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Research on Teaching Design of Open Source Hardware Projects Based on Production Learning

-- Take "Smart Door Lock" as an Example

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Abstract: Digital tools such as mobile terminals, open source hardware, online learning platforms, and programming software continue to flood into our daily lives, gradually increasing people's ability to use digital tools to improve learning and facilitate their lives. In China's information age, using information technology tools to deal with people's daily lives and academic problems has become a very necessary ability. How to integrate the new generation of information technology and digital tools for learning in education and teaching to improve students' digital learning ability and higher order thinking dimension is a question worthy of deep consideration. The article starts from the concept of production learning and analyzes the suitability of the two in the context of the actual problems of teaching high school open source hardware courses, and uses "Smart Door Lock" as an example for classroom teaching. The article aims to improve students' core competency of "digital learning and innovation", and thus provide some useful reference and reference for high school IT teachers to implement open source hardware curriculum teaching.

Keywords: Production learning, Open source hardware, High school information technology.

1. Introduction

The new version of the General High School Information Technology Curriculum Standards includes open source hardware project design courses as optional compulsory modules, aiming to stimulate students' interest in innovation and develop their hands-on skills[1]. Using graphical development software and open source hardware for the design and development of simple information systems, the task-driven approach allows students to experience a relatively complete project development process, participate in thecreation, design, production, testing and operation of their works, and continuously improve their computational thinking. production learning, as a form of learning with visible external activities or concrete behavioral works and emphasizingstudents' active learning, fits well with the cultivation of students' computational thinking in high school IT open-source hardware teaching.

2. Concept Definition

The term production is derived from computer science and is a model of computation. Scholars believe that computers and the human brain have a similar way of processing information. They divide knowledge into declarative and procedural knowledge, and the reason why a computer can perform many tedious operations and solve complex problems is that it stores a series of "if ..... then ..... " form of encoding the reason. The human brain, after learning, can also store a series of rules in the form of "if ..... then .....", and such rules are called production[2]. production is a kind of "condition-action" rule, which can be classified as forward production from condition or reverse production from goal, based on the connection between knowledge and the expression of production in the problem solving process[3]. Solving a complex problem or completing a specific behavioral activity is usually the result of several production formulas acting together, and the conclusion of the former production formulas may serve as the condition of the latter production formulas, and when these production formulas are linked together, they constitute a production system. The mastery of the production system is also a way to use knowledge to solve problems.

The production learning process is divided into three stages: acquiring production, constructing production system, and generating new production, in which "acquiring production" refers tointegrating existing knowledge and skills, identifying problems, defining them, exploring ways to solve them, and acquiring scientific principles and knowledge. Students use the internalized production formulas as a lever to explore user needs, think differently and explore user needs from their own perceptions, thus forming a problem structure. The "constructing production system" points to students' active learning and the output of production learning, creating works in the collision of ideas, iterating on algorithms in model construction andprototyping, realizing the control of data use, and developing diversified thinking skills in reflection and summarization. The "Generate New production" highlights the delayed feedback and migration of production learning, in which students need to use multidisciplinary knowledge and skills to carry out project activities and develop their problem-solving ability, knowledge integration ability, teamwork ability, etc. in the process of actual problem solving, from the design, production, debugging, optimization and generation of works. This growth in thinking will not end with the end of project learning, but will affect all aspects of students' learning life, so as to achieve the effect of delayed feedback.

3. Suitability Analysis

After the promulgation of the new standard, China's high school information technology open source hardware project teaching has been vigorously developed, with the depth of teaching, the hidden problems are also exposed. (1)

Insufficient emphasis. In the teaching practice, teachers tend to focus on the basic knowledge of information, and pay less attention to such elective courses as open source hardware project design course, and the opening rate is low. (2) software and hardware facilities are backward. Open source hardware project teaching requires the simultaneous support of software and hardware facilities, and hardware wear and tear quickly, the construction costs are relatively high. (3) Single teaching method. Teachers lack enthusiasm for exploring teaching methods, and still use the traditional "lecture" method, with poor feedback from students and poor classroom results. (4) Poor learning initiative. Students' learning methods are not good, lack of practical training, learning content according to the gourd, easy to lose interest in learning. To sum up, these have become bottlenecks in the development of high school IT open source hardware project teaching[4].

Based on the problems that arise in the teaching of current open source hardware courses, an attempt is made to combine production learning with open source hardware project-based learning and to analyze their suitability, which is given in Table 1.

Table 1. Suitability Analysis of Teaching production Learning and Open Source Hardware Projects

	Production Learning	Open Source Hardware Project Teaching Process	Suitable Cutting Point
Object	Learner-centered	Learner-centered	Both are learner-centered
Principles	Learners are active learners and have the ability to Body Act Works	Hands-on, action-oriented	Both emphasize developing learners Hands-on skills
Purpose	Develop the ability to identify problems, solve them, and expand their application	Good at problem solving	Both are problem-solving oriented
Method	Brainstorming. Iterative optimization. Communication and collaboration. Prototyping. Presentation. Migration and application.	Teamwork. Self-directed inquiry. Communication and discussion. Prototyping.	Both are project-based and focus on developing students' cooperative learning and creative practice skills

4. Project Teaching Design of Smart Door Lock

4.1. Analysis of teaching and learning

4.1.1. Analysis of Teaching Objects

The object of this lesson is to teach students in the first year of high school open source hardware elective class. In the theoretical study, students have mastered the characteristics and basic functional principles of open source hardware, but there is still a lack of open source work prototypes using sensors, and it is necessary to strengthen students' ability to develop comprehensive open source hardware works.

4.1.2. Teaching Content Analysis

The high school information technology open source hardware elective course is established with the main goal of cultivating students' professional and technical core qualities, while taking into account theoretical knowledge mastery and practical task application, and guiding students to create and realize in the information technology environment. The "Smart Fan" case improves learners' ability to synthesize comprehensive project works made with various program modules and to deal with real-life problems through the design of smart fan works.

4.1.3. Analysis of Teaching Objectives

Knowledge and skills objectives: to understand the working principle and usage of RFID radio frequency identification module, touch sensor and servo; to understand the difference of data transmission methods between digital and analog signals; to master the hardware connection of multiple sensors, draw flowcharts and write programs, correctly build program circuits and connect electronic components.

Process and method objectives: to be able to reasonably design algorithms, call a variety of sensors in an integrated manner, complete data input and output and program control; use graphical programming tools and open source hardware, complete program writing, and create project works, and experience the complete process of production learning works of creativity, design, production, testing, and operation.

Emotional Attitude and Values Objectives: To experience the fun and sense of achievement of creating works from the production learning process, to cultivate students' inquiry ability and practical hands-on ability; to encourage students to use computational thinking, to relate to the practical life, to initially form the ability to use computational thinking to solve problems, and to realize the construction and development of self-knowledge.

4.2. Teaching process Design

4.2.1. Create Situation, Inspire Thinking

The teacher introduces the project learning objectives into the classroom in the form of a life situation: "Ask students to think about what are the ways of opening common smart door locks with their actual life experience and find information to summarize their functional characteristics." Students began to discuss intensely and go online to check relevant information, and concluded that common smart door locks are password locks, fingerprint locks, face recognition locks, etc. Next, the teacher further inspires students to think about how these smart door locks work. The students are assisted to conduct a knowledge review and gain a production experience in learning the knowledge of smart IOT modules. This leads students to conclude that the working principle of smart door locks is essentially sensor smart IOT. This introduces the task problem and stimulates students' interest in learning.

4.2.2. Problem Decomposition, Clear Task

The teacher heterogeneously groups students and guides them to cooperate and explore, controlling each group to 4-6 students, and provides a complete assortment of open source

hardware kits and raw materials needed to make a smart door lock, such as: colored cardboard, scissors, glue, etc. The teacher proposes a project task, i.e. to create a smart door lock with multiple door opening methods and verify its effectiveness. Students are led by the teacher to learn the working principle and hardware connection methods of open source hardware such as touch sensor, 4-digit digital tube, RFID RFID module, servo, and matrix keyboard. Students then construct a problem-solving production system, integrate their existing knowledge and experience, clarify the project learning support materials, and brainstorm in small groups to jointly elaborate the work functions, application scenarios and constraints of the smart door lock. Use mind maps or sketches of the work or text descriptions to make the creative ideas of the work design explicitly represented in the mind.

4.2.3. Exploration design, model construction

After clarifying the project learning tasks, each group summarizes the existing knowledge and the results of communication with peers, decomposes the project tasks of the smart door lock, completes the preliminary design of the project implementation plan, constructs the problem-solving model and fills in the project learning activity log. In this process, the teacher explained the basic concept of program flowchart and the way to draw it, and guided students to first describe the functions of the smart door lock work in natural language, and then convert them into program instructions through graphics and symbols to draw a program design flowchart. At the same time, each group shared the work design plan among themselves, checked the rationality and feasibility against the evaluation index, collected feedback, and made secondary revisions and iterative updates to the work design plan. Subsequently, based on the program flowchart, activities such as algorithm design and program debugging are carried out. The purpose is to develop students' awareness and ability to use program flowcharts to characterize algorithms and mathematical modeling, to guide students to express their thinking explicitly, to experience the logical structure of program design in the process of graphical programming, and to develop collaborative learning ability by cooperating with group members in programming.

4.2.4. Prototyping, Debugging and Optimization

According to the design plan, the team members make a reasonable division of labor and work together to make the prototype. First of all, the open source hardware components are connected, which are divided into matrix keyboard simulating password lock module, RFID RFID simulating access card module and touch sensor simulating fingerprint lock module. Among them, the matrix keyboard simulated password lock module is connected to the matrix keyboard and 4-digit digital tube through the breadboard, set the array variable default password as 1234, detect the digital signal input from the matrix keyboard and output it to the 4-digit digital tube to judge whether it is consistent with the default password; RFID RFID module is to read the IC card tag through the card reader, record the IC card string information, and use the judgment function judge whether the IC card tag identified by the transponder is consistent with the recorded one, if consistent control the servo to rotate and open the lock, if inconsistent, print the error message through the serial monitor. The physical diagram of the prototype connection of Panel 1 "Smart Door Lock" is shown in Figure 1.

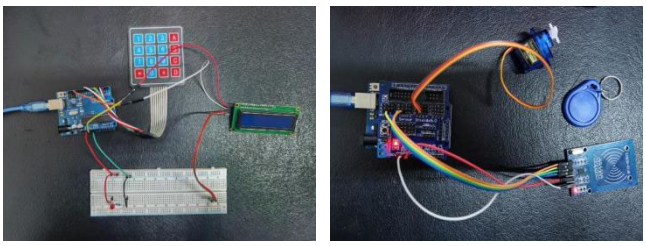

Figure 1. "Smart Door Lock" prototype connection physical diagram (left: combination lock, right: RFID access card)

The next step is to connect multiple open source hardware into a whole through a breadboard, debug the program, check the running effect, and then create the work with tools and materials such as cardboard, colored cardboard, and markers. During this process, the teacher gives advice and guidance to groups that are behind schedule, and assists students in prototyping and debugging their work.

4.2.5. Work Display, Iterative Update

After each group's work is completed, the work will be displayed and evaluated, and the learning group, other groups and the teacher will fill out the Project Work Evaluation Form. Firstly, the group will present their works on the stage in turn, introduce the process of making the smart door lock, the idea of writing the program, and demonstrate their works and report on the team division of labor. Secondly, during this process other groups listened carefully to the report and scored the work of the reporting group. Finally, the teacher will evaluate each group's production learning process and work and make suggestions.

4.2.6. Summarize and Expand, Transfer and Apply

The teacher summarizes the knowledge involved in the case study, RFID radio frequency identification module output is a digital signal, when the sensor recognizes the IC card and match with the stored card number string information successfully, control the servo rotation to open the lock, when the match fails, the digital signal will be transmitted to the buzzer to issue an alarm; touch module is simulated by the fingerprint touch to open the lock, when the detection is touched output high level, and vice versa for low level The matrix keyboard is used to control the rotation of the servo to open the lock by identifying whether the input numbers are consistent with the pre-set password. The teacher then inspired the students to think about the sensors and open source hardware modules used in the project, in addition to making smart locks, what other applications can be used in real life? Students were also encouraged to do secondary development to create other open source works related to the smart door lock. As can be seen, during the design and implementation of the "Smart Door Lock" case, students not only mastered how to connect multiple sensors of open source hardware, but more importantly, learned the ability to use interdisciplinary knowledge to solve complex problems through the analysis of user needs and the design of the work's functions.

5. Teaching Evaluation and Implementation Effect

The project learning of "Smart Door Lock" in programming teaching is mainly for students to learn to synthesize multiple sensors, use program flowcharts to characterize the process of program design logic and thinking explicitly, experience the complete project idea, design,

production, testing and operation process, and produce production learning works. In the process of smart door lock open source hardware connection and work prototyping, students first need to analyze and evaluate the connection of multiple sensor modules and reasonably select digital pins for hardware connection; secondly, they need to conduct repeated program debugging to obtain the optimal data range so that multiple sensors can work independently of each other as well as in unison as a whole. In terms of production learning, students experience the process of "acquiring production" and "constructing production systems", and are able to integrate and integrate their existing knowledge to solve problems, and have a preliminary sense of "generating new production" stage. The teacher only explains the single sensor involved in the project of "Smart Door Lock", and the students need to integrate these knowledge modules. In this process, the students develop new production formulas and acquire the ability of knowledge transfer and application based on the production system they have already built.

6. Conclusion

The essence of production learning is to emphasize students' active learning, focusing on cultivating students' ability to independently discover problems, construct problem-solving models, and practice hands-on problem solving. During the process, it is crucial for students to design problem-solving models and iterative optimization of algorithms, debug their works, repeatedly retrace and verify them, use their existing learning experience to build production learning systems, use open-source hardware and programming tools to realize the expression of abstract thinking into concrete form, and finally produce production learning works. At present, the research on the optimization of open source hardware curriculum still needs to be deepened, to introduce production learning into computer-assisted teaching, to continuously improve the teaching process, and to establish an assessment mechanism for teaching open source hardware curriculum, which has certain implications for high school open source hardware curriculum in cultivating students' creativity and digital learning.

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References

[1] LU Ya, “Design Thinking Based High School Open Source Hardware Project Teaching Design - Taking Little e Sound Control Lamp as an Example,”.Computer Knowledge and Technology,vol.16,pp.124-126,June 2020.

[2] YAO Xinwu, “Production and ITS Study in Mathematics of High School,”.pp. 30,2002.

[3] ZHAO Yiquan, LIU Xiaoming and ZHANG Xiangkui, “Strategic Knowledge: Making Students Independent Learners,”. Modern Education Science, pp.10-14,2003.

[4] LU Ya, YANG Wenzheng and XU Qiuxuan, “Research on Construction and Application of Open Source Hardware Teaching Model Oriented by Design Thinking,”.e-Education Research,vol.42,pp.100-106,2021.

[5] DONG Yan, and SUN Wei, “Research on the Production-based Learning (Do PBL) Model for Promoting Interdisciplinary Learning: Based on the Integrated Perspective of Problem-based Learning and Project-based Learning,”.Journal of Distance Education, vol.37, pp.81-89,March 2019.