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Analysis and Research on Expected Teaching Effects Under Three Different Teaching Models

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Abstract

This paper aims to enhance the teaching effectiveness of the "Software Quality Assurance and Testing" course by focusing on elevating students' learning enthusiasm and practical skills, while nurturing talents adaptable to the evolving demands of the software testing industry. The study uses the aforementioned course as a case study, conducting a detailed analysis of traditional teaching models, student-centered teaching approaches, and teaching models based on innovative classroom design. Building upon this analysis, three expected effect evaluation models are constructed for each teaching model. The CIPP method and expert weighting are employed to calculate transfer coefficients for each level under every model. Results reveal that the traditional teaching model exhibits a significant decline in the expected effect, yielding unsatisfactory outcomes. While the student-centered teaching philosophy produces relatively better results compared to the traditional model, various influencing factors still contribute to declining transfer coefficients. In contrast, the classroom design-based model, which incorporates a student-centric approach by exploring deep-seated needs, implementing motivational strategies, and integrating principles of active learning, applied psychology, cognitive theory, and the energy modulation curve, demonstrates enriched learning outputs. Notably, the transfer effect of skills is remarkable, with expected effect coefficients showing an upward trend. This research provides valuable insights for optimizing future classroom designs.

Keywords: software testing, teaching models, expected teaching effects, transfer coefficients, expert weighting

1. Introduction

The advent of the technological revolution and industrial transformation has brought forth new challenges and demands for talent development in higher education. Over the past decade, the swift progress in digital technology and the continuous expansion of digital media platforms have not only profoundly influenced the lives and identities of learners and educators but have also fundamentally reshaped educational practices and research methodologies. The essence of education has transcended the traditional role of knowledge transmission, placing greater emphasis on nurturing students' abilities to adapt to future industry requirements. Higher

education institutions are now confronted with a series of new questions and emerging challenges. How can teachers achieve effective and efficient teaching in the classroom? How can students attain effective and efficient learning? How can the effective and efficient transfer of knowledge and skills be realized? And how can the expected outcomes of classroom teaching be achieved?

In response to the queries of how to teach and how to learn, numerous domestic universities have embarked on diverse explorations. Presently, traditional teaching models and student-centered teaching models find wide applications in higher education classrooms. For instance, Cao Yuanyuan, building upon the traditional teaching model, introduced an interactive teaching approach involving increased real-life case analysis and adjustments to teaching plans based on student feedback, significantly elevating the quality of classroom teaching (Cao & Cheng, 2020). Lv Shuyuan, guided by a student-centered philosophy, employed a blended teaching model combined with a quality monitoring system, resulting in improved student learning outcomes (Lv et al., 2020). Cui Shengzhong, through an analysis of student-centered approaches, proposed a training model with the goal of developing students' abilities (Cui et al., 2020). These explorations have positively impacted the enhancement of classroom teaching quality. However, there is relatively limited research on which philosophy, under these different approaches, yields superior expected learning outcomes for students.

With the rapid development of information technology, the global software industry continues to expand, accompanied by increasing demands for software quality. To meet societal demand for software testing professionals, many universities have introduced the "Software Quality Assurance and Testing" course. However, the limitations of traditional teaching models in cultivating students' future capabilities have become evident, hindering students' mastery of practical skills and their ability to meet industry demands. Moreover, with the continuous evolution of the educational environment and teaching methods, educators also need to explore and research the impacts of different teaching models on student learning outcomes. Therefore, optimizing the teaching model of the "Software Quality Assurance and Testing" course holds significant practical significance.

This paper focuses on traditional teaching models, student-centered teaching models, and classroom design-based teaching models. By conducting in-depth analyses of their characteristics and constructing expected outcome evaluation models for each model, the aim is to explore the differences in cultivating students' future capabilities under these three models in the current educational context. Additionally, this exploration will help understand the impact of different teaching models on students' learning outcomes, providing valuable references and recommendations for educational practices. Through further research and practical implementation, it is possible to refine teaching models, enhance classroom teaching effectiveness, and cultivate high-quality talents adaptable to the future demands of the software testing industry.

2. Expected Outcomes of Traditional Classroom Teaching

2.1. Overview of the Traditional Teaching Model's Fundamental Philosophy

The traditional teaching model, deeply entrenched in the history of education, has been widely applied in the field. Typically centered around the teacher, this model places a strong emphasis on knowledge transmission and the passive reception of information by students. The traditional classroom setting is seen as a process of restructuring and integrating knowledge, where incremental accumulation leads to shifts in thinking. Within this philosophy, exercises, assignments, and exams are considered the most effective methods for evaluating learning

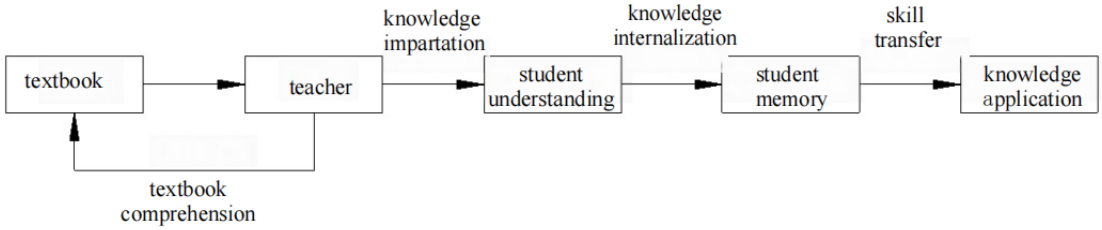
outcomes (Bai, 2017). However, as educational philosophies continually evolve and teaching methods advance, certain limitations of the traditional teaching model have gradually surfaced.

For instance, the traditional teaching model tends to overemphasize rote learning and memorization, providing limited opportunities to nurture students' innovative thinking, critical reasoning, and collaborative skills. Furthermore, this model grapples with issues of teacher dominance and student passivity, falling short in fully unleashing students' initiative and creativity. This uni-dimensional teaching approach confines students, preventing them from applying knowledge in practical scenarios and developing a comprehensive skill set, thus struggling to meet the multifaceted competency requirements of modern society. Consequently, with the diversification of educational objectives and an increased emphasis on holistic qualities, the traditional teaching model is challenged to undergo further adjustments and optimizations.

2.2. Establishment of the Expected Outcome Evaluation Model

The traditional teaching model primarily assesses students' understanding and memorization levels of classroom learning knowledge(Song, 2019). From this perspective, the teaching process represents the flow of knowledge transmission, and the model for evaluating its effectiveness is depicted in Figure 1.

Figure 1: Effect transfer model of traditional teaching mode



Source: (Author's own work)

Based on the knowledge transmission process depicted in Figure 1, the assessment process for students' expected learning effects is as follows:

(1) Classify the knowledge transmission process into different levels. For example, Level 1 transmission refers to the teacher's comprehension of textbook knowledge, which serves as the initial step of knowledge transmission. Level 2 transmission is the teacher's delivery of knowledge in the classroom, and so on.

(2) Determine the factors that influence the effects at each level of transmission. The effects at each level of transmission are influenced by key factors such as engagement, methods, and interest motivation during the transmission process from comprehension to retention.

(3) Establish evaluation methods for the effects at each level of transmission. Based on the factors influencing the effects, adopt appropriate evaluation methods to determine the evaluation coefficients for the effects at each level of transmission.

(4) Calculation of expected effect coefficients. Using the evaluation coefficients for the effects at each level of transmission, calculate the comprehensive evaluation coefficient for the expected effects to assess students' overall learning outcomes.

2.3. Calculation of Expected Effect

According to the model depicted in Figure 1, the number of knowledge transmission levels in the traditional teaching mode can be defined as four levels. The transmission at each level and the corresponding specific content are presented in Table 1.

Table 1: Levels of Transmission and Specific Content

Transfer Level	Transfer Contentt
Level 1	Teacher's comprehension of the textbook
Level 2	Teacher's classroom instruction and students' comprehension of the knowledge
Level 3	Students' assimilation and retention of the comprehended knowledge
Level 4	Students' transfer and application of the acquired knowledge

Source: (Author's own work)

2.3.1. Determination of the Coefficients of Transmission Effects at Each Level

The Improved Guided Evaluation Method (CIPP Evaluation Model) is used to determine the coefficients of transmission effects at each level. The CIPP model consists of four primary indicators: Context Evaluation, Input Evaluation, Process Evaluation, and Product Evaluation. Due to space limitations, this article will only focus on the first-level transmission - the teacher's understanding of teaching materials (Zhao et al., 2020).

The steps to determine the coefficients of transmission effects are as follows:

(1) Set indicators for the teacher's understanding of teaching materials. Based on the four primary indicators of the CIPP model, corresponding secondary and tertiary indicators are determined. For example, the indicator system for Context Evaluation at each level is shown in Table 2 according to the research conclusions in (Zhao et al., 2020).

(2) Set weights for each level indicator. The Expert Weight Method is used in this study(Tang et al., 2004). The process is as follows:

1. Distribute questionnaires to 10 external teaching experts (3 professors, 4 associate professors, and 3 lecturers) to collect weight information.
2. Determine the experts' motivation coefficient based on the questionnaire response rate. The response rate for this study is 100%, indicating a high level of experts' motivation.
3. Calculate the experts' authority coefficient. According to the method in (Tang et al., 2004), the calculated experts' authority coefficient is 0.8. Therefore, the experts' authority coefficient is high, ensuring the reliability of the questionnaire survey results.

In the Context Evaluation the revised weights for each level are presented in Table 2.

Table 2: Indicator System and Weights for the 1st Level Transmission

Primary Indicators	**Secondary Indicators**		**Tertiary Indicators**	
	Indicator Content	***Weights***	***Indicator Content***	***Weights***
Context Evaluation	Alignment between Textbook and Teaching Objectives	35%	Whether the Textbook Content Reflects the Latest Research Findings and Aligns with the Teaching Philosophy of the Course	10%
			Relevance of the Textbook's Knowledge Scope, Structure, and Exercise Sections to the Course's Educational Goals (Knowledge, Skills, Competencies)	25%
	Teacher's Understanding and Translation of the Teaching Plan and Textbook	40%	Quality of Lesson Plan Text	15%
			Quality of Classroom Teaching Materials	15%
			Quality of Post-class Texts	10%
	Interaction between Teachers and the Textbook	25%	Interaction between Curriculum Standards and Textbook Content	10%
			Interaction between Teaching Plans and Curriculum Standards	10%
			In the teaching plan, showcasing interaction between the textbook and students	5%

Source: (Author's own work)

(3) Determination of Weighted Averages: Research experts assess the ideal state of each indicator and determine corresponding coefficients. The weighted averages are then computed using the equation (Tang et al., 2004):

$$y = x_1 f_1 + x_2 f_2 + \ldots + x_i f_i \quad (1)$$

In the equation, x_i represents the calculated average degree of the i-th evaluation indicator, f_i denotes the weight of the i-th indicator, and i represents the number of evaluation indicators in the curriculum system assessment.

(4) Calculation of Weighted Averages for the 1st Level Transmission: Following the calculation of the weighted average for the background assessment with Eq. 1, analogous computations are conducted for input assessment, process assessment, and outcome assessment. Subsequently, utilizing the weights associated with these four first-level indicators, the ultimate weighted average for the first-level transmission - "Teacher's Understanding of the Textbook" is derived using Eq. 1.

(5) Calculation of Weighted Averages for Each Transmission Level under Optimal Conditions: Pursuing the aforementioned steps, the weighted averages (i.e., transmission effectiveness coefficients) for each transmission level under optimal conditions are computed individually. The outcomes are depicted in Table 3.

Table 3: Results of the Effectiveness Coefficients Calculation for Each Transmission Level (Traditional Teaching Model)

Transmission Level	**1st Level**	**2nd Level**	**3rd Level**	**4th level**
Optimal Effectiveness Coefficient	0.93	0.74	0.66	0.41

Source: (Author's own work)

2.4. Calculation and Analysis of Expected Effect Coefficients

In line with the expected effect evaluation model, each level's effectiveness coefficient is transferred based on the preceding level. When knowledge is entirely conveyed between levels, the effectiveness coefficient reaches 1, signifying the efficiency of knowledge transfer built upon the preceding level. The calculation expression is (Wang et al., 2020):

$$E_T = E_1 \times E_2 \times E_3 \times E_4 \times .....E_i \quad (2)$$

Here, ET denotes the overall expected effectiveness coefficient, and E1 to Ei represent the effectiveness coefficients for each level. By substituting the data from Table 3 into Eq. 2, the overall efficiency is computed as 0.186. This implies that under optimal conditions, the expected effectiveness coefficient for knowledge transfer to students' proficient application is only 0.186.

Upon examining the calculation results, it becomes apparent that the unidirectional transfer of knowledge constitutes a progressively diminishing process. Ideally, teachers often possess a thorough understanding of the textbook, resulting in a first-level transfer coefficient of 0.93. However, with the exception of a few students adept at grasping classroom knowledge, the majority experience a notable reduction in the second-level transfer effectiveness due to factors such as knowledge abstraction and diminished concentration. The limited understanding of knowledge by students further leads to a decline in the internalization and application of knowledge. Although short-term reinforcement before exams can partially compensate for the memorization and application requirements, students fail to truly comprehend and internalize the knowledge, and short-term memory does not transition into long-term memory.

3. Expected Teaching Effect with a Student-Centric Approach

3.1. Construction of the Student-Centric Expected Effect Evaluation Model and Coefficient Assessment

Recognizing the limitations of traditional classroom teaching, an increasing number of universities have embraced the student-centric approach in recent years, leading to valuable explorations. Drawing insights from literature (Ge et al., 2020), (Yuan et al., 2020), (Zhang et al., 2020), the student-centric teaching philosophy commonly employs the implementation methods outlined in Table 4.

Table 4: Student-Centric Implementation Methods

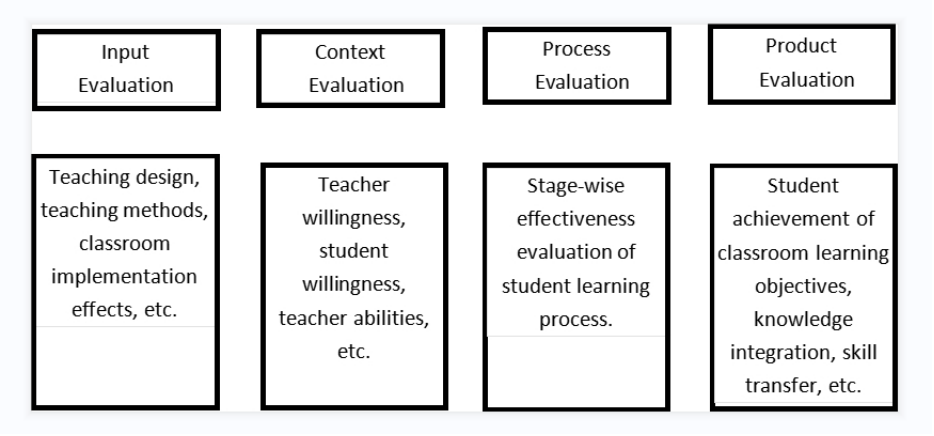
Serial Number	Method Type	Teacher Role
1	Flipped Classroom	Facilitator
2	Blended Learning	
3	Group Discussion	
4	Project Practice	
5	Competition-Driven	

Source: (Author's own work)

Looking at the implementation methods in Table 4, the focus of classroom teaching shifts from teachers to students, requiring a high level of willingness and organizational skills from teachers. Additionally, during activities such as project-based learning and competition-driven approaches, the school's software and hardware infrastructure play a significant role. When using the CIPP method for evaluation, the same approach as outlined in Section 2.3.1 is taken,

setting weights for influencing factors. The expected effect model with a student-centric focus is constructed following the CIPP method, as depicted in Figure 2.

Figure 2: Expected Effect Evaluation Model
(Result Evaluation: Achievement of Student Classroom Learning Objectives)



Source: (Author's own work)

Under the condition of the most ideal state for each level of indicators, the weighted averages for background evaluation, input evaluation, process evaluation, and result evaluation can be calculated, as shown in Table 5.

Table 5: Effect Coefficients Calculation Results for Each Level (Student-Centric Teaching Model)

Transmission Level	1st Level	2nd Level	3rd Level	4th level
Optimal Effectiveness Coefficient	0.95	0.93	0.88	0.87

Source: (Author's own work)

3.2. Calculation and Analysis of Expected Effect Coefficients

By substituting the transfer effect coefficients into Eq. 2, the optimal effect coefficient is determined to be 0.68. This value significantly outperforms the expected effect under the traditional teaching model. The improvement is attributed to the student-centric philosophy, where classroom teaching prioritizes increasing student participation, leading to enhanced active engagement and, consequently, improved expected learning outcomes.

Despite the noteworthy improvement, the optimal expected effect coefficient remains at 0.68. This indicates that achieving comprehensive excellence in learning outcomes for all students is still a challenge. The underlying reasons include: a limited proportion of teachers expressing a willingness to embrace teaching reforms, resulting in a decay in the first influencing factor; variations in classroom design methods among teachers due to the lack of standardized approaches, leading to differing levels of demonstrated ability and a second decay in the overall ability coefficient. Additionally, while schools generally provide sufficient software and hardware platforms, other influencing factors, such as differences in teacher guidance abilities, team role divisions, student capabilities, and team cooperation, contribute to another decay in this stage. It is evident that, despite the student-centric philosophy, factors beyond the provided platform undergo a decay process, preventing the expected outcomes from reaching the ideal state.

4. Expected Value of Teaching Effect Based on Classroom Teaching Design

4.1. Constructivist Theory and the Framework of Classroom Teaching Design

Drawing from constructivist theory, learning is perceived as a dynamic process of knowledge construction. Students actively engage in exploration, selection, processing, and assimilation of knowledge, leveraging their individual experiences and cognitive processes (Xie et al., 2020). This perspective recognizes that students, with varying backgrounds and abilities, undergo diverse pathways in understanding and internalizing knowledge.

In the context of classroom teaching design grounded in constructivist principles, a higher-dimensional and multidimensional learning approach is adopted, emphasizing a student-centered foundation. Before class, teachers serve as planners and designers of learning activities. During the class, they assume roles as organizers, facilitators, and coordinators. After the class, they evaluate the outcomes of the learning process.

Under this framework, students actively participate in knowledge construction guided by the teacher. Teachers play a crucial role, not only assisting students in acquiring explicit knowledge from textbooks but also providing additional support. They guide students in discovering pathways for acquiring knowledge and skills, assisting in obtaining implicit knowledge. Moreover, teachers facilitate the integration of knowledge both vertically (connecting old and new knowledge) and horizontally (across different disciplines). This integration transcends the confines of textbooks and is achieved through thoughtful classroom teaching design.

4.2. Calculation of Expected Effect Transfer Coefficients

To illustrate the calculation of expected effect transfer coefficients, we use the core course "Software Quality Assurance and Testing," offered by the Software Engineering Department at our institute as an example. This explanation focuses on student output evaluation due to space limitations. Student output includes four hierarchical levels: competency types, evaluation levels, competency results proof, and knowledge application. According to the course's training objectives, students are expected to possess competency types such as innovation, practical skills, teamwork, and knowledge integration. Following the CIPP evaluation process, the expected effect transfer includes student motivation and learning style, course design methods, classroom teaching practices, student output evaluation, skill transfer, and professional integration.

Using 85 students from the Software Engineering program as research subjects, divided into 20 learning groups, the expected effect model coefficients obtained through the CIPP evaluation process for the "Software Quality Assurance and Testing" course are shown in Table 6.

Table 6: Expected Effect Transfer Coefficients

Transmission Level	Content	Transmission Coefficient	Remarks
1st Level	Student Motivation and Learning Style Model	0.85	Based on the test results from the Singapore Polytechnic, the optimal coefficient range is 0.75 to 0.85. In this study, the optimal value of 0.85 is chosen.
2nd Level	Course Design Method	0.95	Evaluation criteria: Application of methods such as the energy modulation curve, principles of applied psychology, and cognitive neuroscience; Design of active learning methods (project-based, problem-oriented, task-driven, case analysis).
3rd Leve	Classroom Teaching Practice	0.96	Students' specific outputs in teaching activities include: project reports, experiment records, team works, comprehensive tests, presentation skills demonstrated during sharing sessions, and evaluations from expert observers during class presentations.
4th level	Student Output Evaluation	1.5	Students' final classroom learning outputs include: project reports, test reports, comprehensive tests, defense performances, learning experiences, etc.
5th level	Skill Transfer and Professional Integration	1.8	Application of software testing tools (automation testing application), test process management (agile testing practice), software development collaboration (development and testing collaboration), practical project application, independent debugging and problem-solving, testing process optimization, integration with quality management, collaboration between requirements and testing, teamwork skills, testing skills competition awards, etc.

Source: (Author's own work)

The results shown in Table 6, when substituted into Eq. (2), yield an expected effect coefficient of 2.05.

4.3. Analysis of the Calculation Results

The calculated result for the expected effect coefficient of the course design is an impressive 2.05, surpassing the predefined standard for training objectives. Moreover, each coefficient in the model exhibits a discernible upward trend, marking a notable departure from the expected effect coefficients of the initial two teaching models. The distinctive factors contributing to this disparity are as follows:

(1) Persona Deep Needs Model: The integration of the Persona deep needs model proves instrumental in accurately discerning the individual needs and motivational triggers of each student, resulting in a swifter enhancement of students' proactive engagement in learning.

(2) Standardized Course Design: The meticulous standardization of course design, incorporating elements like the energy-frequency curve and principles of applied psychology, harmonizes with students' developmental patterns, amplifying the efficacy of the learning process.

(3) Diverse Student Outputs: The inclusion of various student outputs, ranging from teaching materials and reports to expressive presentations, caters to the distinctive learning characteristics of individuals. This approach enables students to generate high-quality, personalized learning outputs based on their unique attributes.

(4) Skill Transfer: Following the completion of the course, students actively participated in diverse project practices and subject-related competitions, securing accolades. This underscores the application of acquired knowledge and skills to more intricate domains, showcasing the successful internalization and transfer of knowledge. Throughout the learning journey, a majority of students demonstrated the ability to construct knowledge tailored to their individual characteristics. Ultimately, they achieved the internalization of knowledge through diverse output mechanisms. This conclusion resonates with the foundational principles of constructivism, and the results unequivocally portray a progressive trajectory in expected effects.

5. Conclusion

This study is grounded in three educational models: traditional teaching, student-centered approaches, and classroom teaching design. It delves into the distinctive features of each, constructing expected outcome evaluation models. Through methodologies like the CIPP model and expert weighting, the study computes expected outcome coefficients for these diverse teaching paradigms. Following qualitative and quantitative analyses, the following conclusions emerge:

In terms of learning effectiveness, the traditional teaching model experiences a certain degree of knowledge decay at each level, resulting in a relatively low final expected outcome coefficient. On the other hand, the student-centered model exhibits an improvement in students' active participation and enthusiasm compared to the traditional model, leading to an enhanced expected outcome. However, due to the incomplete coverage of students actively participating in teaching activities, there is a phenomenon of gradual attenuation, limiting the overall effectiveness. In the model based on classroom design, the standardization of the teacher's classroom design methods, the improvement of student motivation mechanisms, and the alignment of teaching activities with the psychological development and cognitive principles of students contribute to a strong willingness for active learning. Under external and self-driven conditions, students actively construct their knowledge system throughout the learning process and transfer the acquired knowledge, methods, and skills to other courses or projects. Consequently, the expected outcome values for learning effectiveness are significantly increased. Examining the final learning outcomes of the "Software Quality Assurance and Testing" course, the expected value reaches 2.05, indicating a clear increasing trend in the transfer coefficients at each level. Students, during the learning process, achieve diverse outputs and successfully internalize and transfer knowledge.

In terms of assessment methods across the three models, the traditional teaching approach relies exclusively on assignments and exam scores, falling short of a comprehensive evaluation of students' enhanced abilities and overall development. Within the student-centered paradigm, the lack of a standardized process in classroom design results in the evaluation system's rationality being contingent on individual teacher capabilities. Additionally, since different teachers employ varying assessment criteria, the evaluation of assessment methods lacks comprehensiveness and cannot deliver a thorough assessment. Conversely, the model based on classroom design adopts a standardized and scientific evaluation model. It imposes requirements on students' knowledge system construction, outputs in teaching activities, knowledge transfer, the degree and results of teamwork, and the final output. This shift towards an output-oriented evaluation is effective in motivating students' learning interest, enhancing active participation in class, outputting learning results, and improving teamwork skills. The expected outcome coefficient results further validate this conclusion.

The analysis and conclusions presented in this article lead to the following recommendations for instructional enhancement:

(1) Empowering Teachers:

1. Begin by guiding teachers towards a shift in their perspectives, moving away from traditional teaching methods and embracing student-centered approaches. Establishing a mindset for classroom teaching design is crucial.
2. Enhance teacher training programs to elevate their skills in designing effective classroom instruction.
3. Prioritize textbook development as a foundational step to foster improved classroom teaching design.
4. Revise the evaluation criteria for teachers, incorporating elements such as teacher-designed classroom plans, student learning processes, and learning outcomes. This approach provides teachers with the motivation to explore and achieve superior learning results.

(2) Empowering Students:

1. Strengthen the design of student-centered teaching activities, with a focus on guiding students towards achieving desired outcomes. This approach aims to ignite strong learning motivation among students.
2. Improve the learning assessment mechanism by giving due emphasis to process evaluation, outcome evaluation, and team evaluation. This approach ensures students generate multidimensional learning outcomes.

In summary, achieving positive expected teaching outcomes necessitates not only that teachers possess the requisite capabilities and attitudes but also that they embrace advanced teaching concepts. These concepts should be applied in designing, providing feedback, and refining the classroom teaching process, ultimately aiming for an effect greater than 1. Therefore, the next steps in this work should involve further refining existing classroom design plans to achieve continuous optimization.

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