# Research on the Teaching Mode of Artificial Intelligence Course Based on CDIO Concept

## Taking Open Source Hardware as an Example

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**Abstract.** The rapid development of the artificial intelligence era has had a profound impact on education, and the majority of experts and scholars are actively carrying out the exploration and practice of artificial intelligence courses at all levels from basic education to higher education. This study explores the model of teaching artificial intelligence in the classroom using the CDIO concept as a guide and open source hardware as an example. An in-depth interview survey of 27 secondary school IT teachers in City C was conducted to analyse the shortcomings of the current secondary school AI curriculum. A controlled experiment was conducted in the second year of secondary school Y. Students' AI literacy was measured using the Artificial Intelligence Literacy Scale, and independent samples t-tests were conducted using SPSS. The experimental results proved that the teaching model of the AI course designed in the study made a significant contribution to improving students' AI literacy.

**Keywords:** Artificial Intelligence; CDIO; Open Source Hardware; Educational Research

## 1 Introduction

Artificial Intelligence has become a strategic new technology for the future, and this new technology has brought new demands for talent training. Education is the main position for talent cultivation, and the New Generation Artificial Intelligence Development Plan released by the State Council as early as 2017 clearly states that AI-related courses should be set up at the primary and secondary school levels. Nowadays, AI education in primary and secondary schools has entered a stage of rapid popularisation, and the development of AI education can cultivate students' scientific and technological literacy and innovation ability, so that they can become talents with AI knowledge and skills, which is consistent with the concept of CDIO education. CDIO engineering education model is the latest achievement of international engineering education reform in recent years, CDIO stands for Conceive, Design, Implement and Operate, and the integration of CDIO concepts gives more possibilities for AI courses.


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The study mainly uses the literature analysis method to analyse the current status of the CDIO engineering education model and the current status of AI course characteristics and teaching. In-depth interviews with 27 teachers in City C identified the main problems in the actual teaching of AI courses in secondary schools. Aiming at the existing problems, research on AI teaching is carried out based on the concept of CDIO, taking open-source hardware as an example, and the designed teaching model is applied in the teaching practice of AI courses in the second year of middle school through controlled experiments. To test the effectiveness of the teaching model, students were tested using the Artificial Intelligence Literacy Scale, and independent samples t-tests were conducted using SPSS to finally analyse and explore the effectiveness of the teaching model in practice.

## 2 Current Situation Analysis

### 2.1 Current Situation of CDIO Engineering Education Model Research

Research into the CDIO engineering education model began earlier abroad, initiated and implemented by the Department of Aeronautics and Astronautics of the Massachusetts Institute of Technology (MIT) in the United States[1]. As early as 2001, the CDIO Competency Framework was officially published, and in 2004 the CDIO Engineering Education Concept was formally created and established as an international collaborative organisation, with subsequent research covering the three main areas of engineering, education and computing[2]. Domestic research on the CDIO education model began in 2005, and the first to introduce the concept of engineering education was Shantou University, with the aim of improving the quality of engineering education[3]. And then the major universities and colleges have launched research, CDIO education research now tends to stabilise the stage, achieved certain theoretical and practical research results[4].

However, there are some problems with the existing studies at home and abroad. In terms of the scope of the studies, there are few studies that are specifically focused on primary and secondary schools. In terms of research subjects, most of the current studies are in science and technology. In terms of research content, the existing research has not yet formed a systematic theoretical system, and the localised research and grounded research results are not plentiful enough[5].

### 2.2 Artificial Intelligence Course Characteristics and Teaching Status

Many countries include AI applications as an important part of the IT curriculum in primary and secondary schools[6]. Foreign researchers consider AI courses to be extremely challenging and need to include common algorithms for teaching[7]. The implementation of an AI curriculum facilitates the acquisition of AI concepts and reduces the gap between students at different levels[8]. Domestic AI education is usually based on the case teaching mode and the project teaching mode, and the AI curriculum in compulsory education can be divided into three sections: "basic experience", "interest

cultivation" and "independent investigation"[9]. Computing power, algorithms and data are the three main technical foundations of AI, which can intelligently solve complex problems with the support of chip computing power, while development boards lower the threshold of chip use and become the AI educational hardware for primary and secondary schools, so that students can understand the basic concepts of AI in a more intuitive way[10].

In general, the current research on AI curriculum for primary and secondary schools is still in the exploratory stage. In terms of teaching objectives, there is a serious polarisation between "theory-oriented" and "technology-oriented". In terms of curriculum resources, there is a lack of good teaching and learning resources that meet the needs of students. In terms of teaching tools, the pace of research into new technologies and hardware is slow.

# 3 Artificial Intelligence Classroom Teaching Model Design

## 3.1 Preliminary Research

In order to further understand the problems in the AI curriculum in secondary schools, a total of 27 IT teachers in some junior high schools in City C were interviewed and surveyed to find out the current status of the curriculum offerings. The analysis of the results of the interviews with teachers is shown in Figure 1, and the results show that there are major problems in the actual teaching, such as the single mode of teaching evaluation, failure to meet students' personalised learning, poor adaptability of teaching resources, inadequate Al Curriculum and inapplicability of traditional teaching modes.

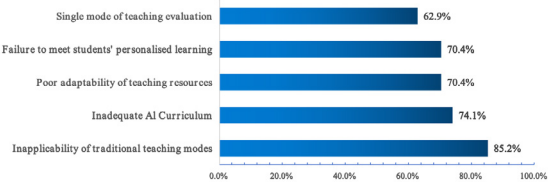


**Fig. 1.** Key Issues in Teaching Artificial Intelligence Courses

## 3.2 Teaching Model Design

Under the guidance of AI literacy, the diagram of secondary school AI classroom teaching mode based on the concept of CDIO is constructed to address the actual problems in teaching (Figure 2). Teacher activities and student activities for each part of CDIO are designed so that the entire activity takes place in an AI teaching and learning environment.

In the “Conceive” session of the CDIO model, a contextual introduction is used to stimulate students' interest. The teacher poses a question based on the situation, the students clarify the question as well as the task for the section, identify the task requirements, and make task assignments.

In the “Design” session of the CDIO model, conceptualising the design. Teachers provide scaffolding and appropriate guidance to help students complete the programme design. Students discuss and exchange ideas in their groups according to the task, formulate a plan and determine its feasibility, draw a flowchart of the procedure and design a work based on the formulated plan.

In the “Implement” session of the CDIO model, the entire work is required to be completed. Teachers observe students' behaviour in the classroom. Students complete hardware construction and programming. Teachers provide the code framework and students only need to consider the parts that are important to understand, and those who are able to do so can complete the entire programme on their own without relying on the reference code.

In the “Operate” session of the CDIO model, teacher organizes students to start communication. Students present their work in groups and actively engage in self and mutual assessment. Then the teacher makes an evaluation and asks the students to think about how to improve the work and to sort out the project considerations. Finally, the teacher summarises the whole lesson.

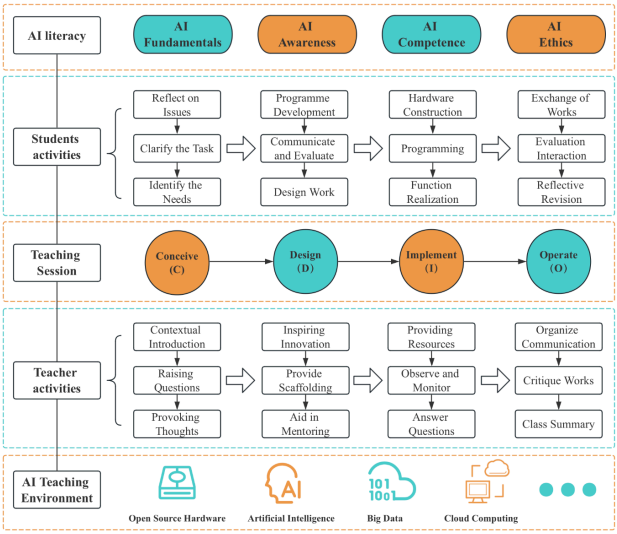


**Fig. 2.** Artificial Intelligence Classroom Teaching Model Based on CDIO Concept

## 4 Artificial Intelligence Classroom Teaching Practices

### 4.1 Objects of Teaching Practice

In the case of secondary school Y, for example, its AI course is offered in the second year of junior high school, with experiments in the form of open source hardware, and students have learned Python in the first year of middle school and have the appropriate programming foundation. Since the inception of the AI course, the school has provided

sufficient equipment support, using the UNIHIKER as hardware and Mind+ as programming software to form the project's operating body, and writing programs by dragging and dropping graphical blocks to program.

Two classes in the second year of the middle school were selected for the control experiment, with 44 students in the control class (Class A) and 42 students in the experimental class (Class B), with the same AI teaching environment and both taught by the same IT teacher. The control class (Class A) was taught using traditional teaching methods, while the experimental class (Class B) implemented the course according to the AI course teaching model based on the CDIO concept. The experiment began in September 2023 and ended in December, with a frequency of one lesson per week for a total of 12 lessons.

### 4.2 Process of Teaching Practice

Students were randomly grouped in groups of three in the first lesson using a set of UNIHIKER Learning Kits. The systematic study of the basics is launched in the first two lessons, students learn the basics independently through teaching resources, and the teacher answers their doubts. The next 10 lessons are dominated by the project operation.Taking the "Home Security Guard Intelligent Guardian Assistant" project as an example to illustrate the specific teaching practice process.

In the “Conceive” session of the CDIO model, using the video "Possible safety hazards at home" as a contextual introduction, the teacher asks the students to summarise what are the possible safety hazards at home. Then suggested that the common thread in these pitfalls is that information about danger is not perceived in time and information about help is not delivered in time. Next, ask students to consider: What features are needed to design an intelligent guardian assistant to keep the family safe? Students brainstorm in groups to clarify the requirements of the task.

In the “Design” session of the CDIO model, the task is concretised. Task 1 is to design an intelligent guardian assistant based on the functions it should have, formulate a design solution and draw a flowchart to solve the problem. The teacher sets up a learning scaffold and introduces the hardware that can be used and its functions. Pupils share the feasibility of the scheme and then make a list of the hardware required according to the need and select the appropriate hardware, e.g.: combustible gas alarm needs a flame sensor, voice alarm needs a voice sensor.

In the “Implement” session of the CDIO model, release Task 2 to complete the hardware build and programming. The teacher demonstrating the flame sensor build as an example. Students work in small groups to build and program the entire Home Security Guard's Intelligent Guardian Assistant work on their own. After students complete the construction and program, release Task 3 to complete the data transfer, hazardous information is transmitted in a timely manner without data transmission, this part of the self-study micro-learning form of development, group work to complete.

In the “Operate” session of the CDIO model, Teacher organizes students to present their group's "Intelligent Guardian Assistant", share their design ideas, problems and confusions encountered in the process of completing the project, and the teacher will do the Q&A and preliminary assessment here. And then the teacher makes a summary

evaluation to clarify the notes of the project. Ask students to think about what optimizations and improvements can be made to the "Intelligent Guardian Assistant", such as: can real-time communication be realized? Is it possible to add the function of one-key alarm? Finally, the teacher sums up the lesson, warns the students to see the value of AI correctly and to use AI wisely, and sublimates the issue.

### 4.3 Analysis of Teaching Effectiveness

A survey of students' AI literacy at the end of the entire teaching process. The Artificial Intelligence Literacy Scale was developed based on a number of national and international literatures and is divided into four dimensions, AI Fundamentals, AI Awareness, AI Competenceand and AI Ethics, and consists of 22 items, each of which is on a five-point Likert scale. A total of 86 questionnaires were sent to the two classes, the return rate was 100% and all were valid, and the independent sample t-test was conducted on the scales to validate the effectiveness of the AI classroom teaching model based on the concept of CDIO.

Before performing an independent samples t-test, the data need to be tested for normality. As can be seen in Table 1, the results of the Jarque-Bera test on the data show that all the AI Fundamentals, AI Awareness, AI Competenceand and AI Ethics do not show significance ($p>0.05$), which means that the original hypothesis is accepted (the original hypothesis: the data are normally distributed) and that the AI Fundamentals, AI Awareness, AI Competenceand and AI Ethics all have the qualities of normality and can be subjected to independent samples t-test.

**Table 1.** Results of the normality test analysis

| Dimension | Sample Size | $\chi^2$ | *df* | *p* |
|---|---|---|---|---|
| AI Fundamentals | 86 | 4.148 | 2 | 0.126 |
| AI Awareness | 86 | 4.109 | 2 | 0.128 |
| AI Competence | 86 | 1.904 | 2 | 0.386 |
| AI Ethics | 86 | 5.743 | 2 | 0.057 |

The data obtained from the scale was analysed using independent samples t-test and the results are shown in Table 2. As can be seen from Table 2, there is a significant difference ($p < 0.05$) in AI Awareness, AI Competenceand and AI Ethics of the students in the experimental group throughout the 3-month AI course,indicating that students in the experimental group showed a significant increase in the level of relevant competences after participating in the course. There was no significant difference in AI Fundamentals, probably due to the fact that both groups of students had a similar background of knowledge before starting the programme. In addition, the introductory content of the course is likely to be more basic and has not yet triggered significant knowledge differentiation, so the two groups of students performed similarly.

**Table 2.** Analysis of the results of AI literacy in the experimental and control groups

| Dimension | Groups | Sample Size | Average | Standard Deviation | Mean Difference | *t* | *p* |
|---|---|---|---|---|---|---|---|
| AI Fundamentals | Class A | 44 | 19.25 | 4.06 | -1.23 | -1.491 | 0.140 |
| | Class B | 42 | 20.48 | 3.53 | | | |
| | Total | 86 | 19.85 | 3.84 | | | |
| AI Awareness | Class A | 44 | 11.11 | 2.58 | -1.15 | -2.278 | 0.025* |
| | Class B | 42 | 12.26 | 2.05 | | | |
| | Total | 86 | 11.67 | 2.39 | | | |
| AI Competence | Class A | 44 | 21.59 | 5.45 | -3.22 | -3.209 | 0.002** |
| | Class B | 42 | 24.81 | 3.72 | | | |
| | Total | 86 | 23.16 | 4.93 | | | |
| AI Ethics | Class A | 44 | 23.80 | 4.83 | -1.87 | -2.073 | 0.041* |
| | Class B | 42 | 25.67 | 3.46 | | | |
| | Total | 86 | 24.71 | 4.29 | | | |
| * $p<0.05$ **$p<0.01$ | | | | | | | |

In order to assess the effectiveness of the course delivery more comprehensively and objectively, the students as a whole were analysed on the basis of scale data, student performance and classroom observation records. The final teaching results of the experimental and control classes show that in the teaching of AI courses, the teaching mode based on the CDIO concept has led to the improvement of students' overall performance and AI literacy compared to the traditional teaching mode.

## 5 Conclusions

This study proposes a research on the classroom teaching mode of AI based on the concept of CDIO, taking open source hardware as an example, and carrying out teaching practice through controlled experiments. The results of the study show that the AI course fully combines theory and practice through the support of open source hardware, which has a positive impact on students' AI literacy, and also verifies that the AI teaching mode based on the concept of CDIO has a certain degree of effectiveness, which provides a reference for subsequent courses. It should be noted that the teaching case has certain requirements for teachers and students' AI foundation and teaching hardware and software, and teachers can flexibly design the course according to the actual situation to cultivate students' AI literacy.

The limitation of the study is that, on the one hand, the number of experimental samples is limited and there are not enough research cases, so we can try to start the practice in other grades and other school segments and test the effectiveness of teaching this model by combining it with more real-life related AI cases. On the other hand, there is a need to further strengthen the correlation between the basic knowledge of AI, so that students can realise the integration of AI in the classroom. Subsequent research

could focus on strengthening the connection between basic AI knowledge and achieving deeper integration of open source hardware and AI.

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