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Development of Required Knowledge and Skills among Students through Applied Learning Modules

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The purpose of this study is to design a set of learning modules for developing the knowledge and skills of 34 students. The set includes 3 modules: Module 1: Monitoring; Module 2: Circuit Design; and Module 3: Transformer Development. The Four-D model is employed, and the study results are divided into 2 parts: 1. an evaluation of the effectiveness of the learning modules and 2. a comparison of pre- and post-test learning achievements after application of the learning modules. The modules are assessed based on standard criteria: the 80/80 rule, a t-test, and the results reveal that the post-test scores are higher than the pre-test scores, indicating that students taught using the model achieved better learning outcomes with a statistical significance of 0.05. In conclusion, the proposed modules allow students to develop knowledge of basic electrical and electronic circuits and develop skills in this discipline.

Keywords: knowledge expected, skills expected, electronics teacher, electrical circuit, electronic circuit

INTRODUCTION

The world is now intensely competitive and has developed into a knowledge-based society and economy. Government policies support and shape the competitive advantages of a country. A government must determine a means of increasing competitiveness and determine key factors in doing so. Most importantly, middle-level managers and technologists, a major force driving the manufacturing sector, which is at the heart of sustainable economic and social development (The Directorate for Education Reform, 2002), must also be involved in developing such a strategy.

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According to National Education Act BE 2542 (1999) amended (No. 2) BE 2545, which is considered the most important law governing Thai education, the principles and objectives of education management are to facilitate Thais' physical, cognitive, educational, ethical, cultural, and social development. The law has an important effect on education and facilitates vocational management.

Section 20 includes this significant rule: "Vocational education management and vocational training will be provided in government educational institutions and private schools based on cooperation between educational institutions, subject to the vocational education law and related laws"(Wirayut, 2007). This section specifically governs vocational education management and is used as an important mechanism for implementing national vocational education reform (Office of Vocational Education Commission, 2004). Teacher development is critical in developing competencies according to professional standards by providing craft and technician training compatible with national economic and social development and the needs of the labour market, which needs more vocational students every year. Therefore, schools should train teachers according to teachers' professional standards so that teachers can develop competencies to create effective curricula compatible with technology. The teacher is central to achieving these goals. The Education Office of the Vocational Education Commission has created a Strategic Plan for Education Act 2009-2018. For more information, please refer to (Nuanjan, 2008) study titled Subject: Learning Factory.

A case study on Thai vocational innovation found teachers' competencies to be incompatible with technology (Banleng & Coterie, 2005) (Aumsri, 2012). In section 4, this study summarizes the problems faced by schools under the Office of Vocational Education Commission. According to the study, the quality of teachers did not comply with requirements of the mission with respect to knowledge and professional experience. A research report on Thai educational conditions in 2007-2008 titled "Role of education and economic development" summarizes issues related to the external quality assessment of vocational education institutions. According to the second edition of the report (2006-2010), vocational education institutions failed the assessment of the Office for National Education Standards and Quality Assessment (PSU) in terms of personnel, teacher quality and teacher qualifications; the percentage of teachers pursuing professional development in teaching and learning management processes amounted to 77.42 percent, meeting the assessment criterion (level 3, 75 percent and above) but showing many teachers had not accumulated sufficient knowledge and experience (Wittayakorn, 2009). A report by the Secretariat of the Education Council on educational reform from 2009-2018 presents the results of a follow-up assessment of educational reforms since 1999. The report identifies problems to address to enhance the quality of vocational education management and especially in the training and development of teachers and faculty members.

The development of teacher performance has not been taken seriously, as teacher performance has been encouraged neither systematically nor sufficiently (Office of the Education Council Secretariat, 2009). Many studies have observed that staffing allocated to planning and production has been insufficient. The development of

professional talent in the country was proposed in a sixth strategy for raising the quality of teachers and professors to improve the quality of teaching by keeping up with modern science and technology (Aramsri, 2012). Industrial technicians were found to lack knowledge and skills in teaching and learning and to lack key traits considered necessary for a quality teacher to possess (Martin et al., 2002). There is a particular lack of professional skills among new vocational teachers, with at least some being unable to teach applied courses in subjects such as electrical and basic electronic circuits. The same trend has been found in other countries, such as at one electrical technician school in Baghdad.

Some teachers have engineering degrees and have had the opportunity to receive training abroad. Most applied skills teachers have received poor training in their profession. In Nigeria, a lack of skills among some graduates of vocational education is a major problem facing the vocational school education system. Vocational and education training (VET) serves as a relevant context from which to examine strategies that promote an understanding of concepts. VET offers "opportunities for young people to gain valuable skills in the labour market" and “includes general knowledge about careers" (Eichhorst, 2015). (Hoeckel, 2007) argued that there is a lack of interest in teaching VET. Likewise, (Lucas, 2014) stated that VET teaching is "under-researched and under-theorized" and has been recognized that "The impact of professional teaching on learners" (Durongdumrongchai, 2009) must be addressed. Tools must therefore be developed to help VET teachers and trainers become more effective at teaching methods. “Teaching with students' needs and contexts in mind" (Cedefop, 2015) is needed and the importance of VET reform and integration calls for "New teaching methods and learning materials" by focusing on project base learning (Barak, 2012) (Soparat et al., 2015). VET teachers also asks, "How can we test new resources and teaching in a functional experimental culture?" In managing undergraduate students’ learning and education, it is important to emphasize applied skills and to require students to prove theories and connect their knowledge to theoretical principles, including motivation between teacher and students for support technology (Blumenfeld et al, 1991).

Although the curriculum on electrical and electronic equipment focuses on practice, there is still insufficient time to obtain all applied skills needed (Hadiati, 2019). Studying electrical and electronic circuit design using computer programs for one semester is insufficient. The use of calculations also involves theories that students do not understand, and students are unable to apply the mathematical knowledge required for industrial technicians to practice. Students remain unable to create circuits and equipment, to use electrical circuit controls, or to maintain equipment; consequently, students have neither enough knowledge nor enough basic skills to become electronics teachers (Hotaman, 2008). (Melo, 2018)

Addressing barriers to the development of the theoretical knowledge, applied skills, and experimental skills of vocational learners will involve conducting research, developing learning models and employing applied learning modules (Farrokhnia & Esmailpour, 2010). The authors believe that a model developed for teachers (electrical and

electronics) can improve the theoretical knowledge, applied skills, and experimental skills of students of this field; improve electronics teachers' theoretical, applied and experimental skills; and better equip industrial technicians to apply such knowledge and skills (Aneale, 2005). For this reason, the goal of the Industrial Teacher Production Institute at King Mongkut's University of Technology Thonburi is to develop theoretical knowledge, applied skills, and experimental skills among vocational learners so that they can become teachers in electrical and electronics fields.

LITERATURE REVIEW

In the 21st century, change has occurred in a globalized context associated with the international economy (Kay, 2010) (Geddes, 2004). The global economy is driven by a knowledge-based economy. Competitive advantages in this knowledge-based economy depend on technological advancement and innovation. Competitive advantages in the 21st century differ from those of the previous century. The production of economically valuable new ideas is critical to the 21st century economy. Knowledge is the main factor that drives not only the economic dimension but also the social dimension. When knowledge is an important factor in all dimensions, knowledge development for human resources is essential (Chayanopparat et al., 2015) (Rusk et al., 2009). Thailand has been affected by change in both its economy and in society at large. In achieving a competitive advantage, technological development and innovation are unavoidable. Thailand's Eleventh National Economic and Social Development Plan of 2012-2016 states that a strategy for the global economy will require focusing on developing the country's strengths to mitigate potential risks.

In the 21st century, changes in learning processes have equipped students with varied knowledge and skills to compete in the global economy. To address this challenge, the quality of education must be improved by changing the learning paradigm (Kay, K., 2010) (Geddes, 2004) (Paitoon, 2007). Learning in the 21st century will require students to gain more skills in development and knowledge acquisition. Advancing in areas such as science, calculus, mathematics, engineering and technology within the framework of globalization has provided many benefits to human life. Now, the focus of education is on improving teaching, styles.Modules have been used as a teaching approach in the 21st century and as a way to help educators work together, share best practices, and apply new skills and practice them in the classroom, in turn helping students be competitive in a global context. The approach is applied with a focus on project-based work (Blumenfeld, 1991) (Lim, 2012). The method also prioritizes community outreach and international participation in one-on-one and online learning (e.g., the Partnership for 21st Century Learning (2009)).

Vocational skills development is paramount to the delivery of vocational education programs at vocational institutions. Planned students, as stated in (Ode, 2002), posited that vocational education at all levels in Nigeria is uncoordinated, unplanned and inadequate. Consequently, some graduates of vocational education lack employable skills due to constraints placed on vocational education programs. Such constraints are viewed as challenges to the implementation of vocational education programs provided through schools.

In India, diploma programs have deteriorated; over time, such programs have lost their skill development components, resulting in them offering a diluted version of an educational degree. Organizations employing graduates from these programs have to retrain them in basic skills. Major problems faced by the polytechnic education system are as follows:

1. A lack of available courses on new and emerging areas.
2. Inadequate infrastructure facilities and obsolete equipment.
3. The educational system's inability to attract quality teachers.
4. Inadequate financial resources.
5. Inadequate or non-existent state policies for training and retraining faculty and staff.
6. A lack of institutional flexibility and autonomy.
7. Inadequate industry institute participation.
8. A lack of research and development in technician education.
9. Outdated curricula.

Based on an analysis of regulatory documents of the Russian Federation; Occupational Standard "Pedagogue of Vocational Training, Vocational Education and Supplementary Vocational Education" ; and Russian and international research on the establishment of a list of competencies of a professor of secondary vocational education, the following conclusions were made:

- Monitoring must be based on a competency model for professors.

- This competency model for professors of secondary vocational education must be related to the competency model of specialists (blue-collar workers) in terms of its structure, but the models must have different focuses.

- As basic (key) and emerging competencies play a major role in the competency model for specialists (blue-collar workers), it is expedient to develop the same structural units for a competency model for professors. Doing so will not only enable the granting of monitoring procedures that reflect current conditions of the system but also establish vectors of advanced development.

- The integration of social and technological occupational approaches; prescriptive and descriptive approaches to strategic analysis and competence; and functional and general pedagogical approaches must form the methodological basis of the development of a competency model for professors of secondary vocational education. Such results will facilitate the development of a monitoring model and of related tools.

The development of a competency model of professors of secondary vocational education, a questionnaire, an organizational and methodological monitoring model and

results of approbation thereof are of applied significance. Monitoring based on the developed model will enable the development of a substantiated approach to setting applicable and prospective objectives for the potential development of the secondary vocational education system, thereby creating optimal forms of psychological pedagogical support for pedagogical staff in the secondary vocational education system.

The Secondary Electrical Technical School in Baghdad has approximately 1,000 students and 50 teachers. Its electronics department employs 5 teachers who teach electronics theory, 11 teachers who teach applied work, and approximately 460 students. The faculty members who teach electronics theory have a fairly theoretical background and a degree in engineering, and many have received overseas training.

The applied skills teachers have generally received very poor training in their profession; many are secondary school graduates without any applied experience. The consultant did not meet teachers in the applied electronics department with formal training in teaching. Very little co-operation between the applied and theoretical teachers was evident. The applied teachers dedicated 85% of their time to training in electronics.

Teaching Methods

(1) The objectives of applied work in electronics: to prove electronics theory, to learn manual skills, and to develop good working habits.

(2) Types of applied work: exercises in measurements integrated with applied explanations for theory (examples of this type of work were demonstrated in a seminar by using exercises) and learning manual skills, e.g., soft soldering, connections, etc.

(3) Project work: integrating manual skills with theoretical knowledge and techniques of measurement, e.g., building and testing amplifiers, rectifiers, and oscillators.

(4) Working with the final product: testing, tuning, and troubleshooting radios, televisions, etc.

Purpose of Module Learning

Lawrence (Lipsitz, 1973) stated that learning modules are not taught from textbooks but involve teaching units with self-contained content created to allow students to learn more than what can be learned from a teacher. This process involves using educational materials and processes to apply course content and using objectives, learning activities, and assessments. Module often involve the use of documents, printed materials, or short booklets. Vichai Wongyai (Wongyai, 1976). Stated that a learning module involves learning activities organized for learners. Teachers must also demonstrate their competence in their profession. Modules are taught as lessons or units that are successful in themselves and that are created for students to study based on clearly established objectives. A module uses required learning materials to enable students to learn and demonstrate their competence as specified by the module's objectives Chompan Kunchorn Na Ayutthaya (Kunchorn Na Ayutthaya, 1976) described a learning module (Instructional Module) as an innovative form of education designed to help

learners develop specific competencies while increasing the efficiency of curriculum development and teaching as part of a specific methodology. Many studies have been conducted on teaching methods suitable for learners with varied knowledge (Jarernwit & Coterie, 2010). In addition, when modules separate content into sections, students can more easily understand new information.

Objectives

1. The learning modules meet the needs of learners.

2. The learning modules provide an assessment of students' knowledge and skills before and after testing.

METHOD

Objective 1: The learning modules meet the needs of learners.

In determining the effectiveness of modules, we begin by determining obstacles to electronics instructor development and what is required to become a competent instructor in this field. Then, Item Objective Congruence (IOC), which ranges from 0.67-1.00, is explored. Finally, experts, including vocational teachers and technical college representatives, are consulted on the appropriate focus and design of learning modules. We applied experimental methods to the control group. The study began with the development of learning tools based on the 4D (Define, Design, Develop, and Disseminated) model developed by (Thiagarajan et al., 1974) and with the use of teaching tools to evaluate in our experimental research.

Participants

The researchers interviewed representatives from technical colleges and a group of expert electronics teachers in separate focus groups to develop a learning module electronics teacher according to technical college requirements and to test the effectiveness of the designed module. In total, 15 electronics teachers and 29 technical college representatives consulted on the electronics module layout.

Instruments

We administered a questionnaire on obstacles to electronics teacher development and on traits required to become a competent electronics teacher according to item-objective congruence (IOC). The suitability of the questionnaire was determined based on the opinions of vocational teachers and technical college representatives.

Procedures

The first step involved reviewing obstacles to instructor development and features of competent electronics teachers. The second step involved conducting a focus group with electronics teachers to determine the layout of the module and then designing the module. The final step involved testing the module's effectiveness by dividing the design process into 2 parts as shown in Table 1.

Table 1
Steps for Designing the Learning Module

Step	Procedures
1	Identify problems, obstacles and features of competent electronics teachers
2	Conduct a focus group to determine the module's design
3	Design the module
4	Test the module

Step 1: Identify problems, obstacles and features of competent electronics teachers

The required characteristics, knowledge and skills of an electronics teacher.

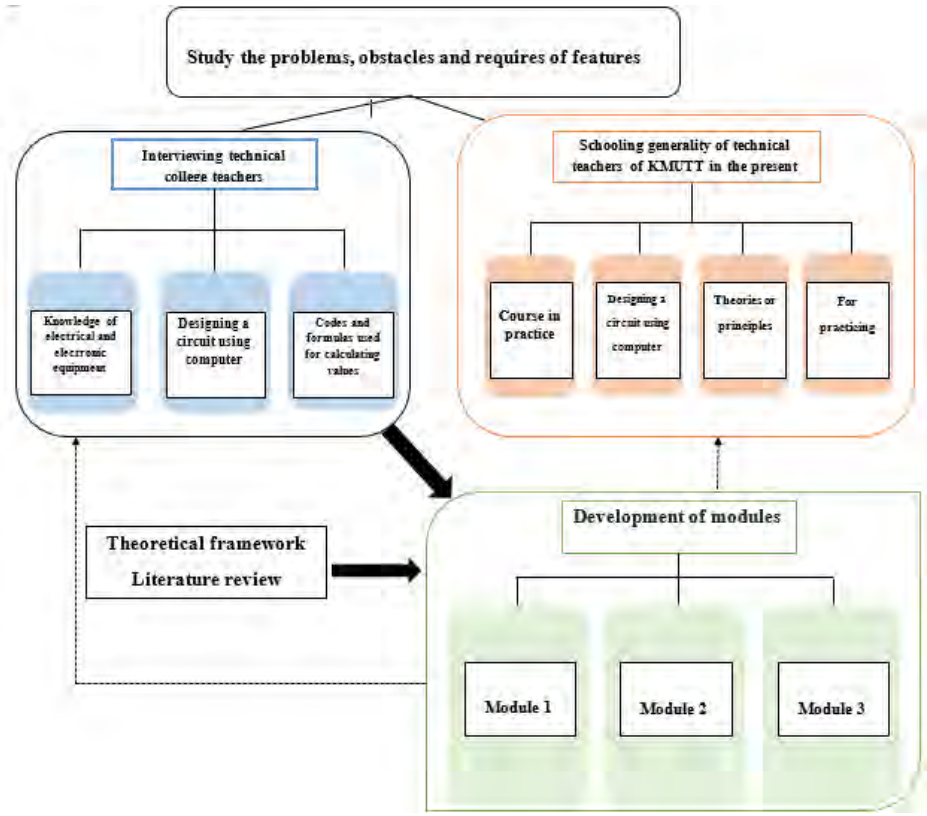

Figure 1
Learning Module Design Process

The process involved 2 phases (Figure 1).

1. The required knowledge and skills of electronics teachers of basic electrical and electronic circuits are determined by interviewing technical college teachers, who are divided into 3 groups:

1.1 Experts in electrical and electronic equipment, measurement tools, test equipment, circuit measurement and inspection, and testing equipment.

1.2 Experts in computer-assisted circuit design, circuit design, computer-assisted design, English, circuit reading and design, and computer-assisted data processing and collection.

1.3 Experts in codes and formulas used for calculating values, adapting science to applied settings, mathematics for industrial technicians, security, estimation, tool crafting, building equipment, electrical circuit control, circuit creation, and equipment maintenance.

2. Current schooling of KMUTT technical teachers

2.1 In electrical and electronics courses, there is little time to practice to acquire skills.

2.2 Practice in circuit design using a computer is insufficient.

2.3 Regarding codes and formulas, students still do not understand certain theories and principles and cannot apply mathematical knowledge required of industrial technicians.

2.4 Students are incapable of creating and controlling circuits and of maintaining equipment.

Step 2: Focus group meeting to define the layout of the module

We held a focus group meeting (by workshop) with experts in electronics instructor development and specifically (Preanhoo, 2002) with technical college instructors who teach electronics teachers. To confirm accuracy, 5 experts (Laksana, 2016) ensured the correctness of equipment, content, and tools using the Delphi technique. The Delphi technique is a systematic method for collecting expert opinions (Skulmoski et al., 2007). The Index of Item Objective Congruence (IOC) ranges from 0.67 to 1.00 according to the opinions of experts in determining the suitability of composition, after which results are compared with two focuses: knowledge and skills.

Step 3: Model design

Using the information collected in Steps 1 and 2, a research model was designed based on the knowledge and skills expected of electronics teachers with respect to their approach to basic electrical and electronic circuits (Korganci et al., 2015). In this step, item-objective congruence (IOC) was used based on the opinions of experts to determine the appropriateness of various forms of knowledge and skills. The experts determined the outline of the model for teaching electronics teachers. The outline of subjects to be taught was set as follows: 1) electrical and electronic equipment, 2) computer-based circuits and circuit design and 3) rules and formulas used to calculate values and scientific applications. Finally, the 3 learning modules were developed.

Development of Learning Modules

Module 1: Monitoring

This module covers the following: improving the use of measurement tools (e.g., use of a multimeter to measure basic values from resistors, transistors, capacitors, diodes, SCRs, LEDs, LDRs, batteries, etc.); building a circuit board from a circuit diagram; and taking questions from students after they have experimented on the circuit board and assembled the equipment to a PCB.

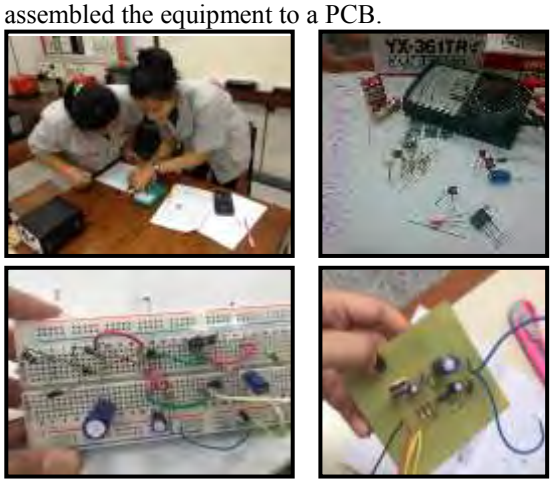

Figure 2
Module 1: Monitoring

Module 2: Circuit design

This module covers the implementation of electric systems and electronic equipment for circuit design by using a computer program to create a circuit diagram. Simulation software is used for testing before assembling a PCB and equipment; the students then test the design (Jaakkola et al., 2011).

Figure 3
Module 2: Circuit design

Module 3: Transformer

This module covers formulas, designs, and mathematics used by industrial technicians to create circuits; equipment; maintenance work; and the benefits of using code. Students

coil a 1-phase transformer to develop their calculation skills by using parameter values to identify the copper coil of the correct size. In addition, the students assemble, test and maintain a transformer.

Figure 4
Module 4: Transformer

Step 4: Testing the performance of the module

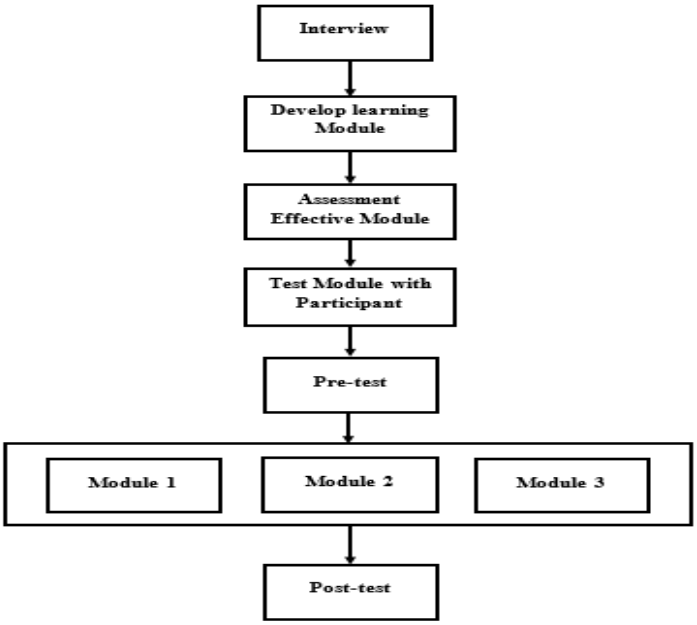

Figure 5
Process for the Testing Effectiveness and Learning Achievement

First, interviews with technical college teachers were conducted to identify problems associated with electronics teacher development and to analyse the module's performance. Students of the Department of Electrical Technology Education (ETE) at

King Mongkut's University of Technology Thonburi (KMUTT). We then developed the module and tested its effectiveness at teaching lessons on electrical and electronic circuits to undergraduate students based on 80/80 criteria and using formula E1 / E2 to set the efficiency value to E1 = Process Efficiency. For our final results, we set the efficiency value to E2 = Product Efficiency. Next, a test was administered before the students studied. After Module 1, 2 and 3 tests were completed; we compared scores before and after the modules and found that the learners' scores had increased significantly according to our statistics. The modules generated E1 and E2 results that approached a score of 100 (Brahmawong, 2009) (Magued, 2008).

Objectives 2: Assessments before and after learning module tests

Participants

The participants were 34 second-year undergraduate students studying ETE 250 Electrical Skill Practices at the Department of Electrical Technology Education under the Branch of Electrical Engineering in the Faculty of Industrial Education and Technology at King Mongkut's University of Technology Thonburi. Student participation was voluntary. The class took 6 hours every week until the end of Module 3.

Instruments

As instruments we used a learning achievement test and pre- and post-tests measuring knowledge and skills in basic electrical and electronic circuits. As other tests, we applied a subjective examination of 30 items of knowledge to measure the students' knowledge of instruments and ways to test equipment for measuring and checking circuit capabilities. Among other skills, the students' abilities to read and create circuits were measured.

Procedures

A pre-test was conducted using the achievement test for basic electrical and electronic circuits. Then, the researcher served as the instructor, and a learning achievement test (the post-test) on basic electrical and electronic circuits was applied. The scores obtained were analysed using statistical methods.

Data Analysis

A comparative analysis of frequency, mean, percentage, standard deviation values of the test scores of one sample group was performed using a t-test (t-test and one sample group).

FINDINGS

Objective 1: Design of effective learning modules according to standards

Learning modules were created by the researchers to focus on applied knowledge and skills required of electronics teachers. Table 2 describes the modules.

Table 2
Applied Learning Skills and Skills Required of Electronics Teachers

Topics of learning modules	Categories PL (K)	Categories PL (S)	Development concepts
Module 1: Monitoring	- Knowledge of equipment and of ways to measure instruments	- The ability to test devices and measure and monitor circuits	Develop measurements used to measure basic electronic devices
Module 2: Circuit design	- Knowledge of computer design and circuit writing - Knowledge of English	- The ability to read and design circuits - Computer processing and data storage abilities	Develop a practice for using equipment and computer programs to design electrical circuits
Module 3: Transformer development	- Scientific knowledge of applications - Knowledge of mathematics for industrial technicians and of how to create tools	- The ability to create devices - The ability to control electrical circuits and circuit construction	Use rules for calculations by applying mathematics for industrial technicians by intertwining 1 phase transformer

The researcher followed the development process to measure test quality and conduct a performance analysis of the average and percentage. To measure the efficiency of the modules on electrical and electronic circuits for undergraduate students, 80/80 criteria were applied using the formula E1 / E2 while assigning an efficiency value of E1 = Process Efficiency and the final behavior (result) set of the efficiency value to E2 = Product Efficiency. Module efficiency is designated when E1 and E2 calculation results of close to 100 are obtained (Chan et al., 2011). The results of the module performance test needed to come close to criteria set of 80/80 and not exceed 2.5%. The results show that the module is effective as a set (Brahmawong, 2009). The information shown in the table demonstrates that the efficiency values of all 3 modules meet the E1 / E2 criteria. The threshold is set to 80/80.

An effective standard for determining of the effectiveness of an experimental set of modules is the 80/80 rule. If the results from the data analysis show that the effectiveness of the experiment set is equal to or higher than the standard, it is considered effective.

Table 3 shows that the effectiveness, knowledge and skills of electronics teachers came close to the standard deviation for classes in basic electrical and electronic circuits. For undergraduates, all 3 units met the 80/80 criterion.

Table 3
An Analysis of the Knowledge and Skills of Electronics Teachers. The Learning Modules on Electrical and Electronic Circuits for Undergraduate Students Tend to be Effective

List	Practice score (E1)	Post test score (E2)	E1/ E2
Module 1: Monitoring	80.78	83.33	80.78/83.32
Module 2: Circuit design	81.88	83.70	81.88/83.70
Module3: Transformer development	82.56	80.31	82.56/80.31

Objective 2: Student assessments before and after the learning module

A comparison of pre- and post-test scores shows that the latter are higher than the former. The t-tests scores obtained from the calculation are higher than the t-values shown in Table 4 at a statistical significance level of .05, indicating that the students achieved better learning outcomes with respect to both knowledge and skills at a statistical significance level of 0.05 after the post-tests as a result of the 3 modules. However, the knowledge test results are lower than the average score for the skills tests.

Table 4
Results of the Pre- and Post-Tests (n=34)

Learning module topics	Subcategories	Pre-test		Post-test		t-test dependent
		$\bar{X}$	S.D	$\bar{X}$	S.D	
Module 1 : Monitoring	Categories PL (knowledge)	20.12	1.57	32.97	1.83	T = 29.14*df = 33 SD = 2.57 Sig = 0.005
	Categories PL (skills)	19.97	1.78	34.32	2.11	T = 27.14*df = 33 SD = 3.08 Sig = 0.005
Module 2 : Circuit design	Categories PL (knowledge)	18.65	2.03	34.12	1.97	T = 29.14*df = 33 SD = 2.57 Sig = 0.005
	Categories PL (skills)	20.09	1.59	35.12	2.32	T = 27.42*df = 33 SD = 3.32 Sig = 0.005
Module 3 : Transformer development	Categories PL (knowledge)	18.59	2.03	35.00	1.94	T = 28.96df = 33 SD = 3.30 Sig = 0.005
	Categories PL (skills)	19.56	1.33	35.68	2.27	T = 34.32*df = 33 SD = 2.74 Sig = 0.005

*p<0.05, t = Tested value of ranked difference.

DISCUSSION

The results of this research show that the applied modules achieved better outcomes in applied skills for students at the Department of Electrical Education at King Mongkut's University of Technology Thonburi. The results of this study can be used to improve and develop the knowledge and skills of electronics teachers, thereby helping learners achieve greater academic achievement. Moreover, our results are consistent with the results of other studies on the development of the students' learning skills using teaching methods that emphasize applied skills. We report t-test scores statistically highly significant at 0.01, echoing the results of (Umunadi et al., 2007) and (Oke, 2010). (Medugu, 2011) confirmed that the use of teaching aids can facilitate learning about

basic electrical and electronic circuits. A study by (Taale & Mustapha, 2014) on the construction of an electrical simulation model by teachers of basic electrical subjects at BORNO State Technical College, Nigeria found that teachers (experimental group) taught using a simulation model achieved an average score of 49.77 after an electricity generation experiment, significantly exceeding scores achieved before the experiment. Before the experiment, the minimum score was 30% and the highest score was 78%; for the control group, the average score was 41.56, the lowest score was 25% and highest score was only 57%. The researchers used conceptual change model activities to examine vocational students' understanding of electrical circuits. They used DIREC along with field notes and interviews to measure conceptual understanding. Their results reveal important developments from pre- and post-tests, with the strongest change between pre- and post-test scores being measured at 54%. Other research results (Yuliati et al., 2018) show that learners should be trained to solve problems using a variety of active learning methods. Some learning methods use scientific methods designed to improve learners' problem-solving skills and emphasize the importance of learning development. Teachers can also apply group work to facilitate self-development and student achievement. According to our calculations on the efficiency of our modules, on average, all 3 modules generated scores of 81.74 / 82.44, exceeding the standard 80/80 value as specified. This result is consistent with those of many researchers. For instance, (Krithawal & Canchalor, 2011) tested the effectiveness of a course on basic DC experimental electric circuits given to 20 vocational electronics students at Samutprakarn Technical College and found an efficiency value of 81.50 / 80.25. (Chanat, 2017) also tested the teaching and learning efficiency of a course on electronic devices and DC circuits and achieved an E1 / E2 efficiency score of 94.70 / 75.00, which is in accordance with established criteria and which shows that the course encourages student learning. (Bundasakti et al., 2013) (Inkaew, 2013) also evaluated the efficiency of a class on virtual electrical circuits and found the developed media to be effective according to E1 / E2 criteria (score of 83.25 / 86.00). Our findings are also consistent with (Simpson, 1972), who shows that skills can be improved through practice. However, effective training, Dexterity Expertise Persistence and modelling are not the only tools that can facilitate students' work, as defining talent as performance may affect personal development in terms of knowledge and skills (Sanghi, 2007). The results of our assessments with experts, practitioners, students and teachers show that the developed modules were easy to understand and useful to the students and teachers (De Freitas & Griffiths, 2008). Our modules are also supported by valid and reliable instruments (Risnawati et al., 2019) and consistent with results showing that students achieve better learning outcomes through module application.

CONCLUSION

We measured the effectiveness of modules on electrical and electronic circuits designed for undergraduate students based on 80/80 efficiency values using the E1 / E2 formula. For Module 1: monitoring was effective at 80.78 / 83.32, for Module 2: circuit design was effective at 81.88 / 83.70 and for Module 3: transformer development was effective at 82.56 / 80.31. All 3 modules exceed 80/80 standards and are used to evaluate the

effectiveness of the use of modules on electrical and electronic circuits for undergraduates through a comparative analysis of frequency, percentage, and standard deviation values. Test scores are then compared and analysed with t-test statistics. The results of the study show that all 3 modules were effective in terms of enhancing students' knowledge and skills. The post-test scores were found to be higher than the average pre-test scores and calculated t values are measured as higher than t values obtained initially at a significance level of .05, indicating that the students achieved scores higher than the standard. In total, 70 percent of the students' taught through the modules showed that they could apply what they have learned. If students at the Faculty of Industrial Education and Technology's Department of Electrical Education at King Mongkut's University of Technology Thonburi gain real work experience, their knowledge and skills will improve, and the best way to further applied learning outcomes is to apply new knowledge and skills according to vocational competence and then disseminate this knowledge to further one's vocational understanding.

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