Engineering and Applied Science Research January – March 2018;45(1):65-69 Research Article

Engineering and Applied Science Research

https://www.tci-thaijo.org/index.php/easr/index

Published by the Faculty of Engineering, Khon Kaen University, Thailand

Development of teaching electrical technology integrating PBL and CBL and supporting STEM education

Supachai Prainetr*[1)], Kowit Yotmongkol[1)] and Natchanun Prainetr[2)]

[1)]Department of Electrical Technology, Faculty of Industrial Technology, Nakhon Phanom University, Nakhon Phanom 48000, Thailand
[2)]Department of Energy technology, Thatphanom College, Nakhon Phanom University, Nakhon Phanom 48110, Thailand

Received 20 August 2017
Accepted 29 November 2017

Abstract

The importance of vocational education that focuses base on learning by doing ,which is context of Nakhon Phanom University (NPU). They emphasized this through integration of existing vocational institutes in Nakhon Phanom Province. This paper aims to develop teaching and created inspiration for students of electrical technology program. The methodology employed teaching by project based learning (PBL) and community based learning (CBL). The student have been created an innovation to involve the control system and application in community knife manufacturing process. The sample group consisted of 13 bachelor degree students in a six week in class, followed by a seven week practical experience in the factory manufacturing knives. The total project required15 weeks. The students applied engineering principles to design and simulate PID and closed loop control for temperature modulation of a furnace. In this case study, students used basic knowledge, practical skills and invoked community participation. The students learned and conducted a project in a real-world practical application.

Keywords: Development teaching, Project based learning, Community based learning, Science technology engineering mathematics

1. Introduction

In 2005, the Faculty of Industrial Technology (ITEC) was relocated to the campus of Nakhon Phanom University (NPU) Thailand. The faculty focuses on vocational education and technology. ITEC trains personnel with vocational skills and has supported private companies and government organizations for many years. Therefore, training students with practical skills is very important. The teaching model and methods of vocational learning provide students with challenges. The faculty conducts research to develop new teaching techniques to impart knowledge and skills through problem solving in different situations. Information technology has been used to present unique pedagogical approaches such as research based learning (RBL) and project based learning(PBL), it have sameness method that to solved problem in real condition case study, next review and finding solution. However, there are often insufficient practical applications that can be incorporated into learning activities [1].

Project based learning is an instructional approach that utilizes integrated projects organized with a unified strategy for educating students. In this approach, students are assigned a project that requires them to use multiple skills such as, reviewing scientific studies, writing, interviewing, and cooperating with people in a larger community [2-3]. Moreover, in modern engineering and technology, professionals need skills in human relations as well as technical competence. The current programs do not provide enough of these experiences to students. In recent years, studies have been done using the PBL teaching method. This has been accepted as an effective learning method that provides new learning styles that application PBL [4].

This paper proposes development of teaching and learning activities that integrate PBL and CBL. The study involved students in an electrical technology program, as part of a systems control course. Section 2 gives detailed concepts and the background of PBL, CBL and STEM education. It discusses how these methods can be used to implement teaching while doing innovative applied research. The theoretical framework, concept of engineering education and research methodology are covered in Section 3. Section 4 presents the results of design and innovative implementation applied to a knife manufacturing community project. Finally, in Section 5, the conclusions are presented about the integration of PBL and CBL in teaching. These were used to improve student learning at the ITEC of Nakhon Phanom University and for rural community projects. Furthermore, it demonstrates how engineering and vocational education should work together in practice. The results of this study indicate that student education and cooperative learning methods can be innovatively implemented in a community project.

*Corresponding author. Tel.: +6681 117 8358
Email address: prainetr@npu.ac.th
doi: 10.14456/easr.2018.4

2. Materials and methods

2.1 Project based learning

Project based learning (PBL) is a form of active learning that focuses on practical applications. It involves participation of students and teachers. Students select an interesting project that involves a community product. They use methods such as surveying, problem study, planning, recruiting participants, and development of methods that can be applied in a community. Student are required to write summary reports, make presentations, gain knowledge and experience, draw conclusion and discuss their work in following ways [4]:

- Research through case study
- Develop a collaborative research methodology
- Engage in research interactivity, problem, aims, methodology, reflective evaluation, innovation
- Use research standards, a scientific approach, develop applications, share the results of their project with the community

2.2 Community based learning

When using the PBL method for teaching, it is sometimes difficult to finance projects. Community based learning (CBL) is an alternative method to address shortages in project funding. The CBL teaching method integrates techniques of communication. Participants learn the following:

- Relationship management
- Communication in action research
- Participation action research
- Inclusion in action research

2.3 STEM learning

STEM is an abbreviation for:

- Science (Science)
- Technology (Technology)
- Engineering (Engineering)
- Math (Mathematics)

These four are linked in technology and they require different knowledge. Cognitive learning in STEM has become a high priority in international education in many countries where it involves projects and programs related to science and technology.

2.4 Methods

We surveyed the student body of the electrical technology curriculum at NPU and found that most students will continue past their vocational degrees. So, this curriculum needs to involve activities and that focus on practical learning.

2.4.1 The course outline in relation to the curriculum

The electrical technology curriculum can be done by students with vocational degrees since their initial training covers:

- Shop drawings for engineering
- Mathematics for engineering
- Control systems
- Electrical machinery
- Microcontrollers
- Safety for engineering
- Electrical systems design

This paper shows an integration PBL and CBL methods using a control system. Students worked on a project with an advisor to solve a problem involving temperature control of a furnace used in a knife manufacturing community project. The study involved furnace design, mathematical simulation to develop a model for PID control and its application. The concept of PID control was applied in a practical system.

2.4.2 PBL teaching process

The PBL process consist of six parts. In the first step, problems that require a solution are identified. The second step involves a literature review of selected methods. The third stage involves design and simulation using principles in the curriculum. Then experimentation and testing are accomplished. Finally, evaluation and presentation are done. A schematic diagram of the PBL process is shown in Figure 1.

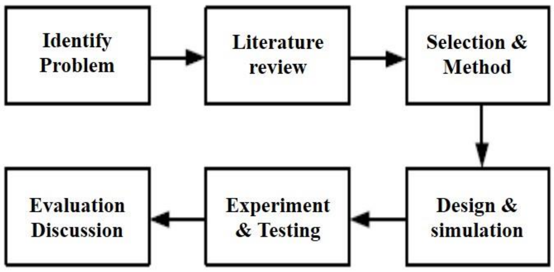

Figure 1 Diagram of the PBL teaching process

2.4.3 CBL teaching process

Most rural community projects are not professionally or optimally conducted. So, the Institute of Rural Technology supports industrial systems development by fostering cooperation between people, teachers and students to solve problems in the manufacture of products within communities. This project created a learning activity for students and development for the community.

The CBL process has five parts. The first step is surveying the community's problem. Next is coordinating the community and proposing a method to solve the problems associated with knife manufacturing. The third phase involved designing and created an innovative solution using an academic concept. The fourth step involves testing the research innovation. Finally, evaluation and presentation are done [4].

Figure 2 shows the activities involved in knife production in a rural community. Fig. 2(a) shows testing of a new furnace, Fig. 2(b) illustrates participation among the people involved, Fig. 2(c) depicts an ordinary furnace, and Fig. 2(d) shows the new furnace that was developed while integrating PBL and CBL teaching strategies [5].

The 13 bachelor degree students in a control systems course engaged in 15 weeks training and seven weeks of practical learning. The teacher assigned problems in this manufacturing process to the students.

Figure 2 Activity to integrated learning by project in community knife manufacturing

Figure 3 Sequence manufactureing process of knife community production

Figure 3 shows sequence manufacturing process of knife production. It consist, first step select material that leaf spring metal. The second step was cutting the steel into a correct form. The third step was the forging knife. Then the steel is melted at 900-1,500 ^{o}C. The next step is welding, grinding, hardening and final grinding. This project focused on problems associated with the furnace used in community production. It burned charcoal to supply the required energy, but the temperature was not well controlled. Accurate temperature control is a requirement of knife production.

2.4.4 Concept of theory relationship for engineering

In PID control theory, the algorithm has proportional, integral, and derivative inputs as shown in Equation (1):

$$u(t) = K_p e(t) + K_i \int_0^t e(\tau)dt + K_d \frac{de(t)}{dt} \quad (1)$$

From Equation (1), a block diagram for PID closed loop control can be written as depicted in Figure 4.

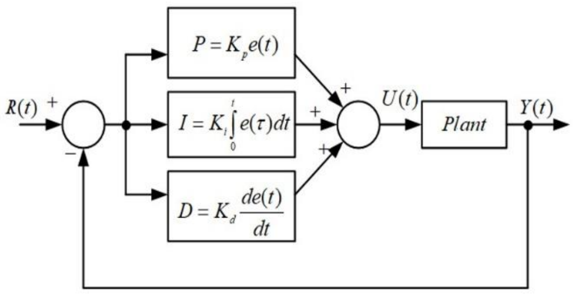

Figure 4 Diagram of PID closed loop control

Each segment of the three modes reacts differently to deviation from a set point. The amount of response produced by each control mode can be adjusted by changing the controller's tuning settings.

2.4.5 Temperature control system

The hardware for temperature control of a furnace for knife manufacturing used a microcontroller to actuate a valve controlling the flow of LPG gas as shown in Figure 5.

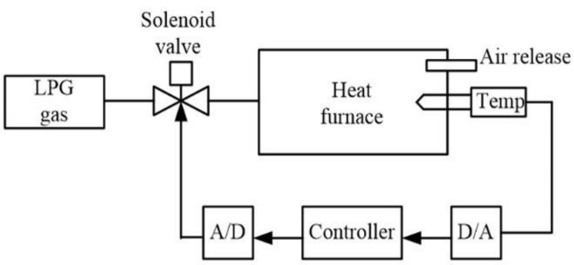

Figure 5 Temperature control in a furnace for a knife manufacturing process

2.4.6 Design control algorithm

The temperature control system with digital feedback control is shown as a block diagram in Figure 6.

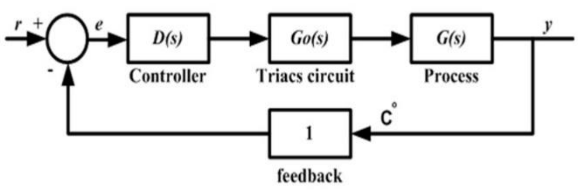

Figure 6 Block diagram model of temperature control

As shown in Figure 6, the controller used a PID algorithm generate an optimal response. The temperature of the furnace should be exactly the set point. However, the temperature varies above and below the set point most of the time and this variation can be substantial. This is where PID is applied.

2.4.7 Simulation and design

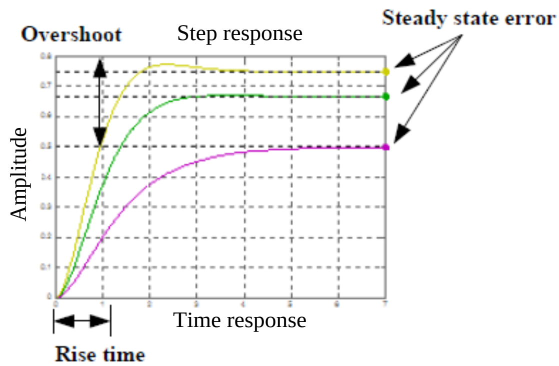

Figure 7 Simulation design of PID control

Figure 7 shows a simulation of PID control that was mathematically designed from simulations done by students. It shows the PID response and superior performance of the designed hardware [6-7].

(a)

(b)

Figure 8 (a) Conventional furnace, and (b) the new furnace

Figure 8 shows a conventional furnace (a), and the furnace developed as part of the current study (b). Teaching with integrated experimental activities led to innovative solutions to the problem of energy of consumption in a basic furnace. This was done through modifications to the furnace and application of PID control [8], impacting fuel costs in the knife production process. When learning by doing, students can see practical applications of theory studied in classroom or laboratory.

3. Results

3.1 Student performance in the control systems course

Student performance in this systems control course using an integrated PBL and CBL approach is depicted in Figure 9.

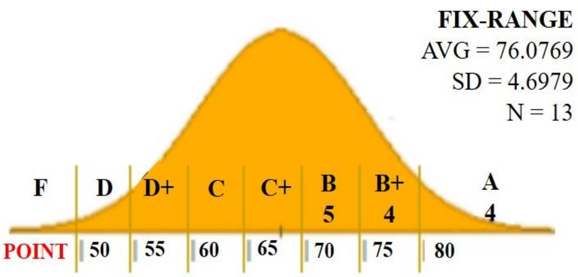

Figure 9 Evaluation of student performance when learning using PBL and RBL approaches

The class consisted of 13 students with an average score 76.0769, and standard deviation of 4.6079. Four students earned A's, four others earned B+'s and five individuals earned B's. No student earned a grade lower than B.

3.2 Evaluation of the teacher by students

Teacher evaluation in this systems control course was done by the 13 students. The evaluation questioned the students about support of active learning, participation, self-learning, teaching aids, collaborative and community relationships. The result showed a mean score of 4.13 and a standard deviation of 0.741, which was at a good level.

4. Discussion

In this work, we proposed an improved teaching method that integrated PBL and CBL in a systems control course for bachelor degree students majoring in electrical industrial technology.

4.1 Knowledge based skill

Student were able to create a self-learning environment integrating computer simulations, laboratory experiments and application of theory to solve a real problem in a rural community.

4.2 Practical base skill

Student retrieved data to design a furnace, set it up, conduct experiments to solve problems in knife production in a rural community.

4.3 Learning relationship skills

Students solved problems in their research with participation of others to support development of their social and communication skills.

5. Conclusions

This research developed a teaching method that integrates the PBL and CBL methods. It was applied in an innovative project to solve problems in a traditional knife manufacturing process in a small community. The students increased their knowledge base, practical skills, presentation skills and social skills. Moreover, this technique supports the STEM area. So, it can be applied to teaching science and technology. Moreover, this work used prior research on STEM teaching methods [9]. This is important to scientists and engineers who need to create active learning practices to better educate the new generation [10]. It confirms that teaching using PBL and CBL methods is a valuable active learning approach in science and technology education [11-12]. This approach can be expanded to other engineering disciplines, such as mechanical, industrial, environment engineering.

6. Acknowledgements

The authors acknowledge the support that they received from the Faculty of Industrial Technology, Nakhon Phanom University (NPU) in Thailand.

7. References

[1] Anderson RS, Specka BW. Oh what a difference team makes, why team teaching makes a difference. Teach Teach Educ. 1998;14(7):671-86.
[2] Achinstein B. Conflict amid community: The micropolitics of teacher collaboration. Teachers Coll Rec. 2002;104(3):421-55.
[3] Atay D. Beginning teacher efficacy and the practicum in an EFL context. Teach Dev. 2007;11(2):203-19.
[4] Prainetr N, Prainetr S. Development of chamber furnace using temperature PID control for the community michelet manufacturing. J Community Dev Life Qual. 2013;1(1)107-13.
[5] Prainetr S. The development of cluster project in knife rural community in Ban Nathon in Nakhon Phanom province Thailand. Research report. Nakhon Phanom, Thailand: Nakhon Phanom University; 2016.
[6] Dequan S, Guili G, Zhiwei G, Peng X. Application of expert fuzzy PID method for temperature control of heating furnace. Procedia Eng. 2012;29:257-61.
[7] Teng T, Peng C, Chuang C. A study on the application of fuzzy theory to structural active control. Comput Meth Appl Mech Eng. 2000;189(2):439-48.
[8] Moon U, Lee K. Hybrid algorithm with fuzzy system and conventional PI control for the temperature control of TV glass furnace. IEEE Trans on Control Systems Tech. 2003;11(4):548-54.
[9] Atay D. Teacher research for professional development. ELT Journal. 2008;62(2):139-47.
[10] American Society for Engineering Education (ASEE). Preparing future engineers around the world. USA: ASEE; 2011.
[11] Banks F, Barlex D. Teaching STEM in the secondary school: Helping teachers meet the challenge. London: Routledge; 2014.
[12] Becker K, Kyungsuk P. Effects of integrative approaches among science, technology, engineering and mathematics (STEM) subjects on students learning: A preliminary meta-analysis. 2011. J STEM Educ. 2011;12(5-6):23-37.