

Comparison of Four Teaching Modes in Standardized Residency Training for Spine Surgery Residents

Fanxing Meng¹, Yan Liang^{1*}, Hongzhen Li¹, Weiwei Xia¹, Chenfu Hu²

¹ Department of Spine Surgery, Peking University People's Hospital, Beijing 100044, China

² Department of Orthopedics, Daxing District People's Hospital of Beijing, Beijing 102600, China

* Corresponding author

Abstract: Objective To compare the application effects of four teaching modes, namely the Feynman Learning Technique, Problem-Based Learning (PBL), the Standardized Quality Control Teaching Method, and Case-Based Learning (CBL), in standardized residency training for spine surgery, and to provide evidence for optimizing residency training curricula. Methods A prospective comparative study was conducted among 120 residents undergoing standardized training in the Department of Spine Surgery at Peking University People's Hospital from April 2022 to April 2026. Using a random number table method, residents were divided into four groups of 30 each. Group A received the Feynman Learning Technique, Group B received PBL, Group C received the Standardized Quality Control Teaching Method, and Group D received CBL. The training period was 12 months. After completion of training, the four groups were compared with respect to theoretical examination scores, clinical skill performance scores, medical record writing quality, clinical reasoning ability, and teaching satisfaction. Results The theoretical examination score of Group A was 92.15 ± 3.87 points, which was significantly higher than that of Group B (88.34 ± 4.26 points), Group C (86.47 ± 4.58 points), and Group D (85.62 ± 4.91 points), with statistically significant differences ($F=12.563$, $P<0.001$). Group B achieved the highest clinical skill performance score (91.78 ± 3.95 points), clinical reasoning ability score (92.36 ± 3.72 points), and overall teaching satisfaction rate (96.67%), all significantly higher than the other three groups ($P<0.05$). The medical record writing quality score of Group C was 91.23 ± 4.08 points, significantly higher than Group A (85.47 ± 5.12 points), Group B (88.65 ± 4.35 points), and Group D (87.34 ± 4.67 points), with statistically significant differences ($F=10.284$, $P<0.001$). Conclusions Each of the four teaching modes has unique advantages. The Feynman Learning Technique is most effective for mastery of theoretical knowledge; PBL demonstrates superior performance in clinical skill acquisition, clinical reasoning development, and teaching satisfaction; and the Standardized Quality Control Teaching Method excels in medical record writing quality. It is recommended that multiple teaching modes be flexibly combined according to different training objectives in spine surgery residency education.

Keywords: spine surgery; standardized residency training; PBL teaching method; Feynman Learning Technique; CBL teaching method; Standardized Quality Control Teaching Method

1. Introduction

Spine surgery is a significant subspecialty in orthopedics and deals with the diagnosis and treatment of a broad range of complicated illnesses such as spinal cord injury, spinal degenerative disorders, spinal deformities, spinal tumors and spinal infections. It is marked by extreme pathologic diversity, anatomical complexity, procedure complexity, and medical risk [1]. Residency training is a standardized way to help medical graduates to achieve qualification as clinicians and a major avenue in the development of high-quality medical clinical personnel. Spine surgery is an extremely specialized branch of medicine where residents have to be well-grounded theoretically, clinically competent, and possess sound clinical reasoning. What makes it a great challenge among spine surgery tutors on how to effectively improve the overall clinical competence of residents in a short training time?

The conventional mode of teaching spine surgery is mostly centered on lecture style of teaching where the faculty delivers theoretical knowledge in a systematic way as per the set curriculum whereas students are passive recipients of the information. However, even though this strategy guarantees a systematic passing of knowledge, it has such drawbacks as low motivation to learn among students or the gap between theory and practice [3]. The last few years have witnessed the introduction of different forms of innovative teaching techniques into clinical education, such as the Feynman Technique, Problem-Based Learning (PBL), the Standardized Quality Control Teaching Method, and Case-Based Learning (CBL). All these approaches have their unique characteristics, and they have shown diverse levels of effectiveness in clinical education in various fields [4-5].

Nobel Prize winner physicist Richard Feynman came up with the Feynman Learning Technique. Its fundamental idea

is the examination and enhancement of knowledge through explaining ideas to other people with simple language, which makes it vital to learn actively and produce knowledge [6]. A problem-based, student-oriented approach to teaching called Problem-Based Learning (PBL) directs students throughout the process of self-directed investigation by setting problems in clinical realistic settings that help them develop the ability to deal with real-life clinical issues [7]. The Standardized Quality Control Teaching Method focuses on the creation of standardized teaching quality standards and evaluation systems that are unified and make teaching results consistent and repeatable by means of process management and quality control [8]. Case Based Learning (CBL) adopts a conventional medical case as the platform of learning, enabling students to combine theoretical knowledge with practical clinical experience by analyzing cases and discussing them, thus enhancing the clinical decision-making skills [9].

To date, there are very few systematic comparative research papers on these four teaching modes in spine surgery standardized residency education. The present study involved 120 residents undergoing standardized training in the Department of Spine Surgery at Peking University People's Hospital between April 2022 and April 2026. We used a prospective comparative study design comparing the effects of its applications with the four teaching modes to offer scientific evidence regarding the choice of teaching methods in spine surgery standardized residency training.

2. Materials and Methods

2.1 General Information

This paper involved all 120 residents who were trained through standard training in the Spine Surgery department at Peking University Peoples Hospital, starting April 2022 through April 2026. The inclusion criteria were: (1) completion of the undergraduate medical education and having a medical practitioner license; (2) spine surgery duration of the training should be at least 3 months; (3) the volunteer and signed informed consent. The exclusion criteria included: (1) personal reasons which led to the termination of training during the training period; (2) previous clinical practice experience in spine surgery more than 1 year; (3) inability to participate in the study or failure in the evaluation.

The random number table was used to divide the 120 residents into four groups containing 30 individuals. Group A (Feynman Learning Technique group): 17 males and 13 females; age: 24-29 years, average age: 26.35 ± 1.52 years; 22 had bachelor's degrees and 8 had master's degrees. Group B (PBL group): 16 males and 14 females; age: 24-28 years, average age: 26.12 ± 1.47 years; 23 had bachelor's degrees and 7 had master's degrees. Group C (Standardized Quality Control Teaching Method group): 18 males and 12 females; age: 24-29 years, average age: 26.58 ± 1.63 years; 21 had bachelor's degrees and 9 received master's degrees. Group D (CBL group): 15 males and 15 females; age: 24-28 years, average age: 26.25 ± 1.39 years; 24 had bachelor's degrees and 6 had master's degrees. The four groups did not have statistically significant differences in general characteristics, including sex, age, and education level ($P > 0.05$) so they are comparable. The research was authorized by the Medical Ethics Committee of the hospital.

2.2 Teaching Methods

2.2.1 Common Teaching Foundation

The four groups of residents were trained based on the spine surgery training requirements set by the National Standardized Residency Training Content and Standards (2022 edition). The duration of training was 12 months that included theoretical learning of general conditions of spine surgery, practical training of clinical skills, and case management. Teaching staff consisted of spine surgeons who had been in clinical practice for a minimum of five years and had an academic position of attending physicians or higher, and they had all undergone standardized training in pedagogics.

2.2.2 Group A (Feynman Learning Technique Group)

The Teaching method used in this case is the Feynman Learning Technique, with these implementation steps: (1) Selection of a concept: Once per week, the faculty chose 1 - 2 main knowledge items or diseases that were covered in spine surgery (e.g., lumbar disc herniation, spinal fracture, cervical spondylosis), and the residents would learn about the chosen concepts through self-directed learning by reading books, guidelines, and other related literature. (2) Teaching others: Residents gave other residents in the same group mini-lectures explaining what they had learned, where they needed to be able to explain complicated medical information in a clear and comprehensible way in 15-20 minutes. (3) Gaps identification and reinforcement of learning: Following every presentation, the remaining residents and faculty made queries regarding the given content, and the presenter addressed them; the faculty quickly identified and clarified unclear explanation or misunderstandings. (4) Simplification and distillation: Based on feedback, the residents reorganized and simplified the knowledge, applied analogies and metaphors to understand it better and developed personal study notes. The Feynman

learning session was held once a week, and its duration was about 60 minutes.

2.2.3 Group B (PBL Group)

The method of PBL was used in teaching: (1) Problem design: The faculty created heuristic and inquiry-based problems using the teaching syllabus and actual clinical cases that included etiology, pathophysiology, clinical manifestations, diagnosis and differential diagnosis, choice of treatment, and management of complications. (2) Small group discussion: The residents were split into small groups (5-6 people per group) to discuss and examine the problems; the residents would work towards solutions by literature search and group discussion. (3) Presentation: A representative was chosen by each group to report back their discussion findings and solutions within about 20 minutes. (4) Summary and feedback: The faculty shared feedback and summaries of each group presentation which helped to organize the logical flow of knowledge points, fix misconceptions, and add additional information to the knowledge. It was held one time a week, and lasted about 90 minutes.

2.2.4 Group C (Standardized Quality Control Teaching Method Group)

The Standardized Quality Control Teaching Method was used, which was applied in the following ways: (1) Development of a standardized teaching system: The spine surgery residents were provided with a standardized training guide that defines the goals of the training, the contents of the training, progression of training as well as assessment criteria to enable the systematicity and standardization of training materials. (2) Uniform teaching process: Teaching processes were carried out under uniform procedures, such as theoretical lectures (one per week, 60 minutes), procedural demonstrations (two per month, 90 minutes), and clinical rounds (two per week, 60 minutes); every teaching segment had its own quality standards and operational parameters. (3) Feedback and quality control: A teaching quality monitoring system was instituted and a teaching management team periodically monitored and evaluated teaching activities, feedback on teaching effectiveness was gathered through questionnaires and score analysis to quickly discover and address any teaching concerns. (4) Further quality advancement: The quality of teaching was discussed and synthesized once every quarter and the improvement strategies were formulated in relation to the identified problems and the teaching plan and processes were optimized continuously.

2.2.5 Group D (CBL Group)

The CBL model of education was applied, and it went thus: (1) Case selection: Faculty chose common cases of spine surgery (e.g., lumbar spinal stenosis, thoracolumbar fracture, cervical disc herniation, scoliosis), and case material comprised full medical history, findings of physical examination, auxiliary examinations (X-ray, CT, MRI, etc.), diagnostic and treatment procedures, and follow-ups. (2) Case discussion: Case materials were given to residents before hand and they had to learn the cases and prepare discussion outlines; during the discussion, residents discussed deeply about diagnosis, differential diagnosis, choice of treatment, surgical planning, and prevention of complications, which were guided and supplemented by faculty. (3) Case summary: After the discussion, the faculty summarized the case in a structured manner where the reasoning behind diagnosis and therapy were systematically organized, major knowledge points highlighted, and development of clinical reasoning skills emphasized. (4) Expansion and extension: The newest developments in research and updating of the guidelines concerning the diseases were presented together with the case studies, which expanded the academic perspective of residents. There used to be one CBL case discussion per week that took about 90 minutes.

2.3 Outcome Measures

2.3.1 Theoretical Examination Scores

Upon finishing the training, the residents of all four groups were given a closed-book theoretical exam. Examination subject matter included general theory of spine surgery, as well as the diagnosis and treatment of common diseases, and appropriate guidelines and consensus statements. The maximum mark was 100 points and the time limit for the examination was 120 minutes.

2.3.2 Clinical Skill Performance Scores

The Objective Structured Clinical Examination (OSCE) was used to evaluate clinical skills. There were spinal-specific physical examination, lumbar puncture, spinal imaging interpretation, cast immobilization technique, and wound dressing in the assessment. All the procedures were evaluated in 20 points and the overall score was 100 points. Three senior attending physicians rated every resident separately based on common scoring criteria and the average score was taken as the ultimate outcome.

2.3.3 Medical Record Writing Quality

Ten inpatient medical records written by every resident throughout the training period were chosen randomly and graded based on the Basic Specifications of Medical Record Writing. The scoring items were history taking, physical examination,

diagnosis and differential diagnosis, treatment plan, progress notes, and informed consent forms and it was scored out of 100 points.

2.3.4 Clinical Reasoning Ability

The clinical case analysis tests were conducted in order to evaluate the clinical reasoning skills of residents. Five complicated cases on spinal surgery were given to the residents who had to write diagnostic basis, differential diagnosis, treatment plans and rationales. The faculty evaluated the residents on four scales, which included the ability to analyze the data, diagnostic reasoning skill, decision making skill, and the creativity of the thoughts. Every dimension was rated on a scale of 25 points, with a combined score of 100 points.

2.3.5 Teaching Satisfaction

One of the self-developed teaching satisfaction questionnaires was given on an anonymous basis to the residents at the completion of training. The questionnaire comprised of 10 questions that addressed the engagement level, heuristic, and practicality of teaching methods, development of self-directed learning skills, and enhancement of clinical reasoning. All items were assessed on a 4 point scale of very satisfied, satisfied, neutral, and dissatisfied. Total satisfaction rate = (number of very satisfied + satisfied) / total number x100%

2.4 Statistical Analysis

The statistical software used in analyzing data was SPSS 26.0. Continuous variables that passed the Shapiro-Wilk test were given as the mean plus standard deviation ($\bar{x}+s$). The one way analysis of variance (one way ANOVA) was applied when comparing more than two groups and the LSD-t test was used when comparing two groups. Frequencies and percentages (n, per cent) were used to represent categorical variables and the inter-group comparison was done using a chi-square (2) test. Statistical significance was achieved when a P-value was less than 0.05.

3. Results

3.1 Comparative Analysis of Theoretical Test Scores and Practical Skills Scores of the Four Groups

Theoretical examination score was highest in Group A which had a score of 92.15+3.87 points, which was significantly higher compared to Groups B, C and D and the differences were statistically significant ($P < 0.05$). The highest clinical skill performance score was recorded by the group B, which had a mean score of 91.78 +3.95 points significantly higher than those of groups A, C and D and the difference was statistically significant ($P < 0.05$). Both Groups C and D had moderate theoretical examination scores and clinical skill performance scores. Namely, Group C scored more on theoretical questions than Group D but less than Groups A and B, whereas Group D scored slightly higher on clinical skills than Group C but less than Groups A and B; all these differences were statistically significant ($P < 0.05$). Refer to Table 1.

Table 1. Theoretical exam scores comparison with clinical skills performance scores in four groups of residents (points, $\bar{x} \pm s$)

Group	n	Theoretical Score	Clinical Skill Score
Group A (Feynman Technique)	30	92.15±3.87	83.24±5.26
Group B (PBL)	30	88.34±4.26 ^①	91.78±3.95 ^{①②③}
Group C (Std. Quality Control)	30	86.47±4.58	84.56±4.87
Group D (CBL)	30	85.62±4.91	86.34±4.65 ^{①②}
F value	-	12.563	15.782
P value	-	<0.001	<0.001

Note: Group A scored the highest on the theoretical examination whereas Group B got the highest on the clinical skills performance. ① $P < 0.05$ compared with Group A; ② $P < 0.05$ compared with Group C; ③ $P < 0.05$ compared with Group D.

3.2 Contrast Between the Qualities of Medical Records Writing and Clinical Reasoning in the Four Groups

The medical record writing quality Group C is ranked the highest with the quality score of 91.23+4.08 points which was significantly higher than that of Groups A, B, and D whose statistically significant differences were observed ($P < 0.05$). The clinical reasoning ability score of Group B was the highest with 92.36+3.72 points, which was significantly higher than Groups A, C, and D with statistically significant differences ($P < 0.05$). Medical record writing quality score of Group B (88.65+4.35 points) is statistically significantly higher than Groups A and D, but lower than Group C. Group D had moderate levels of both medical record writing quality and clinical reasoning ability. Refer to Table 2.

Table 2. Medical record writing quality versus clinical reasoning ability between four groups of residents (points, $\bar{x}\pm s$)

Group	n	Medical Record Quality	Clinical Reasoning
Group A (Feynman Technique)	30	85.47 $\pm$ 5.12	84.23 $\pm$ 5.38
Group B (PBL)	30	88.65 $\pm$ 4.35 ^{②③}	92.36 $\pm$ 3.72 ^{①②③}
Group C (Std. Quality Control)	30	91.23 $\pm$ 4.08 ^{①②③}	85.67 $\pm$ 4.95
Group D (CBL)	30	87.34 $\pm$ 4.67	87.56 $\pm$ 4.43 ^{①②}
F value	-	10.284	16.345
P value	-	<0.001	<0.001

Note: ① P<0.05 in comparison to Group A; ② P<0.05 in comparison to Group C; ③ P<0.05 in comparison to Group D.

3.3 Comparison of Teaching Satisfaction Among the Four Groups

The overall satisfaction rates of the teaching methods were highest among Group B, which was statistically significantly higher compared to Group A (76.67%) and Group C (83.33) and Group D (86.67) with statistically significant differences ($\chi^2=9.876$, $P<0.05$). The level of satisfaction in group D was higher than that of groups A and C where the differences are statistically significant ($P<0.05$). The level of satisfaction in group C was higher than that of group A where there is a statistically significant difference ($P<0.05$). Refer to table 3.

Table 3. Comparison of teaching satisfaction among four groups of residents [n (%)]

Group	n	Very Satisfied	Satisfied	Neutral	Dissatisfied	Overall Satisfaction
Group A (Feynman Technique)	30	8(26.67)	15(50.00)	5(16.67)	2(6.67)	23(76.67)
Group B (PBL)	30	14(46.67)	15(50.00)	1(3.33)	0(0.00)	29(96.67) ^{①②③}
Group C (Std. Quality Control)	30	10(33.33)	15(50.00)	3(10.00)	2(6.67)	25(83.33)
Group D (CBL)	30	12(40.00)	14(46.67)	3(10.00)	1(3.33)	26(86.67) ^{①②}
χ^2 value	-	-	-	-	-	9.876
P value	-	-	-	-	-	<0.05

Note: The quality of medical records written by Group C was the highest and the ability of clinical reasoning in Group B was the highest. ① P<0.05 between Groups A and B; ② P<0.05 between Groups B and C; ③ P<0.05 between Groups C and D.

4. Discussion

4.1 Analysis of Characteristics and Advantages of the Four Teaching Modes

The basis of the Feynman Learning Technique is to learn through teaching. The necessity to explain complicated ideas to other people in a short and clear manner forces learners to consciously structure their knowledge system and recognize gaps in their understanding, thus realizing deep learning [21-22]. In this research, the theoretical examination score of Group A residents (92.15 $\pm$ 3.87 points) was much higher compared to the other three groups, and it was statistically significant ($P<0.05$), which means that the Feynman Learning Technique has specific benefits in systematic mastery and deep understanding of theoretical information. It is also very consistent with the mechanism of the Feynman Learning Technique: in the process of teaching others, learners need to go through deep processing and reorganization of knowledge structures. Such an active construction can be much effective in enhancing the retention of knowledge and transfer ability [23-24]. Moreover, the Feynman Learning Technique focuses on using simple language when explaining difficult concepts, which enables residents to integrate simple theories and form a coherent knowledge base, providing a firm theoretical background to future clinical practice [25].

The Standardized Quality Control Teaching Method focuses on the standardization and normalization of the teaching procedure. It provides stability and uniformity of training quality by creating a single teaching mechanism and quality assessment criteria [26-28]. As evidenced in the current research, the level of medical record writing quality of the residents in Group C was statistically significantly greater compared to the remaining three groups (91.23 $\pm$ 4.08 points; $P<0.05$). Such outcome entirely illustrates the main benefit of the Standardized Quality Control Teaching Method in normative training. The Standardized Quality Control Teaching Method allows developing standardized medical record writing habits among residents via repetitive reinforcement due to the creation of uniform standards of medical records writing, creation of periodic quality inspection and feedback systems, and introduction of standardized medical record writing processes, thus, contributing to increasing the quality of medical record writing [29 -31]. Also, the standardized quality control system

guarantees the full coverage of training content and consistency of training standards, which is an irreplaceable part of keeping the level of the baseline quality of residency training [32-33].

The CBL approach employs the usual clinical case as the means of learning, as it allows bringing together both abstract theoretical information and practical clinical situations, which enables residents to make links between theory and practice and develop clinical decision-making capacity [15-16]. All the indicators of the residents in Group D were higher than average in the present study. Particularly, the clinical skill performance score (86.34+4.65 points) and the clinical reasoning ability score (87.56+4.43 points) were the lowest, after Group B, and the teaching satisfaction (86.67 percent) was also relatively high. It suggests that CBL has a degree of enhancing the comprehensive clinical capability of residents by analyzing and discussing actual cases to some extent, and its educational value is better than the traditional lecture-based teaching [17-18]. Nevertheless, it can be stated that CBL, in comparison with PBL, is less deep in terms of the investigation and student independence, thus somewhat less effective in developing clinical reasoning skills and procedural abilities [19-20].

PBL is a student-centered teaching model with a focus on problem solving. Its highest benefit is its effectiveness in stimulating the self-directed learning capability of students and their ability to think critically [1-3]. As indicated by the findings of the present study, residents of Group B had significantly higher scores compared to the other three groups in three dimensions, including clinical skill performance (91.78+ 3.95 points), clinical reasoning (92.36 + 3.72 points) and teaching satisfaction (96.67%) with statistically significant difference ($P < 0.05$) which clearly demonstrates that PBL has excellent benefits in promoting the clinical practical skills. In contrast to the Feynman Learning Technique, which concentrates on the internalization of theoretical information, PBL involves situating learning within real clinical problem situations, allowing residents to move between acquiring knowledge and developing competencies in a natural way when solving problems [4-5]. Moreover, PBL is also based on teamwork and multi-faceted discussion, which can help to develop clinical decision-making capacity and teamwork spirit among the residents, which are strong reasons behind the high clinical skills and reasoning marks [7-8].

4.2 Analysis of Reasons for Differential Effects of the Four Teaching Modes

The four teaching modes that were used in this study showed different characteristics of their effects, and its primary causes are well associated with the internal workings of each teaching mode and the specific attributes of spine surgery discipline.

(1) Theoretical benefit of the Feynman Learning Technique mechanism. The Feynman Learning Technique uses the concept of learning by teaching where learners have to actively engage in deep processing and active output of knowledge. This technique follows the generation effect principle in cognitive psychology, which states that actively creating information leads to more effective storage in the memory compared to passively reading information [21]. In spine surgical theoretical education, there is an abundance and abstraction of basic theoretical topics like anatomy, biomechanics, and pathology. It has been established that the Feynman Learning Technique can be used effectively in promoting systematic mastery and deep understanding of theoretical knowledge through simplification of complex ideas into simple words and recognition of knowledge gaps in the teaching process [23-24]. Also, the knowledge output aspect highlighted by the Feynman Learning Technique assists residents in developing a whole knowledge network and enhancing the structural organization of knowledge [25].

(2) Clinical skill and reasoning benefit mechanism of PBL. With a focus on clinical issues, PBL puts education in real life and complicated clinical settings. Such a contextualized learning strategy is highly effective in facilitating the conversion of knowledge into clinical skills [13]. Both spine surgery disease diagnosis and treatment need to consider various information sources including patient history, physical signs, and imaging findings, and clinical reasoning development is crucial. Through planning hierarchical and logical problem chains, PBL helps residents to look at and solve clinical problems in several ways and eventually form a scientific clinical reasoning plan [5-6]. At the same time, PBL offers small group discussions and role-playing opportunities to the residents to simulate clinical decision-making and perform procedures that enhance clinical skill performance [8-9]. Moreover, PBL places more emphasis on student-centeredness and maximum mobilization of the learning initiative and motivation, which is why it achieves the highest level of teaching satisfaction [10].

(3) Medical record writing benefit of the Standardized Quality Control Teaching Method mechanism. The Standardized Quality Control Teaching Method creates a closed-loop management system of the form of standard-implementation-inspection-improvement by creating common normative standards, carrying out process-oriented quality control, and giving instant feedback and corrections [26-28]. With regard to medical record writing, the method is used to create detailed specifications of medical record writing and scoring rules. The residents will acquire standardized writing habits due to repeated reinforcement under the constant supervision of the resident staff. The operation-related medical records in spine surgery are associated with sophisticated anatomical descriptions, imaging evaluations, and operative documentation, and

their quality is directly linked to medical safety and quality [31]. The Standardized Quality Control Teaching Method has the ability to quickly enhance the standardization and completeness of residents medical record writing through systematic normative education that results in the highest medical record writing quality score as the primary cause of its success [32-33].

Discussion on causes of the discrepancies between teaching satisfaction. The highest level of teaching satisfaction (96.67%) was achieved by Group B (PBL) in the present research that can be explained by the fact that PBL focuses on student-centeredness, active exploration and interactive discussion [47]. The PBL interrupts the unidirectional flow of knowledge delivery in conventional lecture-based instruction, and converts residents into active learners rather than passive recipients. Such feeling of participation and success may contribute greatly to the quality of learning experience and satisfaction [10]. Nevertheless, despite the good theoretical learning results of the Feynman Learning Technique, it requires more self-directed learning efforts of students, and other residents who have poor foundations might experience increased stress levels and thus, lower levels of satisfaction [25]. Although Standardized Quality Control Teaching Method is extremely normative, it is more rigid and non-involving and interactive, which also has an effect on satisfaction to a certain degree [29].

4.3 Study Limitations and Future Perspectives

The present research has some shortcomings. To begin with, the study was carried out in one center and involved a small number of respondents, which can limit the applicability of the results. Second, the duration of observation was twelve months, and the process of monitoring clinical competence development over time in the four groups has not been done yet. The third one is that teaching effectiveness assessment mostly utilized examination scores and questionnaire surveys; this might be prone to some degree of subjective bias. Subsequent research might use multi-centre, large sample designs, longer follow up periods and the introduction of additional objective evaluation indicators to confirm the long term effects of various forms of teaching.

Moreover, the four teaching modes also have individual characteristics and complementary benefits. In real teaching practice, they may be chosen or combined in a flexible fashion based on the stages of training and teaching goals. As an illustration, during the initial training stage, the Standardized Quality Control Teaching Method can be applied to instill normative consciousness and build the basis of writing medical records and the Feynman Learning Technique can be applied to introduce systematic learning and profound comprehension of theoretical concepts. The middle training stage can be mainly implemented through PBL and CBL to develop clinical reasoning skills and procedural skills. The final training stage can see the incorporation of the Feynman Learning Technique to enhance the process of knowledge internalization and output ability. With the synthesis of various teaching modes, the benefit of each approach could be maximized and contribute to the overall enhancement of the quality of spine surgery residency training [34-36].

5. Conclusions

This paper has shown that all the four types of teaching modes, including the Feynman Learning Technique, PBL, the Standardized Quality Control Teaching Method, and CBL, can enhance the theoretical knowledge and clinical capabilities of spine surgery residents to some extent, but each has its unique focus. Of these, the Feynman Learning Technique is the most successful in gaining theoretical knowledge; PBL has superior benefits in enhancing the clinical skills performance and clinical reasoning ability and teaching satisfaction of the residents; the Standardized Quality Control Teaching Method is highly successful in developing the quality of medical record writing; and CBL performs well on all aspects. The four teaching modes have both strengths and weaknesses. It is suggested that the various teaching modes should be flexibly integrated based on different training stages and teaching goals in the standardized residency training in spine surgery so as to realize overall quality improvement in the training.

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