Application and evaluation of "CDIO" in innovation and entrepreneurship education in higher vocational colleges

Faqiang Cui
Shandong Institute of Commerce and Technology, Jinan, China

Corresponding author and e-mail: Faqiang Cui, cuifaqiang@126.com

Abstract. This article, adopting the "CDIO engineering teaching concept and model" and facing the field of innovation and entrepreneurship education, conducted an experiment for a whole semester to test the effectiveness of CDIO in higher vocational college education. The survey results fully show that CDIO has a significant role in improving the overall level of students' innovation and entrepreneurship. At the same time, through CDIO, students' personal professional skills and practical ability have been significantly enhanced while their theoretical foundation ability has declined slightly. Finally, according to the analysis of the research results, CDIO's suggestions and solutions during the implementation of higher vocational college education are put forward.

1. Introduction
Since 2000, Academician Edward Crawley of the Massachusetts Institute of Technology, in conjunction with the National Chalmers University of Technology, Royal Institute of Technology and Linköping University in Sweden, conducted a four-year study and created the "Engineering Education Concepts and Models" (CDIO) [1]. C (Conceive) stands for conceive, D (Design) stands for design, I (Implement) stands for implementation, and O (Operate) stands for operation. CDIO takes students as the main body and takes product development cycle as the carrier, cleverly integrating courses and practice, focusing on students Cultivation of understanding [2]. In the same year, CDIO took the lead in trial use at the Massachusetts Institute of Technology, and gradually promoted the application of more than 100 colleges and universities in 28 countries and regions around the world, and achieved good results in engineering [8]. China Research CDIO (2005, Gu Peihua), and proposed EIP-CDIO training model (2006, Gu Peihua) [6]. From 2008 to 2010, the Ministry of Education of China identified 39 colleges and universities to carry out research in engineering fields such as mechanical, electrical, chemical and civil engineering, with remarkable results [7]. In 2016, Chinese Ministry of Education proposes to build an OBE-CDIO integrated teaching model [5]. At present, the universities adopting CDIO are basically ordinary higher education (undergraduate) universities, and their application and effectiveness analysis in higher vocational education (junior college) colleges are still in their infancy. In this article, the author will share CDIO's teaching experiments and experience in higher vocational education (junior college) colleges, and test the effectiveness of CDIO in certain specific skills in the field of innovation and entrepreneurship education.

2. Research design
Since September 2018, in order to further optimize innovation and entrepreneurship education, Shandong Institute of Commerce and Technology (SICT) has pioneered the establishment of SME entrepreneurship and management majors in the field of higher vocational education (specialty), and independently established the Innovation and Entrepreneurship Institute for independent teaching and reform exploration. Although the introduction of school-enterprise cooperative enterprises has increased the training of practical skills in the teaching content of some courses, most courses still use the traditional "teacher-learning-practice" teaching model to help students lay a solid foundation for innovation and entrepreneurship. The results show that students are not interested in classroom learning under the traditional teaching model and their learning efficiency is low. Based on the above problems, satisfying the students' internal learning needs in the field of innovation and entrepreneurship in a short period of time, comprehensively improving the learning effect, and enhancing students' learning initiative, enthusiasm and creativity are the key issues that need to be solved at present. To this end, this study focuses on solving two types of problems with the help of the CDIO model. First, can CDIO help students improve the overall ability of innovation and entrepreneurship? Second, what are the most effective basic theories, professional skills, entrepreneurial literacy and practical skills in CDIO?

2.1. Subjects of the experiment
The target of this research project is 201 first-year students majoring in from SICT Innovation and Entrepreneurship. The experimental group consisted of 44 students in 2 classes. In the college, all students are evenly distributed into 4 classes according to the total score of the college entrance examination. The total score is composed of 30% of the theoretical test score and 70% of the professional skill literacy score. Students enter the college and have completed the final exam of the first semester of the university. However, regardless of the grades of the students, the college requires that the original class size remains unchanged. The four classes are all parallel classes. The control group is composed of 55 students in parallel classes of other colleges, and the common teachers follow the traditional "teaching-learning-practice" teaching mode to provide instruction. There is also a parallel class consisting of 77 students from different professional backgrounds throughout the school. 201 students from the College of Innovation and Entrepreneurship were used to analyze the above two parallel classes. Because the first control group has a big difference in the course structure and assessment content, the author cannot use CDIO teaching simultaneously. The difference between the professional background of the second class and the infrastructure of innovation and entrepreneurship focuses on the cultivation of innovative thinking, and CDIO teaching cannot be adopted simultaneously. Therefore, regardless of the pre-test and post-test, the author excludes the above two classes.

2.2. Preparation for the experiment
The experimental teaching of CDIO lasts for 16 weeks, with 3 standard class hours per week, for a total of 48 class hours. All students experienced 16 hours of theoretical study through the Internet and completed the design tasks required for each unit. The following 32 class hours will be practiced in the enterprise management simulation training platform. These two projects are composed of five standard units, and each standard unit sets goals such as thinking, design, ability, and practice. The goals correspond to learning tasks and practical tasks. The former includes innovative thinking, innovative literacy, entrepreneurship, etc. The latter includes teamwork, practical deductions, financial analysis, product development, and company operations. Different tasks consist of different subtasks. The teaching process strictly follows the four steps of CDIO "conception-design-implementation-operation", and the assessment of students is based on CDIO standards 2, 3, 4 [2-3]. In order to carry out the experiment effectively, the author has formulated an overall evaluation plan for the course at the beginning of the semester. The free combination is divided into 10 groups, each with a team leader. The overall score consists of 20% individual scores and 80% team scores. The achievement evaluation standard is 10% teacher evaluation and 90% software evaluation (learning software and training software). The software focuses on the whole process of recording learning information and performing quantitative evaluation.
3. Research process
This study used two sets of test data. The first group is the vocational skills test for students, which is synchronized with this experiment and includes basic knowledge, professional ability and practical skills. The entrance examination adopts the standard of the college entrance examination and is conducted in the ordinary classroom of the school. After the examination, the machine will standardize the answers to the objective test questions, and the teacher will focus on the subjective test questions. The second group tests the final exam of the first semester of the freshman year, which contains the same test items as the first group, and the evaluation method is the same as the first group. Therefore, there is no significant difference between the evaluation criteria of the first group and the second group. The author used spss25.0 software to analyze the quantitative data of the differences and abilities between the two groups of students.

3.1. Pre-test analysis

3.1.1. Comparison between experimental group and average entrance level of college students. The experimental team comes from the Innovation and Entrepreneurship Institute of SICT. Based on accurately grasping the true level of the students before the experiment, which is different from the average score of the entire university, the author chose the average score of the College of Innovation and Entrepreneurship to compare with the score of the experimental group. The author converted the entrance test score (out of 150 points) using a percentage system. The average score of the entire college was 64.83, and the average score of the experimental group was 65.20.

Table 1. One-sample t test of scores of experimental group in pre-test 1 (T0).

|               | t     | df | Sig. (2-tailed) | Mean Difference | 95% Confidence Intervals of Difference |
|---------------|-------|----|----------------|-----------------|----------------------------------------|
| T0            | 0.553 | 44 | 0.583          | 0.37000         | -0.9791 to 1.7191                      |

Analyzing Table 1, although the average score of the experimental group is higher than the average score of the college, the critical confidence (2 tails) is 0.583, which is greater than 5%. It shows that there is no significant difference between the average score of the entrance exam for the students in the experimental group and the average score of 64.83 for the entire college. It is concluded that the academic level of the experimental group is basically the same as the average level of the entire college.

3.1.2. Comparison of the entrance level of the experimental group and the control group. For the 55 students in the control group, their admission scores are not used as reference points, but are distributed in 11 unused classes according to professional categories. Four innovative and entrepreneurial instructors carry out teaching activities according to traditional teaching methods and models. The author did not participate in the teaching of 11 classes. After the first semester examination of the first year of college, the author used Excel2016 to calculate all the scores of the experimental group and the scores of all students in the parallel class. The average score of the experimental group was 70.04, while the average score of the university was 69.30. The test results are as follows:

Table 2. One-sample t test of scores of experimental group in pre-test 1 (T1).

|               | t     | df | Sig. (2-tailed) | Mean Difference | 95% Confidence Intervals of Difference |
|---------------|-------|----|----------------|-----------------|----------------------------------------|
| T1            | 0.448 | 44 | 0.656          | 0.74444         | -2.6047 to 4.0936                      |
Analyzing Table 2, different teachers have used the same traditional teaching methods and models, and have carried out a semester of teaching work in different classes. Although the average score of the experimental group is slightly higher than the average level of the entire college, the significance (2-tailed) is 0.656, which is greater than 5%. Therefore, the results of the first semester of the experimental group did not differ significantly from the average score of 69.3 for the entire college. Therefore, using the same teaching method, the overall level of innovation and entrepreneurship in the experimental group has not improved significantly.

3.2. CDIO teaching process
The teaching process of CDIO covers four stages: conception, design, implement and operate. The role of teachers lies in teaching, guidance and bridge.

3.2.1. Conceive. Based on CDIO teaching standard 9, curriculum teaching is closely integrated with innovation and entrepreneurship. Teachers should teach students to think about the crisis management plan in advance through the conception and planning of start-up enterprise goal setting, enterprise positioning, cost structure and benefit analysis, and to predict the risks and challenges that may be encountered during the operation of the enterprise, so as to better ensure the enterprise operation and management activities. Such as, constructing the task of a competition named "One Hundred Dollars and One Hundred Days Entrepreneurship Management Activity", effectively arousing students' enthusiasm and initiative, broadening and enhancing students' logical thinking and strategic thinking, and consolidating the "ideological" foundation of innovation and entrepreneurship.

3.2.2. Design. The focus is on entrepreneurial ideas and creative design, specifically answering the content and ideas of the idea stage. Teachers give full play to the guiding role, helping students to realize product creativity and R & D based on TRIZ theory. Use tools such as "mind maps" to train students to develop systematic design thinking to solve problems such as project selection, project design, and investment optimization in business operations. For example, through the optimization of the "business plan" to achieve the above problems.

3.2.3. Implement. The focus is on the transformation of creativity and design into practical activities. Teachers should act as a bridge to build practical links, such as "enterprise simulation business competitions" and other activities, to improve students' hands-on practical skills, teamwork and professional integration skills. So that the craftsmanship and entrepreneurship will continue to deepen students' thinking in practical activities.

3.2.4. Operate. To promote the continuous development of practical activities with inspection and evaluation. Teachers and students clearly check and evaluate the standards, and jointly focus on tracking the company's operating life cycle, the degree of product innovation iteration, crisis handling capabilities, service level improvement, corporate profitability and corporate credit, and promote the true landing and sustainable development of corporate projects.

4. Results and discussion
The author tested the CDIO teaching effect of the experimental group based on the final exam scores of the second semester of freshman year. The following is the effectiveness report of CDIO on improving students' overall innovation and entrepreneurship and personal practical skills.

4.1. Influence on students' overall innovation and entrepreneurship
Based on the same principles as the first semester exam of the first year, the experimental group compared the average results of the second semester college exam of the first year. The evaluation items and examination methods of the two are the same. In the test, the average score of the experimental group is 74.133. According to the one-sample t test, the results are compared as follows:
Table 3. One-sample t test of scores of experimental group in post-test (T3).

| Test Value = 69.30 |
|-------------------|
| t     | df   | Sig. (2-tailed) | Mean Difference | 95% Confidence Intervals of Difference |
|-------|------|-----------------|-----------------|----------------------------------------|
| T3    | 2.937 | 44              | .005            | 4.83333                                |
|       |       |                 |                 | Lower: 1.5164                          |
|       |       |                 |                 | Upper: 8.1502                          |

Analyzing Table 3, after one semester of CDIO teaching test, compared with the college as a whole, the overall average score of the experimental group increased by 4.83333 points. And Sig. (Two-tailed) is 0.005, far less than 5%. This shows that there is a significant difference between the student performance of the experimental group and the school's overall average of 69.3 points. It can be concluded that CDIO helps to improve the overall innovation and entrepreneurial ability of college students in higher vocational education (junior college).

The comparison between the experimental group and the control group objectively proves that after a semester of CDIO teaching, the average score of the experimental group is significantly higher than the average score of the entire college. Based on the comparison of eliminating the differences between teachers' abilities, the authors again conducted a result comparison between the experimental group and the control group. In the pre-test 1, the results showed that there was no significant difference between the experimental group and the control group, indicating that there was no significant difference in innovation and entrepreneurship ability between the two groups. After a semester of traditional teaching, in the second pre-test, the difference in scores between the two groups is still not obvious, indicating that there is no significant difference in the ability of the two groups of teachers. The following is the change in innovation and entrepreneurial ability of two groups of students after a semester of CDIO teaching.

Table 4. Comparison of post-test between the experimental group and the controlled group.

| Group          | N  | Average   | Std. Deviation | Mean Difference | Sig. (2-tailed) |
|----------------|----|-----------|----------------|-----------------|-----------------|
| Experimental   | 44 | 74.1333   | 11.33610       |                 |                 |
| Controlled     | 55 | 65.9091   | 11.19403       | 8.22419         | .000            |

Table 4 is analyzed through adopting the method of t test for the equal variance of two samples. Sig. (Two-tailed) is 0.000, less than 5%, indicating that in the second semester of the test, the scores of the two groups are significantly different. At the same time, after the traditional teaching in the second semester, the gap between the control group and the experimental group in the level of innovation and entrepreneurship is increasing. The main reason is that traditional teaching methods can not stimulate students' enthusiasm and initiative. Repeating the same traditional model of teaching has made students lose interest in innovation and entrepreneurship learning, and their level of innovation and entrepreneurship is basically the same as when they were enrolled.

4.2. Influence on personal skills

It has been previously shown that CDIO has a significant impact on improving the overall level of students' innovation and entrepreneurship. Below, the author will focus on analyzing which skills CDIO has improved. Here, the quantified data is used, including basic theory, professional skills, and practical ability. Since entrepreneurial literacy cannot be accurately quantified, it was not adopted in this test.

Table 5. Comparison of individual skills between the experimental group and the controlled group.

| Item          | Item          | Experimental group average | College average | Std. Deviation | Mean Difference | Sig. (2-tailed) |
|---------------|---------------|---------------------------|-----------------|----------------|-----------------|----------------|
| Basic theory  | 17.3182       | 18.7091                   | 3.88062         | -1.39091       | .078            |
| Professional skill | 17.3682       | 14.4909                   | 1.27202         | 2.87727        | .000            |
| Practical ability | 35.9364       | 26.2909                   | 3.52856         | 9.64545        | .000            |
Analysis Table 5 shows that the professional skills and practical abilities are less than 5% in the comparison of the three skills (2 tails), indicating that the professional skills and practical abilities of the course are 14.44909 points and 26.2909 points among the average scores of all the students. There are significant differences between them, indicating that CDIO teaching has greatly improved students' professional skills and practical ability. In the comparison of basic theories, the significance (2 tails) is slightly greater than 5%, indicating that compared with the average level of the entire college, the advantages of CDIO teaching are not obvious.

5. Conclusions
The teaching test based on the CDIO concept has been carried out for one semester and will continue to be carried out. Teachers and students have accepted the teaching concept and model of "conception-design-implementation-operation", and have achieved more obvious teaching effects. Through research, CDIO can effectively improve students' professional skills and practical ability, and promote students' comprehensive development in the field of innovation and entrepreneurship. Based on the influence of subjective and objective factors, the design of this study still has deficiencies. First, the short research cycle is limited, and the assessment of student changes and learning effects is insufficient. If you can track and study for more than 4 semesters in a row, you can believe that it will inevitably greatly improve students' overall level of innovation and entrepreneurship. Besides, professional skills and practical ability will be exerted a more significant impact. Second, there is no good evaluation standard for the evaluation of entrepreneurial literacy. It is subjective and cannot be effectively measured and evaluated. Third, CDIO is a new thing for teachers and students of higher vocational education (junior colleges) colleges and universities, which requires uniform requirements of the college, otherwise teachers and students may refuse to participate in the research work. Fourth, the differences between the existing textbooks and the CDIO structure requires teachers to reconstruct strictly in accordance with the CDIO standards, which will greatly increase the difficulty and working time of teachers. If CDIO can be promoted throughout the college, and enterprise mentors are introduced to form an excellent teaching team, I believe that CDIO will have a more promising future.

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