A Project-Based Learning Approach to Reforming Quantity Surveying and Costing Curriculum for International Students

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Abstract: *This paper proposes a teaching reform proposal based on Project-Based Learning (PBL) to address the challenges faced by international students in learning Quantity Surveying and Costing, such as language barriers, cultural differences, and knowledge system disparities. By integrating the PBL model into the curriculum, the aim is to cultivate high-quality engineering talents with international perspectives and innovative capabilities.*

Keywords: *Project-based Learning, Quantity Surveying and Costing, International Student Education, Teaching Reform*

1. Introduction

With the deepening of globalization and the advancement of the Belt and Road Initiative, engineering projects have become increasingly internationalized. Chinese enterprises are undertaking more and more engineering projects worldwide, leading to a growing demand for compound talents with global minds, cross-cultural communication abilities, and proficient engineering costing skills. Engineering education for international students in China aims to cultivate practical and innovative talents with a global vision and a deep understanding of China. These talents are expected to be able to engage in the full life-cycle management of engineering projects, serve the Belt and Road Initiative, and contribute to global construction and management. Mastering international knowledge and skills in engineering costing is crucial for international students to adapt to the global construction industry as it permeates the entire life-cycle of an engineering project and plays a vital role in project success.

Teaching Quantity Surveying and Costing to international students teachers often face several challenges related to language barriers, knowledge systems and cultural differences. This course involves a significant amount of specialized terminology, and there are notable discrepancies between Chinese and English terms used in the context of cost estimating practices. In some cases, the same term, although seemingly identical after translation, may carry different meanings depending on the context, which can complicate understanding for non-native Chinese-speaking students. Additionally, differences in cost estimating concepts, methodologies, and processes across countries and regions, as well as the varying provisions of engineering contracts and industry standards, further exacerbate these challenges. International students tend to be influenced by the engineering principles of their home countries, which necessitates overcoming cognitive biases. In their studies, they must not only familiarize themselves with the cost estimating practices in China, but also understand the standards and regulations of their home countries, as well as globally recognized practices. This requires the development of cross-cultural learning competencies.Furthermore, some international students may face gaps in foundational knowledge, such as mathematics, physics, and engineering mechanics compared to the requirements of the educational system in China, potentially affecting their learning of subsequent courses. There are also significant disparities in the level of knowledge mastery related to cost estimating among students from different academic disciplines, which calls for targeted adjustments in teaching strategies.

To enhance the teaching quality of courses for international students in China and cultivate high-quality engineering professionals with international perspectives and innovative capabilities, this paper proposes a teaching reform model based on Project-Based Learning (PBL). Although many scholars[1-5] have conducted in-depth discussions on the significant value and implications of PBL in

the current educational context,there are relatively few studies on its application in courses related to Quantity Surveying and Costing. This paper presents a teaching model characterized by the integration of a single engineering case throughout the entire course, supported by modular and diversified teaching methods, evaluation approaches, and internationally-oriented course content.

2. Project-based Learning

Project-based learning (PBL) has gained significant traction as a pedagogical approach aimed at revolutionizing student learning. PBL empowers students through active engagement in authentic, personally meaningful projects that mirror real-world challenges. Over an extended period, ranging from a week to a semester, students tackle complex questions or solve practical problems, culminating in a public product or presentation for a relevant audience. This immersive experience fosters deep content knowledge acquisition and cultivates essential skills, including critical thinking, collaboration, creativity, and communication. PBL creates a dynamic and engaging learning environment for both students and educators[1].

Several key characteristics define the PBL methodology:

2.1 Facilitative Teaching and Formative Assessment

The teacher's role transitions from a traditional instructor to a facilitator of learning. While targeted instruction, such as workshops or mini-lectures, may be incorporated, the teacher primarily orchestrates student-driven inquiry. This involves designing and managing learning experiences that guide students through a process of discovery. Crucially, frequent, ongoing assessment is integrated throughout the project lifecycle. Teachers provide regular feedback and opportunities for reflection, enabling students to refine their understanding and skills. These active check-ins are essential for adapting instruction and responding to individual student needs and interests.

2.2 Student-Centered, Authentic Projects

Teachers select authentic projects relevant to the discipline, prioritizing those that resonate with student interests and align with academic standards. Projects present students with real-world challenges akin to those encountered in professional practice. Integrating student interests significantly enhances engagement and fosters a sense of ownership over the learning process, including task management and decision-making. PBL moves beyond rote memorization, requiring students to engage in deeper learning and critical thinking through the application and innovation of ideas and solutions.

2.3 Action and Process Oriented Learning

PBL emphasizes the practical application of knowledge. Students are expected to do something with what they learn, translating their understanding into tangible project outcomes. Activity-based learning is central to this process, requiring students to conduct research, make decisions, and communicate their findings. Furthermore, PBL is process-centered rather than solely product-centered. The focus is on developing problem-solving strategies, a crucial skill in rapidly evolving technological landscapes. This includes the ability to effectively locate and synthesize information. By providing opportunities for students to demonstrate their capabilities, PBL can significantly increase motivation to address complex problems. Learning occurs organically as students work through the project, often presented as a case or narrative of a complex, real-world challenge. These challenges rarely have a single "correct" answer, instead requiring students to develop reasoned solutions based on the application of knowledge, critical thinking, and problem-solving skills[2].

3. Objectives of Teaching Reform Based on the PBL Model

In the context of globalization, engineering professionals must possess a range of competencies, including cross-cultural communication, teamwork, and innovation. In response to the opportunities and challenges presented by courses for international students, this paper proposes a teaching reform based on the Project-Based Learning (PBL) model. PBL is a student-centered, problem-driven pedagogical approach that simulates real-world engineering projects. It provides a platform for students to develop essential competencies, enabling them to better meet the demands of a globalized

engineering workforce. Through independent inquiry and group collaboration, students complete a project connected to the real world, acquiring knowledge and cultivating skills in the process of solving problems. The teaching objectives are as follows:

3.1 Enhancing Cross-Cultural Communication Competence

In today's increasingly globalized world, engineering projects often span across national borders and involve collaboration among individuals from diverse cultural backgrounds. As a result, possessing exceptional cross-cultural communication skills has become an essential quality for a competent engineering professional. PBL emphasizes teamwork, with students coming from various countries and cultural contexts. Throughout the collaborative process of completing projects, students are required to engage in continuous communication, negotiation, and coordination. This cross-cultural interaction not only enhances students' linguistic proficiency but also allows them to gain insights into different cognitive frameworks and value systems, thereby fostering the development of cross-cultural communication competence[3].

In terms of language practice, PBL offers international students a wealth of opportunities to apply classroom-acquired knowledge to real-world scenarios, which facilitates the development of their language proficiency and practical communication skills. In terms of cultural understanding, through collaborating with classmates from diverse cultural backgrounds, international students are able to better comprehend the differences between cultures and cultivate an attitude of respect and inclusiveness. With regard to teamwork, within a diverse team, international students must learn to adapt to various work styles, coordinate relationships among team members, and cultivate a spirit of collaboration. Furthermore, by studying the Chinese construction cost estimation system, international students can gain a deeper understanding of the cultural context and industry standards within China's construction sector, thereby promoting cross-cultural communication.

3.2 Cultivating Problem-Solving Abilities

In the context of globalization, construction projects are increasingly subject to uncertainties such as policy changes, market fluctuations, and technological advancements. Consequently, construction professionals must possess the ability to make decisions under uncertain conditions, respond quickly to changes, and adjust plans accordingly. The core of PB lies in problem-solving. Through independent inquiry and collaborative group work, students are required to engage in deep thinking, analysis, and decision-making when confronted with real-world issues. This process not only fosters critical thinking skills but also enhances their ability to solve problems.

PBL is problem-oriented, stimulating students' curiosity and desire for knowledge, thereby motivating them to actively seek solutions. In the PBL framework, students take on an active role in their learning, collecting information, analyzing data, and making decisions autonomously, thereby developing their self-directed learning capabilities. Furthermore, PBL encourages students to propose innovative solutions, fostering their creativity and innovative thinking.

3.3 Enhancing Engineering Practical Abilities

Quantity Surveying and Costing is a highly practical discipline, where theoretical knowledge can only be truly effective when integrated with real-world engineering projects.Practical engineering skills enable students to transform theoretical concepts into solutions for actual problems, thereby improving work efficiency. PBL tightly integrates theoretical knowledge with practical application, simulating real engineering projects to provide students with opportunities to apply what they have learned in hands-on contexts. This approach not only deepens students' understanding of theoretical concepts but also cultivates their engineering practical abilities.

PBL emphasizes hands-on experience, allowing students to engage in activities such as experimentation, design, and creation, thereby converting theoretical knowledge into practical skills. It encourages students to approach problems from an engineering perspective, analyze issues, and develop solutions. Throughout the project, students are required to use various engineering tools and software, enhancing their competency in applying these tools in professional practice.

4. Teaching Reform Measures Based on PBL Model

4.1 Setting Teaching Objectives

In the PBL model, students engage in autonomous inquiry and collaborative teamwork to complete a project of practical significance. Through this problem-solving process, students acquire knowledge and develop skills. The teaching objectives are outlined as follows:

4.1.1 Competency Objectives

The course aims to enable students to understand the basic concepts and principles of construction cost management. Students should be capable of preparing cost estimation documents, such as bill of quantities, detailed estimates, tender control prices, and bid quotations, as well as performing cost analysis in construction management. The specific competency objectives are as follows:

4.1.2 Competency Objective G1

Understand the fundamental theories and methods for determining construction cost. Master the principles and methods for preparing detailed estimate and cost estimate based on bill of quantities[4].

4.1.3 Competency Objective G2

Understand construction measurement rules and pricing principles, and be able to determine project costs and prepare cost-related documents. Additionally, students should be able to perform cost management analysis using contract management as a tool.

4.1.4 Competency Objective G3

Given the design drawings, students should be able to prepare a bill of quantities in accordance with current measurement regulations.

4.1.5Competency Objective G4

Develop the ability to search and consult relevant literature, standards, and technical specifications in both Chinese and English. Students should be able to select appropriate construction plans, material prices, and other pricing bases for complex projects. Furthermore, students should be able to prepare tender control prices or bid quotations and analyze the impact of project feature descriptions on the comprehensive unit price.

4.1.6 Competency Objective G5

Analyze the components of the comprehensive unit price and assess factors affecting pricing decisions, providing a foundation for bidding and quotation decisions.

4.2 Grouping Students Based on Cultural Background and Skill Level

Since PBL is primarily conducted in groups, student grouping is necessary at the beginning of the course. This course uses teacher assessments of each student's cultural background, strengths, weaknesses, and skills to form balanced and effective project teams. By assigning students to groups based on these factors, teachers ensure that each group has diverse abilities, thereby maximizing the potential for collaboration, learning, and high-quality outcomes.

The following is the grouping process based on cultural background and skill level:

4.2.1 Pre-course Assessment

The objective of pre-course assessment is to collect data on each student's skills, previous experiences, and preferences to ensure a balanced group composition.Before the first class, students are asked to complete a questionnaire or survey form to collect information on the different aspects, including cultural background, academic background, specific skills and academic and practical situation.

To elaborate, the information collected mainly involves investigating students' nationality and cultural characteristics; students' prior coursework or professional experience related to architecture, cost estimation, project management, or engineering; students' ability to use professional software (such as AutoCAD, Revit) or understand technical drawings; communication, teamwork, leadership, and problem-solving skills; and performance in relevant courses (such as construction technology, building materials etc.).

4.2.2 Group Composition

Teachers try to create diverse and balanced groups by mixing students' cultural differences and complementary strengths.After statistically analyzing the questionnaire results, students are classified into advanced, intermediate, and beginner levels according to their skill level.

Advanced: Proficient in understanding technical drawings, able to accurately measure quantities from drawings, and possess strong spatial reasoning skills. Familiar with advanced technologies or software tools. Possess strong organizational, planning, and leadership skills.

Intermediate: Need support in understanding drawings. Familiar with basic tools and formulas such as Excel. Need guidance in task organization and leading teams.

Beginner: Lack the ability to read architectural drawings. Do not have the ability to operate basic software.

By mixing advanced, intermediate, and beginner students in each group, groups of 4-5 students from different countries are created. This approach not only enhances students' cross-cultural communication skills, but also ensures that each group has an advanced student who can provide guidance, and students at intermediate and beginner level can learn from more experienced peers, while also contributing valuable ideas[5].

4.3 Analysis of PBL Activities and Content

After confirming the competency objectives, it is essential to design corresponding instructional content that aligns with these objectives, ensuring that the competency goals effectively guide the teaching activities. Competency objectives are central to instructional design. Once these objectives are established, instructors need to carefully select teaching content, design diverse instructional activities, and implement appropriate evaluation methods. By integrating the competency objectives throughout the entire teaching process, instructors can effectively guide students and support them in gradually achieving the established learning goals, thereby fulfilling the expected educational outcomes.

Instructors must first clarify the core knowledge, skills, and competency indicators that students should acquire through PBL activities. Additionally, considering individual differences, teaching content, and real-life scenarios, they should design specific, actionable project tasks for students. When designing PBL tasks, the instructor should adopt a student-centered approach, taking into account learners' cognitive levels, interests, and learning styles. This ensures that tasks are both challenging and feasible, closely related to the instructional content, and designed to stimulate students' interest in learning while fostering the development of core knowledge, skills, and competencies. The tasks should include driving questions that are fully aligned with the project goals, ensuring that the PBL activities remain focused on the course's objectives. Students should be required to engage in an ongoing process of planning, comprehensive analysis, and data collection to solve the problems posed. Based on the aforementioned competency goals G1 through G6, the following outlines the teaching content and project-based learning activities for this course.

4.3.1 Unit 1: Introduction to Engineering Cost Estimation

This unit covers the basic concepts of engineering cost estimation, the composition of engineering costs, and construction cost data, corresponding to competency goal G1. The project-based learning tasks are as follows:

Task 1: The instructor selects a real-world engineering project. Students are tasked with reviewing the project documentation to understand the project’s overview, including its nature, scale, and location, and list the cost components associated with the project.

Task 2: Students are asked to consider and respond to the following questions: What is the role and significance of engineering costs in this project? What are the main stages of the cost estimation process?

Task 3: Students are asked to conduct an interview either virtual or in-person with an individual whose responsibilities include construction cost management to investigate the role of cost management within the construction industry.Potential interviewees may include cost estimators, project managers, project engineers, architects, engineers, and building material sales representatives.Following the interview, students need to prepare a written summary addressing the questions below and be prepared to discuss your findings in class.：

a:What is the purpose of construction cost estimation?

b: At what stage(s) of the construction process is cost estimation involved?

c:What are the consequences if the cost estimate is slightly off? What if it's significantly off?

d: How do you typically prepare a cost estimate? Which estimation method do you find most suitable and why?

e: How long does it usually take to prepare a cost estimate?

4.3.2 Unit 2: Basic Theories of Engineering Cost Estimation

This unit focuses on the fundamental principles of engineering cost estimation, including bill of quantities and unit pricing, corresponding to competency goals G1 and G2. The PBL learning tasks are as follows:

Task 1: Based on the selected engineering project, students analyze the potential cost estimation methods involved, comparing the applicability and advantages and disadvantages of different methods.

Task 2: Students are tasked with reviewing relevant codes and cost data to understand the basic principles and foundations of engineering cost estimation.

Task 3: The instructor selects various structural components.Students, in groups, determine the composite unit price (CUP). Subsequently, a classroom discussion will be conducted, focusing on the following:

a:What factors can influence fluctuations in the composite unit price?

b: How does adjusting the profit margin affect the overall cost?

c: What strategies can be employed to reduce the composite unit price without compromising quality?

d: Why is accurate estimation of the composite unit price (CUP) crucial prior to bid submission?

4.3.3 Unit 3: Quantities Surveying and Unit Price Determination

This unit covers the calculation of building area, measurement and unit price determination for building and decorative works corresponding to competency goals G3 and G4. The PBL tasks are as follows:

Task 1: Students use specialized software to model a case project.

Task 2: The instructor assigns tasks based on subdivisions of the selected engineering project, dividing the work among students. Students must complete and explain how they performed quantity surveying. Specific requirements include calculating the building area of the selected project according to measurement rules, and taking off quantities for earthworks, foundation works, masonry works, etc.

Task 3: Students determine the appropriate unit prices for different project sections and construction conditions.

5. Conclusion

Integrating the PBL model into the curriculum of Quantity Surveying and Costing for international students provides an opportunity to apply theoretical knowledge to real-world engineering projects. Through collaborative learning and hands-on experience, students have developed critical thinking, problem-solving, and communication skills. Furthermore, this curriculum reform has deepened international students' understanding of Chinese engineering practices and culture, equipping them for future careers in the global engineering industry.

The PBL approach has proven effective in enhancing student learning outcomes, engagement, and overall satisfaction. Students have shown significant progress in key competencies essential for an internationalized engineering environment. PBL has fostered substantial improvements in critical thinking, problem-solving, innovation, and teamwork. Students have demonstrated the ability to think independently, analyze problems, and propose innovative solutions. Moreover, through collaboration with peers from diverse cultural backgrounds, they have developed cross-cultural communication skills and a strong sense of teamwork. These enhanced competencies provide a solid foundation for students to tackle complex engineering challenges in their future professional careers.

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