Perceptions of Vocational Education and Training Teachers with regard to an Industrial Robot Training

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***Abstract* – In the last decade, industrial robots have been used in a variety of ways in manufacturing. Owing to the increasing demand for industrial robots, many institutions offer industrial robotic courses. However, industrial robots have been accepted as an emerging tool when it comes to teaching in the area of vocational education and training (TVET). However, it has proved difficult for teachers to adapt to teaching in this way. This paper presents the investigation of TVET teachers' perceptions of an industrial robotic training course in Thailand. This course provides in-service training for 67 teachers who teach electrical, mechanical, or mechatronic engineering in vocational colleges. The training course uses a four-phase learning cycle: preparation with regard to the concepts of industrial robotics, pedagogies for teaching and learning, presentation, and the professional learning community. The results show that teachers face barriers and have expectations prior to training. Teachers' satisfaction with the training course after training was also investigated.**

***Keywords* – industrial robot, vocational education, active learning**

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1. Introduction

Over the past decade, industrial robotics for promoting learning has been used in Thailand. In particular, the educational system associated with the fourth industrial revolution, means that the requirements with regard to the use of educational robotics have rapidly increased during the last decade. Consequently, robots have been regarded as an asset to be employed in educational classroom activities. Many studies have explored the use of robotics for enhancing learning [1], while such a use has led to positive student's feedback and improved student's academic outcomes [2]. In addition, robot-based learning is important within the work dynamic of students in robotics classes as a means of creating learning activities involving discussion, and as a means of promoting inclusiveness so that all students and teachers participate [3].

Industrial robot education has been emphasized in many schools and universities, and particularly in vocational colleges, because industrial robots are widely used in many manufacturing industries. Consequently, such a use increases the career prospects of vocational students on graduation. An industrial robot involves an understanding of complex theoretical concepts. Consequently, this discipline may be viewed as difficult by students, while teachers may find it difficult to determine a learning strategy for use with classical teaching methods.

Many studies have verified that the new technology can be used to support classroom activities which are attractive to students by combining multimedia objects with educational robots [4]. Other studies have reported on developments in robotics courses with the inclusion of hands-on experiments involving robot systems, based on robotic exercises in the laboratory, and competition-based learning activities [5]. Consequently, many studies have attempted to present a methodology and the use of simulation tools based on active learning, as part of industrial robotics education [6]. Furthermore, many researchers have proposed a training course or curriculum aimed at supporting TVET teachers to effectively teach industrial robotics based on pedagogical insights and hands-on activities [7], [8]. Some teacher training courses have focused on more than just building and programming robots, and expect teachers to be able to build on the educational benefits of robotics in such a way as to provide a learning landscape that fosters a range of skills on the part of the students [9].

However, industrial robots have been accepted as an emerging tool when it comes to teaching in the area of vocational education and training (TVET). However, it has proved difficult for teachers to adapt to teaching in this way.

In this study, we focus on the design and implementation of a training course for TVET in-service teachers that teaches them how to use industrial robots to support their teaching in a college setting. During this research, we not only investigated barriers to teaching with the use of industrial robots, but also the teachers' expectations with regard to the training course. Furthermore, we surveyed the teachers' satisfaction with the training course.

This paper described a training workshop for TVET in-service teachers from a number of different colleges in Thailand. The training objective was to enhance the use of industrial robotics in the TVET system. The objectives of this study were to answer three research questions:

RQ1: What are the barriers facing in-service teachers when it comes to teaching with the use of industrial robots?

RQ2: What are the in-service teachers' expectations with regard to the training course?

RQ3: How satisfied were the in-service teachers with regard to the training course?

2. Related Work

The design of this course involved a robot-based learning framework that makes use of three components. The robotic element is in the form of a robot arm used in manufacturing. Industrial robotics are involved in a number of manufacturing tasks including welding, assembly, pick-and-place, palletizing, product inspection, and testing. Finally, students graduating from such a course are prepared to work as a technician or an engineer in industry.

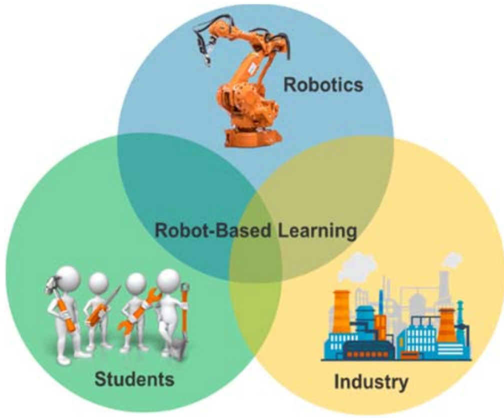

Figure 1. Robot-based learning framework

Based on the robot-based learning (RBL) framework, we designed a course for in-service teachers. We prepared the industrial robot arm concept based on the Thai TVET curriculum. The course is divided into nine units consisting of 1) fundamental concepts relating to industrial robot arms; 2) the structure of industrial robot arms; 3) the components of industrial robot arms; 4) the moments of industrial robot arms I; 5) the moments of industrial robot arms II; 6) programming simulation; 7) using grippers for industrial robot arms; 8) the application of industrial robot arms; and 9) the maintenance of industrial robot arms. TVET teachers know the industrial robot content of their subjects and curriculum. They know and understand the fundamental concepts, structure, and learning processes relevant to the programs they teach.

Each unit makes use of instructional materials, activity sheets, and assessment sheets. ABB Industrial robots are employed in learning activities because of their compact robot, and the off-line programming software, Robot Studio, which enables students to prepare realistic simulations of real-life robotic applications. TVET students therefore have hands-on experience, and the opportunity to learn the skills needed for the effective use and management of modern robotic manufacturing systems.

3. Method

3.1. Participants

During this study, 67 vocational in-service teachers (3 females and 64 males) were recruited from vocational colleges located throughout Thailand. The workshop was designed to prepare the TVET to integrate industrial robots into their teaching in the classroom. The age range of the participants was 26 to 55 years. The TVET teachers had teaching experience ranging between 1- 5 years (24.64%), 6-10 years (17.39%) and more than 10 years (57.97 %).

3.2. Instruments

The researchers developed instruments for data collection purposes. The open-ended questions are part of a survey that allowed the TVET teachers to answer in an open text format. It was used to examine the barriers facing teachers and their expectations before starting the workshop. After the training, we used the TVET teachers' satisfaction survey with regard to the workshop. This survey was meant to be completed within the period of the training course. The three dimensions of the questionnaire involving a 5-point scale, were found to be highly reliable (12 items: α=0.92).

3.3. Industrial Robot Training Workshop

This training course included 4 phases (the 4Ps): Preparation of industrial robot concepts. Pedagogies for teaching and learning, Presentation, and Professional Learning Community. The training course that was held over four days (even hours/day, 28 hours in total).

Phase 1: Preparation of the industrial robot concepts

At the beginning of the course, it is necessary to prepare the TVET teachers with regard to the industrial robot concepts. This section is important for enhancing the teachers' knowledge with regard to the industrial robot arm, the components of an industrial robot, and also any programming language used to control industrial systems. The TVET teachers have to be able to develop some specific competence arising from the concepts training as part of the goals of this workshop. Consequently, they learned the principles of kinematics, dynamics, control, and how to optimize the conditions of the industrial robotic systems, to solve problems in a factory situation and the maintenance of industrial robots in a manufacturing facility. In addition, the TVET teachers learned how to remotely control a pendant device on an industrial robot. Therefore, they learned both about robotics hardware and offline programming through the virtual robot simulator for use with regard to teaching and learning.

Figure 2. TVET Teachers learning and practice of the industrial robot concepts

Phase 2: Pedagogies for teaching & learning

In this phase, the TVET teachers learned how to teach the students. Due to the fact that teaching robotics to students who have never had any experience in this field is very difficult, the teachers needed to identify appropriate learning pedagogies to help students overcome their learning barriers. Therefore, we selected an appropriate teaching and learning pedagogy for the integration of industrial applications, in such a way as to support the work readiness and 21st-century skills of the student. Industrial robotics makes use of many pedagogies. These are as follows: Inquiry-based learning (IBL) is a multifaceted approach that involves reviewing information about what is known about a problem, gathering additional information, proposing solutions or explanations, and communicating or acting on the results [10]. Problem-based learning (PBL) is a learning approach that supports students' ability to problem solve, and to transfer their knowledge to real-life problem scenarios [11]. Competition-based learning (CBL) is an approach where learning outcomes are achieved through competition. This approach has been successfully applied in several studies in the context of technology-enhanced learning [12].

In addition, in the workshop, the TVET in-service teachers learned about all the active pedagogies, and about several technologies for learning. in addition, they practiced the writing of lesson plans and the creation of industrial robot worksheets for each unit of the robot teaching syllabus, as shown in Figure 3.

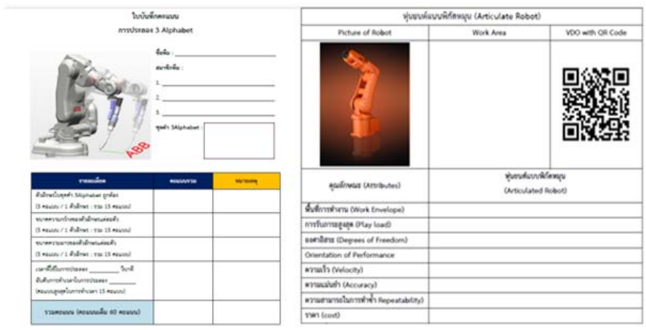

Figure 3. Industrial robot worksheets

Phase 3: Presentation

TVET teachers were divided into groups to discuss how to teach the industrial robot. They can communicate and transfer the knowledge based on active pedagogies. A part of the teaching process is presented for approximately 20 minutes. Each group was assigned a specific teaching process. Furthermore, they have to actively contribute to leading the team to complete the task. After that, they will be displayed in every group and discussion together, as shown in Fig. 5.

Figure 4. Teachers display and class discussion

Phase 4: Professional learning community

In the last phase dealing with Online Professional Learning Communities (OPLC) these were introduced as a tool to connect a group of robotic educators that meets regularly, share expertise, and work together. This can be an effective method for teacher learning and instructional improvement, partly because they help changing the professional culture, encourage collaboration and reflection, and share values [13]. Effective social media can be used to share and create communities between TVET teachers. The Facebook platform was used to share activities and knowledge related to industrial robots for the realization of the workshop aims during the period of the workshop. The familiarity with the use of groups on Facebook opens the possibility for teachers to communicate and participate in online groups [14], [15]. Facebook states that groups are designed for members to connect, share, and even collaborate on a given topic or idea. Thus, TVET in-service teachers joined Facebook groups during the collaboration or planning period, or as informal opportunity to chat with a teacher friend about the industrial robot teaching and learning process in each college, as shown in Fig. 5.

Figure 5. Facebook interaction

4. Results

The results of this study indicate the great potential impact of the industrial robotics training course for the TVET teachers involved. The first research question concerned the barriers teachers faced with regard to industrial robot teaching.

Table 1. Teachers' perception of barriers

Teachers' barrier responses	Percentage
The robot equipment available is inadequate for teaching purposes	57.97 %
The problems are caused by the teachers' lack of knowledge	24.64 %
The students are not interested in the subject	14.49 %
College policies are important problems for teachers	3.90 %

Table 1 shows the main barrier facing the TVET teachers when it comes to teaching about industrial robots, that is the robot equipment is inadequate for teaching purposes (57.97 %). Because of its nature, the cost of an industrial robot is high. Some colleges are equipped with robots for students to operate, but some colleges are not in this situation. Consequently, learning industrial robotics without having access to an actual robotic system has proved difficult for both teachers and students.

In addition, there are problems caused by teachers' lack of knowledge (24.64%). This is because some teachers have never used an industrial robot for teaching purposes, so this is an obstacle when it comes to effectively teaching industrial robot concepts. Moreover, they have noted that traditional teaching methods may cause the students to have little interest in the subject (14.49 %), especially since the industrial robot concept is difficult for TVET students to grasp. Many students considered that they do not enjoy learning about the robotics concept. Finally, the TVET teachers were of the opinion that college policies were a problem in terms of allowing the teachers' teaching to prepare quality (3.90 %). The belief is that policies are key to the success of TVET, in terms of providing many learning materials and keeping them up to date.

The second research question aimed to check the TVET teachers' expectations regarding the workshop. We found that they had anticipated developing teaching and learning approaches with regard to industrial robotics (34.78 %). This was the core reason for participating in this activity. They wanted to develop a new tool for industrial robotic teaching (17.39%). In addition, they expected to apply appropriate pedagogies for their students (27.54 %). They realized the concerns of the TVET teacher in terms of quality improvement and developing teaching competencies (7.25%). Finally, they wanted to share knowledge of robotic technology (1.45%) with others in the industrial robot learning community, as shown in Table 2.

Table 2. Teachers' expectations regarding the training workshop

Teachers' expectations	Percent
To develop teaching and learning strategies with regard to industrial robotics	34.78 %
To learn new tools for teaching industrial robotics	17.39 %
To apply appropriate pedagogies for teaching the students	27.54 %
To improve teachers' knowledge	7.25 %
To share knowledge of robotic technology	1.45%

To answer our last research question, we investigated the TVET teachers' satisfaction with regard to the training workshop.

Table 3. Teacher' satisfaction with the training workshop

Items	M	SD	Interpretation
Satisfaction with the training process	4.75	0.47	Highest
Satisfaction with the training activities	4.61	0.65	Highest
Satisfaction with the usefulness of the training workshop	4.69	0.57	Highest
Overall	4.65	0.61	Highest

According to Table 3, there are three dimensions of TVET teachers' satisfaction towards the industrial robot training workshop, including the training process, the activities, and its usefulness. The results show that the TVET teachers were satisfied at the highest level with regard to the training course overall (M=4.65, SD=0.61). They expressed the highest level of satisfaction with regard to the training process (M=4.75, SD=0.47) while the usefulness of the training (M=4.69, SD=0.57) and the training activities (M=4.61, SD=0.65) were also thought to be at the highest level.

5. Conclusion

This study contains an evaluation of an industrial robot training course for TVET teachers. We attempted to prepare the teachers who teach in vocational education to be masters of the technical and pedagogical skills needed when it comes to using robot technologies in vocational colleges. In the workshop, the participants developed their robotics activities by using innovative pedagogies. In addition, they are now able to continue to discuss and share knowledge about teaching using industrial robots through participation in a professional learning community.

However, the researchers found that it is essential to provide sufficient time for incorporation of the learning into teaching practice, so that the teacher can carry on improving their teaching as part of their professional development.

A potential challenge that teachers raised is the amount of time needed to complete industrial robotics training for TVET teachers. Moreover, the proposed training course requires the application of technology to enhance teaching and learning. For example, the personalized learning systems, the personal industrial robot concepts level, and the learning problems are usually analyzed in order to provide proper instruction for individuals.

In addition, the study suggests that the Thai government should allocate sufficient funds to improving facilities and providing the necessary robot equipment to allow industrial robotic learning to take place, and to ensure that effective vocational education can be achieved

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