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Research on the design course of intelligent electromechanical products

Wan Hongqiang[a,*], Han Quanli[b], Zhang Geng[c], Wang Li[d]

School of Mechatronic Engineering, Xi'an Technological University, Xi'an, China
[a]413162931@qq.com, [b]925465354@qq.com, [c]315699602@qq.com, [d]1040981108@qq.com
[*]Corresponding author

Abstract: *The research and development course of intelligent electromechanical products is an important course to train students' mechanical structure design, electromechanical control, innovative thinking and practical ability. How to let students realize the learning of "application, analysis, design and creation" and realize the multi-dimensional training goal has become the key research content. After years of exploration, the teaching team has built a knowledge system, integrated teaching content, improved course materials, created a CDIO project-based teaching model with industry background, constructed a project-research-led learning environment, and inserted curriculum ideological and political content to achieve a training mechanism for innovative talents.*

Keywords: *electromechanical products; CDIO teaching mode; Project research; Curriculum ideology and politics*

1. Introduction

"The research and development course of intelligent electromechanical products" is a comprehensive theoretical and practical course, aiming to develop students' ability to discover, think and solve problems through project traction in a problem-oriented manner, and thus improve their comprehensive literacy[1-2]. This course is based on the CDIO (Conceive-Design-Implement-Operate) approach to project practice[3-4]. Teachers organize discussions and on-site guidance, and student teams discuss, communicate and evaluate. Through this course, students are able to master the development and development process of intelligent electromechanical products, such as market investigation, product design, engineering analysis and manufacturing, prototype manufacturing, market and economic analysis. It cultivates students' comprehensive research and development ability in design, manufacturing and electromechanical control, as well as independent learning ability, team building and economic management ability[5-6].

2. Program Objectives

The objectives of this course are rationally determined based on the indicators of graduation requirements in the Common Criteria for Accreditation of Engineering Education Programs, which cover the indicators of graduation requirement competencies in seven areas: ideology and ethics, design/development of solutions, engineering and society, environment and sustainable development, individual and team, project management, and lifelong learning. Specifically:

- To be able to identify urgent mechanical engineering problems in today's society through social research and market demand analysis, and the research process should practice socialist core values (social research).

- To be able to seek solutions to problems based on a practical engineering problem by forming a team, dividing the work with team members, understanding their responsibilities in the team and their tasks (forming a team).

- Through literature search and online course platforms, learn relevant subject knowledge independently, discuss and propose multiple feasible solutions to engineering problems through teamwork, and be able to stand in the perspective of environmental protection and sustainable development, think about evaluating the possible damages and hidden dangers to human beings and the environment caused by system solutions, and determine the best solution (conceptualization).

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▪ Team members are able to learn relevant knowledge, techniques and tools independently, and are able to utilize modern design means and tools to complete the detailed design and research of the mechanical system components for which they are responsible, and are able to consider the innovation needs and development directions, and are able to communicate, exchange and collaborate effectively in the design and research process (design).

▪ Be able to apply basic methods of engineering management and economic decision-making to the manufacture and procurement of components, taking into account their social, health, safety, legal, and cultural impacts (realization).

▪ Team members share the work, can complete the assembly and debugging and operation of the product by themselves, and evaluate it, with labor spirit and frustration tolerance (operation).

3. Curriculum Development

The content of the course construction is carried out in terms of the syllabus, learning guidance programs, course ideological resources, labor education resources and other course resources.

▪ Improve the course syllabus. In accordance with the professional talent training objectives and graduation requirements, combined with the team characteristics, revise and improve the course syllabus of the research and development of intelligent electromechanical products, sorting out the nature and purpose of the course, the course objectives, the graduation requirements supported, the teaching content and arrangement, the allocation of class hours, the assessment methods and evaluation criteria.

▪ Develop learning guidance programs. Set up a learning guidance project library in four specialized fields, including special machining, precision measurement, precision and ultra-precision machining, and surface forming. Based on the scientific research projects of the instructors, each research team taps into the results of their respective research fields to set up learning guidance projects for undergraduates that are suitable for undergraduate practice, which can promote students' independent learning, articulate knowledge modules, cover the core knowledge of the corresponding courses, promote students' multidisciplinary knowledge cross-fertilization and integration of practice, allow students to apply the knowledge they have learned to do hands-on practice, and cultivate a sense of social responsibility in the students, teamwork, scientific research, and evaluation of students' learning output.

▪ Build the resources of course ideology and politics. Implement the ideological and political education into the whole process of CDIO, integrate the ideology and politics of the curriculum into scientific research and innovation, and continuously improve the innovation and entrepreneurship ability.

▪ Build labor education resources. Each team establishes hands-on projects suitable for undergraduates, changing from “designing ideas” to “submitting physical objects with certain functions”, so that students must use their brains as well as their hands to complete the project practice. In the practice of declaring Innovative Entrepreneurship Training Program for college students, the team guides the students in the project declaration, project contract signing, completing the project work, project completion of the whole practice process to get exercise.

▪ Building other curriculum resources. Integrate the scientific research resources of teachers' subject groups and institutes to prepare study guides for this course.

4. Course Content

The basic content of this course (Figure 1) includes:

▪ Overview part, mainly introduces the basic concepts, composition, characteristics and applications.

▪ Mechanical ontology design part, introduces the basic concepts of mechanical principles and mechanical design, contains the basic requirements of mechanical design, the design of main working parts of machinery, transmission system analysis and calculation.

▪ Product digital design - Solid works modeling part, introduces the principle of three-dimensional software modeling, including parts modeling, assembly, explosion diagram, rendering, finite element

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simulation. And combined with gearboxes and other typical mechanical design comprehensive examples.

▪ Product finite element simulation - ABAQS simulation part, introduces the basic principles and basic operation of finite element software, gives the shaft, gears, wheels, frames and other typical parts of the mechanics of the mechanics of the frame, heat, drop, impact and other examples.

▪ Virtual prototype dynamics simulation -- Adams simulation part, introduces the basic principles and basic operation of multi-body dynamics software, parts of the basic modeling, analysis of the work of the steps, Solid works model import and processing, gives the connecting rod, cams, gears, sprockets, and other typical examples.

▪ Drive system design part, introduce the basic drive mechanism, 1) motor drive system contains asynchronous motor, dc motor, stepping motor, servo motor selection principles and application examples; 2) hydraulic drive system introduces the hydraulic power system composition, component selection and basic design; 3) pneumatic drive system design introduces the gas source, pipeline, valve and its control system.

▪ Perception system design part, introducing the concept, role, selection and basic application of sensors.

▪ Control system design section, introducing control system concepts, classification, common control system hardware, robot control system, electrical control system design, the basic circuit of the commonly used control lines.

▪ PLC control system design section, introducing PLC control system hardware design, programming software, basic principles and programming methods, PLC system debugging.

▪ Microcontroller and Internet of Things system part, introduces microcontroller control principle and basic operation, connection of hardware circuits, gives examples of language control module, voice output, signal access, signal output, etc., and Internet of Things system gives functions, applications, architecture, terminals and application examples.

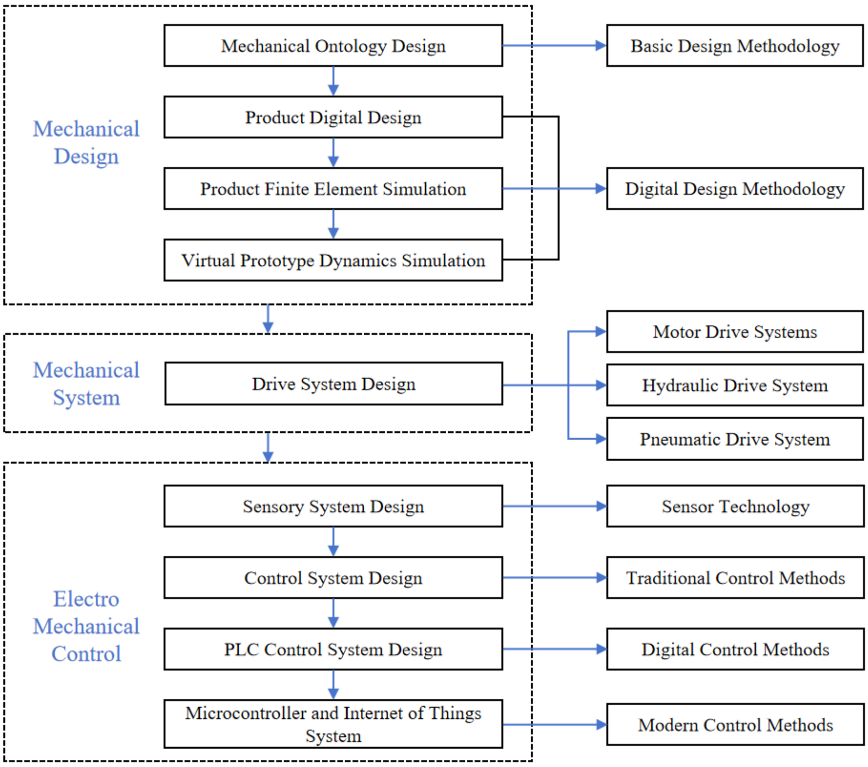

Figure 1: Course Content Structure.

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5. Textbook Development

The textbook "The research and development course of intelligent electromechanical products" is designed to help students to establish the concept of research and development of intelligent electromechanical products and to quickly acquire the basic knowledge of mechanical design, manufacturing, control and designing abilities. The textbook is a textbook written for students majoring in machine and near-machine, aiming to cultivate students' professional ability to solve the problems of plant design planning and implementation. The textbook is modularized and divided into three modules: mechanical design, drive system design and control, each module covers specific work task units. The teaching concept focuses on practice as the main line and ability as the center, and advocates gradual progress, starting from interest, innovative cultivation, and enhancement of students' innovative consciousness. The textbook combines engineering cases with three-dimensional solid drawings and physical photos to improve the practicality of teaching and students' intuitive understanding. Each module is introduced with real-life engineering cases to guide students into the learning scenario and increase their interest in learning. Through the systematic teaching content and rich practical cases, the textbook aims to help students fully grasp the knowledge and skills of mechanical design, manufacturing and control, and train them to become mechanical professionals with innovative ability and engineering practice ability.

6. CDIO Mode of Operation

After receiving the research topic, students conceptualize the design idea under the guidance of the tutor, who also influences the students in terms of academic ethics and norms. In the steps of implementing the program, the team formed by undergraduate and graduate students cooperates and performs teamwork for the implementation of the project, realizing teamwork and complementary advantages. In the process of running the project, students realize the breakthrough of the project through independent thinking and research, and realize the re-learning of knowledge blind spots and gap filling. The process of harvesting results realizes the exercise of innovative thinking and entrepreneurial practice. The whole operation process is shown in Figure 2.

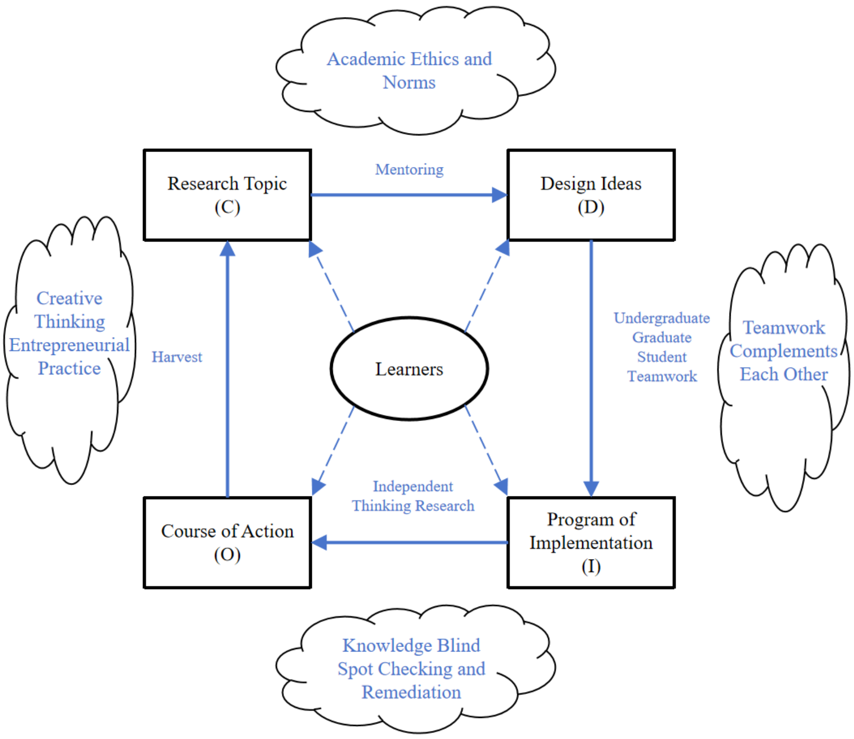

Figure 2: CDIO Operation Process

The dual-drive model of "Research Project + Discipline Competition" takes students' active participation in teachers' research projects and discipline competitions as the starting point, and applies their professional theoretical knowledge to the practice of scientific research projects and discipline

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competitions to improve their scientific research ability and innovation and entrepreneurship skills. Based on the project operation mode, we have created a mentorship management system for undergraduates. Students are organically integrated into the project team, participate in the research projects of teachers, doctoral students and master's students, and are involved in a series of workflows, such as literature review, research, outsourcing processing, drawing design, data processing, simulation experiments, physical experiments, project testing, thesis writing, patent writing, and project completion, so as to obtain comprehensive practical exercise opportunities. According to the actual situation, determine the mentor's research topic and research direction. According to the research projects of the project team and the important disciplinary competitions of the mechanical specialty, the project direction is formulated and the innovative design is carried out.

As a result of the operation of this model, it is possible to strengthen the students' knowledge and skill reserves and help them to initially form innovative thinking. Teaching will be closely integrated with theoretical knowledge and practical teaching, with the help of integrated teaching of science and practice to continuously improve the knowledge and skill level of students, but also enable students to further understand the process of research and development of electromechanical products. It can assist students to master the core knowledge of mechanical design, electronic design and control technology, and continue to strengthen the sense of teamwork, and further enhance their own independent investigation ability. It can cultivate students' comprehensive application ability and innovative practical ability.

7. Civic and Political Construction of the Curriculum

The specific implementation program is shown in Figure 3. According to the construction requirements of the course, corresponding to the important knowledge points, and then according to the multiple sources of the Civics content, to determine the Civics elements, the two combined with reference to the content of the available case library, the organization of the case, the coordination of the three, to complete the matching of the course and the case.

The design of the case base has strong typicality and comprehensiveness, which can stimulate students' learning interest. Cases are extracted from teachers' scientific research projects, enterprises' production and R&D projects, and students' competition and practice projects, and the projects are transformed into teaching resources, and more typical cases are excavated. The elements of Civics and Politics include the cultivation of patriotic sentiment, socialist core values, cultivation of vocational quality, and improvement of professional quality.

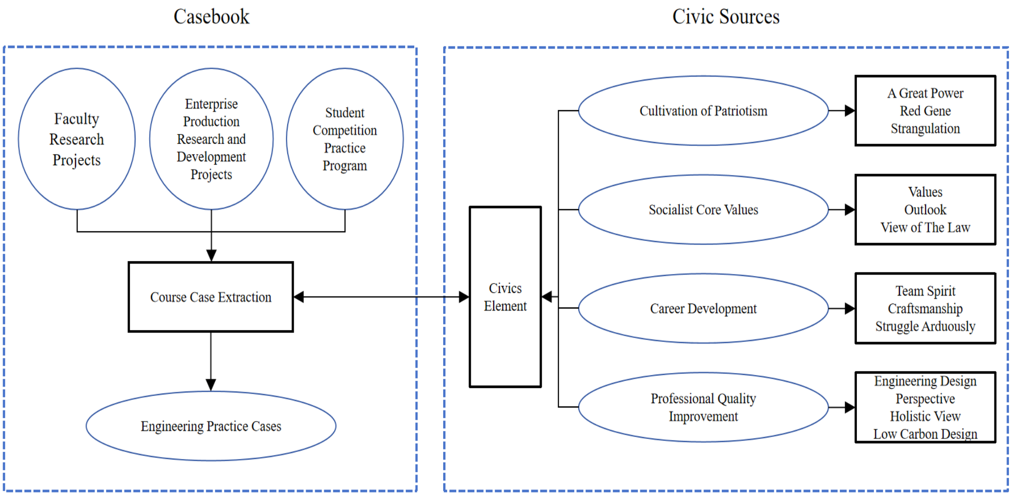

Figure 3: Diagram of the Implementation Scheme

8. Features

Figure 4 forms four major innovation systems for this course in terms of teaching mode, teaching method, course content, and evaluation system.

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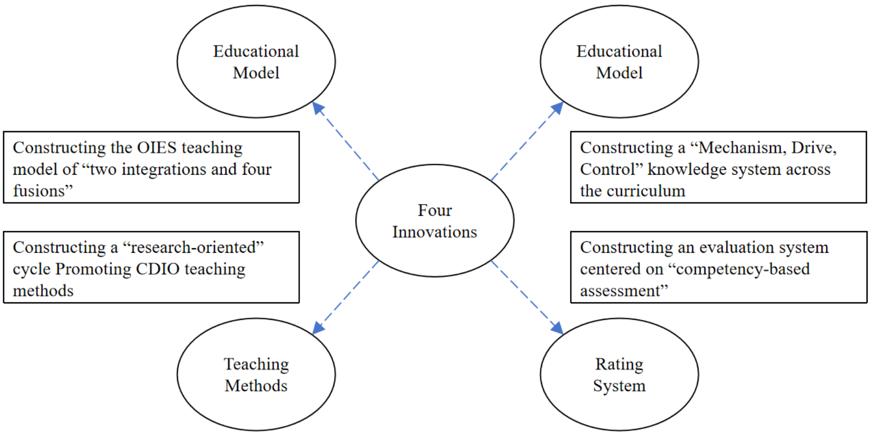

Figure 4: Course Characteristics.

8.1. Constructing the OIES teaching model of "two integrations and four integrations"

A new teaching mode oriented to outputs, internal drive, engineering ability and scientific literacy, which can realize "two integrations and four fusions": the integration of national sentiment and scientific attitude, which reflects the responsibility to the country and the nation, as well as the attitude of pursuing scientific truth and rigorous study; the integration of knowledge and theory and engineering training, which refers to theoretical knowledge and scientific truth, and the attitude of rigorous study; the integration of knowledge and theory and engineering training, which refers to theoretical knowledge and engineering training, which refers to theoretical knowledge and scientific truth, and the attitude of rigorous study. The integration of national sentiment and scientific attitude reflects the responsibility to the country and the nation, as well as the attitude of pursuing scientific truth and rigorous study; the integration of knowledge and theory and engineering training refers to the close integration of theoretical knowledge and practical skills.

In terms of teaching and learning, "four integrations" are met: online and offline integration, which refers to the combination of online digital teaching resources and offline physical teaching activities to improve the teaching effect and learning experience; science and education integration, which refers to the in-depth integration of scientific research and education and teaching; class and competition integration, which refers to the combination of course learning and competition activities; and specialization and thinking integration, which refers to the combination of specialized knowledge learning and critical thinking; and the integration of professional knowledge and engineering training. The integration of science and education refers to the in-depth integration of scientific research and education and teaching.

8.2. Constructing the teaching method of "research-oriented cyclic promotion of CDIO"

The teaching method is shown in Figure 5, through the project research (orchard hail disaster treatment problems), students understand the mechanical design, energy, control problems involved in the analysis, and then carry out the project - orchard intelligent hail prevention system design. Subsequently, students write feasibility analysis reports, overall program design (market research, program demonstration), mechanical system design (design, finite element simulation, dynamics simulation), power system selection (motor selection), control system design (control circuits, microcontrollers, sensors, control software), experimental physical prototype, system debugging, testing and improvement. After the completion of the project, it is also necessary to display and report the session, and the results are evaluated by experts to form a complete project cycle.

Through multi-link training, students' abilities can be cultivated in all aspects, project research to cultivate social responsibility awareness, project development to cultivate teamwork awareness through component teams, student-student cooperation, teacher-student cooperation, through repeated discussion of the project to cultivate critical questioning awareness, feasibility analysis report to cultivate awareness of social, safety, health, legal, environmental and sustainable development, design links to cultivate systematic thinking and innovation awareness, the design links to cultivate systematic thinking and innovation awareness. The experimental physical prototype session develops engineering literacy, and the debugging session develops the sense of striving for excellence.

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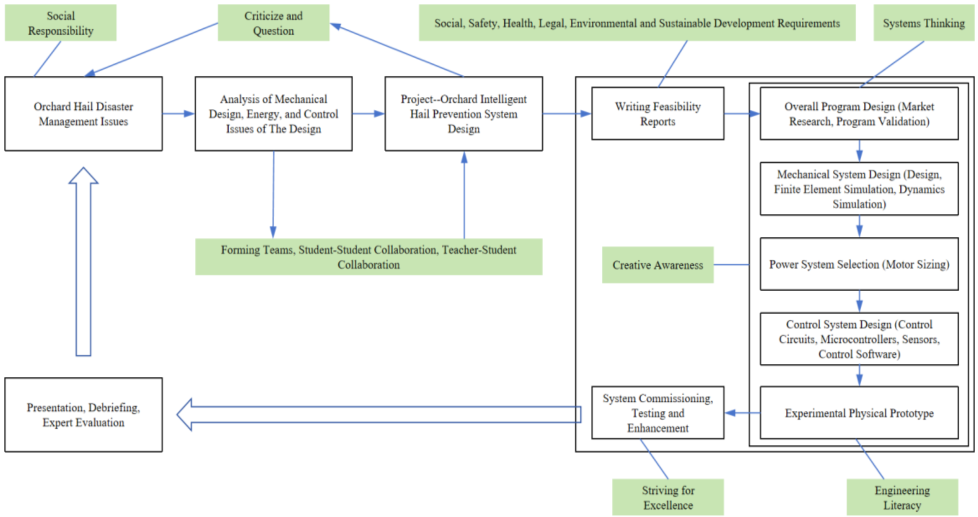

Figure 5: Teaching methods.

8.3. Constructing an evaluation system centered on "competency-based assessment"

The grade composition of the course is shown in Table 1. The proportion of process assessment and summative assessment, the evaluation method, the score, the corresponding course objectives and the proportion are given.

Table 1: Composition of grades in courses.

Composition of results	Evaluation methods	Points awarded (percentage)	Corresponding Course Objectives
Process assessment (80%)	Social research	10	Program Objectives1
	Formation of the team	10	Program Objectives2
	Program conceptualization	20	Program Objectives3
	Detailed design	20	Program Objectives4
	Prototyping	20	Program Objectives5
Summative assessment (20%)	Commissioning and acceptance	20	Program Objectives6

The course assessment is a diversified, whole-process evaluation (Figure 6), including online learning and testing, engineering practice project design and presentation reporting, physical production and debugging, and defense-based final assessment, and these tests to evaluate the four major literacies acquired by the students.

Knowledge ability literacy assesses students' ability to analyze problems, design systems, design and build experimental programs, use tools and analyze data; management and communication ability literacy assesses students' ability to analyze problems and question and criticize, divide and collaborate in teams, write literature, and express and communicate; information literacy assesses students' ability to obtain information, analyze literature and draw effective conclusions; values literacy assesses students' ability to be autonomous and innovative, and socialist core values; and values literacy assesses students' ability to learn and understand socialist values. Information literacy assesses students' ability to acquire information, analyze literature and draw effective conclusions; values literacy assesses students' ability to be autonomous and innovative, and socialist core values.

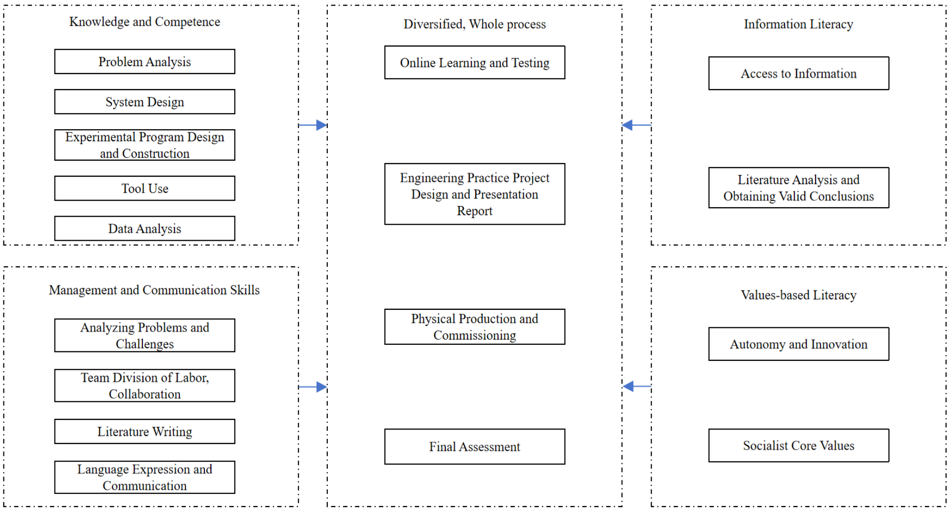

Figure 6: Course Assessment and Evaluation.

9. Conclusions

(1) Teaching effectiveness has been significantly enhanced. According to the results of the course assessment, students' motivation to participate in competitions in various subjects and to join teachers' laboratories has been significantly improved. The degree of teacher-student interaction has also significantly improved, and the quality and effectiveness of teaching has been significantly enhanced. Students' identification with and satisfaction with the course have increased, thanks to the richness and enhanced practicality of the course content.

(2) Fruitful student awards. During the implementation of the program, students actively participated in and won awards in high-level competitions such as the National Mechanical Innovation Design Competition and 3D Competition, which fully reflected their innovative ability and practical level. In addition, two projects were successfully selected into the National Innovation and Entrepreneurship Training Program for College Students, and five projects were approved as provincial programs. Meanwhile, the students have published several academic papers and applied for several patents, which not only enhance their academic level, but also lay a solid foundation for their future development.

(3) Students' innovative consciousness and ability have been greatly improved. According to the survey of some graduates and students' self-evaluation reports, students generally said that they have significantly improved their self-innovation consciousness, innovation ability, practical operation, teamwork and self-expression. They have constantly challenged themselves and transcended themselves through activities such as participating in project practice, taking part in competitions, publishing papers and applying for patents, etc., and have realized personal growth and progress. In addition, students who participated in faculty research projects and gained experience in disciplinary competitions showed obvious advantages in job interviews and interviews for graduate school entrance exams.

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