THE EVALUATION METHOD OF ABILITY ACHIEVEMENT LEVELS IN A CDIO SYSLLABUS

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ABSTRACT

As engineering education has continued to improve, more colleges and universities have adopted the CDIO engineering education model for the development of course majors and project design， which has improved the engineering skills of their students. However, there are few reports in the literature of the research and development of methods used to evaluate the levels of skills achievement in engineering. . Measurement of the effectiveness and achievement of an engineering education can be determined by a scientific evaluation using the engineering education reform. Therefore, determining the best method for guiding the evaluation of teaching techniques and exploring methods for evaluating levels of engineering ability are of very significant in understanding and implementing CDIO education and teaching reform.

In our CDIO syllabus the capabilities of engineering students can be classified into four categories, basic engineering knowledge, personal ability, teamwork and engineering system capability. In this reported study, an artificial intelligent model car project was used as an example to demonstrate how these engineering capabilities are achieved during the process of principle analysis, abstract modeling, plan design, intelligent car platform construction, debugging and operation among others. Measurement standards and scoring systems were established for each stage of the practice process. The evaluation methods were operational and quantifiable throughout the entire practice process and they ultimately ensured an overall improvement in the outcome of the practice of engineering design.

KEYWORDS

Evaluation methods, Ability achievement levels, Intelligent model car project, CDIO syllabus, Standards: 2, 7, 11

1. INTRODUCTION

The CDIO engineering education mode emphasizes a project-oriented and task-driven education, in which students can acquire the necessary knowledge and skills to complete their tasks and enhance their comprehension and innovation in solving practical problems. Establishment of a CDIO-based learning assessment system can assist in the analysis and evaluation of the students' achievements, and encourage the students' enthusiasm for learning during the entire process of a project design. In addition the assessment system also helps to summarize the experience and discover the problems in the links of teaching and learning to instruct teachers to better fulfill teaching responsibilities in the next teaching process.

There are several evaluations methods that can be used to assess technical projects and design-build-test experiences. In the area of program evaluation, Kaplan *et al*. described an approach called the Balanced Scorecard [1], which includes baseline interviews, and longitudinal studies to assess student learning during project practice. Balanced Scorecards were used to display the status of a program together with a range of techniques for project evaluation. Spady *et al*. first proposed a new idea for educational reform, called Outcome-Based Education (OBE) that consisted of "student centered" teaching concepts to evaluate the curriculum and the effects of teaching [2]. MIT evaluated engineering educational programs using the Accreditation Board for Engineering and Technology (ABET) EC 2000 [3]. Furthermore, OBE has also been used to establish engineering education accreditation standards by ABET [4]. In addition, Vijayalakshmi M. *et al.* [5] used evaluation criteria and a matrix to establish an evaluation of the learning requirements of teaching performance based on the results of a course of study.

Dalian Neusoft University of Information (DNUI) is one of the Chinese universities that has pioneered the CDIO engineering education reform, and as such has developed a TOPCARES-CDIO (T-C) educational model that was adopted from the CDIO international engineering education initiatives. The acronym describes the first-level of eight skill standards for measuring capability. In essence, TOPCARES means Technical knowledge and reasoning, Open minded and innovation, Personal and professional skills, Communication and teamwork, Attitude and manner, Responsibility, Ethical values and Social value created by application practice. Using these 8 first-level skill standards, 32 second-level and 110 third-level skill standards were developed. Over the past several years, continuous effort has been made by DNUI to realize the vision of the CDIO reform.

In this reported study, an intelligent car project for students in the electronic information engineering major was used as a model to evaluate the TOPCARES system through a combination of the knowledge of an electronic information system, personal ability, teamwork and the construction of the intelligent model car. To accomplish this, first, the TOPCARES-CDIO skill standards for the intelligent car project were established using the training objectives of the study major. Then, using an intelligent car system theory analysis, abstract modeling, program design, intelligent car platform construction process, commissioning and other practical processes, four steps that included Conception— Design— Implementation— Operation, were used as skill assessment standards. Finally, a result-oriented analysis of the ability to achieve a select degree of accomplishment that corresponded to a standard practice was established. A two-way system of teaching and learning was achieved by the construction of a closed-loop system for four learning process aspects, which included learning objectives- practice process- results assessment– skill achievement. The effectiveness of instruction teaching was continuously improved, which improved the quality of the students.

2. LEARNING OUTCOMES AND SKILLS TRAINING OF THE INTELLIGENT CAR PROJECT

The training objectives of the engineering curriculum have been established so that the students can master the basic theory of electronics technology and information systems, which will enable him/her to design and develop electronic products and embedded software. In addition, this course of study will also impart the ability to analyze and resolve complex technical engineering issues. Based on the requirements of the curriculum training objectives, an intelligent car project was established in the second semester of the sophomore year in the electronic information engineering major. This project plays an important role in summarizing and improving the students' previous course work. During the first year of college, students must complete the basic courses of electronic circuits, C language programming and an electrical technology practice project. They must also master the basic knowledge of the course of study, and possess circuit design and software programming skills. In the first semester of the sophomore year, students learn microcontroller theory and application courses, master the knowledge of the Micro Control Unit (MCU) principles, and must understand embedded software development.

The intelligent car practice project is designed to train students how to apply their knowledge of circuit design, embedded development and software programming that they have learned in previous course work. In this project, the students must employ the Altium Designer the industrial EDA tool to design the electronic circuits, C language to program the microprocessor, and the Keil MDK the software programming platform to complete the system requirements analysis, system design, system implementation, system integration, debugging and testing. This latter requirement must be done according to the basic project development flow on the hardware platform and model car which is designed and developed as part of the study major. Students must purchase their own components and tools, and then fabricate a smart car that can track, speed test and perform wireless communication, as shown in Figure 1.

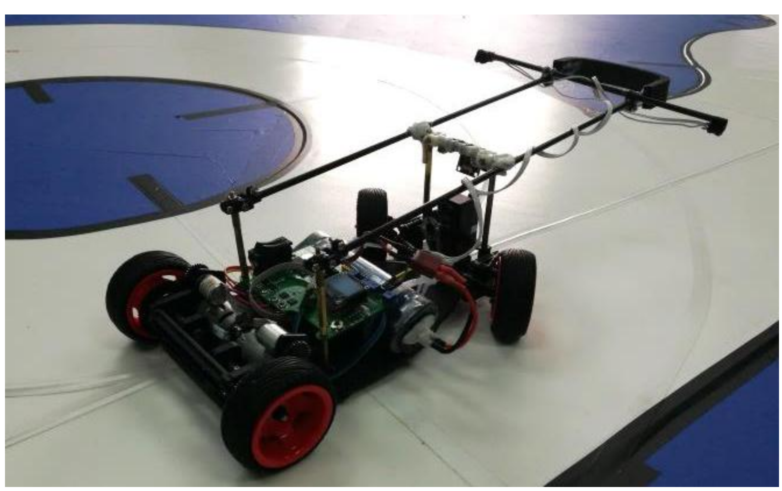

Figure 1. Photo of intelligent car

The intelligent car is composed primarily of a power module, driver module, tracking module, communication module and main control module, the typical design of each functional module is shown in Table 1. Multi-disciplinary technologies are combined in the intelligent car, including intelligent sensing and detection technology, motor control technology, mechanical engineering technology and wireless communication technology.

Table 1. Intelligent car system functional structure and typical design

Module Name	Typical Design	Notes
Main Control Module	Microcontroller	1. Each functional module circuit designed by students. 2. The typical design in this table is for student's reference. 3. Students can also propose other designs in the development of their intelligent car.
Power Module	Switching Mode Power Supply(SMPS)	
	Low Dropout Voltage Regulators(LDO)	
Driver Module	H-Bridge	
	Metal-Oxide-Semiconductor Field Effect Transistor (MOSFET)	
	Integrated Circuit driver chip	
Tracking Module	Electro-Optical Sensor	
	Electromagnetic sensor	
	Camera	
Communication Module	Bluetooth	
	ZigBee	
	2.4GHz	
	LoRa	

Based on the major training objectives and industrial product design and development process, the teaching goals of the intelligent car project are defined so that the student will master the required professional knowledge and proficiently apply this to the MCU system design and other projects. This will improve the students' practical ability and help them to apply their acquired skills to problem solving, and it will cultivate the students' technical writing capability by writing project documents. The teaching objectives of this project can be summarized into four levels: teaching of electronic information, training students' technical abilities, development of teamwork and intelligent car system construction. The T-C skill standards that are taught in this project are determined by a combination of the T-C syllabus and the teaching objectives of this project, as shown in Table 2.

The development process of intelligent car practice project was divided into four stages that included, Conception, Design, Implementation and Operation, which are executed with the guidance of the CDIO education concept. These stages cover the general development process of electronic products as shown in Figure 2.

Table 2. Three level T-C skill training standards in the intelligent car project

Project Teaching Objectives	Project T-C skill Training Standards (1st-Level Index)	Project T-C skill Training Standards (2nd-Level Index)	Project T-C skill Training Standards (3rd-Level Index)	Description	Weight
Knowledge of Electronic Information	1 Technical knowledge and reasoning	1.2 Core engineering fundamental knowledge	1.2.1 Professional fundamental knowledge	Basic concepts, laws and calculation methods of electrical engineering; basic principles, analysis and design methods of analog circuits; basic principle and analysis and design methods of digital circuits.	4%
			1.3.1 Professional knowledge	Embedded software programming knowledge, hardware design and development methods of electronic product, and PCB layout, PCB processing, welding and debugging methods	10%
Personal technical skills	2 Open thinking and innovation	2.4 Innovation skills	2.4.1 Introduction, digestion, absorption and re-innovation	Adapting to the needs of social development, you should be aware of continuous innovation and development, and be ability to study alone, developing and researching new technology. Referring to the method introduced and according to the actual needs use the advanced EDA tools to solve the problems during design and test of complex embedded systems.	5%
	3 Personal and professional skills	3.1 Analytic reasoning and problem solving	3.1.1 Problem Identification and Formulation	Define system performance metrics, based on customer needs. Propose and describe engineering problems that need to be solved. In a timely manner, identify the problems in design, welding and debugging.	8%
	4 Communication and teamwork	4.1Communication skills	4.1.3 Written Communication	Compose technical documents, project reports (including charts)	3%
		4.2 Skills for communications in foreign languages	4.2.2 Reading and understanding professional literatures	Read and understand the literature in the field, and be capable of using the English version of the development tools	5%
	5 Attitude and manner	5.1 Personal attitude and habits	5.1.2 Learning attitude and habits	Develop a good learning attitude and learning habits	5%
Teamwork skills	4 Communication and teamwork	4.3 Teamwork	4.3.1 Forming Effective Teams	Be able to establish form teams, and complete project collaboratively	5%

Project Teaching Objectives	Project T-C skill Training Standards (1st-Level Index)	Project T-C skill Training Standards (2nd-Level Index)	Project T-C skill Training Standards (3rd-Level Index)	Description	Weight
System building skills	8 Social contribution by application practice	8.6 Conceiving system engineering and management	8.6.1 Understanding Needs and Setting Goals	Define system performance metrics and system goals and requirements, based on function requirements	5%
		8.8 Implementation	8.8.1 Designing a Sustainable Implementation Process	Design the software and hardware development plan of the car project, implement this plan, draw the hardware circuit schematic and complete the embedded software programming work.	10%
			8.8.2 Hardware Manufacturing Process	Draw circuit schematic, and PCB to produce the intelligent car control.	10%
			8.8.3 Software Implementing Process	Based on to the requirements of the system design, complete the design and implementation of the software system using the advanced programming language and algorithm. Write the main program, the photoelectric sensor collection, the motor drive code, implement these with the hardware to obtain the complete system.	10%
			8.8.4 Hardware Software Integration	Integrate an implement the software and hardware.	5%
			8.8.5 Test, Verification, Validation and Certification	Based on to the design requirements of the system, test the functions of the software and hardware in the system and verify using scientific verification and testing methods.	15%
Total					100%

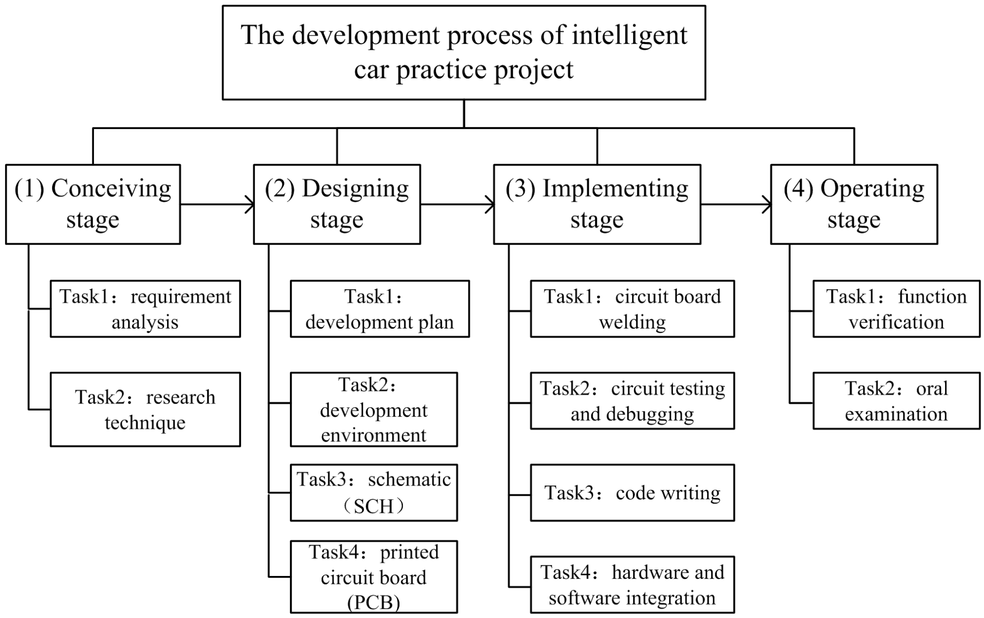

Figure 2. The development process of intelligent car practice project

(1) Conceiving stage

In this stage of the project the student must analyze the intelligent car system, research technical information, read the documents of the professional field, propose the technical features and design requirements for the intelligent car system, and write a technical report.

(2) Designing stage

In the design stage, the student must design the overall plan of the intelligent car based on the results of the concept stage, and using the requirement analysis, the circuit principles and the micro-controller working principles must be articulated and a functional block diagram of the system must be drawn.

(3) Implementing stage

Here the student will draw the schematic circuit diagram based on the function module of the intelligent car system, and complete the PCB design and wiring work and build the embedded operation system on the embedded system development platform. The student must also complete the software functional design using modular software programming ideas and methods, and the sensor detection, motor and servo control algorithms. A software flow chart is then constructed of each function module. The software code is written and the program is downloaded to the microcontroller.

(4) Operating stage

In this stage the student completes the circuit board welding, makes and assembles the car. In addition the student designs a program to test and debug the system and verify its function.

3. DESIGN SKILL ASSESSMENT METHOD FOR THE INTELLIGENT CAR PRACTICE PROJECT

The evaluation of students' learning outcomes is used to measure the achievement of the expected learning goals for each student, which is an important part of teaching. The evaluation of the students' skills should be planned and implemented based on the expected learning outcomes of the project. The intelligent car practice project focuses on the cultivation of students' skills and the assessment of this process is combined with the major training objectives of the T-C syllabus. To reform the teaching process by changing from a single learning assessment, a new, dynamic learning assessment method has been gradually established to adapt to the needs for training senior personnel.

The intelligent car practice project was used to assess the four stages of the project development, and develop detailed examination and scoring standards. We assessed the weight of the expected standards' value according to the importance of the students' skills, and the process for this specific assessment and scoring standards are shown in Table 3. The evaluation process and the skill assessment method of the four project stages are introduced in the steps below combined with the T-C teaching model. Student achievement is divided into five levels (1 = Poor, 2 = Pass, 3 = Middle, 4 = Good, 5 = Excellent).

Step1: Conceiving stage

In the concept stage, the students are required to analyze the requirements of the project, identify the problems and their solutions. The students must apply their basic engineering knowledge to analyze the relevant circuit principles of the project, search the technical chip datasheets and related professional technical documents of the project, write technical reports using professional terms, discuss system requirements, and produce written communications. Therefore, in the concept stage, we primarily assess the students' 'Professional Fundamental Knowledge', 'Problem Identification and Formulation', 'Written Communication', and 'Reading and Understanding Professional Literatures'.

Step2: Designing stage

In the design stage, the students must finish the design of the system plan and draw a functional block diagram of the system based on the system goals and requirements. They must also formulate a detailed project development plan, cultivate a good learning attitude and develop industrial product design skills. Students then install related software development environments and drivers to prepare for the design and implementation of the project. They design the circuit schematic diagram and PCB diagram for each functional module of the intelligent car using a combination of their professional knowledge of circuits and signals, and by researching related design information. They must use their experience with existing circuit design to determine if this can be applied to the intelligent car project. In addition, the students need to check the design rules and be sure that the design for the manufacture of the PCB is valid, and establish requirements for the hardware manufacturing process. At the later part of the designing stage, the students will generate photo plots of the designed PCBs and send to the related PCB manufacturing unit to create a printed circuit board for the intelligent car project. Therefore, in the designing stage, we will assess the students' 'Professional Knowledge', 'Learning Attitude and Habits', 'Understanding Needs and Setting Goals', 'Designing a Sustainable Implementation Process', and 'Hardware Manufacturing Process'.

Table 3. Intelligent car project development process and skill standards assessment scoring instruction

Project Developing Process	**Assessment Content**	**Score**	**Scoring Standards**	**Total Score**	**Index of T-C Skill Standards(3rd-Level)**													
					1.2.1	**1.3.1**	**2.4.1**	**3.1.1**	**4.1.3**	**4.2.2**	**4.3.1**	**5.1.2**	**8.6.1**	**8.8.1**	**8.8.2**	**8.8.3**	**8.8.4**	**8.8.5**
Conceiving Stage	Datasheet Reading	5	analyze requirements,search and read datasheets,5 points	15	4			3	3	5								
	Technical Report Writing	10	requirements analysis, principle analysis, technical report, 10 points															
Designing Stage	System Design	5	system design scheme, system block diagram, 5 points	30		5	5					5	5	5	5			
	Development Environment Building	5	(AD17, Keil5, Driver),5 points															
	SCH	10	SCH(power: 2, detection module: 3, driver module: 2, mainboard: 3),total 10 points															
	PCB Layout	10	PCB(power: 2, detection module: 3, driver module: 2, mainboard: 3),total 10 points															
Implementing Stage	Circuit Board Welding	5	good welding quality, 5 points	35							5			5	5	10	5	5
	Circuit Testing	5	no problem in circuit testing, 5 points															
	Coding	15	total 15 points (program flow: 5, code structure: 5, function realization: 5)															
	Hardware Software Integration	5	download, debug, 5 points															
	Teamwork	5	teamwork, answer questions in turn,5 points															
Operating Stage	Oral Exam	10	professional knowledge: 5, system scheme: 5	20		5		5										10
	Function Verification	10	tracking: 3, running: 2, servo controlling: 2, communication:3															

Step3: Implementing stage

In the implementation stage, the students in each project team execute the project according to their designated roles. Using the circuit design, the students will acquire the required components and welding tools, and weld the chosen electronic components to the printed circuit boards to fabricate the required circuits. After the completing the circuit board welding, the students must determine the quality of solder joint and the circuit reliability. The circuit board performance is then tested and verified using a multimeter, an oscilloscope and other instruments and equipment, to test the electronic connectivity, integrity of the chip performance and that the output signal waveform is correct. After testing the circuit board, the students must assemble the model car using the assembly instructions, and connect all the functional PCB modules in the model car using generic cabling to complete the assembly of the car. The software will be developed by research and discussion in the group to ascertain the best software using the software design flow chart for each functional module. This will include writing the code, compiling, debugging, running and downloading the program into the software programming platform. This will entail modular programming ideas, programming languages and knowledge of MCU development. The students will then complete the integration of the hardware with the software. Therefore, in the implementation stage, students' will be assessed in how they 'Form Effective Teams', and 'Design a Sustainable Implementation Process', 'Hardware Manufacturing Process', 'Test &Verification &Validation &Certification', 'Software Implementing Process', 'Hardware Software Integration' etc.

Step4: Operating stage

In the operation stage, the functions of each teams' intelligent car are verified including the tracking function, detection function, wireless communication and turning angle etc. In addition, the intelligent car project establishes an innovative function assessment item that requires each project group to design at least one additional function in the intelligent car, such as obstacle avoidance and remote control. An oral examination of the students is conducted to determine their application knowledge of the microcontroller, the principles of each circuit, the problems encountered in the development of the project and the solution process. Therefore, in the operation stage, students are assessed for their 'Professional Knowledge', 'Problem Identification and Formulation', 'Test & Verification & Validation & Certification'.

Developing detailed assessment and scoring standards is valuable to teachers, and it also conveys the teachers' expectations for the students' performance through scoring standards. Since these same standards are used throughout the class, the students are assured that the evaluation is fair and objective. But the construction of the assessment is time-consuming and challenging; therefore, it must be taken seriously, studied and researched by the teachers.

4. ASSESSING STUDENT PROJECT SKILLS ACHIEVEMENT

The assessment of the relative achievement of students' profession skills for this practice project is the final and the most important step in the evaluation process of learning. Evaluation results were obtained through the project development process assessment and record of each student's skills, and the analysis of collected data. These data are used to determine the learning level of each student and skill achievement of the entire course of study. In addition, these data are used for the final measure of each skill index compared to the expected learning outcome that was established set by the course plan. The teaching, learning and overall course plan can then be improved by analyzing the results of the evaluation.

The results for an individual student and the average grade for the entire class are used as examples to determine the skill achievement as an evaluation results. Table 4 shows a representative student's skill achievements, while Table 5 lists the calculation for the achievement of a representative class. A radar chart was plotted using the average achievement from Table 5. Figure 3 shows a comparison of the actual learning outcomes and the expected learning outcomes for students. The teaching effectiveness of this course can be analyzed using the results shown in Table 5 and Figure 3. As shown, the intelligent car practice project produced students with good T-C skills that allowed them to grasp the 'Reading and Understanding Professional Literatures (92%)' and '1.2.1 Professional Fundamental Knowledge (89%)'. However, the skills that were not as well developed included '2.4.1 Introduction, Digestion, Absorption and Re-innovation (66%)' and '1.3.1 Professional Knowledge (71.1%)'. We can understand the advantages and disadvantages of the teaching process by the analysis of its learning effectiveness. For the unsatisfactory aspects, a careful analysis should be conducted of the causes, so that corrective measures can be formulated to strive for improvement and overcome the drawbacks. This course of action will help us to achieve continued improvement.

Table 4. Scores for a representative student's skill standards assessment

<table>
<tr><th rowspan="2">Project Developing Process</th><th rowspan="2">Assessment Content</th><th rowspan="2">Score</th><th colspan="14">Index of T-C Skill Standards（3rd-Level）</th></tr>
<tr><th>1.2.1</th><th>1.3.1</th><th>2.4.1</th><th>3.1.1</th><th>4.1.3</th><th>4.2.2</th><th>4.3.1</th><th>5.1.2</th><th>8.6.1</th><th>8.8.1</th><th>8.8.2</th><th>8.8.3</th><th>8.8.4</th><th>8.8.5</th></tr>
<tr><td rowspan="2">Conceiving Stage</td><td>Datasheet Reading</td><td>5</td><td rowspan="2">3</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2">2</td><td rowspan="2">3</td><td rowspan="2">5</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>Technical Report Writing</td><td>10</td></tr>
<tr><td rowspan="4">Designing Stage</td><td>System Design</td><td>5</td><td rowspan="4"></td><td rowspan="4">4</td><td rowspan="4">3</td><td rowspan="4"></td><td rowspan="4"></td><td rowspan="4"></td><td rowspan="4"></td><td rowspan="4">4</td><td rowspan="4">4</td><td rowspan="4">4</td><td rowspan="4">4</td><td rowspan="4"></td><td rowspan="4"></td><td rowspan="4"></td></tr>
<tr><td>Development Environment Building</td><td>5</td></tr>
<tr><td>SCH</td><td>10</td></tr>
<tr><td>PCB</td><td>10</td></tr>
<tr><td rowspan="5">Implementing Stage</td><td>Circuit Board Welding</td><td>5</td><td rowspan="5"></td><td rowspan="5"></td><td rowspan="5"></td><td rowspan="5"></td><td rowspan="5"></td><td rowspan="5"></td><td rowspan="5">5</td><td rowspan="5"></td><td rowspan="5"></td><td rowspan="5">4</td><td rowspan="5">5</td><td rowspan="5">7</td><td rowspan="5">4</td><td rowspan="5">4</td></tr>
<tr><td>Circuit Testing</td><td>5</td></tr>
<tr><td>Coding</td><td>15</td></tr>
<tr><td>Hardware Software Integration</td><td>5</td></tr>
<tr><td>Teamwork</td><td>5</td></tr>
<tr><td rowspan="2">Operating Stage</td><td>Oral Exam</td><td>10</td><td rowspan="2"></td><td rowspan="2">4</td><td rowspan="2"></td><td rowspan="2">4</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2">9</td></tr>
<tr><td>Function Verification</td><td>10</td></tr>
<tr><td rowspan="3"></td><td>Total</td><td>82</td><td>3</td><td>8</td><td>3</td><td>6</td><td>3</td><td>5</td><td>5</td><td>4</td><td>4</td><td>8</td><td>9</td><td>7</td><td>4</td><td>13</td></tr>
<tr><td>Full Scores</td><td>100</td><td>4</td><td>10</td><td>5</td><td>8</td><td>3</td><td>5</td><td>5</td><td>5</td><td>5</td><td>10</td><td>10</td><td>10</td><td>5</td><td>15</td></tr>
<tr><td>Achievement</td><td>82.0%</td><td>75.0%</td><td>80.0%</td><td>60.0%</td><td>75.0%</td><td>100.0%</td><td>100.0%</td><td>100.0%</td><td>80.0%</td><td>80.0%</td><td>80.0%</td><td>90.0%</td><td>70.0%</td><td>80.0%</td><td>86.7%</td></tr>
</table>

Table 5. Skills achievement of a representative class

Number	Name	Achievement of T-C Skill Standards（3rd-Level）														Total Achievement
		1.2.1	1.3.1	2.4.1	3.1.1	4.1.3	4.2.2	4.3.1	5.1.2	8.6.1	8.8.1	8.8.2	8.8.3	8.8.4	8.8.5	
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
12	WZ Cong	75.0%	70.0%	80.0%	75.0%	66.7%	80.0%	80.0%	80.0%	80.0%	90.0%	90.0%	80.0%	80.0%	73.3%	79.0%
13	QQ Zhao	100.0%	80.0%	60.0%	87.5%	100.0%	80.0%	80.0%	60.0%	80.0%	70.0%	80.0%	70.0%	80.0%	66.7%	76.0%
14	Shuai Li	100.0%	90.0%	80.0%	87.5%	100.0%	80.0%	80.0%	80.0%	100.0%	90.0%	90.0%	80.0%	80.0%	80.0%	86.0%
15	Zhe Cui	75.0%	80.0%	60.0%	75.0%	100.0%	100.0%	100.0%	80.0%	80.0%	80.0%	90.0%	70.0%	80.0%	86.7%	82.0%
16	Tong Zhang	75.0%	70.0%	80.0%	75.0%	66.7%	60.0%	80.0%	60.0%	80.0%	80.0%	80.0%	70.0%	80.0%	60.0%	72.0%
17	XT Ren	75.0%	80.0%	60.0%	87.5%	66.7%	80.0%	60.0%	80.0%	60.0%	70.0%	70.0%	70.0%	80.0%	66.7%	72.0%
18	XP Han	100.0%	70.0%	80.0%	100.0%	66.7%	80.0%	80.0%	80.0%	80.0%	70.0%	80.0%	80.0%	80.0%	86.7%	81.0%
19	ZX Li	75.0%	60.0%	60.0%	87.5%	66.7%	60.0%	60.0%	60.0%	60.0%	60.0%	70.0%	60.0%	60.0%	66.7%	65.0%
20	QL Guo	100.0%	80.0%	80.0%	100.0%	66.7%	80.0%	80.0%	80.0%	80.0%	70.0%	80.0%	90.0%	80.0%	93.3%	84.0%
21	Liang Xu	50.0%	60.0%	40.0%	75.0%	66.7%	60.0%	60.0%	60.0%	60.0%	60.0%	70.0%	60.0%	80.0%	60.0%	62.0%
…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…	…
Average Achievement		89.0%	71.1%	66.0%	72.8%	85.7%	92.0%	80.0%	76.4%	82.4%	75.1%	81.3%	78.3%	74.6%	81.9%	78.4%

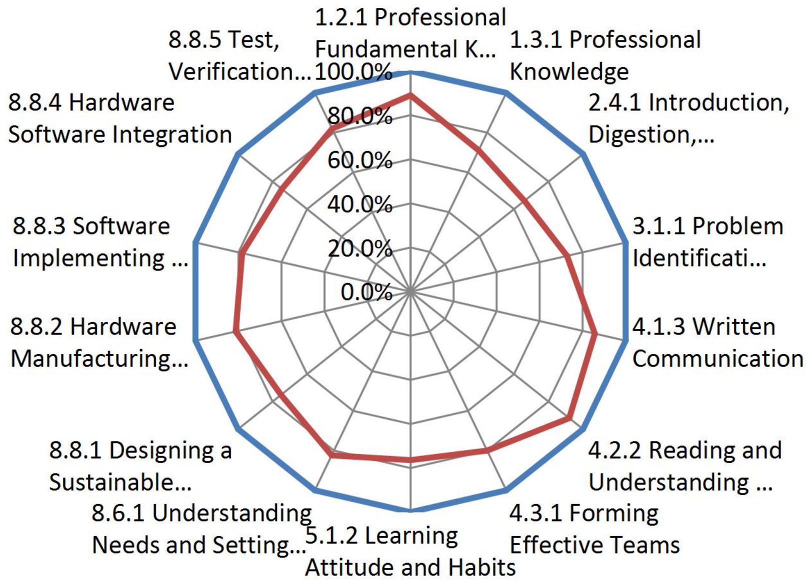

Figure 3. Analysis of radar chart for the intelligent car project

5. CONCLUSIONS

In this reported study, an intelligent model car system was used as a demonstration of a learning assessment system. The learning objectives (CDIO STANDARD 2) of the project were established as four dimensions that included electronic information system, personal ability, teamwork and construction of the an intelligent model car model. In addition, the intelligent car system was fabricated using the integrated CDIO learning experience which included the following stages concept, design, implementation, and operation. The work performed in each of these stages was assessed to determine the achieved skills to determine if the talent training objectives were consistent with the engineering practice process (CDIO STANDARD 7). This process included questioning the students, having them complete assignments, write technical reports, as well as assessment tables, oral exams and other diversified assessment methods. This process increased the reliability and effectiveness of the assessment data, but also allowed for a more reliable measurement of student achievement (CDIO STANDARD 11).

Compared with References [4] and [5], this evaluation method focuses on the practical process of students, and which is more extensively to outcome-oriented-ability assessment. The analysis method of skill achievement used in this study that was based on a practice project can be used to measure the specific learning outcomes of each student, and can also be used to determine the skill achievement by the overall learning outcomes of the course. The results of this analysis can serve as a basis for teachers and students to continuously improve and enhance their learning outcomes.

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