Curriculum and Teaching Methodology (2026)
Clausius Scientific Press, Canada

DOI: 10.23977/curtm.2026.090417
ISSN 2616-2261 Vol. 9 Num. 4

Application and Effectiveness Evaluation of a Problem-Based Learning Model in a Graduate Course on Medical Statistics in Practice

Hui Peng[1,2,a], Lijuan Ma[2,3,b], Jiucui Tong[2,4,c,*]

[1]Department of Science and Technology Management, The First Affiliated Hospital (Yijishan Hospital) of Wannan Medical University, Wuhu, 241001, China
[2]Teaching and Research Office of Evidence-Based Medicine, Wannan Medical University, Wuhu, 241001, China
[3]Department of Medical Record Management, The First Affiliated Hospital (Yijishan Hospital) of Wannan Medical University, Wuhu, 241001, China
[4]Office of Educational Administration, The First Affiliated Hospital (Yijishan Hospital) of Wannan Medical University, Wuhu, 241001, China
[a]phui.1234@163.com, [b]328491360@qq.com, [c]tongjiucui@wnmc.edu.cn
**Corresponding author*

Keywords: Medical Statistics; Graduate Education; Problem-Based Learning; Educational Reform; Effectiveness Evaluation

Abstract: This study evaluated the effectiveness of a problem- and case-based practical statistics course for medical postgraduates through a questionnaire survey of 65 master's students from the Classes of 2023 and 2024 at a medical undergraduate university. The survey covered their undergraduate statistics background, baseline knowledge before the course, and their post-course perceptions. Results showed that while 81.54% had taken a standalone medical statistics course as undergraduates, 84.62% rated themselves as "completely unfamiliar" or "not very familiar" with the subject beforehand—yet 87.69% considered statistics "very important" for research. After the course, 67.69% reported a mastery level of 50% or above, with 26.15% reaching 70% or higher. Nearly all students (98.46%) gave positive feedback on the depth of instruction, and 75.38% said they were "very satisfied." Students who found the teaching "in-depth yet accessible" tended to perform better in terms of mastery, and among those very satisfied with the course, over 80% rated it as "effective" or above. Overall, the problem-oriented teaching model yielded promising results in both knowledge acquisition and student satisfaction. However, the findings also highlighted difficulties for students with weaker foundational backgrounds, suggesting that future adjustments, such as moderating the pace, increasing hands-on practice, and smoothing the transition from basic concepts to applied use may further enhance the course.

1. Introduction

Medical statistics is one of the core courses for developing research competency in medical postgraduates, and an indispensable tool in medical research [1]. However, for a long time, statistics education has faced a notable tension: the content is abstract, the formulas are complex, and students commonly find it "hard to learn, hard to understand, and hard to apply." Misuse of statistical methods in actual research is also frequently observed. In a multi-center survey of 274 Chinese medical students (including 22.63% master's students and 2.19% doctoral students), Ouyang et al. found only 10.22% of Chinese students reported strong interest in statistics and 8.76% are hard-working, while 75.18% perceived it as difficult and 64.23% spend less than 3 h per week studying statistics [2]. The traditional lecture-based teaching model no longer meets the needs of graduate education, which increasingly emphasizes the application of knowledge. Abou et al. reported that 57.7% of students perceived that lack of practicing exercises might contribute to making the course more difficult [3].

How to enable postgraduates to truly master statistical methods within limited class hours and apply them in their own research has become a key issue in medical education reform. In recent years, various institutions at home and abroad have piloted new approaches, including module integration combined with literature reading [4], research proposal- and paper-oriented teaching [5], and case-based, task-driven learning [6,7]. The common thread across these reforms is a shift from "knowledge transmission" to "competency development," and from "theoretical instruction" to "problem solving."

Drawing on these ideas, a medical undergraduate university implemented an innovative reform to its postgraduate statistics course during the 2022–2023 academic year, adopting a problem- and case-based practical teaching model. This study uses a questionnaire survey to evaluate the teaching effectiveness and student satisfaction with this model, with the aim of providing evidence for future course improvements.

2. Subjects and Methods

2.1 Study Subjects

The study targeted all master's students enrolled in the elective Medical Statistics Practice course at Wannan Medical College, from both the Class of 2023 and the Class of 2024. A total of 65 valid questionnaires were collected, yielding a response rate of 100%.

2.2 Teaching Reform Design

The central idea behind this teaching reform was to shift the focus of statistics instruction from a theory-driven approach to a problem-driven one. Specifically, we took the following steps. First, we restructured the course content. Instead of following the traditional chapter-by-chapter sequence of textbooks, we reorganized commonly used medical statistical methods into five integrated modules: basic concepts, univariate analysis for detecting differences (comparing means and proportions), bivariate analysis for examining associations, multivariate analysis for identifying independent risk factors, and ROC (receiver operating characteristic) curve analysis for diagnostic prediction. Each module was built around a clinical research question, and we walked through the entire process—from method selection to software operation to interpretation of results—within that context. Second, we used case-based teaching. We selected real clinical research examples from high-quality journals and focused on dissecting how the authors chose their statistical methods, how they presented their results, and how they drew their conclusions. The goal was to help students see the role statistics plays in actual research, rather than just memorizing formulas. Third, we incorporated hands-on practice during class. Students were asked to bring their laptops to every session, and we shared

software installation files and operational resources with them. For each software tool (such as SPSS, R, and GraphPad Prism), we introduced its development background and typical use cases, aiming to boost students' understanding and interest. Every time we covered a new statistical method, we designed a short, focused in-class exercise and guided students step by step through the software procedures, explaining the purpose of each step and, more importantly, walking through the statistical meaning and clinical relevance of the output.

2.3 Survey Instrument

We developed a self-designed questionnaire with 15 items in total—13 multiple-choice questions and 2 open-ended questions. The multiple-choice items covered the following: grade level (item 1), gender (item 2), undergraduate institution (item 3), undergraduate major (item 4), type of graduate program (item 5), prior undergraduate training in statistics (item 7), perceived importance of statistics (item 8), sources of statistical knowledge (item 9), self-rated familiarity before the course (item 10), overall evaluation of teaching effectiveness (item 11), self-assessed mastery of course content (item 12), evaluation of the depth of instruction (item 13), and overall satisfaction with the course (item 14). The two open-ended questions asked about the student's specific master's major (item 6) and any additional comments or suggestions (item 15).

2.4 Statistical Analysis

Questionnaire data were entered into an Excel database and then analyzed using SPSS 21.0 and R 4.4.1 software. We used descriptive statistics, with categorical variables presented as percentages (%). Group comparisons were made using the Chi-square test, and associations between ordinal variables were examined using the Cochran-Armitage trend test. The significance level was set at $\alpha = 0.05$.

3. Results

3.1 Student Backgrounds

Of the 65 respondents, 35 (53.85%) were from the Class of 2023 and 30 (46.15%) from the Class of 2024. There were 34 females (52.31%) and 31 males (47.69%). In terms of undergraduate institution, the majority came from Wannan Medical College (42 students, 64.62%), followed by Bengbu Medical College and Anhui Medical University, each contributing 5 students (7.69% respectively), with the remaining 13 students (20%) from other institutions. As for undergraduate majors, clinical medicine dominated, with 47 students (72.31%), while 2 students (3.08%) came from basic medicine and 16 (24.62%) from other fields. Regarding degree type, 64 students (98.46%) were enrolled in academic master's programs, and only 1 student (1.54%) was a professional master's student. This distribution reflects the university's graduate education policy: academic master's students are required to take Medical Statistics as a compulsory course, whereas the same requirement does not apply to professional master's students.

3.2 Pre-course Background and Perceived Importance of Statistics

A total of 53 students (81.54%) had taken a standalone medical statistics course during their undergraduate studies, 10 students (15.38%) had learned statistics as part of an integrated course, and only 2 students (3.08%) had no such course offered at all. When asked about their sources of statistical knowledge before this course, undergraduate classroom learning topped the list (80%), followed by self-study online (41.54%). Despite the fact that most students had some prior exposure to the subject,

their self-rated familiarity before the course was quite low: 13 students (20%) described themselves as "completely unfamiliar," 42 (64.62%) as "not very familiar," 9 (13.85%) as "somewhat familiar," only 1 (1.54%) as "competent," and none as "proficient." In other words, over 80% of the students felt they had insufficient grasp of the material going in. In stark contrast, students' recognition of the importance of statistics was remarkably high—57 students (87.69%) considered it "very important," and the remaining 8 (12.31%) considered it "important," with no one choosing "moderately important" or "not important" (Table 1). This striking gap between high perceived importance and low baseline knowledge suggests that while students are motivated to learn, their prior preparation is weak, and the course must therefore address the dual challenge of building foundational knowledge while also enhancing applied skills.

Table 1: Pre-course statistics background and perceived importance.

Items/Options	Number(n)	Proportion (%)
Undergraduate statistics training		
Standalone medical/health statistics course	53	81.54
Integrated into other courses	10	15.38
No relevant course offered	2	3.08
Sources of pre-course statistical knowledge (multiple choice)		
Undergraduate classroom instruction	52	80.00
Self-study online	27	41.54
Self-study from textbooks	13	20.00
Discussion with instructors or peers	16	24.62
Other means	3	4.62
Self-assessed pre-course familiarity		
Completely unfamiliar	13	20.00
Not very familiar	42	64.62
Somewhat familiar	9	13.85
Competent	1	1.54
Proficient	0	0.00
Perceived importance of statistics		
Very important	57	87.69
Important	8	12.31
Moderately important	0	0.00
Not important	0	0.00

3.3 Evaluation of Teaching Effectiveness

3.3.1 Knowledge Improvement

Overall, 61.54% of the students felt that the course was either "effective" or "very effective" in improving their statistical knowledge. More specifically, 20 students (30.77%) rated it as "somewhat effective," 28 (43.08%) as "effective," and 17 (26.15%) as "very effective." No one chose "not effective at all" (Table 2).

When we looked at whether prior undergraduate training made a difference, students who had taken a standalone statistics course in college were more likely to rate the course positively—73.58% (39/53) in that group considered it "effective" or above, compared to 50.00% (6/12) among those who had not. Interestingly, students' baseline familiarity before the course did not seem to affect their

ratings much, except for one notable pattern: among those who had been “completely unfamiliar” before the course, 38.46% (5/13) rated the course as “very effective,” whereas only 23.81% (10/42) of those who had been “not very familiar” gave the same rating. This suggests that the students with the weakest starting point perceived the most noticeable gain from the course.

Table 2: Teaching effectiveness and knowledge mastery.

Items/Options	Number(n)	Proportion (%)
Self-assessed teaching effectiveness		
Not effective at all	0	0.00
Somewhat effective	20	30.77
Effective	28	43.08
Very effective	17	26.15
Level of knowledge mastery		
Understood nothing at all	0	0.00
30%–50%	21	32.31
50%–70%	27	41.54
Above 70%	17	26.15
Evaluation of teaching depth		
Too shallow and overly simplistic	0	0.00
Somewhat deep and required thought	33	50.77
In-depth yet accessible and engaging	31	47.69
Too profound to follow	1	1.54
Overall satisfaction		
Very dissatisfied	0	0.00
Dissatisfied	0	0.00
Moderately satisfied	16	24.62
Very satisfied	49	75.38

3.3.2 Level of Mastery Achieved

In terms of post-course mastery, 21 students (32.31%) reported mastering 30%-50% of the material, 27 (41.54%) mastered 50%-70%, and 17 (26.15%) achieved over 70%, with no one indicating they “understood nothing at all.” Altogether, 67.69% of the students reached a mastery level of 50% or higher (Table 2).

There was some relationship between post-course mastery and students’ pre-course self-assessed familiarity. Among the 13 students who had been “completely unfamiliar” before the course, 5 (38.46%) still managed to achieve over 70% mastery by the end. Among the 9 who had rated themselves as “somewhat familiar” beforehand, 5 (55.56%) reached the 50%-70% range, and 2 (22.22%) achieved over 70% (Table 3). This suggests that while students with a stronger starting point were more likely to reach higher levels of mastery, a fair number of those with weaker backgrounds were also able to make substantial progress.

Table 3: Pre-course familiarity and post-course mastery.

Pre-course self-assessed statistical knowledge	Level of knowledge mastery				Total
	Understood nothing at all	30%-50%	50%-70%	Above 70%	

Completely unfamiliar	0(0.00%)	5(38.46%)	3(23.08%)	5(38.46%)	13
Not very familiar	0(0.00%)	14(33.33%)	19(45.24%)	9(21.43%)	42
Somewhat familiar	0(0.00%)	2(22.22%)	5(55.56%)	2(22.22%)	9
Competent	0(0.00%)	0(0.00%)	0(0.00%)	1(100%)	1
Proficient	0(0.00%)	0(0.00%)	0(0.00%)	0(0.00%)	0

Students' post-course mastery was closely tied to how they perceived the depth of instruction. Among those who described the teaching as "in-depth yet accessible and engaging," 32.26% achieved a mastery level above 70%. In contrast, only 21.21% of those who found it "somewhat deep and required thought" reached the same level, and the one student who felt the content was "too profound to follow" ended up mastering less than 50% of the material. Overall, students who rated the instruction as "in-depth yet accessible and engaging" not only showed a clear trend toward higher mastery compared to those with other perceptions, but also reported a very high satisfaction rate of 90.32% with significantly higher than the satisfaction level among other students ($\chi^2 = 7.13$, $P = 0.008$) (Table 4).

Table 4: Perceived depth of instruction in relation to knowledge mastery and teaching satisfaction.

Evaluation of teaching depth	n	Post-course mastery level (%)			Very satisfied (%)
		Below 50%	50%-70%	Above70%	
In-depth yet accessible and engaging	31	22.58	45.16	32.26	90.32
Somewhat deep and required thought	33	39.39	39.39	21.21	63.64
Too profound to follow	1	100	0.00	0.00	0.00
Too shallow and overly simplistic	0	0.00	0.00	0.00	0.00

3.3.3 Overall Satisfaction

Student satisfaction with the course was remarkably high. Nearly three-quarters of the respondents, 49 students (75.38%), said they were "very satisfied," and the remaining 16 (24.62%) were "moderately satisfied." No one reported being "dissatisfied" or "very dissatisfied" (Table 5).

When we broke this down by how effective students perceived the course to be, the pattern was quite clear. Among those who rated the course as "somewhat effective," 45% were very satisfied; among those who considered it "effective," that figure rose to 82.14%; and among those who found it "very effective," every single student (100%) was very satisfied. In other words, perceived effectiveness and satisfaction went hand in hand, and the association was statistically significant ($Z = -3.92$, $P < 0.001$), as shown in Table 5.

Table 5: Association between perceived teaching effectiveness and satisfaction.

Self-assessed teaching effectiveness	Satisfaction, n (%)		Total
	Moderately satisfied	Very satisfied	
Not effective at all	0(0.00)	0(0.00)	0
Somewhat effective	11(55)	9(45)	20
Effective	5(17.86)	23(82.14)	28
Very effective	0(0.00)	17(100)	17

3.4 Student Feedback and Suggestions

The open-ended question (item 15) yielded comments that fell into four main categories. First, regarding pacing—some students felt the instructor moved too quickly through the material and suggested slowing down the demonstrations and compiling key steps into the slides for easier reference. Second, concerning class hours—a number of students thought the allocated time was insufficient and the content felt rushed, and they recommended either adding more sessions or adjusting when the course was offered. Third, regarding hands-on practice, many students expressed a strong desire for more opportunities to work with the software in class; they proposed that the instructor first give a complete demonstration and then guide them through step-by-step exercises, and also make video tutorials available after class for review. Fourth, on foundational preparation—some students with weaker backgrounds suggested offering a brief review of basic concepts at the beginning of the course, or scheduling the course after relevant prerequisite subjects had been covered.

4. Discussion

4.1 Effectiveness of the Problem-Based Teaching Model

The results of this study show that the problem- and case-based practical teaching model yielded good outcomes in both knowledge acquisition and student satisfaction. After the course, 67.69% of students achieved a mastery level of 50% or above, 98.46% gave positive feedback on the depth of instruction, and overall satisfaction reached 100% (from "moderately satisfied" upward). These figures suggest that this teaching approach effectively addressed the long-standing problem in traditional statistics education—namely, that students "learn it but don't know how to use it."

This success can be attributed to several features of the course design. First, the reorganization of content reduced cognitive load. By restructuring scattered statistical methods according to the logic of research questions (univariate → bivariate → multivariate), students were able to see the connections between different methods rather than memorizing formulas in isolation. Previous studies have also confirmed that modular, integrated teaching helps graduate students build a coherent conceptual framework for statistics [8]. Second, case-based teaching bridged theory and practice. By carefully dissecting how statistics were applied in published papers from high-quality journals, students gained a concrete sense of how these methods are used in real research—an approach consistent with the idea of project- and paper-oriented instruction [5]. Third, in-class hands-on practice reinforced internalization. The "lecture a bit, practice a bit" format prevented the all-too-common frustration of understanding everything during the lecture but being unable to do anything when left on one's own.

4.2 The Relationship Between Prior Background and Teaching Outcomes

One finding worth noting is that among students who rated themselves as "completely unfamiliar" before the course, the proportion who considered the course "very effective" was actually higher than among those who had been "not very familiar" (38.46% vs. 23.81%). This seemingly counterintuitive pattern may reflect two underlying mechanisms. On one hand, the lower the starting point, the greater the room for improvement, and students may perceive a stronger sense of progress. On the other hand, those who described themselves as "completely unfamiliar" might have had a more accurate self-assessment, whereas those who said "not very familiar" might have suffered from some degree of unconscious incompetence—they didn't know what they didn't know. That said, this observation also suggests that the teaching model is acceptable even for students with weak backgrounds, provided that the instructor stays attuned to how well students are following along and adjusts the pace

accordingly.

At the same time, the link between mastery and how students perceived the depth of instruction highlights that managing the difficulty level is a critical factor in teaching effectiveness. Among those who found the teaching "in-depth yet accessible," 32.26% achieved over 70% mastery, compared to only 21.21% among those who found it "somewhat deep." This reinforces the value of keeping theoretical demands moderate while strengthening case-based support. Earlier research has similarly shown that student satisfaction with teaching approaches is positively correlated with learning outcomes [9].

4.3 Directions for Course Improvement

Although the overall results were encouraging, the feedback from students and the limitations of our sample point to areas for further refinement.

First, more attention should be given to accommodating students with weak foundational knowledge. Altogether, 84.62% of the students rated themselves as "completely unfamiliar" or "not very familiar" before the course, yet the course jumped directly into modular case-based teaching, and some students reported struggling to keep up. In future iterations, we plan to add one or two sessions at the beginning to review basic concepts, or provide pre-course self-study materials and quizzes to help students fill in the gaps.

Second, hands-on practice should be increased. Many students stressed that practical work is more important than just learning theory on paper, which aligns with the broader trend in medical statistics education toward emphasizing applied skills. We suggest incorporating a full software exercise after each theoretical session, with small case-based assignments that guide students through the entire process—from selecting the right method to reporting the results—using real or realistic data.

4.4 Study Limitations

This study has several limitations. First, the sample size is small (only 65 students) and relatively homogeneous, which limits the generalizability of our conclusions. Second, our evaluation of teaching effectiveness relied mainly on students' self-reports and lacked objective performance data for comparison. Third, we did not include a control group taught with traditional methods, making it difficult to isolate the net effect of the teaching model itself. Fourth, this was a cross-sectional survey conducted at the end of the course, and we did not follow up with students to see how well they applied statistical methods in their later research work. Future research could expand the sample, incorporate objective assessment measures, and include longitudinal follow-up.

5. Conclusions

The problem- and case-based practical teaching model for graduate medical statistics, through strategies such as content integration, case guidance, and simultaneous hands-on practice, effectively improved students' knowledge mastery and satisfaction. The reality that students come in with weak backgrounds but high motivation means that course design must strike a balance between building foundational knowledge and enhancing applied skills. Going forward, while optimizing the pacing, strengthening foundational bridging, and increasing practical training, we should also pay closer attention to the diverse needs of students with different degree types and academic backgrounds, so as to improve the external validity of the teaching reform.

Acknowledgements

This research was supported by the Wannan Medical College 2025 University-Level Quality Project — Teaching Reform Research Project (2025jyxm055).

References

[1] Brimacombe M. B. (2014) Biostatistical and medical statistics graduate education. BMC medical education. 14, 18.
[2] Ouyang H., Wang S., and Huang L. (2025) Survey on the current status of statistical cognition and teaching needs of Chinese medical students. Frontiers in Public Health, 13, 1621667.
[3] Abou Dargham, N., Sultan, Y., Mourad, O., Baidoun, M., Aboul Hosn, O., Abou El Naga, A., Hisham F B. and Azakir, B. (2021) Perception of biostatistics by Lebanese medical students: a cross-sectional study. Alexandria Journal of Medicine, 57, 103-109.
[4] Hayes P. M., Cherney A., and Papanagnou D. (2023) An interactive module to teach common biostatistical tests to learners in the health professions. Cureus, 15.
[5] Kldiashvili, E., Al-Rustum, S., Zarnadze, M., Goderdzishvili, D., Tvildiani, M., and Mamiseishvili, A. (2025) Application of project-based and simulation-based approaches in medical curriculum. BMC Medical Education, 25, 1707.
[6] Bland J. M. (2004) Teaching statistics to medical students using problem-based learning: the Australian experience. BMC Medical Education, 4, 31.
[7] Muthuswamy V. V., and Nijarubini V. (2026) Integrating Epidemiological and Biostatistical Concepts into Classroom Teaching Through COVID-19 Case Study Methods. Letters in Biomathematics, 13, 144-154.
[8] Varghese S. S., Ramesh A., and Veeraiyan D. N. (2019) Blended module-based teaching in biostatistics and research methodology: A retrospective study with postgraduate dental students. Journal of Dental Education, 83, 445-450.
[9] Kim K. J., Lim C. Y., and Hwang J. Y. (2019) Predictors of medical student satisfaction with pre-clinical courses. J Contemp Med Educ, 9, 99-104.