GOAL-ORIENTED MODULAR TEACHING REFROM BASED ON CDIO CONCEPT

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ABSTRACT

Goal-oriented modular teaching reform based on the concept of CDIO is proposed to meet needs of the current teaching reform and the talent cultivation for Measurement and Control Technology and Instrument majors in Yanshan University. Its goal is to built new curriculum architecture and modular teaching system based on the concept, syllabus and standards of CDIO, improve the students' CDIO skills, especially including the innovative and practical abilities, and enhance the teaching quality. In this paper, we take the digital signal processing(DSP) subject as an example to describe the detailed implementation. The new curriculum system of DSP education under the implementation of CDIO framework has been rebuilt, which mainly includes two modules of theoretical teaching and project based practical teaching. It puts emphasis on the organic connection of the correlated curriculum content and the comprehensive practice requirements through various forms of classroom explanations, MATLAB assignments, comprehensive experiments, classroom discussions, and project designs. This new teaching reform mode can integrate theoretical learning with practical training and thus develop independent thinking, analyzing, and problem-solving abilities, enhance cooperation and communication skills, and promote the comprehensive practice and innovation abilities. After 2 years' teaching reform practice, good effects have been achieved on enhancing teaching quality and improving students' abilities.

KEYWORDS

CDIO, Goal-oriented modular teaching reform, project-based teaching, digital signal processing, Standards: 1, 2, 7, 8, 11

1. INTRODUCTION

The CDIO initiative is an innovative educational framework for producing the next generation of engineers which was first proposed in 2004.The CDIO concept is based on the design process in actual systems and product development, and the educational program. By taking this educational program, learners can acquire the abilities to "conceive", "design", "implement", and "operate" as defined by CDIO Initiative. Nowadays many engineering colleges and universities have paid considerable attention to cultivate the application-oriented high-level engineering talents.

Digital signal processing (DSP) is a major professional course opened for junior students majoring in Electronic Information Engineering, Measurement and Instrumentation and Automation. The teaching content of the course includes theory teaching and practice teaching, which are usually set separately but have close connection with each other. Therefore, it is necessary to explore the teaching reform and innovation in DSP course based on CDIO which is demand-oriented and capability-oriented in the society.

In order to overcome the existing problems in the teaching system of DSP course, goal-oriented modular teaching mode based on the concept of CDIO is proposed to meet the cultivation requirements for majors of Measurement and Control Technology and Instrument. The DSP course reform has been done from many aspects of class teaching, experimental teaching, students' task and graduation projects, which provide students more chances to confront with engineering practice. This teaching mode can combine theoretical learning with practical training, develop the independent thinking, analyzing, and problem solving abilities, enhance cooperation and communication skills, and promote the comprehensive practice and innovation abilities, thus improving the students' CDIO skills.

2. THE EXISTING PROBLEMS IN TRADITIONAL TEACHING PROCESS

DSP is one of the principle courses for Measurement and Control Technology and Instrument majors, whose main task is to enable students to master the theoretical methods of signal acquisition, transform, processing and analysis, and then apply them to engineering fields. In general, there exists the following problems in traditional teaching process: (1) we usually emphasize theoretical teaching for DSP with those abstract basic principles and mathematical concepts involved in the curriculum and students accept the knowledge passively; (2) we neglect the relationship between theory and practical engineering so that the students' multi-abilities do not be cultivated. Therefore, there is a need to explore and find the answers on how to organize the teaching contents and increase practice training so as to improve the students' comprehensive skills and implement "learning by doing".

In order to deal with the above mentioned problems, many efforts have been made. Since 2003, a series of reforms on teaching means and methods have been taken, which including writing the supporting textbook, combining multi-media teaching with network teaching platform, enriching the content of classroom teaching and promoting after-class autonomous learning .These reforms are helpful to improve the teaching quality and teaching efficiency. In 2013, we began to explore the new CDIO based teaching mode. As a result, on the basis of the teaching reform project practices we have done, goal-oriented modular teaching mode based on the concept of CDIO is proposed to improve the education quality of DSP course. After 2 years of teaching reform practice, good effects have been achieved on the teaching effectiveness and feedback from students and the new teaching mode also has been applied into other courses. In the next section, the new teaching reform mode based on CDIO concept will be described in details.

3. TEACHING REFROM OF THE COURSE BASED ON CDIO

Yanshan University joined CDIO Initiative in May 2013 and is promoting advanced engineering education in China. The core subjects of the engineering design education curricula of our university are "project-based teaching" (PBT) which combine theory teaching and project practice effectively based on the CDIO idea. Based on this, goal-oriented modular teaching mode of DSP course is proposed here under the implementation of CDIO framework as shown in Figure 1. It shows the detailed steps to perform the task (task investigation, task discussion division, task design and analysis, task implementation and evaluation), and thus the modular teaching and practice model is built composed of various forms of classroom theoretical teaching, MATLAB assignments, comprehensive experiments, classroom discussions and project designs and problem implementation.

According to the proposed reform mode in Figure 1, DSP course is implemented through “goal-oriented” classroom teaching and project practical teaching which offer students more

chances to perform engineering tasks in signal processing field. Students need to apply the theoretical knowledge to deal with practical engineering problems and thus it helps them master the main theory of courses clearly and completely by questioning, discussing, analyzing and practicing in the end. Through the practice of the teaching reform in the course, relevant abilities and CDIO skills can be cultivated including autonomous learning and independent thinking, analyzing and solving the problem related to signal processing, and improve the comprehensive quality of students.

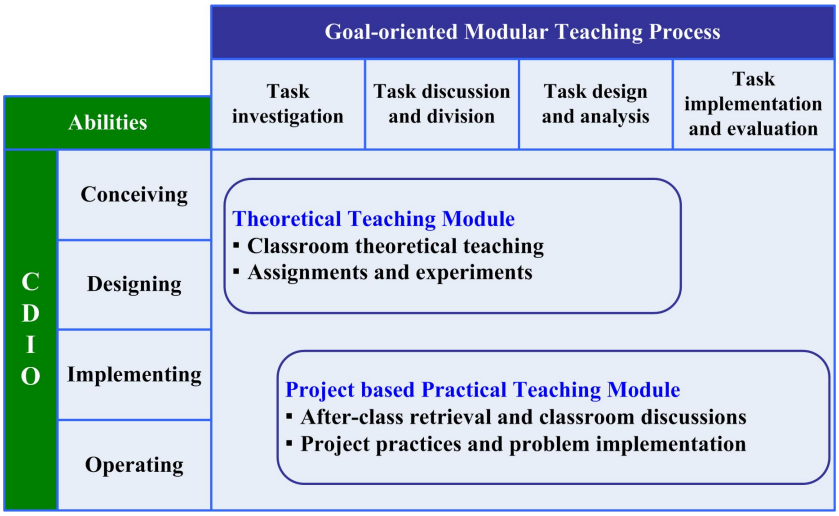

Figure 1 Goal-oriented modular teaching reform mode based CDIO concept

The primary premise of teaching reform implementation is the construction of the teaching system, namely the organization of teaching content and the adjustment of teaching methods. Figure 2 shows the system reform of modular teaching practice system in DSP course, with the aim to integrate theory teaching with practice teaching effectively and reaching an agreement with training objectives of the course, which is based on the proposed reform mode shown in Figure 1.

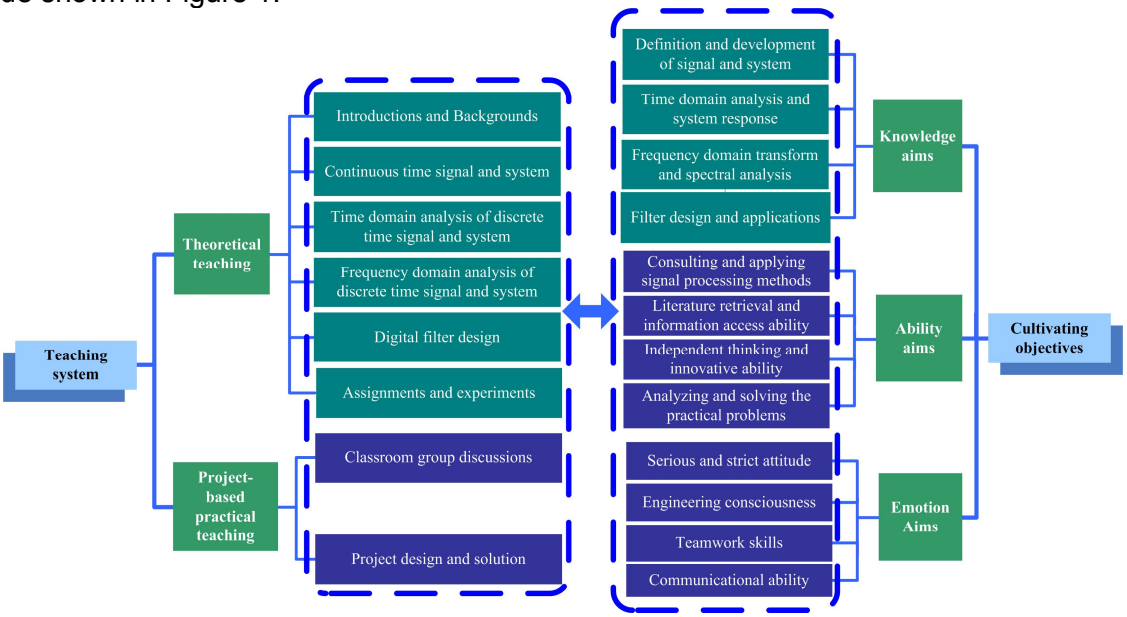

Figure 2 Teaching system and cultivating objectives of the course

3.1 Cultivating objectives and teaching system construction

The starting point of goal-oriented modular teaching is to construct the curriculum knowledge system and teaching methods with the guiding of training professional ability. In other words, it is to construct teaching objectives and organization means of this course with knowledge aim, ability aim and emotion aim. According to the proposed modular teaching reform mode, we emendate syllabus and teaching plan, improve teaching system and teaching content, and furthermore add practical teaching links, such as classroom group discussions, project designs and solutions, etc., so as to form modular teaching system based on the concept of CDIO.

3.2 Organization of teaching content and adjustment of teaching methods

Table 1 Cultivating of professional knowledge of the course

Level I	Level II	Level III	Degree	Main links
Preliminary knowledge and theory	Background	Definition, description and classification of signal and system	2	Classroom teaching
		Applications of digital signal processing	2	Classroom teaching and discussions
	Theoretical foundation	Time domain analysis of discrete time signal and system; convolution	2	Classroom teaching and experiments
		Frequency domain analysis of discrete time signal and system	3	Classroom teaching and experiments
		Network types and design methods of filters	3	Classroom teaching, discussions and experiments
Design and application		Signal convolution and its application	4	Classroom teaching and projects
		Essence of FFT and its practical applications	3	Classroom teaching and projects
		Design principle and method of digital filters	2	Classroom teaching and projects

The orientation of DSP course in Measurement and Control Technology and Instrument specialty, different from that in Telecommunication Engineering specialty, is that in the absence of Signal and System prerequisite course, discrete time signal and system analysis is the main line with the relevant complementary content about continuous time signal and system; meanwhile, the organic combination of theoretical teaching and project-based practical teaching is also the core so as to realize the integration and transfer of knowledge and ability. Moreover, organization of the teaching content and methods during the reform should follow the following principles: a) the systematization and symmetry of knowledge

(continuous and discrete, time domain and frequency domain and various transforms, etc); b) the organic combination of theory and practice (theoretical explanation, project assignments, engineering cases); c) combination of tutor classroom teaching and students' self-study (knowledge mainline study and project practice).

Cultivating orientation of knowledge in the course and teaching methods can be determined based on the principles mentioned above, as listed in Table 1, where various links including classroom theoretical teaching, group discussions, experiments and practical projects, etc., are flexibly organized. Meanwhile, considering teaching key points and engineering application background, several application examples and practice topics, such as speech signal processing, electrocardiosignal signals processing, earthquake pulse analysis, etc., are determined and implemented on the schedule.

3.3 Modular teaching modes

The key of goal-oriented modular teaching reform based on the concept of CDIO is to achieve the combination of various teaching modules and to supply the teaching process embodied in the clues of theory and the practice teaching supported by each other, specifically referring to CDIO Standards 7 and 8. Thus the students' comprehensive abilities including personal and interpersonal skills and problem-analyzing and problem-solving skills could be cultivated in the organic combination of "learning-thinking-practice" process. Figure 3 shows a modular organization means of the teaching system.

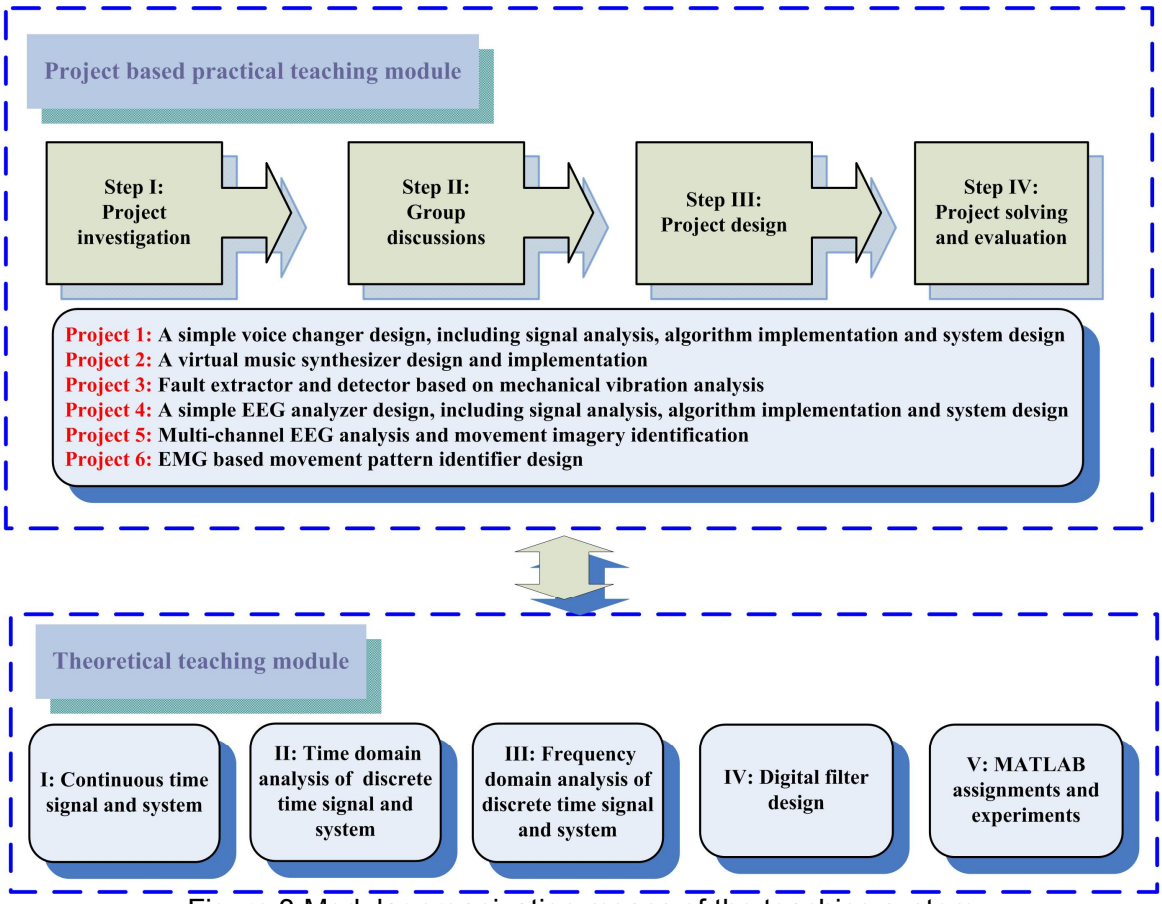

Figure 3 Modular organization means of the teaching system

3.3.1 Theoretical teaching module

Theoretical teaching is the foundation of the whole teaching process of the course. To focus on the explanation of core knowledge in limited class hours, three key points need to be noted. Firstly, the key points, clues and guide in theoretical teaching must be outstanding; Secondly, knowledge should be explained symmetrically (time-frequency, continuous-discrete) and consistently (different FT transform and Z transform, etc.). We combined theoretical derivation, case studies with cutting-edge presentation to help students deepen their understanding of key signal processing methods and application knowledge. Meanwhile, the third point is to arrange the homework in MATLAB software design and discussion topics after class based on a certain mission objective to guide students learning autonomously and exploring in a team to carry out the follow-up discussion sessions.

3.3.2 Project based practical teaching module

Based on the theory teaching of the course, aiming at the core knowledge in the content, such as frequency-domain signal analysis, digital filtering ,etc, some typical applications and practical topics according to the engineering background are set as the project tasks (such as music signal processing, speech signal processing, etc. as shown in Figure 3). And the project-based practice process is implemented, which composed of consultation after class, task division, group discussion and reporting in the class and project design.

Firstly, aiming at the key theory and application issues, discussion topics with certain engineering significance and common concern are selected, such as (a) MH370 black box and signal processing, (b) " distinguish man from sound " (c) signal processing behind earthquake localization, etc. Students are grouped as teams to apply signal processing knowledge and methods to analyze practical problems, making full use of the initiative of students. Based on the literature review, analysis seminar, presentation and teacher commenting in discussion sessions, the students are trained to develop the ability of autonomous practice and solving signal processing with the learned knowledge, and students' cooperation and communication skills are improved too.

Secondly, on the basis of implementation on discussion steps, MATLAB assignments and experimental designs are combined effectively and further extended into the project practice of the course. The process is to apply the typical digital signal processing algorithm to analysis one kind of specific signal discussed in the previous section, finish the corresponding software design and obtain the analysis results. The student group division and the content of the project and discussion are matched up and complemented together, which is advantageous to the modular teaching steps and would achieve preferable effect. The detail of the modular teaching practice process is shown in Figure 4. It can be seen from the figure that the feature of interactive teaching---"Take the student as the main body, teacher as auxiliary" is reflected in the modular teaching process. On the other hand, the CDIO concept namely Conceive, Design, Implement and Operate are integrated in the goal-oriented teaching process. Through the implementation of the project practice and modular teaching methods, the students could improve the ability on applying the knowledge in the software design, solving the problems in signal processing, analyzing and explaining the experimental data, and also the cooperation and communication skills to solve the engineering problems.

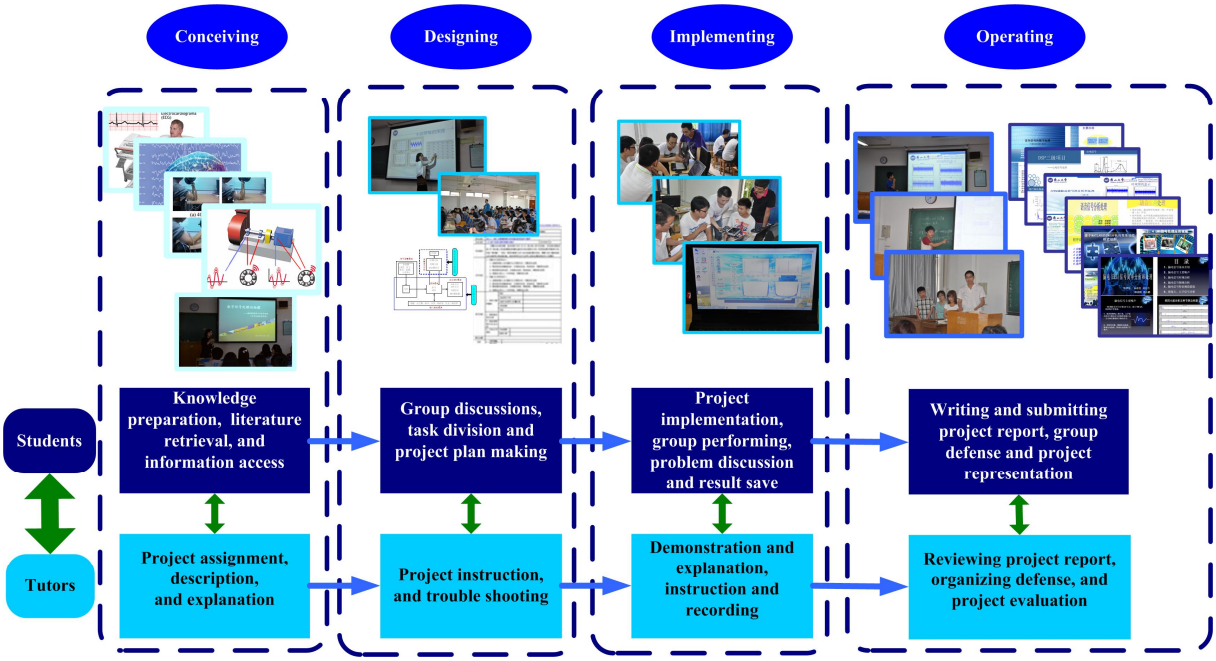

Figure 4 Project-based practical teaching process

3.3.3 Teaching assessment methods

In order to improve the comprehensive quality and cultivate the students' innovation spirit, a multi-aspects evaluation scheme was adopted under guidance of the CDIO Standard 11. The course assessment includes six parts, of attendance (5%), MATLAB assignments (10%), class discussion (10%), project design (15%), experiment (10%) and final exam (50%). For each student, the score of the course is the sum of the six parts mentioned above. In order to evaluate the overall quality of students and develop the teaching reform, the setting of the final examination goes around the teaching programs and teaching requirements, takes key content as the main line, focuses on basic content and practical application, contains comprehensive analysis, and also covers key contents in each chapter.

Meanwhile, to ensure the effective implementation of teaching reform, it is necessary to adjust the course content and implement modalities dynamically. To do so, a feedback mechanism is constructed and adopted based on questionnaires for the teaching content, teaching methods, topics of the discussing course, the organization, the implementation effect of third level project, etc. Opinions and suggestions from different grades are processed, summarized, analyzed and provided as the feedback to the teacher to overcome shortcomings in teaching reform timely and accurately and push the teaching reform towards optimal goals gradually.

4. EVALUATION AND FEEDBACK

In order to evaluate the status of implementation and actual effect of the teaching reform, 100 students were also randomly chosen from Grade 2010 and 2011 (50 for each, who are majored in Measurement and Control Technology and taught after teaching reform) for investigation, meanwhile, another 100 students were randomly chosen from Grade 2008 and 2009 (50 for each, who are all majored in Measurement and Control Technology and taught before teaching reform) for comparison. The investigation focused on the following nine aspects on development of the students:

- **Item 1:** Satisfaction on theoretical learning;
- **Item 2:** Accuracy in concept comprehension;
- **Item 3:** Consolidation of theoretical knowledge via course experiment;
- **Item 4:** Enlightenment of practice teaching for engineering application;
- **Item 5:** Systematic comprehension of the course content;
- **Item 6:** Improvement on problem finding;
- **Item 7:** Improvement on literature review and anglicizing
- **Item 8:** Improvement on problem solving;
- **Item 9:** Improvement on team cooperation.

Figure 5 shows the investigation results . It can be seen that through the teaching reform, combining the theory of teaching with engineering background, the satisfaction degree of students for theory learning have improved up to 85%(75% before the reform) due to curriculum development(Standard 2), 85% of the students consider that this teaching method is helpful to understand the basic concepts and methods(75% before the reform) owing to the reform of teaching and learning methods(Standards 7 and 8), 75% of the students consider that this teaching method makes course experiments helpful to deepen the understanding of the theory of learning content(70% before the reform)(Standard 7), 80% of the students hold that the practice teaching methods based on CDIO is enlightening for engineering practice of this course (65% before the reform), 75% of the students think that this kind of method of modularization contributes to their understanding on courses content system (70% before the reform), more than 80% of the students think that the abilities of finding problems, literature review and analysis, solving problems, teamwork have been improved remarkably (50%-60% before the reform) owing to more reasonable evaluation and feed back strategies (Standard 11).

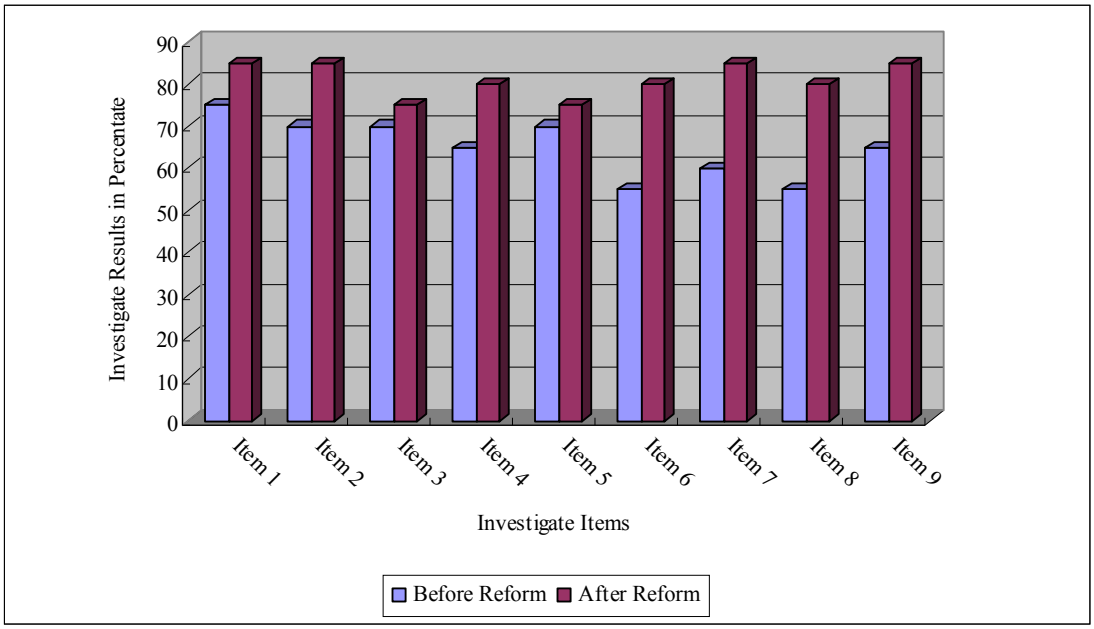

Figure 5 Investigation Results

5. COUCLUSION

The teaching and practicing process in digital signal processing course is designed here based on CDIO idea and implemented by the proposed goal-oriented modular teaching

reform mode. In order to meet the cultivation requirements for majors of Measurement and Control Technology and Instrument, the cultivating objectives of the course are set up and the modular teaching and practice system composed of theoretical teaching, classroom discussion, comprehensive experiments and project practice are designed to train students' innovative and practical abilities.

Good effect on the reform practice has been obtained by the feedback from students and shows that this teaching reform mode can combine theoretical learning with practical training, develop the abilities of independent thinking, problem analyzing and solving, enhance the skills of cooperation and communication, and promote the capabilities of comprehensive practice and innovation.

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