Research on the Influencing Factors of PBL-CDIO Project-based Teaching in Exhibition Design Courses

Cheng,Rui

Krirk university, Bangkok,10220, Thailand

Abstract: This paper explores the integrated application of PBL (project-based learning) and CDIO (idea-design-implementation-operation) in exhibition design courses. The paper analyzes from the aspects of curriculum design, subject correlation, engineering practice, and reform strategies, and points out that although PBL and CDIO share common values and educational strategies, they only have partial intersection in implementation. Practice has proven that these two teaching methods can complement and effectively combine with each other, thereby significantly improving the teaching quality of exhibition design courses.

Keywords: PBL; CDIO; Art education; Project-based learning; Teaching evaluation

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This paper emphasizes the shortcomings of traditional education models in cultivating students' comprehensive literacy and innovative abilities in the context of global education reform. The demand for innovative talents in society has prompted the education sector to seek new educational models. STEAM education, as an interdisciplinary educational concept, aims to enhance students' comprehensive literacy, innovation ability, and practical skills by integrating science, technology, engineering, art, and mathematics. It is gradually receiving global attention and being promoted and applied.

1. Introduction

This paper discusses the application of STEAM education in the field of art education, emphasizing the importance of interdisciplinary integration of science, technology, engineering, art, and mathematics to cultivate students' comprehensive literacy, innovation ability, and practical ability. The core concept of STEAM education is to enhance students' innovation and problem-solving abilities through interdisciplinary learning. PBL (project-based learning) and CDIO (idea-design-implementation-operation) models have shown great potential in STEAM art education, promoting student communication, teamwork, and leadership development through student-centered art activities and a complete process from idea to operation. Although there are challenges in implementing PBL, such as selecting teaching strategies and developing project tools, the combination of PBL and CDIO provides new perspectives and methods for art and design education, aimed at improving students' practical operational ability, innovation ability, and teamwork ability.

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About the Author

Cheng,Rui (1982-), DFA student at krirk University, Thailand, research direction: display design.

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2. Literature Review

(1) Innovative application of STEAM project in art education

The implementation of STEAM education needs to take into account the unique status and role of art. Although STEAM education has achieved positive results in promoting students' creativity and social skills, art education is often overlooked or only stays in form (Cai Ting, 2019). Therefore, it is necessary to delve into the exact position of art in STEAM education in order to achieve true integration of art and STEM disciplines (Raquel Sanz Camarero, 2023). The new focus of education requires application, creativity, and originality. As one of the measures to promote student creativity, STEAM involves key processes of creativity and innovation. It allows students to connect established elements of STEM in artistic practice, design principles, and assessment (James, 2016).

The implementation of STEAM education in art education requires special attention to the unique value of art and its core role in interdisciplinary education. Arts education is often marginalized in STEAM, but it is essential for developing students' creativity and social skills. Exploring the integration of art and STEM disciplines in depth is the key to achieving educational innovation. STEAM education not only promotes the all-round development of students through interdisciplinary integration, but also emphasizes application, creation and originality, allowing students to combine STEM elements with artistic practice. [1]

(2) Application of PBL in exhibition design related courses

PBL, as a constructivist teaching method, encourages students to complete tasks based on real-life experiences and enhance their ability for self-directed learning (Govers et al., 2014). Faced with complex design problems, the PBL teaching model helps students improve their self-directed learning abilities through various methods. The PBL teaching model emphasizes a student-centered learning process, encouraging students to actively explore and solve problems. This learning approach requires students not only to actively participate in the classroom, but also to engage in extensive self-directed learning and research outside of class (John R. Savery, 2006). For example, in engineering education, PBL is used as a tool to cultivate lifelong learning abilities, including developing students' self-directed learning abilities (R Ulseth; Bart Johnson, 2017).

The PBL model emphasizes a student-centered learning process, cultivating students' critical thinking and problem-solving abilities through real-world problem situations. This practice not only enhances students' critical thinking and problem-solving abilities, but also promotes their self-regulated learning skills (M Almulla, 2019). For example, research has shown that PBL can enhance students' intrinsic motivation and interest in the subject, which further supports the development of self-directed learning (Satish Nargundkar, 2014). In addition, the scaffolding teaching strategy in PBL teaching mode is also a key factor in promoting self-directed learning. By gradually reducing external guidance and support, students are encouraged to manage their own learning process, thereby gradually developing the ability to learn independently (C Hmelo Silver (2007). This gradual letting go approach helps students to apply their learned knowledge and skills more confidently when facing new challenges.

In addition, the scaffolding teaching strategy in PBL helps students gradually develop independent learning abilities, but the effectiveness of PBL is also influenced by students' beliefs and attitudes.

(3) Influencing factors of PBL CDIO project-based teaching in exhibition design courses

The CDIO model is highly compatible with the actual workflow of art and design majors. By implementing the CDIO model, combined with PBL problem-solving and student-centered learning methods, teaching quality and students' comprehensive abilities can be effectively improved. [2] In this mode, students need to actively explore and solve problems, which can stimulate their creativity and critical thinking abilities (Hao Rui, 2018).

Combining CDIO and PBL modes of presentation design courses can optimize teaching effectiveness through the following aspects:

1) Integration and Innovation of Course Content: Based on the requirements of the CDIO model, the course content is re planned and designed to better meet industry demands and students' career development needs (Li Fenghua, 2020). At the same time, utilizing the characteristics of PBL mode, more practical cases and problem scenarios are introduced to enable students to learn and apply new knowledge in the process of solving practical problems. [3]

2) Diversification of teaching methods: adopting various teaching methods and technologies, such as flipped classroom, online teaching, workshops, etc., to adapt to the learning styles and needs of different students (Cui Junfeng, 2020). At the same time, strengthen teacher-student interaction and cooperation among students to enhance their participation and effectiveness in learning. [4]

3) Reform of evaluation system: Establish a more scientific and diversified evaluation system, which not only assesses students' knowledge mastery, but also evaluates their project execution ability, innovation ability, and social responsibility (Chen Dai, 2021).

4) School enterprise cooperation and industry linkage: Strengthen cooperation with enterprises, provide internship and practical opportunities for students, and enable them to learn and apply their knowledge in real work environments (Wang Kun et al., 2018).

The combination of PBL-CDIO project-based teaching mode provides a new perspective for art and design education, which helps to meet the needs of society and the market, cultivate students' practical operation ability, innovation ability, and teamwork ability.

3. Problem Statement

(1) How to effectively integrate PBL and CDIO modes to improve the teaching effectiveness of exhibition design courses

To improve the teaching effectiveness of exhibition design courses, the following steps need to be taken to integrate PBL and CDIO modes:

1) Clarify teaching objectives and combine the four stages of CDIO (idea-design-implementation-operation) with the active learning advantages of PBL.

2) Build interdisciplinary project teams to promote teamwork and understanding of the actual work environment. Through the CDIO model, students can be encouraged to collaborate across disciplines and work together to complete a project. This interdisciplinary collaboration not only enhances students' teamwork skills, but also strengthens their understanding of the actual work environment. [5]

3) Adopt diverse evaluation methods such as self-assessment, peer assessment, and teacher assessment to ensure students' comprehensive development. (K. Edström; A. Kolmos, 2014).

4) Utilize modern technological tools to support project organization and management, facilitating teaching feedback. In presentation design courses, modern technology tools such as Google Sheets can be utilized to support the implementation of CDIO and PBL. These tools can help students better organize and manage their projects, while also facilitating teachers' teaching management and feedback. [6]

5) Continuously improve teaching methods to meet students' needs and social development trends. By constantly reflecting and adjusting teaching strategies, combined with the advantages of CDIO and PBL, we can better meet the learning needs of students and the development requirements of society (Chong Hwa Lee,

2018).

(2) Challenges faced in implementing the PBL-CDIO project-based teaching model

The main challenges faced in implementing the PBL-CDIO project-based teaching model include resource requirements, teacher role transformation, adjustment of student assessment methods, and matching course content with industry demands.

1) Teaching resources: including time, space, and technical support. For example, PBL may require more time to discuss and solve problems, while CDIO requires appropriate facilities and equipment for design and operational activities (Pang Wenyan et al., 2014).

2) Teacher role transformation: Teachers need to transition from knowledge transmitters to guides and coordinators. This requires teachers to possess higher professional abilities and teaching skills to adapt to new teaching models.

3) Adjustment of student assessment methods: shifting from traditional exams to focus on process and ability assessment. This requires schools to develop new assessment tools and methods to accurately reflect students' learning outcomes and skill development.

4) Matching course content with industry demands: Collaborate with the industry to update course content in real-time. In order to ensure the relevance and practicality of educational content, schools need to work closely with the industry, regularly update course content, and ensure that it meets current technological and market demands.

(3) Establishing a scientific and diversified evaluation system to assess student performance under the PBL CDIO project-based teaching model

1) Diversification of evaluation subjects: including teachers, classmates, industry experts, and self-evaluation (Zhu Zhenghua, 2011). This diversified evaluation subject can more comprehensively reflect students' learning outcomes and abilities.

2) Systematic and comprehensive evaluation: using formative assessment and student feedback to ensure the comprehensiveness of the evaluation. The multi-dimensional evaluation system can systematically evaluate students' project practice ability and has strong operability (Song Guoqing, 2012). At the same time, forming assessments and student feedback is also an indispensable part of the evaluation process, which helps to achieve full process and systematic evaluation.

3) Evaluation indicators for scientificity and diversity: Evaluation indicators should include multiple dimensions such as mastery of professional knowledge, teamwork ability, problem-solving ability, etc. In addition, the proposed comprehensive evaluation model based on the combination of Analytic Hierarchy Process and Fuzzy Evaluation provides methodological support for constructing scientific evaluation indicators.

4) Innovative evaluation method: A multidimensional flexible feedback mechanism centered on students' self problem-solving has been proposed, which can better adapt to the characteristics of the CDIO education model (Liu Haixue, 2017). Meanwhile, the comprehensive evaluation model based on fuzzy mathematics mentioned in the paper also demonstrates the innovation of the evaluation method.

5) Application evaluation results: Used for teaching feedback, student development, and career planning, providing a basis for employers.

Through these steps and measures, it is possible to ensure the effective integration of PBL and CDIO models in showcasing design courses, overcome challenges in the implementation process, and establish a comprehensive and scientific evaluation system to promote the development of students' comprehensive abilities and innovative thinking.

4. Research Design Methods

(1) Measures

In order to ensure the effective implementation and evaluation of the PBL-CDIO teaching model in art and design courses, the following optimized data collection and evaluation measures have been implemented:

1) Data collection methods

A multi-method data collection strategy of interviews, classroom observations, and document analysis was employed to ensure comprehensiveness and depth of data. We chose these methods because they are relevant to the research topic and problem, and can provide rich first-hand information.

2) Development of evaluation tools and scoring criteria

Based on the national curriculum evaluation standards, adjust and customize the existing PBL-CDIO assessment tool to meet the specific needs of art classrooms. Ensure that assessment tools can comprehensively evaluate students' learning process, knowledge mastery, creativity, and soft skills.

3) Customization of evaluation content

Teachers can use customized assessment tools to evaluate students' performance in PBL learning process, problem-solving, STEAM creativity, final product production, and personality or soft skills.

4) Preparation and use of observation table

Researchers have prepared multiple sets of observation forms to record classroom interactions, student engagement, project progress, and team collaboration. The observation table will be designed based on different analytical dimensions to capture various aspects of PBL teaching practice.

(2) Participants

This study focuses on the implementation of PBL method in STEAM projects in display design classrooms, which takes approximately 3 to 6 months from the preparation process to the presentation of the art project. A total of 60 sophomore students majoring in exhibition and convention participated in this study in groups.

(3) STEAM Project

Projects	Project Theme	science and technology	project	Art	Mathematics
Sustainable Home Exhibition Project	Showcasing sustainable lifestyles and environmentally friendly building designs.	Students research the application of renewable energy sources such as solar and wind power, and learn about energy-saving building materials and technologies.	Design and construct a small sustainable residential model that considers structural stability and energy efficiency.	Show the beauty and comfort of sustainable homes through paintings, illustrations, etc.	Calculate energy consumption, material costs, etc., conduct data analysis and optimize design.
Exhibition project of "Science and Technology Innovation Museum"	Project theme: Showcasing the history of technological development and the latest innovative achievements.	Science: Understanding the principles and development history of different technological fields, such as physics, biology, computer science, etc. Technology: Use multimedia technology, interactive display equipment, etc. to enhance the interest and interactivity of the exhibition.	Design exhibition layout and display rack to ensure the safety and display effect of exhibits.	Using design aesthetics to create attractive exhibition spaces.	Conduct spatial planning and size calculation, and arrange exhibition exhibits reasonably.

Ecological System Exploration Exhibition Project	Showcasing the composition, interrelationships, and protective measures of ecosystems.	Science: Studying concepts such as biodiversity, food chains, and ecological balance in ecosystems. Technology: Using virtual reality (VR) or augmented reality (AR) technology to allow viewers to experience the ecosystem in an immersive way.	Create an ecosystem model to showcase the structure and functionality of the ecosystem.	Show the beauty and fragility of the ecosystem through art forms such as painting and photography.	Analyze ecological data, such as species abundance and habitat area, to support conservation decisions.
Future Transportation Exhibition Project	Showcasing the development trends and innovative solutions of future transportation.	Science: Research related scientific knowledge such as new energy, autonomous driving, intelligent transportation systems, etc. Technology: Create traffic models or demonstration devices to showcase the technological features of future transportation vehicles.	Design transportation hubs or urban transportation planning models that consider traffic flow and efficiency.	Using creative design to showcase the convenience and aesthetics of future transportation.	Conduct traffic flow analysis and route optimization to improve the operational efficiency of the transportation system.
Cultural Heritage Protection Exhibition Project	Showcasing the value and protection methods of cultural heritage.	Science: Understanding the scientific principles of cultural relic protection, such as material analysis, restoration techniques, etc. Technology: The use of digital technologies, such as 3D scanning, virtual exhibitions, etc., to protect and display cultural heritage.	Design cultural relics protection facilities or display devices to ensure the safety and display effect of cultural relics.	Show the charm of cultural heritage through art forms such as painting, sculpture, etc.	Conduct cultural relic data analysis and formulate protection strategies to ensure the sustainable protection of cultural heritage.

5. Data Analysis

This project needs to be completed twice a year, and the final project is required to be prepared and presented at the end of each semester. Based on the concepts, stages, and processes in the PBL-CDIO method, data collection is divided into several key points: (a) teacher profile (options, knowledge, and skills), (b) school (classroom layout, art studio, infrastructure), (c) preparation and planning, (d) theme determination (SDL, production questions, FILA), (e) content understanding (subject integration, PBL process, stages), (f) final product (STEAM project), and (g) community reflection (Douglas&Jaquith, 2018; Stanley, 2018; Wurdinger&Haar, 2007; Lambros, 2002; Wee, 2004) as shown in Table 1.

Table 1 Data Analysis Steps

Step	Contents
S1	Starting from the fundamental problem of openness, versatility, and the need for multiple solutions. These questions engage students in real-world topics, ultimately leading to in-depth, authentic, and impactful investigations. The most important thing is that these issues are related and can be linked to students' environment and life.
S2	Select appropriate content and involve students in designing project plans. These activities promote diverse curriculum based choices and support real questions/doubts.
S3	Create schedules and schedules for students. The curriculum should be more flexible and subject to change at any time. They need to be reminded when to complete their ideas, discoveries, and evaluations. Teachers provide guidance to help them stay on track without setting too many restrictions.
S4	Monitor students' progress, promote progress, and encourage collaboration. Teachers play an important role in using team and individual grading standards, as well as providing resources, guidelines, and tools to assess student progress.
S5	Evaluate progress and provide feedback to students, indicating their level of understanding of the information and areas for improvement. Evaluation can also help teachers design teaching guidance to teach more effectively. Students can also use designated assessment tools for self-assessment.
S6	Reflect on daily activities during the learning process. Teachers allow individuals to reflect through diaries, group reflections, and discussions. Students can share their feelings and experiences to reflect on their work progress, changes, ideas sharing, and evaluation process.

The planning of this project indicates a curriculum plan that conducts in-depth analysis of collected observational data to evaluate the implementation effectiveness of PBL teaching practices, the PBL process in STEAM project creation, collaboration strategies, and the individual values of teachers and students. [7]

6. Conclusion

The conclusion drawn from this study emphasizes the potential of the PBL-CDIO method in improving the quality of art education courses. The PBL-CDIO method provides teachers with a tool for evaluation, assessment, and providing teaching feedback, which is crucial for improving teaching quality. Teaching design not only focuses on the final product, but also meticulously measures and evaluates the planning and implementation of each stage, ensuring that every intensive aspect of the teaching process receives appropriate attention. The research results help eliminate the misconception that the PBL-CDIO method only focuses on the final product, emphasizing the importance of the steps and preparation work involved in the course process. The results provide educators with a tool to evaluate the effectiveness of the PBL-CDIO method, demonstrate the success of teaching practice, and provide necessary input for curriculum developers and scholars to assess the effectiveness of this method as a teaching strategy. The effectiveness evaluation results of PBL-CDIO method support its potential as one of the teaching strategies in various educational fields of schools and higher education institutions. Research encourages educators to continuously improve their teaching methods based on evaluation results to adapt to changing educational needs and student expectations. The contribution of the research results to educational practice lies in providing empirical evidence to support the PBL-CDIO method as an innovative and effective teaching model.

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