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Teaching Design and Implementation of PBL Project STEAM Course in Primary and Secondary Schools

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Abstract

Taking the application status of steam curriculum in primary and secondary schools as the starting point, by analyzing the needs of Project-based steam curriculum at the national level, school level and learner level, this paper explores the teaching design process of PBL Project-based steam curriculum: theme design, goal design, project design Activity design and evaluation design provide a practical and methodological perspective for steam curriculum research.

Keywords

Project-based Learning; Steam Courses; Instructional Design.

1. Introduction

With the rapid development of modern science and technology, society has entered a period of transformation and development, and mankind is making great strides into the era of information society and knowledge economy. The new era has put forward new requirements for talent literacy. Although the old ability structure, such as language ability and computing ability, is important, it is far from meeting the development needs of the new era. Therefore, there is a growing voice for new ability structures such as problem-solving ability, innovation ability and cooperation ability. In order to cultivate high-quality compound talents needed in the new era, school curriculum, as the carrier of teaching content, first needs to be optimized and reformed. Stem courses originated in the United States have gradually become an important way to realize the above vision. Stem is the abbreviation of science, technology, engineering and mathematics. Later, art was added. In 2011, the National Science Council officially changed stem into steam. Project-based learning, which is also concerned by the educational circles, is a teaching method that starts from a real project task and under the guidance of teachers, learners divide their work and cooperate to solve problems together. It needs to use interdisciplinary knowledge, emphasize task orientation, advocate cooperation, and embody learner centeredness. These characteristics coincide with the concept of steam curriculum. Therefore, the design of steam curriculum based on Project-based learning has attracted great attention in the academic circles.

The primary and secondary school stage is an important period for shaping students' imagination, creativity, interdisciplinary learning ability, critical thinking and other abilities and good habits. The design and implementation of practical steam courses in this school stage can achieve twice the result with half the effort in terms of training effect, and contribute to students' continuous learning and lifelong learning. Dong Zehua and Zhuo Zelin [1] believe that stem integrated curriculum takes Project-based learning as the carrier, which is helpful to achieve the goal of stem education. Based on this, taking the compulsory education curriculum standards as the research samples, this paper forms a preliminary Project-based steam curriculum content system, designs a unified experimental platform based on the Arduino open source platform in line with international standards, and forms a steam experimental toolbox to meet the learning needs of students from different sections, It is expected to make up for the

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lack of Project-based steam education research in the current domestic basic education curriculum research center.

2. Demand Analysis of PBL Project Steam Course

In recent years, some primary and secondary schools in China have begun to offer steam courses. To effectively carry out Project-based steam courses in primary and secondary school courses, we need to first understand the attitudes and actual needs of various objectives and objects towards Project-based steam courses. This study will be analyzed from the following three aspects.

2.1. National Level

China is accelerating the construction of an innovative country. Under the current strategic background, steam education has attracted national attention because of its broad development space and bright development prospects [2]. In terms of national policy documents, there are 2035 of China's educational modernization [3], white paper on China's stem Education (2017), etc. Both documents put forward the training needs for top-notch innovative talents. The latter proposes to integrate the development of stem education into the national innovative talent training strategy, build a set of systematic steam courses in line with China's strategic development, and increase the proportion of applied, compound and skilled talents. Under this trend, there is a growing demand for the design and implementation of steam curriculum in primary and secondary schools. Due to the inclination of national policies, the school will gradually increase its investment in maker education, steam education and other courses and teacher training expenses. It can be seen that the construction and development of steam curriculum, the development of diversified school-based curriculum and the design of rich and colorful teaching activities will help to solve many practical difficulties in developing steam education in the field of basic education in China.

2.2. School Level

In the industrial age, in order to improve the efficiency of running a school, the class teaching system is favored by the public because of its large-scale and neat characteristics. In the 21st century, with the emergence of the Internet of things, the use of big data in education, the development of artificial intelligence technology and the transformation of society, mankind has entered the information age. Under the new social background, primary and secondary schools should have a new form, and primary and secondary school classrooms should explore a more progressive model. The indoctrination teaching mode of teachers' speaking and students' listening no longer meets the requirements of the new era, and the teacher role of "knowledge Porter" should be replaced by "cognitive coach". Project-based learning is a teaching method that conforms to the trend of the times and helps to cultivate high-quality compound talents. The reform of primary and secondary schools needs to start with curriculum teaching.

2.3. Learner Level

Learners are the masters of learning and the starting point and foothold of curriculum teaching. The emergence and change of any new way of learning should first consider learners' attitudes and needs. The disadvantages of traditional teaching that has been used for a long time have long been exposed. Primary and secondary schools are originally a period when students have a strong desire for knowledge and ask countless "why". However, learners' learning enthusiasm and desire for knowledge are gradually eroded in the old pile of difficult papers. They use multiple efforts to endorse and do questions, but they are at a loss in the face of practical problems. Some studies have found that through the implementation of the project, students

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can apply the learned book knowledge to the solution of practical problems, exercise the quality of not afraid of difficulties and failures, develop from receiving knowledge to a high-level thinking mode of independent thinking and problem solving, and receive modern science and technology education in a safe environment More empirical studies have proved that steam courses with Project-based as the carrier can improve learners' learning effect and learning satisfaction It can be seen that the Project-based steam course is helpful for learners' development.

3. Teaching Design and Implementation of PBL Project Steam Course

The new talents in the 21st century are compound talents with scientific literacy, teamwork spirit and innovation ability. Therefore, the teaching activity design of Project-based steam course is particularly important. In the process of participating in activities, students can not only understand scientific knowledge, but also exercise their ability to observe, think and solve problems independently by completing projects; At the same time, it can also improve the ability of innovation and cooperation with people; It is more important to understand the complex relationships among science, technology, society and environment. PBL Project-based steam curriculum design focuses on student development, gives full play to students' subjective initiative, emphasizes the activity design of "theme project" of the curriculum, emphasizes the authenticity and concreteness of the created learning situation, and emphasizes student-centered practical exploration and personal experience, which is more conducive to the cultivation of students' scientific spirit and scientific attitude. This paper discusses the teaching design and implementation of steam course from five aspects: theme design, goal design, activity design, evaluation design and summary reflection.

3.1. Theme Design

In recent years, steam courses have been opened in many primary and secondary schools, but there are no unified teaching materials and evaluation standards. Many schools are developed by the teacher team. Therefore, a set of scientific and feasible Project-based steam curriculum design process is needed. Project-based learning is a practical activity in which students mainly study independently and cooperate in groups to jointly complete a theme task. Therefore, the design and selection of Project-based learning theme is very important. Usually, teachers will start from real life experience, ask teachers to ask questions or let students find out the problems encountered in life and learning, and determine the problems to be solved through discussion and consultation between teachers and group members. Usually, a topic is a large category, and a topic includes several subprojects to be solved. Students need to complete each sub project through literature search and group cooperation, so as to find the method to solve the whole problem, which requires the theme to be expandable, open and flexible, so that students can not only use the cultural knowledge learned from books, but also exercise their practical ability and cultivate students' innovative thinking and innovative ability.

The author illustrates the ideas and methods of theme design through two examples, taking the practical activity of "dripping experiment" in grade 4 of primary school as an example. (1) In daily life, if the faucet is not tightened and dripping all the time, how much water will a faucet that is not tightened drip in a year? Do you know how long these wasted water can be used for a family? (2) Many families have travel plans during the holidays. During the travel period, the plants raised at home will die due to lack of water. It is very troublesome to entrust the plants to the care of friends. Students can design an automatic watering device, so that the automatic watering instrument can automatically water the flowers according to the amount of water evaporated every day when there is no one at home. These two themes are put forward around the practical problems in students' life. Students can form groups to complete the project through online information search and consultation and discussion. Students complete tasks

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through hands-on experience and develop the ability of independent thinking and problem solving.

3.2. Objective Design

The teaching goal of PBL project steam course needs to complete the task through group cooperation, integrate the learned knowledge through the integration of multi-disciplinary knowledge, and transfer it to real life to solve problems, so as to improve students' practical ability, communication ability and problem-solving ability. The teaching objectives of Project-based steam course are designed from three dimensions: knowledge and skills, process and methods, emotional attitude and values.

From the perspective of knowledge and skills, it is mainly the cultivation of students' subject knowledge and professional skills. The design of teaching objectives should consider the standards of science, technology, engineering, art and mathematics in primary schools of compulsory education in China. For example, the K-12 standard mainly focuses on the cultivation of students' Computational Thinking. Therefore, when designing teaching objectives, teachers should fully consider students' age, school and region, and design teaching objectives hierarchically according to students' thinking development level.

From the perspective of process and method, it is mainly through the completion of projects and tasks to learn the methods to solve various complex problems and cultivate students' engineering design thinking, Computational Thinking and creative thinking. Steam course involves the knowledge points of various disciplines. The goal of steam course is not to add the curriculum standards of various disciplines, but to combine the curriculum standards of various disciplines to enable students to summarize a set of unique thinking modes and methods by completing step tasks.

From the perspective of emotional attitude and values, we should cultivate students' attitude of actively discovering, analyzing and solving problems; The life attitude of not avoiding, not flinching back and facing difficulties in the face of problems; The attitude of comprehensively analyzing problems and cooperating with peers to solve problems. The cultivation of students' emotional attitudes and values can not be achieved overnight, and can only be formed after long-term persistence. Therefore, when designing curriculum objectives, we should consider students' age and anti stress status, and teachers should give guidance and help in time.

3.3. Project Design

PBL Project-based steam curriculum design is mainly carried out through theme projects. Since the design of this project is very critical, a series of themes are usually designed, and each theme includes 2-6 projects. If there are too many items, the content of the whole course is too complicated, which is not conducive to students' learning; If there are too few projects, it will affect the systematicness and continuity of the course. The difficulty of each project and the range of knowledge points involved should have a gradient, progressive and spiral, so that students can systematically learn a certain knowledge point. Teachers determine the scope of knowledge and knowledge points according to the selected curriculum objectives. The knowledge points should also be designed according to the students' grade and the original knowledge base. If the knowledge points are too many or too difficult, students will lose interest in learning because they can't complete the project. In addition, when choosing knowledge points, teachers should choose knowledge points that are easy to practice or resonate with students. For example, the knowledge points of dripping experiment investigation are to master the measurement method, measure the volume of water, conduct time conversion, and be familiar with the conversion relationship between the volume and weight of water; Print a straw hat with a 3D printing pen; Understand why the sky is blue; Using scratch graphical

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programming language to make a teacher's Day e-card; A water cup with visible temperature is made according to module programming and mechanical principle.

3.4. Activity Design

Teaching activity design is the main part of Project-based steam course teaching design. Activity design is mainly to enable students to learn knowledge by completing tasks. At the same time, teaching activities are also the basis for students to carry out practical activities. Therefore, teachers should consider the following points when designing teaching activities: (1) teaching activities should focus on a task or solving a problem; (2) The knowledge points of an activity should be different according to students' age, knowledge base and cognitive structure; (3) Activities should not involve too many knowledge points; (4) Activity design should include specific operation steps and processes, and there is a certain logical relationship between each step. The operation steps should be concise and easy to understand, and students can operate independently according to the description. Project-based steam course teaching design generally includes five links: problem introduction, scientific research, activity production, communication and cooperation, summary and reflection. The corresponding teaching objectives are designed according to the specific contents, and the specific links of teaching activities are designed according to the teaching knowledge points. For example, the case knowledge points and activity design of dripping experiment.

Knowledge points of dripping experiment cases: understand the principle that dripping water adds up when the faucet is not tightened in daily life, find a way to measure the amount of dripping water in unit time, calculate the amount of dripping water in a year according to the time conversion relationship, design a scheme, calculate the monthly water consumption of a family, and then estimate how long the wasted water can be used by a family. Problem representation puts forward the key steps to solve the problem, and lists the problems to be solved by the subproject according to the learned knowledge. The dosage cup measures the dripping amount in 10 minutes, and calculates the dripping amount in a year by calculating the number of 10 minutes in a year. Master the measurement method and measure the weight of dripping water in 10 minutes. You can solve problems with the help of calculator and mathematical knowledge.

Activity design: (1) topic introduction. On November 19, 2020, affected by extreme weather, some communities in our city were cut off from water and power. Let's once again deeply realize the importance of water in people's life. However, in daily life, we always see the waste of water resources. For example, if the faucet that is not tightened is dripping all the time, how much water will it drip in a year? (2) Scientific inquiry. Find specific solutions to problems according to life experience and knowledge base. (3) Activity production. Use stopwatch, measuring cup and electronic scale to measure the dripping amount of faucet for 10 minutes, calculate the weight of water, and then calculate the annual dripping amount according to the time conversion relationship; Calculate the average daily water consumption by observing and recording your own tap water meter for a week, and then calculate how many days the tap water drops for a family according to the division knowledge. (4) Communication and cooperation. Communicate and share with students to see if there are many solutions to problems, which is more scientific, and what are their advantages and disadvantages. (5) Summarize and reflect. Summarize which links in the activity process are well done and which scenes can be extended to life.

3.5. Evaluation Design

The teaching objectives of Project-based steam course have many dimensions and strong operability. The design of teaching evaluation can be carried out by means of multiple evaluation. (1) Diversified evaluation objectives. In addition to evaluating the objectives from three dimensions, the Project-based steam course also evaluates the improvement of students'

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ability. (2) The evaluation subject is diversified. Teaching evaluation includes teacher evaluation, student evaluation, group evaluation and expert evaluation. In teaching evaluation, it mainly evaluates the improvement of students' enthusiasm to solve problems independently, communication and negotiation ability and creativity. (3) The evaluation methods are diversified. The evaluation of curriculum should be based on formative evaluation and combined with summative evaluation. Teachers can take the forms of observation, interview, questionnaire survey, group report and final report. Encourage students to display and report through PPT to exercise students' organizational expression ability; Students are encouraged to share their mental journey in the process of completing the project, the process of completing the project, what difficulties they have encountered in the process of completing the project, and how team members solve problems through unity and cooperation. Teachers comprehensively evaluate students' inquiry activities through students' filling in the project completion record form, PPT report display and writing the final report. Finally, teachers collect and sort out data information to understand students' activities, adjust the teaching design scheme and revise the teaching activity design process according to the analysis of students' learning situation.

4. Conclusion

Steam education emphasizes the integration of multiple disciplines and pays attention to the cultivation of students' practical ability, problem-solving ability and creative ability. The teaching practice activities of steam courses in primary and secondary schools are more and more widely used and valued. Designing teaching activities suitable for students of different ages' cognitive characteristics and experience, stimulating students' interest in scientific inquiry, guiding students to carry out problem analysis, engineering design, practical operation and creative programming, and cultivating primary and middle school students' practical ability, problem-solving ability, engineering design thinking, Computational Thinking and creative thinking are the direction we have been trying to study.

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