ICIC Express Letters ICIC International ©2019 ISSN 1881-803X
Volume **13**, Number **1**, January **2019** pp. **41–49**

EVALUATING THEMATIC-APPROACH TEACHING OF ROBOT DESIGN AND PRACTICE COURSE THROUGH PSYCHOMOTOR AND AFFECTIVE DOMAINS

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Received June 2018; accepted September 2018

Abstract. *This study primarily aims to develop evaluation forms for psychomotor and affective domains to assess the Robot Design and Practice course through Automatic Measurement Technology course. This course is established for college-level robot education, and MyRIO and LabVIEW, which are often applied in the industry, are combined and proposed as its core equipment. This technology-based course is designed for engineering and technology fields at the University of Technology. In this research, teaching evaluation indicators from psychomotor and affective domains are built by literature review and expert examination. Experimental teaching based on thematic approach is completed. Apart from the results of evaluation, the evaluation forms are tested and confirmed to possess reliability and validity for effective assessment.*
Keywords: Evaluation, Psychomotor, Affective, Robot, Course

1. **Introduction.** In Taiwan, robot education gained considerable attention in the past 10 years as a result of talent demand in the industry. To provide focused professional skills for student learning is a very important issue at University of Technology [1]. At present, the government and business communities invest their resources for talent development with regard to robot education [2]. Current resource of robot education centers in colleges and universities in Taiwan. Elementary schools, junior high schools, and senior high schools do not offer formal courses on robot education. Students need to participate in robot clubs in schools or attend cram school for robot education. This research not only provides the industry with talent demand but also trains learners to popularize robot education. Determining the effectiveness of robot course is the purpose and motivation of this research.

The three domains of educational activities or learning are cognitive, which entails mental skills (knowledge); affective, growth in feelings or emotional areas (attitude or self); and psychomotor, manual or physical skills (skills). The cognitive domain involves knowledge and development of intellectual skills. In this research, the evaluation focuses on psychomotor and affective domains due to the fact that the learners are students of skill-based oriented university. Psychomotor skills range from manual tasks, such as digging a ditch or washing a car, to more complex tasks, like operating a complex piece of machinery or dancing. The affective domain includes the manner in which individuals deal emotionally, such as feelings, values, appreciation, enthusiasm, motivations, and attitudes [3,4].

Thematic approach is a way of teaching and learning, whereby many areas of the curriculum are connected together and integrated within a theme. Usually, the teaching

DOI: 10.24507/icicel.13.01.41

evaluation is proceeded after thematic-teaching in the same individual course [5,6]. However, in this research, thematic-approach teaching and evaluation are processed for the Robot Design and Practice course under the experimental class called Automatic Measurement Technology [7]. Psychomotor and affective evaluation forms are developed and utilized to understand the teaching results. Based on this approach, the teaching evaluation of the goal of the Robot Design and Practice course to design and construct a robot can be simplified.

2. **Problem Statement and Preliminaries.** The Robot Design and Practice course is established for college-level robot education. MyRIO and LabVIEW, which are often applied in the industry, are combined and proposed as core equipment of this course. This technology-based course is designed engineering and technology fields at the University of Technology. Course indicators are provided in the Delphi questionnaire, which is drafted based on literature review, expert consultations, and interviews. Four indicator dimensions are presented for chapter titles, 21 first-level course indicators for section titles, and 62 second-level course indicators for lesson titles. Analytic hierarchy process (AHP) is utilized to design the time arrangement for each chapter [8,9]. Four types of robots are proposed and constructed to demonstrate hardware and software integration.

According to property and equipment training difficulty, course arrangement order was designed in three levels: a) basic concepts and skills, inclusive of "Robot Technology" and "LabVIEW Design"; b) expanded concepts and skills, inclusive of "MyRIO Technology"; c) advanced applications, inclusive of "Robot Design and Implementation".

Table 1. Schedule design of chapter and sections

Chapter Subject	Section Outline	Time	Note
Robot Technology	1-1. Evolution of robot 1-2. Present and future of robot industry 1-3. Present robot technology 1-4. Robot education 1-5. Robot structure and design	2 weeks/6 h	
LabVIEW Design	2-1. LabVIEW program 2-2. Usage and test for various loops 2-3. Usage and test for array and data 2-4. Usage and test for graphics and charts 2-5. Usage and test for string and file I/O function 2-6. I/O interface of signal transmission 2-7. Functions of remote control 2-8. Tool palette of NI Myriad	3 weeks/9 h	Expert Lecture
MyRIO Technology	3-1. Using NI MyRIO 3-2. Integration of sensor and MyRIO 3-3. Integration of controlled device and MyRIO 3-4. Integration of additional devices and MyRIO	5 weeks/15 h	Expert Lecture
Robot Design and Implementation	4-1. Wheel robot design and construction 4-2. Balance arm design and construction 4-3. Self-balancing two-wheel robot design and construction 4-4. KNR robot design and construction	8 weeks/24 h	

Remark: 18 weeks/54 h/semester.

Table 1 shows the teaching schedule design. By applying AHP, the weight of each subject chapter can be transformed into teaching hours. In Table 1, schedule arrangements of chapters and sections are listed based on weight-to-hour transformation. To consider the industry experience's connection with the designed course, two expert lectures are suggested to be conducted during the semester based on the Delphi questionnaire. Four types of robot are designed in Robot Design and Implementation chapter for thematic teaching based on other three chapters [10].

Based on designed chapters and sessions, 383-pages teaching material is completed. Four types of robot are constructed as Figure 1 to Figure 4. Figure 1 presents a wheel robot, Figure 2 illustrates a self-balancing two-wheel robot, Figure 3 shows a balance arm robot, and Figure 4 displays a KNR robot.

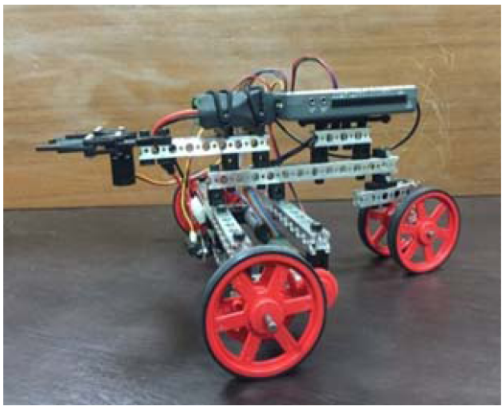

Figure 1. Wheel robot

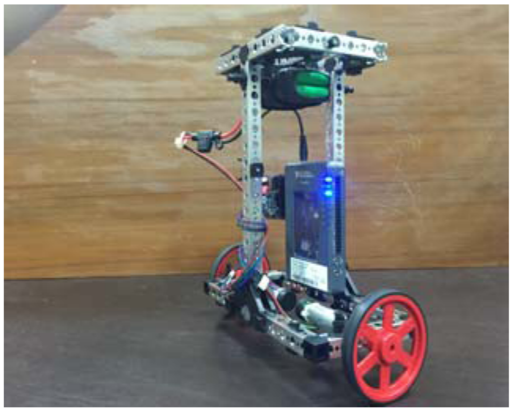

Figure 2. Self-balancing two-wheel robot

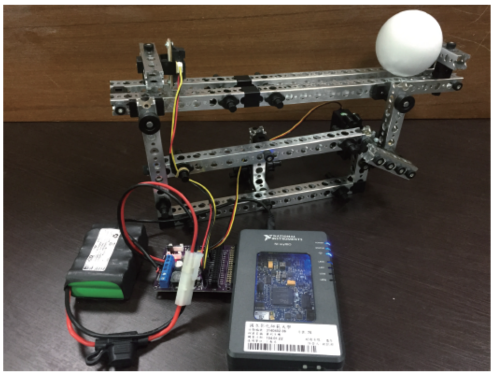

Figure 3. Balance arm

Figure 4. KNR robot

3. **Main Results.** A robot design and practice skill ability assessment form shown in Table 2 is designed to assess skill performance. This assessment form has four dimensions, namely, robot equipment assembling ability, robot equipment operation ability, robot equipment integration ability, and robot design ability. A 5-point Likert scale is used in every dimension for assessment. An affective scale form is developed using expert opinions for the affective domain. The content has four dimensions: teaching material and equipment, cognitive development, skill performance, and self-exploration. Each dimension consists of seven questions, for a total of 28 questions. After item analysis, all 28 questions are retained. The experimental class that proceeds thematic-approach teaching is offered as a requirement in 2017 fall and 2018 spring semester in the Department of Industrial Education and Technology, National Changhua University of Education (NCUE),

Table 2. Psychomotor scale form

Dimension	Question	Grading	Explanation
1) Robot equipment assembling ability	1) MyRIO controller setting and testing	☐ very good ☐ good ☐ neutral ☐ poor ☐ very poor	Correct MyRIO controller setting and successful communication with computer
	2) Robot structure assembling	☐ very good ☐ good ☐ neutral ☐ poor ☐ very poor	Robot structure assembling (including controller reasonable displacement)
2) Robot equipment operation ability	1) Front panel operation ability of LabVIEW	☐ very good ☐ good ☐ neutral ☐ poor ☐ very poor	Abilities to use LabVIEW and I/O of MyRIO controller
	2) Block diagram operation ability of LabVIEW	☐ very good ☐ good ☐ neutral ☐ poor ☐ very poor	
	3) I/O Utilization ability of MyRIO controller	☐ very good ☐ good ☐ neutral ☐ poor ☐ very poor	
3) Robot equipment integration ability	Integration ability of software and hardware	☐ very good ☐ good ☐ neutral ☐ poor ☐ very poor	Order, wiring correction and controllable system
4) Robot design ability	1) LabVIEW program design – Creativity	☐ very good ☐ good ☐ neutral ☐ poor ☐ very poor	Creativity and structure assessment on program and function
	2) LabVIEW program design – Function	☐ very good ☐ good ☐ neutral ☐ poor ☐ very poor	
	3) Robot structure design – Creativity	☐ very good ☐ good ☐ neutral ☐ poor ☐ very poor	
	4) Robot structure design – Function	☐ very good ☐ good ☐ neutral ☐ poor ☐ very poor	

Taiwan. This course is named Automatic Measurement Technology for 3 h and 3 credits. Forty students enrolled. The embedded thematic-teaching strategy model shown in Figure 5 is embedded in Automatic Measurement Technology course. The advantage of this teaching strategy is no need to open a new course for evaluation and saving time to evaluate the developed course. The disadvantage is that the evaluation result is an approximately assessment. However, there are conditions to perform such teaching strategy. The first is both courses must possess the same core technology. Second, both courses must be product-oriented course structure. The product-oriented course structure stands for the product needed to be built in the end of the course. A quasi-experimental design is applied in the teaching experiment because the teaching material and equipment are newly developed. Pre-test and post-test design methods are used in this course evaluation. Figure 6 shows the schedule for formally evaluating affective and psychomotor domains.

Thematic approach teaching of wheel robot, which is one of the robot design projects in Table 1, is carried out in a 40-student course called Automatic Measurement Technology for three weeks in the Department of Industrial Education and Technology, NCUE. The other three subjects of Robot Design and Practice course in Table 1 can be also replaced in this three-week experimental teaching and evaluation. The reason for using this course to perform experimental teaching is that LabVIEW and MyRIO are also taught in this

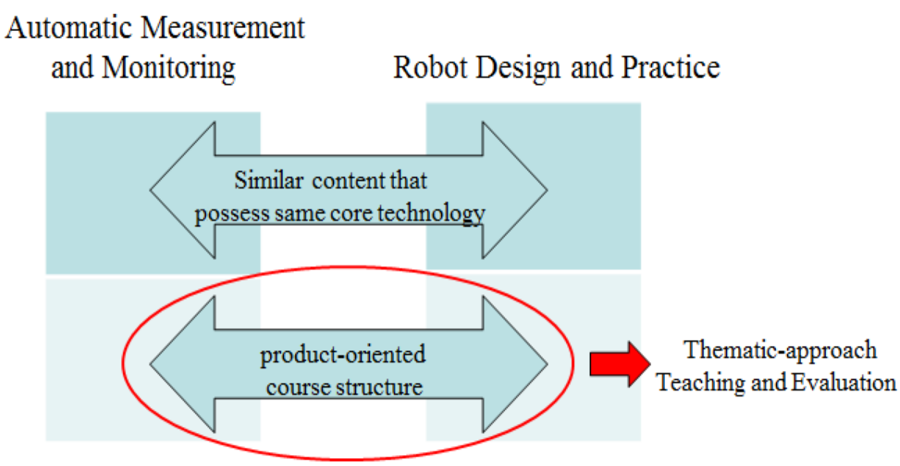

FIGURE 5. The thematic-approach teaching model

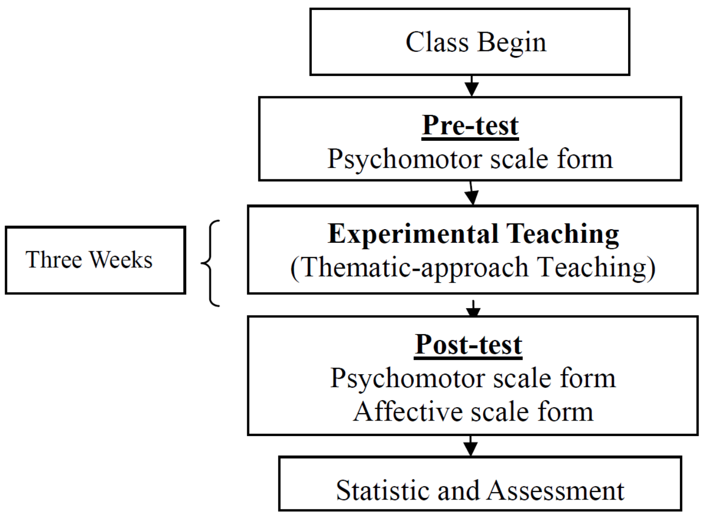

FIGURE 6. The schedule for formally evaluating these two domains

course. The psychomotor scale form has four dimensions, namely, robot equipment assembling ability, robot equipment operation ability, robot equipment integration ability, and robot design ability. A 5-point Likert scale is used in every dimension for assessment. The total score of the evaluation form is 50 points. The grading point for every question is very good = 5, good = 4, neutral = 3, poor = 2, and very poor = 1. The grading ranges from 10 to 50 points. The psychomotor scale form (see Table 2) is used to evaluate only one type of robot learning project, such as wheel robot or self-balancing two-wheel robot. In this paper, the project of wheel robot is selected as theme project to be taught and evaluated.

3.1. **Differential analysis of skill performance.** To realize how effective the developed teaching material and equipment is in enhancing students' skill performance, pre- and post-tests are given to see the difference using paired-sample t-test. In the pre-test, Kendall's coefficient of concordance (Kendall's W) is utilized to test the grading consistency and trustworthiness of three teachers. The results show that Kendall's W = 0.885, Chi-square test = 99.232, and significant test $p < .05$, ensuring the consistency of grading. In the psychomotor scale form, the full sore is 50 points and the least score is 10. Table 3 shows the statistical results of the paired-sample t-test for skill performance. Table 4 shows the difference between the pre- and post-tests and the t-test results. The table indicates the differential mean value of the two tests M = −24.62. Moreover, t = −39.022, and df = 39, with .001 significance level. After taking this class, the students demonstrate greatly enhanced skill performance.

Table 3. The paired-sample t-test results

Paired variables	N	M	SD	SE	t
Pre-test	40	16.20	1.96	.31	−39.022***
Post-test	40	40.82	5.05	.80	

***p < .001

Table 4. Paired-sample difference of t-test

Item		Paired difference					t	df
		M	SD	SE	95% CI			
					UL	LL		
Paired Sample	Pre-test Post-test	−24.62	3.89	.49	−25.87	−20.60	−39.022***	39

Remark: CI = Confidence Interval; UL = Upper Limit; LL = Lower Limit

***p < .001

3.2. **Affective scale test.** To understand the reaction and thought of this class of students, an affective scale form is filled by the class students. The affective scale is developed by literature review and expert consultation, and it contains four dimensions: teaching material and equipment, cognitive development, skill performance, and self-exploration. The affective scale form is designed as a 5-point Likert scale, which consists of strongly agree, tend to agree, neither agree nor disagree, tend to disagree, and strongly disagree. In the final week of the class, this form is given and filled by all students, and the reliability test shows Cronbach $\alpha = .928$, indicating a very good internal consistency reliability. The statistical results for each dimension are shown below.

1) Teaching material and equipment in Table 5.
2) Cognitive development in Table 6.
3) Skill performance in Table 7.

4) Self-exploration in Table 8.

Table 9 shows the mean value and standard deviation of all four dimensions. The mean values are 4.28, 4.27, 4.66, and 4.63. The results show that these four dimensions tend to agree and reach a 4.46 average.

Table 5. Mean value and standard deviation in the teaching material and equipment dimension

No.	N	M	SD
1) The teaching material content is correct and easy to read.	40	4.40	.62
2) The content amount and difficulty are appropriate.	40	4.05	.65
3) The teaching material content is logical and well organized.	40	4.45	.40
4) The teaching material has good connection with the teaching.	40	4.45	.65
5) The teaching material and experimental equipment contain enough knowledge and practices.	40	4.35	.50
6) The teaching material and experimental equipment can clearly explain the experimental process.	40	4.15	.55
7) The teaching material and experimental equipment can integrate other related professional knowledge to solve the problems.	40	4.10	.65

Table 6. Mean value and standard deviation in the cognitive development dimension

No.	N	M	SD
1) The goal of each chapter clearly expresses the key learning points.	40	4.05	.64
2) The teaching material can help me learn many new professional concepts in this field.	40	4.10	.64
3) The teaching material contains innovative skill content.	40	4.20	.60
4) The teaching material can enhance my application ability.	40	4.36	.65
5) The teaching material and experimental equipment stimulate personal learning motivation and interest.	40	4.45	.40
6) The teaching material and experimental equipment correspond with the teaching goals of this course.	40	4.50	.55
7) The teaching material and experimental equipment inspire me to develop new products.	40	4.25	.65

Table 7. Mean value and standard deviation in the skill performance dimension

No.	N	M	SD
1) The course helps to increase ability of robot design.	40	4.65	.40
2) The course and teaching materials excite me to apply myself to LabVIEW programming.	40	4.60	.55
3) The course promotes personal knowledge and skill in understanding MyRIO controller.	40	4.62	.40
4) The course and teaching materials can improve practical skills on robot construction.	40	4.70	.45
5) This course can help student to increase innovative development ability of robot.	40	4.65	.40
6) The teaching material and experimental equipment provide students practical support for the current learning demand needed in the industry.	40	4.68	.45
7) This course promotes personal multi-dimensional professional skills.	40	4.70	.46

Table 8. Mean value and standard deviation in the self-exploration dimension

No.	N	M	SD
1) The skill training in this course matches industry needs.	40	4.55	.64
2) This course contains professional skill and knowledge on robot design and practice.	40	4.50	.55
3) This skill training in this course matches the skill needs of industry robot design and practice.	40	4.65	.58
4) This course can help me understand the current trend in industry robot design and practice.	40	4.60	.65
5) This course helps me to understand if I fit this professional field.	40	4.68	.62
6) This course increases my practical experience in robot design and Practice.	40	4.75	.50
7) The course offers a personal professional advantage for future jobs.	40	4.65	.56

Table 9. Mean value and standard deviation of the four dimensions

Dimension	Question numbers	N	M	SD
1) Teaching material and equipment	7	40	4.28	.57
2) Cognitive development	7	40	4.27	.59
3) Skill performance	7	40	4.66	.44
4) Self-exploration	7	40	4.63	.59
Total	28	40	4.46	.55

4. **Discussion and Conclusions.** To evaluate thematic-approach teaching results in Robot Design and Practice course through Automatic Measurement Technology course. The affective and psychomotor scale forms were developed for experimental class assessment. In the psychomotor post-test performance, with developed teaching material and training equipment, the post-test was considerably better than the pre-test. The analysis results show an obvious difference between the two tests. The affective domain concerns four dimensions. 1) In the teaching material and equipment dimension, the teaching material content is correct and easy to read. It presents a well-organized, logical arrangement with enough knowledge and practices. The experimental parts of the teaching material clearly explain the experimental process. 2) In the cognitive development dimension, the goal of each chapter clearly expresses the key learning points. The teaching material and experimental equipment stimulate personal learning motivation and interest. 3) In the skill performance dimension, the course and teaching materials can improve practical skills on robot construction. 4) In the self-exploration dimension, the course increases students' practical experience in robot design and help them understand if they fit this professional field. Finally, the affective and psychomotor scale forms were also tested and confirmed to possess reliability and validity for effective assessment. In the further research, evaluation can be proceeded through giving Robot Design and Practice course and check the assessment error of this research.

Acknowledgement. This study was funded by a grant provided by the Ministry of Science and Technology, Taiwan, under the grant number MOST 106-2511-S-018-015 -.

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