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Exploration and Practice of the Training Model for Curriculum in Engineering Education: A Case Study of Emergency Communication

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Abstract: In the field of emergency communication teaching, traditional approaches are increasingly struggling to keep pace with the rapid development of modern industries. These conventional models focus primarily on one-way transmission of theoretical knowledge, leading to a disconnect from real-world application scenarios. Consequently, students lack practical proficiency and fail to meet the industry's talent requirements. Through a thorough analysis of the shortcomings in existing curriculum plans, this paper innovatively proposes a teaching model based on OBE-CDIO and actively applies it to the teaching practice of emergency communication technology. During implementation, teaching content is systematically broken down into multiple interrelated sub-projects to form a complete project chain. For each project, the four key phases of the CDIO framework are strictly adhered to: Conceive (to inspire creativity), Design (to formulate plans), Implement (to put ideas into action), and Operate (to test outcomes). Simultaneously, assessment methods have been reformed: open-ended questions are used to evaluate students' thinking abilities, while project-based assessments measure their practical achievements. This enables a comprehensive and accurate evaluation of teaching effectiveness. Finally, student feedback was collected via questionnaires to conduct an in-depth analysis of the application of this emergency communication curriculum training model in engineering education. The results indicate that this model has yielded significant results in boosting students' learning interest and practical abilities, while also significantly enhancing the quality of emergency communication teaching.

Keywords: OBE; CDIO; Emergency communications; Course teaching mode

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1. Introduction

Emergency communication is an important part of the emergency response mechanism, drawing increasing attention not only from the communications sector but also from governmental authorities. Emergency communication systems in city operations during sudden disasters or accidents bear the function of timely, accurate, and smooth transmission of first-hand information, as the decision-makers correctly direct the rescue

and relief of the central nerve [1]. At present, the country the provinces, and cities are in urgent need of talent in this area, and the construction of an emergency communication teaching system provides a basic guarantee for talent cultivation.

ITU-T began to pay attention to emergency communication in 2001, mainly from the provision of international emergency calls and network support for emergency communication needs to enhance the capacity and other aspects of research, involving the emergency communication service ETS (Emergency Telecommunications Service) and disaster reduction communication service TDR (Telecommunication for Disaster Relief). ITU-R, as an international standard organization, mainly conducts research on emergency communication from the perspective of early warning and disaster mitigation, including the use of fixed satellites, radio broadcasting, mobile, wireless positioning, etc., to provide the public with emergency services, early warning information, and disaster mitigation [2].

The Outline of the National Plan for Medium- and Long-term Educational Reform and Development (2010–2020) highlights quality improvement as the core task of higher education development. The supply-side structural reform of higher education is to improve the quality of talent training on the supply side, oriented to social demand so that graduates can meet the needs of society and their development, and so that China can move from a large country of higher education to a strong one at an early date [3].

Over the past two decades, numerous countries have been actively promoting the reform of engineering education, exploring the cultivation mode of innovative engineering and scientific talents, optimizing the engineering education mode and teaching methods, and improving the comprehensive ability of graduates. The CDIO initiative, a modern outcome of global engineering education reforms, focuses on equipping students with essential engineering and technical knowledge, personal and team skills, and system abilities necessary for thriving in modern engineering environments. And advocates the educational concept of 'learning by doing'. It advocates the educational concept of 'learning by doing' and guides students to learn engineering content in an active, practical, and organically linked way between courses [4–6].

The teaching objective of the emergency communication course is to enable students, through learning, to master emergency communication-related technologies, and to be able to choose efficient communication technologies to deal with and respond to the occurrence of events in response to sudden and specific emergency events, and to play a role in mitigating emergencies. In this paper, we will combine the CDIO engineering education model with the OBE teaching concept as a guide to explore the teaching mode of the emergency communication course applicable to emergency management and communication engineering majors [7–10].

2. Features and challenges in the emergency communication course teaching

"Emergency Communications" is a professional limited course in the teaching of emergency management and communication engineering, and the teaching content is built based on "Emergency Management" as well as "Principles of Communication," "Computer Communication," and other basic compulsory courses, involving relevant knowledge of system science and information science. Starting from the goal of safety rescue, the course applies the basic principles and methods of communication engineering to provide emergency protection for public emergencies. Emergency communication is characterized by the suddenness of time, the uncertainty of location, the uncertainty of capacity demand, the diversity of information, and the complexity of the environment, which puts forward higher requirements on the transmission and exchange of information, and constitutes its industry characteristics. It seeks to find accident warnings from human-machine relationships and methods to

improve system reliability communication.

Due to the content of the emergency communication course involves architecture, emergency communication vehicles, satellite communication technology, individual emergency systems, digital trunking communication, short-wave communication, microwave communication, wireless positioning technology, and the development of new technologies, etc., the knowledge structure is more complex, the application requirements are higher, and at the same time, there are big differences in the mastery of students for the basics of wireless communication, which leads to a big difference in the teaching process of students' understanding of the knowledge points, and the effect of classroom teaching is difficult to achieve the intended goal [11–13].

Teaching challenges in the emergency communications course are as follows:

(1) Students have low attention spans in the classroom. Emergency communications courses are usually offered in the seventh semester when students are facing graduation and are at a stage where they need to think about their future development. Things such as postgraduate exams, job searches, and various civil service exams affect students' interest in learning their professional knowledge, and learning efficiency is generally low.

(2) Classroom teaching methods are boring. The emergency communication system has many knowledge points, and each knowledge point is scattered and abstract, the traditional PPT lesson plan teaching, it easy to cause students to have a lower understanding of knowledge points in class, and cannot stimulate the students' interest in learning, after the class is even less interested in reviewing the contents of what has been learned.

(3) A single method of assessment. Before the examination, students usually just combine the examination papers of recent years and adopt a rote learning way of preparing for the examination, without understanding the meaning of the knowledge points, which leads to students forgetting what they have learned after the examination.

(4) The experimental operation is unclear. The traditional experiment is a kind of operation procedure arrangement; students follow the steps to experiment. Students do not have a full understanding of the relevant theoretical knowledge, and cannot analyse the causes of different experimental phenomena from those in the experimental guidebook, which fails the experimental class to foster problem analysis and problem-solving skills.

The above aspects have led to a year-on-year decline in the pass rate of the course and a gradual decrease in the number of students taking the course. How to improve the teaching quality of the course has become an urgent problem for the emergency communications program.

3. Existing teaching reform programs for professional courses

With the rapid development of modern information technology, college students in higher education have a strong interest in and acceptance of new things, new technologies, and new forms of application. The richness of network resources and the widespread popularity of streaming media have provided more and wider new ideas for modern teaching. Aiming at the problems existing in the teaching of traditional professional courses, many education practitioners have researched and summarized the corresponding reform model, which can inhibit or improve the effect of one or several problems [14,15].

The content of the emergency communications course covers a wide range of technologies and application areas, which requires students to have strong knowledge of the fundamentals of wireless communications and

the ability to quickly adapt to new technologies. Because of the teaching problems faced by the emergency communication course, the following improvements are suggested:

(1) Increase student motivation: Since students are distracted as they are approaching graduation, they can improve their interest in learning by adjusting the course schedule and advancing courses with strong practicality. At the same time, the importance of emergency communication in students' future career development should be emphasized to stimulate their learning motivation. Meanwhile, different levels of teaching content are designed according to the student's basic knowledge level, for students with a weak foundation, remedial courses or tutorial session on the basics of wireless communication can be added.

(2) Adoption of diversified teaching methods: To address the problem of boring traditional classroom teaching methods, case teaching, role-playing, simulation exercises, and other interactive teaching methods can be used to increase students' participation and interest. Encourage students to participate in classroom discussions, and stimulate students' interest and initiative in learning through questions and group discussions. For example, by simulating emergency communication scenarios, students can operate equipment in a simulated environment to enhance their practical ability.

(3) Reform of appraisal methods: To address the problem of a single assessment method, diversified assessment methods, such as project reports, practical tests, and group discussions, can be adopted to comprehensively assess students' learning effectiveness. At the same time, students are encouraged to demonstrate an in-depth understanding of the knowledge points in the examination instead of just memorizing them. Through regular tests and assessments, students' learning progress is monitored and timely feedback is provided to help them adjust their learning strategies.

(4) Enhancement of experimental teaching: For problems where the experimental operation is unknown, students can take the initiative to explore and solve problems in the experiment by designing more challenging experimental projects. Teachers should provide clear experimental instructions and guide students to understand the experimental principles and operation steps during the experiment. Online courses and virtual simulation experiments, such as 5G airwave propagation and wireless channel measurement experiments, are utilized to provide students with flexible learning methods.

(5) Use of information technology: Promoting the development of 'education + Internet', establishing a system of digital educational resources covering all grades and subjects, accelerating the construction of digital campuses, and actively exploring Internet-based teaching. The latest emergency communication technologies, such as satellite communications and unmanned aerial vehicle emergency communications, have been integrated into the curriculum so that students are aware of the latest trends in technological development.

(6) Strengthening the teaching staff: Improving teachers' educational and teaching skills, especially their practical teaching skills. Teachers' professionalism and teaching skills can be upgraded through teacher training and industry exchanges.

(7) Optimizing course content: The course content is regularly updated according to the development trend of the industry and the needs of students to ensure that the teaching content is cutting-edge and practical. Students are encouraged to learn across disciplines and incorporate knowledge from other fields, such as geographic information systems (GIS) and data analysis, to enhance their understanding of the application of emergency communication technologies.

(8) Enhancement of practical teaching equipment: Increase practical teaching equipment to improve the hands-on ability of students and ensure that they can acquire the necessary skills in practical operations.

Through case studies, laboratory practice, and on-site exercises, students' practical skills are improved. For example, the use of emergency communication vehicles for practical training allows students to understand the specific applications of the equipment.

(9) Create an interactive learning environment: Encourage students to ask questions and discuss in class, and improve their participation and cooperation through cooperative group learning. Explain the specific requirements of emergency communication for networks and equipment, such as network flexibility, rapid deployment, miniaturization, energy efficiency, ease of operation, and good service quality assurance. Through analysing the application cases of emergency communication in actual disaster response, such as the drone emergency communication guarantee program in the Henan floods, students will understand the application of theoretical knowledge in practice.

(10) Focus on individual student differences: Personalized teaching support is provided to help each student make progress, based on their different learning styles and ability levels.

Through the above measures, the teaching quality of emergency communication courses can be effectively improved, students' interest in learning can be stimulated, and their professional skills and practical ability can be enhanced.

4. OBE-CDIO-based teaching model for emergency communication

Aiming at the teaching characteristics of the emergency communication system, combined with the OBE output requirements and CDIO process-led teaching ideas, the innovative teaching mode based on OBE-CDIO is proposed to adapt to the talent training objectives of the emergency communication system. The OBE-CDIO teaching mode is shown in **Figure 1**, which consists of the knowledge and skills, specific projects, whole-process assessment, and the assessment results. The knowledge and skills that students need to master through the study of the course are taken as input, the whole process assessment is carried out through the execution of specific projects, and the output is the result of the systematic assessment method. Emergency tasks, as a single project, form a teaching cycle, by using multiple tasks with the same knowledge and splitting different knowledge to form a multi-cycle chain, constituting the entire OBE-CDIO emergency communication teaching mode. In each segment of OBE-CDIO, the teacher guides the students through the instructional design to conceptualize and design the product attributes, such as what software and hardware the system needs to output consists of and what functions it can realize, and finally, realize and run the designed system. The meanings of the components are as follows:

(1) Project. Aiming at specific practical projects, set up project groups containing most of the main teaching contents according to the teaching requirements of emergency communication. Teachers explain the relevant knowledge in the classroom and guide students to complete the practical objectives of the projects. Unlike the existing project teaching mode in which students are required to master the relevant knowledge base on their own, the basic content of teaching in OBE-CDIO is still led by teachers in the classroom, which helps to improve the average learning efficiency of students' classroom learning.

(2) Conceive. After setting up project clusters, each project relies on the development process of an emergency product. The form, attributes, performance, and realized functions of the product are first conceptualized. Learning is done after listing all the product attributes one by one. At this stage, the teacher needs to prepare all the attributes of the product and related teaching content in advance. After students complete the conception of the product, timely supplement the content that students have not considered, and at the same time expand the corresponding professional basic knowledge. Different

from the existing teaching mode, OBE-CDIO pays more attention to the teacher's control of classroom dynamics in the classroom and can correct the unsatisfactory teaching atmosphere at any time. It is more conducive to teaching reform experiments and prevents students from feeling the abruptness of the teaching content or the discomfort of the teaching method.

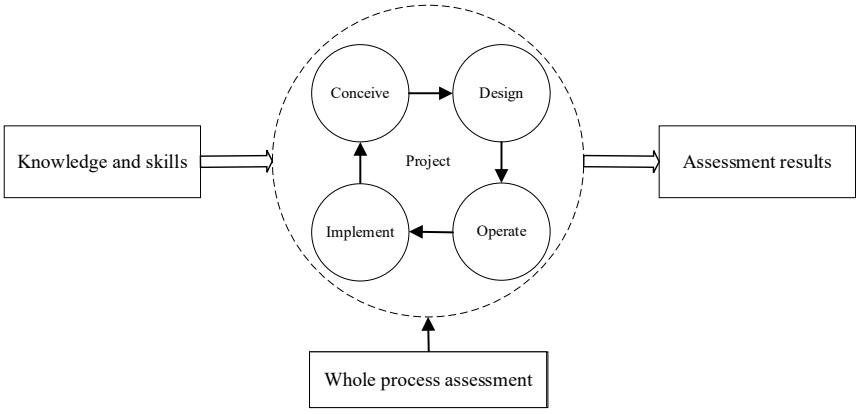

Figure 1. OBE-CDIO based teaching model for emergency communication.

(3) Design. After completing the conception, according to the attribute requirements of the emergency communication product and the project objectives, students design the product, including the specific implementation steps, what kind of tools to use, including hardware, software, and professional process, product compliance requirements, etc. If the product is an APP, the design includes programming language (Python, C, Java, etc.) selection, hardware platform performance configuration, algorithmic process, realization of the function, and so on. In short, it is the design of the specific process steps for the production of the product. At this stage, the teacher needs to prepare relevant process methodology teaching and a standard reference example in advance, while paying attention to the scalability of the example, to help students realize the personalization of the design. Reminders are given on factors that may lead to failure. This part is demanding and requires that students be prepared beforehand to efficiently complete the required product design.

(4) Implement. After the design is completed, the implementation verifies the product design. A feasible design completes the output of the result through the implementation. In contrast, a defective design will result in a non-ideal output. Feasible product designs are distinguished into different grades based on the variability of the realized output, i.e., failed, feasible, reasonable, and preferred. The corresponding grades are assigned to the students' realizations, and the designers are assigned the corresponding marks. The realization component strengthens the assessment of the students and increases their initiative more effectively.

(5) Operate. The main elements that operate in OBE-CDIO are the evolution of the implementation improvements and technical support. The main embodiment of the product realization through the previous stage, and at the same time, based on feedback, to decide whether the product needs to be upgraded and improved. All products require technical support, with the instructor playing the role of the consumer to examine the product and provide feedback on the application of the product, and the student giving the appropriate technical response or demonstration at a specified time. Similar to the realization phase, this phase also provides suggestions for assessment methods.

The OBE-CDIO model combines the experimental character of teaching reform at the primary level,

improves the weakened dominance of teachers in the existing active teaching mode, and enables teachers to better revise the development direction and presentation effect of teaching. Students are better able to adapt to the change in teaching methods under the OBE-CDIO teaching model, and differences in learning bases are not magnified as a result. Teachers in the conception and design phase of the basic teaching of emergency communications ensure the integrity of the knowledge in the classroom, laying a knowledge foundation for students to design. In the stage of realizing the implementation phase, the teacher switches from the dominant mode to the guiding mode, which activates the students' innovativeness and prompts them to think on their own.

5. Teaching cases and effectiveness analysis

In the teaching of emergency communication systems for communication engineering majors, the total credit hours are 32 credit hours, of which 24 credit hours are theoretical and 8 are practical. OBE-CDIO teaching mode is applied to the teaching of the emergency communication system, and the allocation of credit hours and the corresponding teaching contents are shown in **Table 1**.

Table 1. Emergency communications systems credit hours allocation and instructional content

Project chain	Conceive	Design	Implement	Operate
Overview of emergency communications	1C	1D	0	0
Satellite emergency communications	2C	2D	0	0
Wireless emergency communications	1C	1D	1I	1O
Mobile emergency communications	2C	2D	0	0
Network emergency communications	1C	1D	1I	1O
Mine rescue communications	2C	2D	1I	1O
Integrated emergency communication	2C	2D	1I	1O
Underwater emergency communications	1C	1D	0	0
Total	12	12	4	4

Since the "air, sky, earth, and well" integrated emergency communication takes up nearly 20% of the total content, the allocated hours are 6 hours (4 theory hours + 2 practical hours). It includes three parts: a high-altitude mobile stationary communication carrier, a satellite emergency communication vehicle, and an "air, sky, earth, and well" integrated emergency communication platform. Through the establishment of three projects for these components, the theoretical knowledge involved is interspersed into the process of emergency rescue, and the teacher guides the students to think about how to accomplish the goal of emergency communication from conception and design in the classroom. The realization and operation phases are planned to be completed in unison, simulating the production practice of emergency rescue in mining operations. The high-altitude mobile stationing emergency platform, "Static Communication" satellite emergency communication vehicle, and "Dynamic Communication" satellite emergency communication vehicle will achieve the management of emergency operations and resource scheduling, providing timely feedback on the emergency business needs, and rationally utilize the system's emergency resources (Including emergency command vehicles, satellite communications equipment, trunked communications equipment, mobile communications equipment, etc.), to ensure the availability of communications before the repair of traditional public communications services, and to

select the appropriate means of emergency communications as far as possible according to actual business needs, to improve the effectiveness of communications.

At the beginning of the practical, students work in groups of 5. Mainly through the division of labour and cooperation in the implementation and operation stages to complete corresponding tasks. To verify the teaching effectiveness of OBE-CDIO emergency communication, the assessment does not use the traditional way of exam plus usual grades, but evaluates each project to avoid too much influence on the total assessment results due to a certain failure. The total score for each sub-project is 100 points, with each stage accounting for 25%, thus comprehensively examining the learning effect of students' theory and practice.

E0120 (emergency management) and C0620 (communication engineering) of class 2020 were selected for teaching comparative analysis. A total of 61 students of E0120 were used as the control class to implement the traditional teaching mode; a total of 127 students of C0620 were used as the experimental class to implement the OBE-CDIO teaching mode, and taught by the same instructor. After one round of teaching, the application effect was investigated through a WeChat questionnaire, and a total of 159 people were obtained to participated in the survey of the mini-program, with a recovery rate of 84.6%.

5.1. Basic knowledge

The teaching mode reform is based on the fact that the teaching content must be executed following the syllabus to ensure the integrity of teaching. Therefore, we designed a self-assessment questionnaire on the mastery of basic knowledge to conduct a survey, so as to analyse the students' mastery of the teaching content under the two teaching modes, and the results are shown in **Figure 2**.

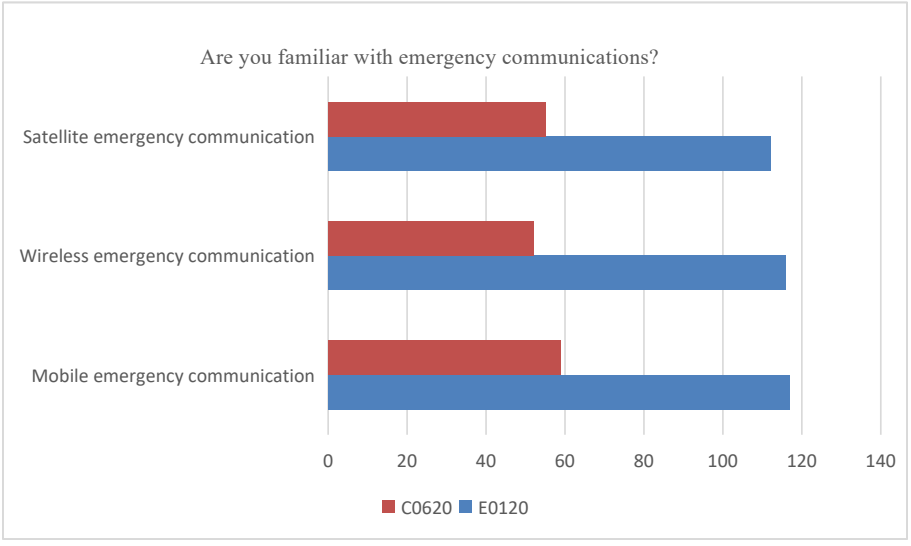

Figure 2. Survey on mastery of basic knowledge.

5.2. Skill mastery status

In the OBE-CDIO teaching mode, more attention is paid to the cultivation of skills, and points are assigned at each stage to judge the mastery of students' skills. Emergency communication skills mainly include satellite emergency communication, wireless emergency communication, mobile emergency communication, network emergency communication, mine rescue communication, "air, sky, earth, and well" integrated emergency communication, and underwater emergency communication. For comparison, students' self-assessments were also used for analysis, and the results are shown in **Figure 3**. In terms of theoretical knowledge and experimental

operation skills, both teaching modes can play a better role; in terms of expanding skills, such as hardware line connection, man-on-a-street task execution, and comprehensive business processing, students in the experimental class show stronger confidence.

5.3. Interest in learning

Interest is the best teacher and the motivation for students to learn independently. A good teaching mode not only improves the teaching effect but also stimulates students' interest in learning, building a positive cycle of "learning - realizing - learning again". The investigation on the impact of the change of teaching mode on learning interest is shown in Figure 4, which shows that the application of the OBE-CDIO teaching mode can obviously increase students' interest in emergency communication.

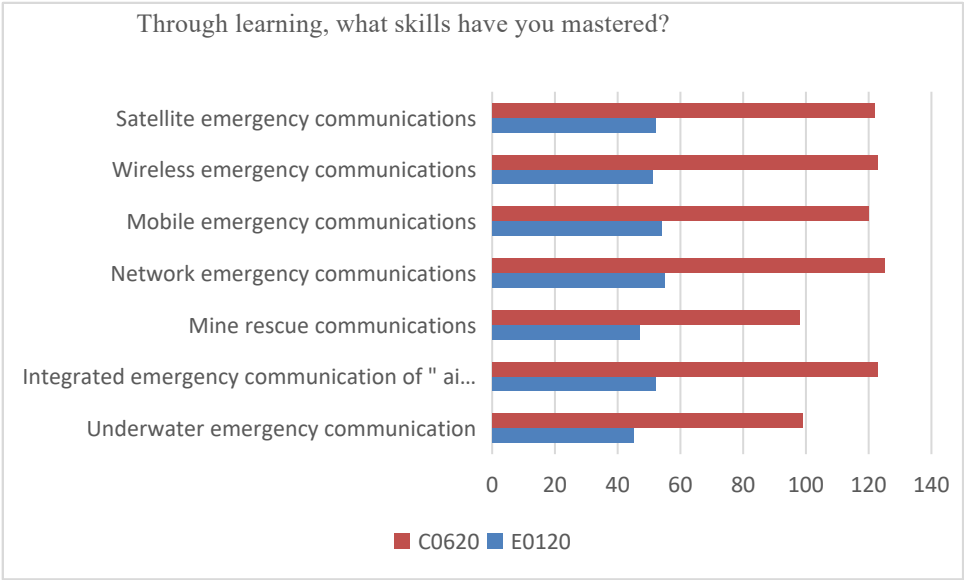

Figure 3. Questionnaire survey on skill mastery.

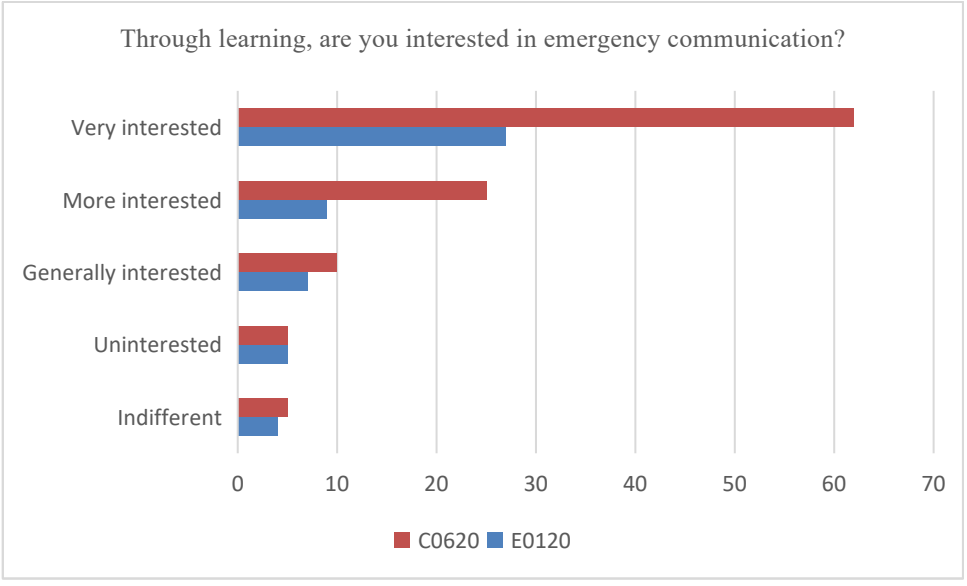

Figure 4. Questionnaire on learning interests.

From the survey, it can be found that the OBE-CDIO model brings new learning experiences to students, and most students tend to accept modern teaching methods and prefer to utilize new tools, such as WeChat applets and official accounts, to communicate and learn. In the subsequent teaching process, we will continue to study the application of the OBE-CDIO teaching model, expand the scale of the reform test subjects, and make the test results more reasonable and credible.

6. Conclusion

Considering the rapid pace of updates in the modern communication industry and combined with the teaching conditions of higher education institutions, the OBE-CDIO teaching mode is proposed to promote students' understanding of the field of emergency communication and improve their professional skills, to reduce the extra learning costs when they are employed. At the same time, the OBE-CDIO teaching model requires teachers' professional skills to be greatly improved, and the novel and practical teaching content can greatly increase students' interest in learning and ultimately achieve the combination of industry and education and foster the growth of teaching and learning.

Teaching practice has proven that the OBE-CDIO model implements an integrated curriculum program. This program is both an engineering education implementation framework and an open engineering education concept. In practice, it can be used to build a fruitful new model of engineering education by strengthening exploration in both theory and practice concerning the different characteristics of each specialty. Taking the practical teaching reform in the emergency communication course module as an entry point, it integrates and optimizes the existing teaching and practice content, and we have established a four-dimensional integrated engineering practice teaching system, and also promotes the multi-dimensional cooperation mechanism of "industry-university-research-use".

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