Code Generation Teaching Cases Exploration for Software Engineering Based on CDIO-OBE

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Abstract—According to the demand of college curriculum reform, to enhance software engineering theory with practice, we have adopted the Outcome Based Education (OBE) educational concept based on field research on student internship units and enterprises. And explored software engineering teaching cases reform according to actual needs, we have put forward a software engineering teaching case design mode integrating CDIO-OBE, which is to explore, implement, and reform curriculum teaching cases that match the training of software engineering application-oriented talents. The teaching mode integrates CDIO-OBE, which takes the software reverse engineering and software development with automatic code generation cases as the carrier, combines the curriculum and practice to design and implement the project, and improves the students' practical ability and innovation ability.

Keywords—software engineering, reverse engineering, code generation, CDIO-OBE, powerdesigner

I INTRODUCTION

One of the goals of college curriculum reform is to cultivate applied talents, and the Outcome Based Education (OBE) model has flourished with the development of the times. OBE is a final result-oriented engineering education model, which aims to cultivate graduates who have the professional technical knowledge and professional skills and can quickly integrate into society. The basic idea of OBE is to grasp the reverse design method when implementing the course. Based on the course content, structure, and typical results of software engineering, implement the reverse design to select and arrange the teaching content, cultivate students' in-depth understanding of knowledge, and comprehensively apply all aspects of knowledge to solve the practical problems. The course implementation process includes the presentation of learning outcomes and the evaluation methods for the outcomes. The learning process should focus on the mastery of basic knowledge, the proficient use of environmental tools, the student-centered practical operation, the comprehensive application of knowledge, and the cultivation of innovative ability.

Reasonable connection of professional knowledge skills and social needs in the overall design of teaching cases, guiding students to master scientific thinking methods, promoting craftsmanship, integrating correct ideals and beliefs and social value orientation, identifying research directions,

and reforming teaching modes. It cultivates students from passive learning to proactive innovation and research and development through "case project-driven". And it improves students' learning ability and innovative consciousness with the help of various online and offline learning media. The CDIO engineering education model represents Conceive, Design, Implement and Operate, which meets the software industry's training requirements for applied talents, and is widely used in software engineering teaching reform practice. The complete and accurate operational steps are implemented in the document as a carrier to improve students' sense of achievement.

The CDIO-OBE engineering education model is conducive to students' observation, learning, imitation, exploration, analysis, innovation, etc. The student-centered teaching practice is conducive to students' acquisition of operational experience and knowledge skills, self-design of learning methods and processes, and then obtaining values and ability development. According to the actual needs of technological development in the software industry, and the skills, knowledge, and literacy requirements of enterprise work tasks, the teaching cases are reconstructed, so that students can grasp important knowledge and learn how to learn this knowledge. Finally, it lays a good foundation to provide students with sustainable development and employment in the future.

II INTEGRATION OF OBE AND CDIO EDUCATIONAL CONCEPTS

OBE originated in the 1990s and is a student-oriented, result-oriented educational teaching mode proposed by American educator William G. Spady [1]. At present, OBE [2] has been implemented in many countries such as New Zealand, the United States, and Australia, and has achieved good teaching feedback. In China, OBE is known as a result-oriented educational model [3]. And the three core conceptual models emphasized by OBE are output-oriented, student-centered, and continuous improvement. These concepts represent the direction of engineering education reform and advanced education concepts.

The CDIO [4] engineering education model is a teaching mode that reflects the innovative characteristics of the times and is based on engineering education. It was created by the

Massachusetts Institute of Technology and the KTH Royal Institute of Technology through long-term research, exploration, and teaching practice. As an emerging educational model and teaching concept, CDIO has become a profound change in engineering education with the rapid development of information technology. CDIO [5] represents Conceive, Design, Implement and Operate. Through the life cycle from software research and development to software operation and maintenance as the carrier, students can personally operate, personally experience the situation, and directly experience as the basis, emphasizing the whole process of participation in a learning-by-doing way. CDIO focuses on cultivating students' basic engineering knowledge and professional skills, emphasizing teamwork ability, and cultivating students to use scientific thinking methods to complete the conception, design, implementation, and operation of software, and become an innovation that meets the needs of the new era and can meet future challenges and achieve lifelong development talents in engineering.

Teaching cases are designed based on the educational concept of OBE-CDIO. Course cases correspond to the ability and knowledge cultivated in the course, clarify each person's expected learning output, strictly implement the CDIO education demonstration project, and ensure the effect of engineering teaching. Classroom teaching is student-centered, and teachers actively answer questions in the classroom, guide students to complete projects through design teaching, and supervise project quality. The course case adopts a variety of teaching methods to guide students to actively study, cultivate good study habits, and regularly summarize, reflect and evaluate the difference between the actual learning output and expected learning output at different stages, and can scientifically analyze the problems in the implementation process and overcome the constraints, find the reasons, adjust plans in time and improve teaching strategies.

Ⅲ DESIGN OF SOFTWARE ENGINEERING CASE TEACHING MODULE

The course case of software engineering is based on a RuoYi system as the mainline. According to the characteristics of the CDIO-OBE mode, it focuses on the combination of theoretical knowledge and practical content of the course, also better reflects the student-centered autonomous learning method. In the design of the course teaching case, the interaction between various knowledge modules is emphasized. Through the systematic study of modules, students should master the basic methods of the software engineering project implementation. Teachers can grasp the teaching content by comparing the knowledge point modules before class. The teaching of software engineering cases is divided into four modules according to the knowledge modules, namely: RuoYi system data model design (Design), the MVVM scheme conception (Conceive), RuoYi framework code generation (Operate), the front-end and the back-end implementation (Implement), and fully demonstrate OBE in each module of the case. In this teaching case, the learning outcomes of each module of the project can be displayed in the form of visualization, so teaching evaluation and quality testing can be carried out on this basis, and further improvement and expansion can be discussed.

A. RuoYi framework system class diagram

In the teaching case design with integrating OBE and CDIO, the requirement analysis of information systems in the early stage includes system function modeling, system object modeling, and system dynamic modeling. The system outline design includes system architecture design and database design. Taking data model design as an example, it provides examples of systematic data models. By establishing basic conceptual data models, logical data models, and physical data models, the concept of design (Design) is emphasized in CDIO. The design of the conceptual model is shown in Fig. 1. The data models in the examples can be used for reference by students, and the students can put forward improvement plans and optimized designs. In the process of information system project development, the functions of insertion, deletion, updating, and searching do not need to write code by yourself to improve work efficiency. A complete set of code can be generated directly according to the template and database, including the front-end and the back-end so that the operation of the database can be realized directly through the front-end. This greatly improves the efficiency of development. Students can quickly build a system only by building compound queries. Taking the software engineering reverse engineering project code automatic generation case module as the carrier, integrating the CDIO-OBE teaching mode, and combining the curriculum and practice to design and implement the project.

B. MVC, MVVM, and the design in CDIO
- MVC

The design in CDIO is relatively abstract, and it is difficult for students to learn and quickly concentrate on training. Good cases help students understand the content of engineering design, break through difficulties, and improve the training environment. A good design pattern can also make software easier to modify and maintain, and its structure has been developed over a long period to form a solution, reflecting the integrity of the creative design. This design has certain innovations based on feasible implementation. Design is a mode in the design process in which students focus their energy on the generation of design. MVC, namely Model-View-Controller model, corresponds to internal data, data representation, and input/output control parts, and they are designed separately. The process is: first, the Controller receives the user's request, and decides which Model to call for processing; then the Model uses business logic to respond to the user's request and returns data; finally, the Controller uses the View to represent the data returned by the Model to the user. The Model focuses on data and functions, the View focuses on data display, and the Controller focuses on user input, which has the advantage of expressing data and business rules separately.

(1) Model object

The Model object is the part of the application that handles the data logic. Changes in the Model object notify the View objects and the Controller objects through event processing.

(2) View object

The View object represents GUI objects, and represents the Model states in the format required by the user. The View object is the interface between the interactive system and the outside world. The View object can contain sub views, which are used to display different parts of the Model. Typically, each view object corresponds to a Controller object.

(3) Controller object

The controller object represents events, processes the user's input behavior, sends business events to the Model, and parses them into actions performed by the model. At the same time, the update and modification of the Model are notified to the View through the Controller, so that each View is consistent with the Model.

- MVVM

MVVM improves upon the MVC with better separation of the View and the Model.

(1) Composition structure of MVVM

a) Model layer (Model): refers to the data model, or refers to the data access layer of the content. In the architecture where the front-end and the back-end are separated, it can be understood as the data passed from the back-end to the front-end.

b) View layer (View): refers to the user interface.

c) View Model layer (View Model): This layer is mainly responsible for the communication between the Model layer and the View layer, and the binding of data and views. This layer encapsulates and passes data to the View layer, and passes the behavior and state changes of the View to the Model layer.
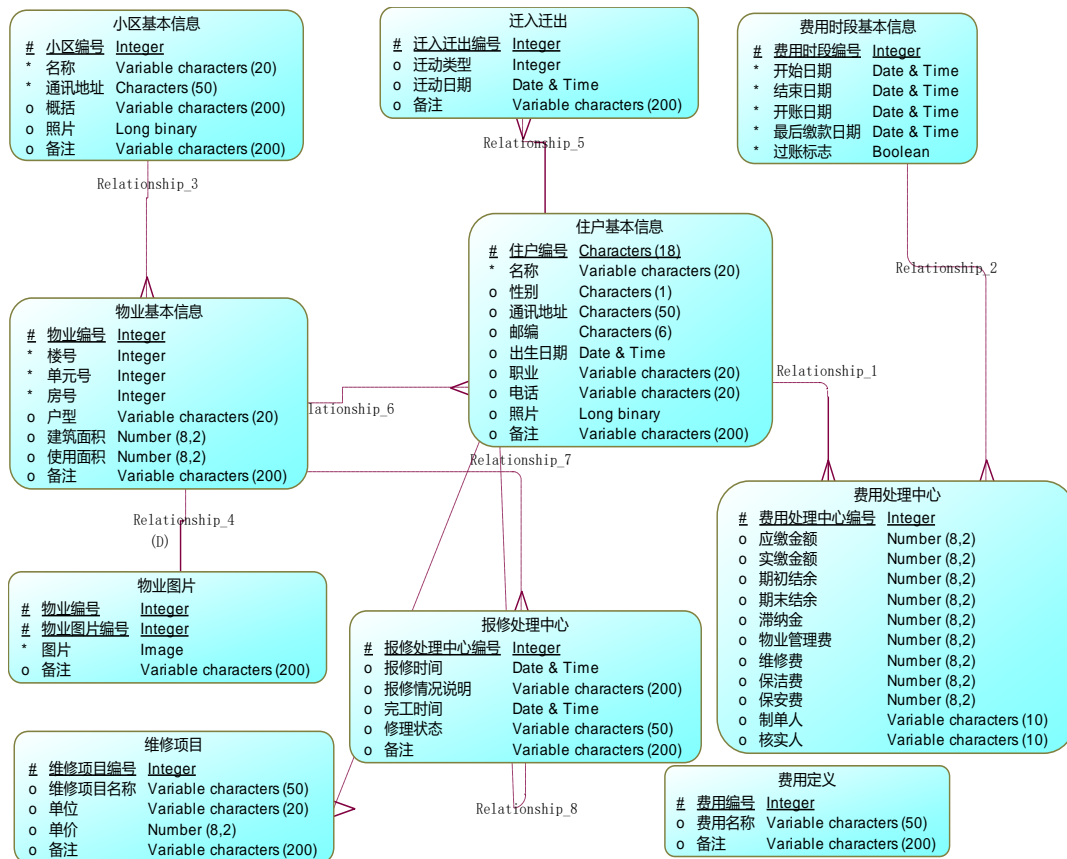

Fig.1　Design of the conceptual model

(2) MVVM and developed separately from the front-end and the back-end

The course cases in this paper are developed using a front-end and back-end separation architecture. In this architecture, the back-end corresponds to the Model layer in the MVVM, which processes business logic about the database system, encapsulates data (mainly in JSON format), and transmits it to the front-end. The front-end corresponds to the View Model layer and the View layer in the MVVM. The data obtained by the front-end from the back-end is encapsulated by the JavaScript code to generate a view data model that meets the expectations of the View layer, and display it in the form of a web page. When the View changes, the front-end initiates a request to the back-end through the JavaScript code according to the interface rules agreed with the back-end. The MVVM reduces the coupling between modules, and the front-end and

back-end separation architecture improves development efficiency.

- Design in CDIO

The student-centered teaching mode emphasizes individualized learning for students. In the technical application of the front-end and back-end separation, some students will ask questions. Many codes in the project are duplicated, and the codes of almost every basic module are functions of insertion, deletion, updating and searching, and these functions are similar. If you write these codes yourself, it will reduce the efficiency. Inspire students to think actively and seek solutions by themselves. These repetitive codes can be generated using code (java, html, xml and sql for front-end and back-end code), through unified JSON data format design, and code generation through tables imported into the database.
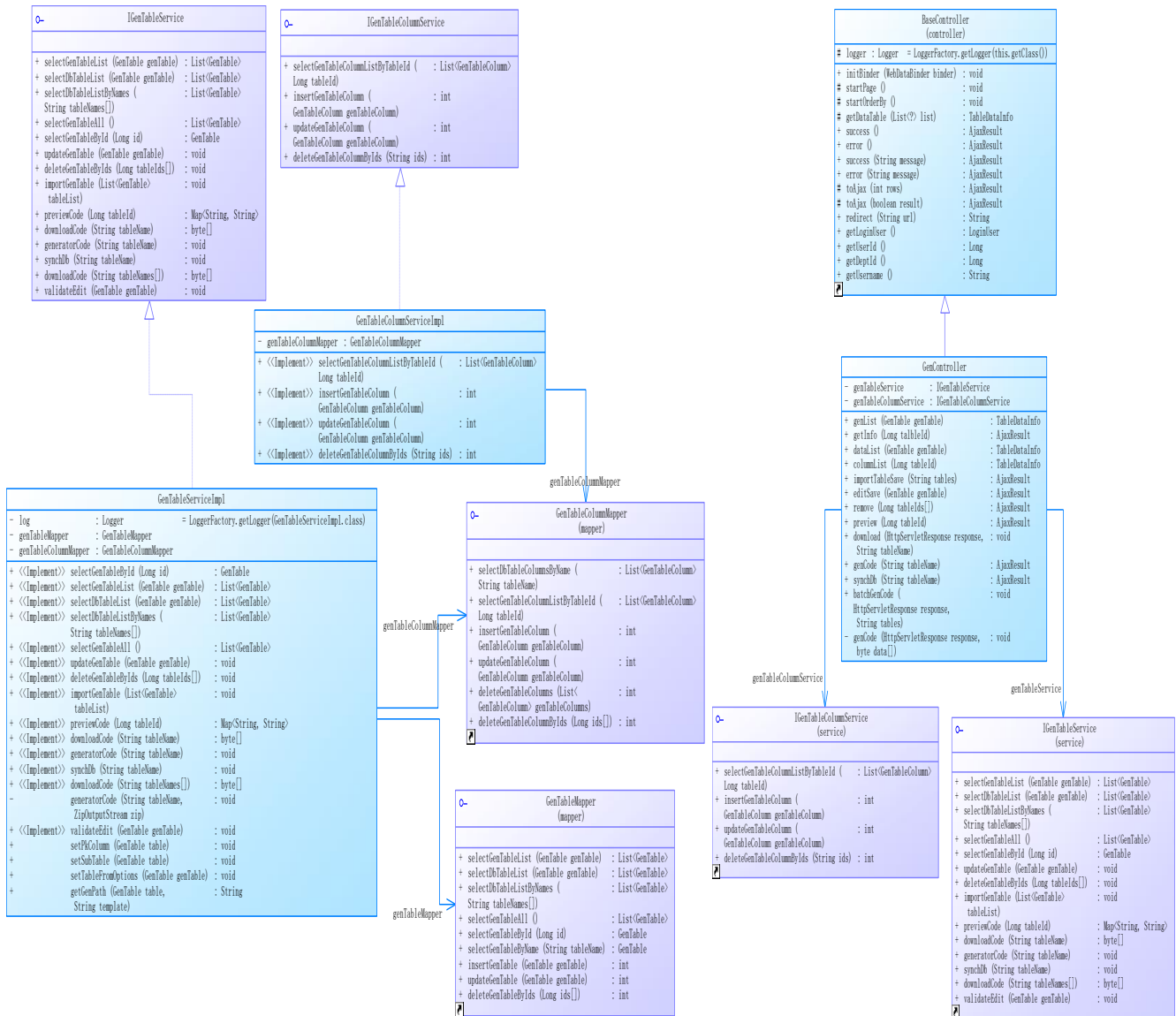
Fig. 2   RuoYi framework code generation service and controller class diagram

C. RuoYi framework code generation case

RuoYi framework which is shown in Fig. 2 is a back-ground management system developed based on Java technology. At present, officially maintained are three versions including RuoYi (non-separation), RuoYi-Vue (the front-end and back-end separation), RuoYi-Cloud (micro service). And the license agreement is MIT (open source). This case mainly uses RuoYi-Vue for code generation based on the front-end and back-end separation. The framework is based on a combination of classic technologies. The front-end uses Vue, Element UI, and the back-end uses Spring Boot, Spring Security, Redis, MyBatis, Jwt technology, which is a Java EE enterprise-level rapid development platform. Its built-in functions include user management, department management, menu management, role management, operation log, login log, code generation, system interface, etc. It supports online scheduled task configuration; supports cluster; supports multiple data sources; supports distributed transactions. This teaching case mainly uses the menu management and code generation functions in the RuoYi

system, allowing students to experience the simplicity and efficiency of development, thereby stimulating their interest in learning. The following will show the code generation process by adding a new community user management module:

- Environment set up

Install and configure IEDA, node.js, MySQL, and Redis environments on Windows system.

- Modify the configuration

Open the RuoYi-Vue project with IDEA, install the Vue.js plugin, find the RuoYi-admin module, create a database named ry-vue in the database, and execute the sql script in the sql folder. Check the username and password in the application-druid.yml file in the admin module (default username is root and password is 123456).

- Project operation

Run the main( ) of the RuoYi Application class in the ruoyi-admin module, enter the ruoyi-ui folder on the front-end, enter npm run dev, the RuoYi project runs successfully, click to log in (initial username is admin and password is admin123).

- New a user basic information table (est Owner)

The table fields and tables of the RuoYi database table need to add comments, the comments are the display content of the generated page.

序号	字段列名	字段描述	物理类型	Java类型	java属性	插入	编辑	列表	查询	查询方式	必填	显示类型	字典类型
67	OwnerCode	住户编号	char(18)	String ∨	ownercode	☑	☐	☐	☐	= ∨	☐	文本框 ∨	∨
68	est_EstateId	费用编号	int	Long ∨	estEstateId	☑	☑	☑	☑	= ∨	☐	文本框 ∨	∨
69	Name	名称	varchar(20)	String ∨	name	☑	☑	☑	☑	LIKE ∨	☑	文本框 ∨	∨
70	Sex	性别	char(1)	String ∨	sex	☑	☑	☑	☑	= ∨	☐	下拉框 ∨	∨
71	Address	通讯地址	char(50)	String ∨	address	☑	☑	☑	☑	= ∨	☐	文本框 ∨	∨
72	PostalCode	邮编	char(6)	String ∨	postalcode	☑	☑	☑	☑	= ∨	☐	文本框 ∨	∨
73	Birthday	出生日期	datetime	Date ∨	birthday	☑	☑	☑	☑	= ∨	☐	日期控件 ∨	∨
74	Career	职业	varchar(20)	String ∨	career	☑	☑	☑	☑	= ∨	☐	文本框 ∨	∨
75	Telphone	电话	varchar(20)	String ∨	telphone	☑	☑	☑	☑	= ∨	☐	文本框 ∨	∨
76	Photo	照片	longblob	String ∨	photo	☑	☑	☑	☑	= ∨	☐	∨	∨

Fig.3   Modify field information

Fig. 4   Generated code preview

- New a module

New a module named ruoyi-est, and introduce the new ruoyi-est module into the pom.xml of the entire RuoYi project and the pom.xml of the ruoyi-admin module. Because the automatically generated code should use the con- tent in ruoyi-common, you need to introduce ruoyi-common into the new module. Then click [System Management]-[Menu Management]-[New Menu Directory], new a community user management directory, and the routing address is est (new module name).

- Code generation

Find [System Tools]-[Code Generation]- [Import Table], select to import the sys_est table just new, click [Edit], [Generate Information] after importing, you can choose to generate a single table or tree or main-sub table according to your need. Modify field information is shown in Fig. 3. You should note that the generated package path (com.RuoYi.est) is the package path of the generated back-end code. The generated module name and the generated business name together constitute the automatically generated request path in the back-end code, that is, the page path. Therefore, the

generated module name and the generated business name should be inconsistent. You can click to preview the code as shown in Fig. 4. Finally, you can generate the code (select the zip file).

- Run the back-end code

The sql file in the compressed package of the code generation is used to generate the menu, and the generated xxx.sql file is executed in the ry- vue database. Copy the main directory of the automatically generated code file directly to the src directory of the new module (ruoyi-est), and replace the original main directory. Finally, compile and restart the back-end service.

- Run the front-end code

Copy the automatically generated code file vue directory directly to the src directory of the front- end project, replace the original directory, and restart the front- end service. You can see the new function menu (community user management) as shown in Fig. 5.

Fig. 5   Generate page

At this time, you can visually insert, delete, update, search and export user information. Click the button on the right to modify the overall page style, theme color, navigation mode, and table general style to your favorite style.

D. *Front- end and back- end interface*

At present, many systems adopt the development mode of the front-end and back-end separation, and the work of the front-end and the back-end are completed by different engineers. In this development model, maintaining a timely

and complete Rest API documentation will greatly improve our work efficiency. Traditional interface documents are manually written by the back-end developers, but this method is difficult to ensure the timeliness of documents and will lose reference significance over time. Swagger gives us a whole new way to maintain API documentation. To make the development process more concise and efficient, the RuoYi

system provides Swagger to generate interface documents. The following will introduce the interface documents provided by the RuoYi framework:

(1) Open the [System Tools]-[System Interface], click http://localhost:8000/api/v3/api-docs to view the interface documentation in json format.

(2) json format verification through online tools is shown in Fig. 6.

IV IMPLEMENTATION POINTS BASED ON INTEGRATING WITH OBE AND CDIO

Course cases and practical projects need to keep up with the development trend of the software industry, and students' learning outcomes need to meet the requirements of enterprises. Through the reform of teaching case, develop the students' ability of software engineering application, software project development and testing ability, professional quality, etc., make the students familiar with the software project

development process and specification, to develop good software, cultivate good habits of development. Improve students' ability to use what they have learned through teaching cases, learn to solve specific problems according to actual situations, which cultivates students' sense of innovation and teamwork spirit. And more importantly, students can contact the most cutting- edge new technologies through cases. The phenomenon of "working behind closed doors" can be avoided, and effectively promote the growth of students.

Fig. 6   json format verification

Theory and practice are two important aspects of the teaching process, neither is indispensable, and the two complement each other. The practice system of software development should closely follow the development of the software industry, and pay attention to the cultivation of the comprehensive quality of software talents and innovation consciousness. Therefore, the actual system of software development should be layered. First, the course cases are divided into knowledge blocks, and teaching, imitation, upgrading, and comprehensive projects are provided for each knowledge block. Second, these projects are CDIO projects, and among stages is the comprehensive application of multiple knowledge blocks. The classroom is student-centered. By designing project case modules, improving the detailed operation guide document of each module, and guiding students to complete the tasks of each module step by step according to the document steps. Teachers are carefully guiding, supporting, and cultivating students to complete tasks, and improve students' real interests, patiently pointing students to confusion so that students continue to progress. Teachers should pay attention to education in the teaching process so that students can enjoy the joy of success. Students complete knowledge learning in advance according to the teaching micro-video before class. Teachers teach basic projects in class, guide students from simple to complex, from easy to difficult, and connect before and after. The teaching level is more in-depth and thorough.

V CONCLUSIONS

This paper discusses the design and implementation of the software engineering teaching case module with the CDIO-OBE education mode. The teaching of software engineering cases is divided into four modules according to the knowledge modules, namely: system software structure design and data model design (Design), MVVM scheme conception (Conceive), RuoYi framework (Operate), front-end and back-end implementation (Implement), and fully demonstrate OBE in each module of the case. In this case, the learning outcomes of the project can be displayed in the form of visualization. The concept of the engineering education mode based on CDIO-OBE can cultivate students' innovative spirit and improve students' ability to solve practical problems, which is an effective means to strengthen practice. From the review and evaluation results, it can be seen that the teaching effect of this teaching concept mode is obvious, and it has teaching theory and application value.

VI ACKNOWLEDGMENT

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