality and effectiveness of the Oncological Rehabilitation course have significantly improved. In the future, we plan to introduce the PAL teaching model and the joint assessment system of DOPS and Mini-CEX into more medical courses,

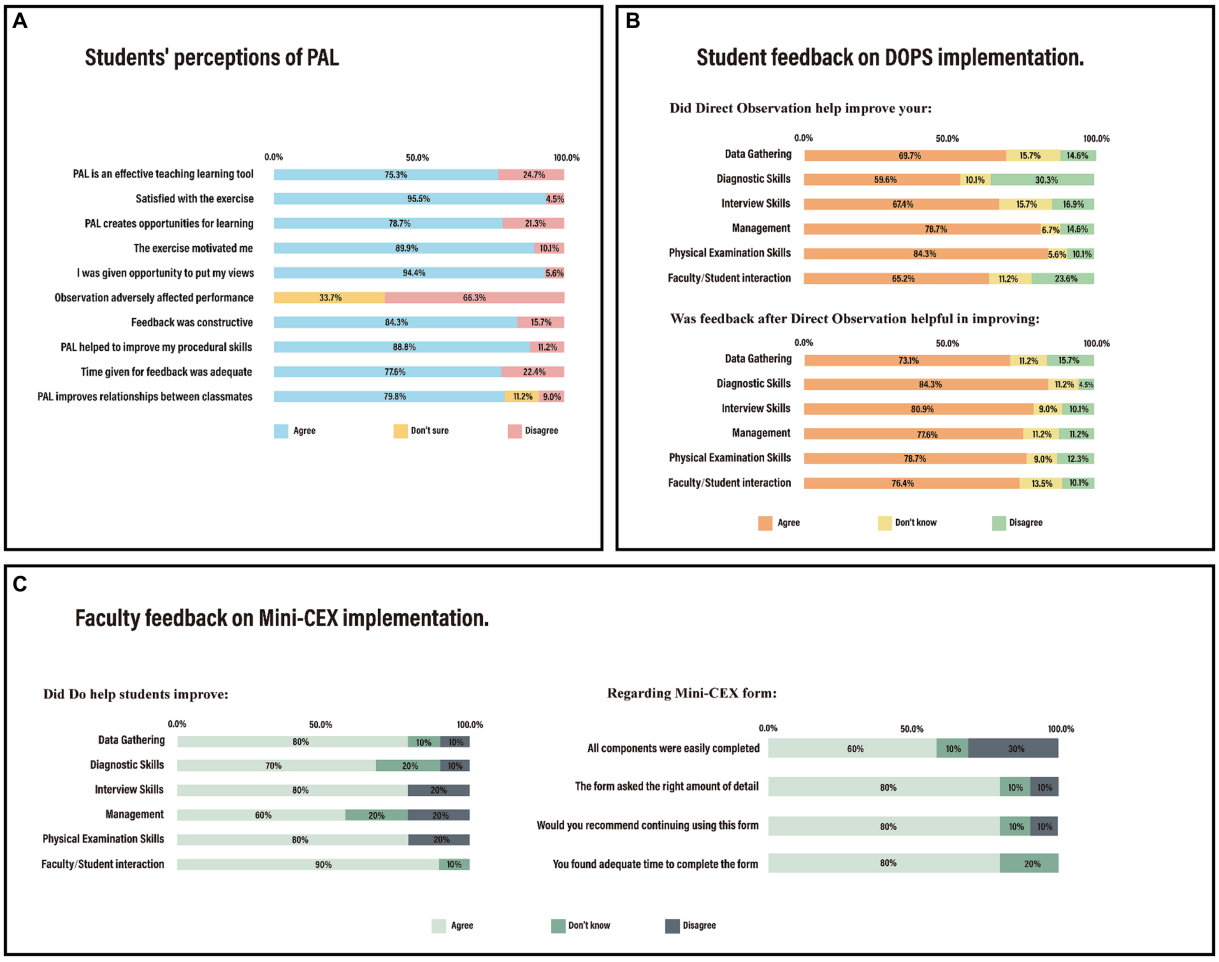

FIGURE 3
Evaluation of the three methods (PAL, DOPS, and Mini-CEX) from both student and faculty perspectives. The figure presents: students' perceptions of PAL, showing high approval, particularly in direct observation. Student feedback on DOPS implementation, highlighting its effectiveness in assessing clinical skills. Faculty feedback on Mini-CEX implementation, emphasizing its practicality in direct observation, skill assessment, and its positive impact on teaching quality and student competency.

such as various clinical practice courses and medical laboratory courses. This aims to promote students' interdisciplinary and comprehensive learning. By expanding the use of these innovative teaching methods, we aim to comprehensively optimize more courses, providing students with high-quality educational resources and training platforms.

Author contributions

YL: Conceptualization, Data curation, Investigation, Writing – original draft, Writing – review & editing. X-mL: Conceptualization, Investigation, Writing – review & editing. HL: Methodology, Writing – original draft. QW: Conceptualization, Data curation, Writing – original draft.

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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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