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PAPER

Enhancing Teachers' AI Competencies through Artificial Intelligence of Things Professional Development Training

Pornchai Kitcharoen, Suppachai Howimanporn, Sasithorn Chookaew(✉)

King Mongkut's University of Technology North Bangkok, Bangkok, Thailand

sasithorn.c@fte.kmutnb.ac.th

ABSTRACT

The rapid increase in new challenges of the combination of the Internet of Things (IoT) and artificial intelligence (AI), which are emerging technologies, can play a compelling role in prompting the development of artificial intelligence Internet of Things (AIoT). Therefore, the demand for AI competencies for everyone will increase. Educational institutes focus on encouraging AI education because the demand for AI-literate workers will increase in the industrial sector. However, teachers' lack of AI knowledge is a significant barrier to AI education. Thus, developing the teacher's AI competencies and educating them about how to use and teach students is critical. In this study, we proposed artificial intelligence of things professional development (AIoT-PD) training to prepare the AI competencies of teachers ready to teach. A quasi-experimental design with a two-day training workshop was conducted among 13 teachers to examine its impact on AI competencies, including AI knowledge, AI skill, and AI attitude. The quantitative data were collected via a pretest and posttest after the training activity, while qualitative data were collected via interviews. This study showed that teachers' AI knowledge significantly improved. These findings revealed the AIoT training workshop's effectiveness in enhancing teachers' AI competencies, which can help them effectively teach students in AI education.

KEYWORDS

teacher professional development, AI competency, AI education, AIoT, Arduino

1 INTRODUCTION

Professional development training to prepare teachers may be an essential question for the future of engineering education [1] to train teachers in teaching technological competencies to increase efficiency in specific aspects of education [2]. Educational systems using artificial intelligence techniques are not intended to replace teachers. However, they are helpful support tools through

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appropriate programmatic teaching practices within themselves through digital media that affect students' inspiration [3–5]. Many studies proposed artificial intelligence in education (AIE) with the integration and application of AI technologies within the field of education. It involves using AI tools, algorithms, and systems to enhance various aspects of the educational experience, including teaching, learning, assessment, and administration. AIE can involve intelligent tutoring systems, virtual reality simulations, adaptive learning platforms, automated grading systems, and data analytics [6–9]. AIE technologies can help personalize learning, provide intelligent feedback, support student engagement, and optimize curriculum design [10–11]. In addition, AI education focuses on educating individuals about AI. It involves teaching and learning about the principles, concepts, and applications.

Usually, AI education covers topics such as machine learning, neural networks, natural language processing, computer vision, data analysis, and the societal implications of AI. Many studies have proposed methods to equip students with the knowledge and skills to understand, evaluate, and contribute to AI advancements to develop students' understanding of the potential impact on society and the ethical considerations associated with AI [12–14]. Some studies attempt to propose the methodology of artificial intelligence education. For example, an effective AI program in technology education and career exploration for middle school in the free semester includes three steps: preparation, development, and improvement [15]. Furthermore, some studies proposed three courses for senior secondary students to evaluate AI literacy: machine learning, deep learning, and developing AI applications [16].

Although the research on AIE has increased, the number of qualified teachers and curricula that can teach AI is disproportionately low compared to the exploding demand for AI education. AI tools are new to teachers, so they must gain rich technical knowledge to use AI educational applications to facilitate their teaching [17]. AI technologies for education and training can cause anxiety for teachers because they have a complex conceptual understanding and need a learning tool [18]. Additionally, teachers' lack of AI knowledge is a significant barrier to AI education. Therefore, the challenge to enhancing AI education is teaching AI effectively. AI education is essential to understanding how ready teachers are to teach the emerging subject, as the success of AI education is closely dependent on teachers' readiness [19].

The new challenges of the combination of the Internet of Things (IoT) and artificial intelligence (AI) that are emerging technologies can play a compelling role in prompting the development of artificial intelligence Internet of Things (AIoT) that brings the benefit of both technologies as a new structure known comes into play in many fields in engineering education [20–21]. IoT refers to the network of physical devices and other objects embedded with sensors, software, and connectivity, enabling them to collect and exchange data over the Internet. It is a web-based object network that can communicate and share data [22]. While AI refers to developing computer systems that can perform tasks that typically require human intelligence, AI enables machines to learn from data, recognize patterns, make decisions, and carry out tasks with a level of autonomy. Therefore, AI and IoT are combined to achieve a more effective technology, namely benefits combined with Internet devices and artificial intelligence processing.

At the same time, teachers should update their technological knowledge of AI concepts, such as machine learning and application software, to promote teacher readiness to teach their students AI knowledge and skills via professional development courses that upskill and reskill teachers' AI knowledge and skills [23].

In this study, we proposed artificial intelligence of things professional development (AIoT-PD) training to prepare the teachers' AI competencies to be ready to teach AI in their college. This training activity employs the basics of microcontrollers, and the application of fuzzy logic imitates human reasoning and cognition in AI systems. To investigate the performance of this proposed approach, we design a research experiment to conduct professional development training to answer the following research questions:

RQ1: Does artificial intelligence professional development training significantly improve the teachers' AI competencies?
RQ2: What is teachers' perception of artificial intelligence education after participating in artificial intelligence professional development?

2 RELATED WORK

2.1 AI and IoT concepts

Artificial Intelligence (AI) refers to developing computer systems or machines that can perform tasks that typically require human intelligence. It is a branch of computer science that focuses on creating intelligent machines capable of simulating human cognitive processes, such as learning, problem-solving, perception, and decision-making [24]. AI involves designing and developing algorithms and models that enable machines to acquire and process information, extract meaningful insights, and make informed decisions or take appropriate actions based on the available data. AI systems can analyze vast amounts of data, detect patterns, and learn from experience to improve performance. IoT technology involves connected devices comprising IoT devices and a cloud or server. IoT devices transmit sensing data acquired by sensors to the IoT via the sensor network [25].

2.2 Teachers' AI competencies

AI competencies have been variably defined. However, in an educational context, most definitions of competency describe a combination of skills, attitudes, and behaviors that an individual or the organization expects of a particular person, including knowledge, skills, and attitudes [26]. This study defines AI competency as combining cognitive, behavioral, and affective elements to perform a real-world task or activity effectively. Thus, AI competencies for teachers refer effectively to utilizing artificial intelligence (AI) technologies to enhance their teaching practices and improve student learning outcomes [27]. Thus, this course was designed to promote teachers' understanding and application of AI technology. The competency framework provides an inventory of expected knowledge, skills, and attitudes that lead to performance. Figure 1 shows the conceptual framework of AI competencies, including three components: First, knowledge refers to understanding AI's concepts, principles, and theory. Second, skills refer to applying knowledge in practice to develop practical skills in related AI. Last, attitude relates to awareness of the importance of using AI in daily life and the social impact of AI.

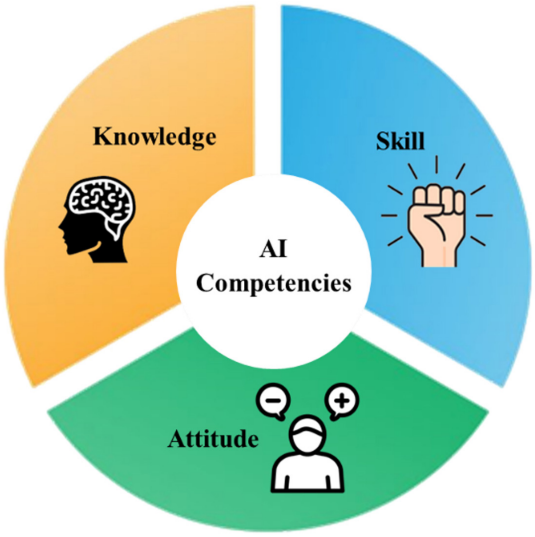

Fig. 1. The conceptual framework of AI competencies

3 ARTIFICIAL INTELLIGENCE OF THINGS PROFESSIONAL DEVELOPMENT TRAINING COURSE

This course aimed to promote the teachers' AI competencies of applying knowledge and practical skills to teaching through hands-on training. Thus, we design learning activities to promote understanding of AI concepts and principles and then construct the knowledge to create AI solutions appropriately. We focus on the AI concept of applying fuzzy logic and imitating human reasoning and cognition rather than strictly binary cases of truth, and fuzzy logic includes 0 and 1 as extreme cases of truth but with various intermediate degrees of truth. This training activity was to design an AIoT system to help understand the basic idea of machine learning by controlling the dimming LED with a fuzzy logic rule. The Arduino Uno R3 is a microcontroller board that processes rules and data for processing AI algorithms. In addition, it is a low-cost microcontroller board [28]. Figure 2 shows the three phases of the structure of the AIoT-PD training concept, including input, process, and output. In the first phase, the teacher will learn about many hardware devices to use the input data and then they can learn application program and microcontroller to process data. After that, they will learn about the output data or display through the monitor and mobile device.

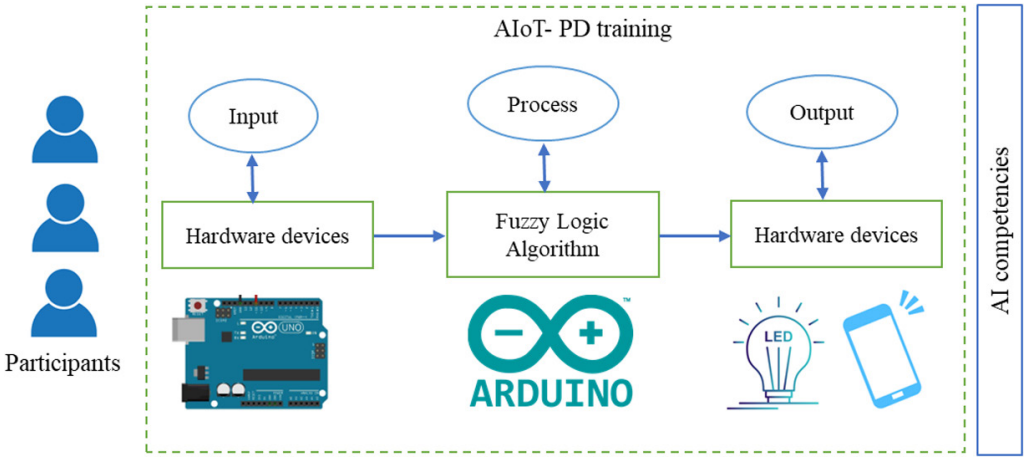

Fig. 2. The structure of AIoT-PD training

4 METHODOLOGY

4.1 Participants

The study implemented the program as a professional development training during the holidays of teachers, who taught related engineering and technology such as electrical, electronic, mechanical, and computer. The participants are 13 teachers (seven males and six females) from Thailand vocational colleges. All teachers have a bachelor's degree, and they have different teaching experiences. The demographic information of the participants is shown in Table 1.

Table 1. Participants' demographic information

Category	Item	Frequency	Percent
Gender	Male	7	53.85%
	Female	6	46.15%
Age	20–30 years	6	46.16%
	30–40 years	2	15.38%
	40–50 years	3	23.08%
	50–60 years	2	15.38%
Teaching experience	1–5 years	4	30.77%
	6–10 years	1	7.69%
	10–15 years	5	38.46%
	More than 15 years	3	23.08%
Major	Mechanical	3	23.08%
	Electrical/ Electronic	7	53.85%
	Computer	3	23.08%

4.2 Instruments

This research conducted a pretest and posttest of a single group to investigate the AI competencies. The pre-and post-AI conceptual understanding tests and the AIoT performance checklist test were developed by three experts with many years of experience in teaching topics related to AI and IoT. The AI conceptual understanding test comprised 16 items with a total score of 160 to evaluate the teachers' knowledge gained from the learning activities before and after the experiment. The AIoT performance checklist test and scoring rubrics include 32 items with a total score of 160 to evaluate teachers' performance gained from the learning activities' final training. The attitude toward AIoT questionnaire has eight items for assessing the AI attitude dimension. The items were constituted using 5-point Likert-type scales. Items on the scales are anchored at 1 = strongly disagree, 2 = disagree, 3 = no opinion, 4 = agree, and 5 = strongly agree.

In addition, the open-ended questionnaire for teachers' interviews was conducted by asking the following questions: (1) What do you learn in AIoT training? (2) What are the advantages of this AIoT training?

4.3 Training activities

In this study, we design learning activities with an AI platform of relevance based on scenarios or everyday experiences that are smart farming. It uses many data inputs for analysis with the algorithm. It helps to promote teachers' engagement to learn and to develop the projects in the training process [29]. The teachers take the AIoT training course for two days (12 hours). The proposed AIoT-PD includes the training material package, lesson plans, training slides, and experimental worksheets. Table 2 shows the structure of the AIoT-PD consisting of 7 topics designed to achieve consistent learning outcomes.

Table 2. The training guidelines and learning outcomes

Days	Topics	Learning Outcomes
1	**1.** Introduction to AI	Explain the importance of AI
	2. Basics of microcontrollers	Use the basics of Arduino
	3. Arduino programming	Conduct the basic Arduino programming
	4. Digital output to control LED lighting and analog input with variable resistor, Pulse Width Modulation (PWM)	Operate the digital output to control an LED
		Operate the analog input with a variable resistor and PWM signal
2	**5.** Principle of Fuzzy logic in AI	Explain the principles of Fuzzy logic in AI
	6. Fuzzy logic conditions to control LED	Use fuzzy logic conditions to control LED
		Apply AI to real-world situations
	7. Dashboard	Display data on the dashboard

We use a microcontroller board for data processing, Arduino Uno R3, as an electronic kit proven to be an educational platform with great potential in embedded engineering. It can cover many core units under the embedded system knowledge scope [28]. It is a low-cost hardware device used to learn in AIoT training and can process data using Fuzzy logic (see Figure 3a and b). Further, Node-RED is a visual programming tool used to create the dashboard for AIoT in this course (see Figure 4a and b). All teachers have AIoT kits to practice in the training activities (see Figure 5a and b).

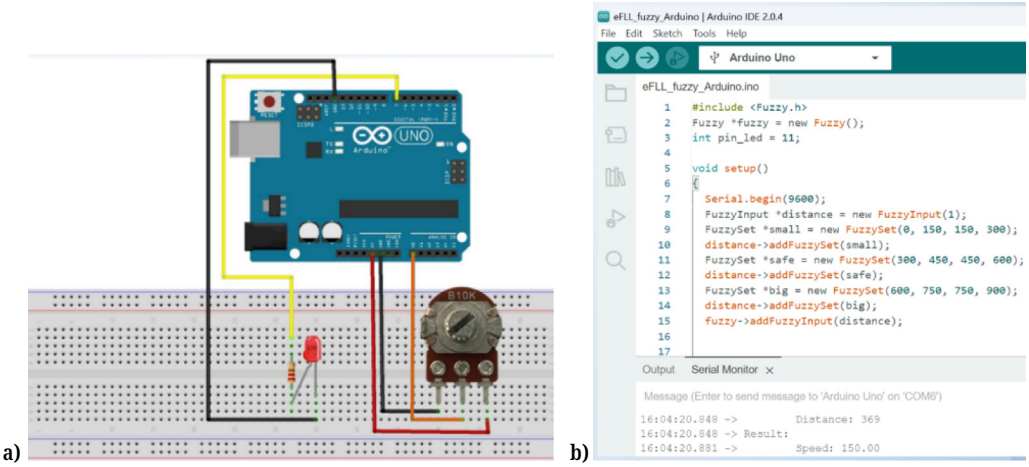

Fig. 3. (a) connecting Arduino board Uno R3 (b) using Fuzzy logic algorithm to control an LED with Arduino programming

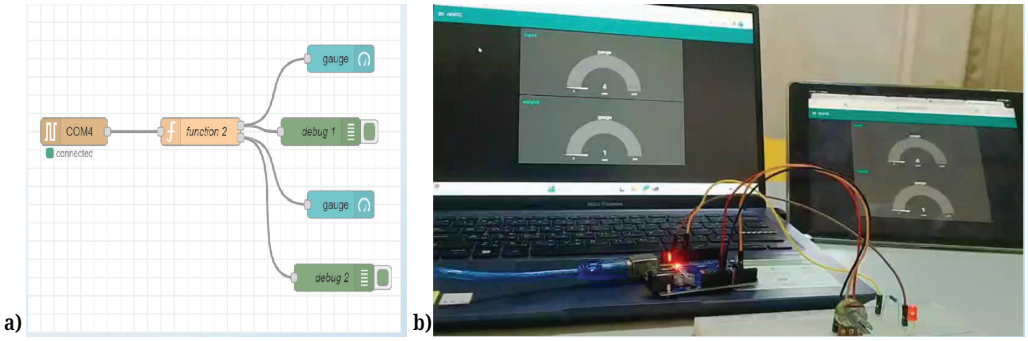

Fig. 4. (a) screenshot of Node-RED software (b) the final output dashboard on devices

Fig. 5. (a) the teacher used an AIoT training kit (b) teachers' practice in the activities

5 RESULTS

5.1 RQ1: Does artificial intelligence professional development training significantly improve the teachers' AI competencies?

The first research question examined whether artificial intelligence professional development training significantly improves the teachers' AI competencies, including three dimensions: AI knowledge, AI skills, and AI attitude. The descriptive statistics were calculated, and nonparametric tests were conducted. The descriptive statistics of the teachers' pre- and post-test AI knowledge is presented in Table 3. The result shows a statistically significant difference between the pretest (M = 16.15, SD = 7.11) and post-test (M = 84.62, SD = 34.61) total score is 160. Wilcoxon's signed-rank test was used to test the significance of the difference between the pretest and post-test AI knowledge scores. Table 2 shows that the AI knowledge scores after the participating learning activity (Z = –3.190, p < .001) were significantly higher than the teachers' AI knowledge scores before the participation in training.

Table 3. Wilcoxon signed-rank test results of the difference between the pre-and post-test of teachers' AI knowledge

Pre- and Post-Test Measurement	N	Mean Rank	Sum of Rank	Z	p
Negative Rank	0	.00	.00	–3.190	0.001***
Positive Rank	13	7.00	91.00		
Ties	0				
Total	13				

Note: ***p ≤ .001, indicates a significant change from pretest to post-test.

In addition, we use the performance percentage of results from a total score of 160 to evaluate teachers' performance in the teachers' AI skills dimension. After training, the teachers take the AIoT performance checklist test and scoring rubrics. The performance criteria are 80%–100% = very well, 60%–79% = well, 40%–59% = satisfactory, 30%–39% = weak, 0%–29% = very weak. The results show that most teachers perform very well (10 teachers), while three teachers perform well, as shown in Figure 6.

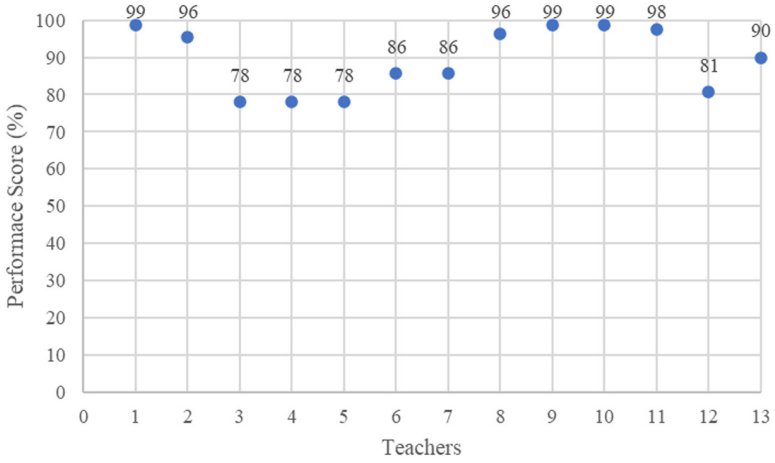

Fig. 6. The teachers' performance percentage of results

5.2 RQ2: What are teachers' perceptions of artificial intelligence education after participating in artificial intelligence professional development?

The second research question examines teachers' perception of AI education after participating in training courses. We selected three teachers: one with teaching experience of 1–5 years, one with 6–10 years, and one with more than 15. The semi-structured interviews were conducted with teachers about their learning experiences in AIoT training.

Table 4 shows the questions in an 8-item scaled survey that measured teachers' AI attitudes toward the training course. The results indicated that most teachers strongly agree that this activity can help them understand and apply AI to their classrooms. The teachers believe it is a learning platform to use AI technology in real life and need to learn more.

Table 4. The teachers' attitude results

Items	Mean	SD
I like AIoT training as learning tools that make AI education easier.	5.00	0.00
I understand the rules and conditions of AI more.	4.38	0.74
I understand how to apply AI technology in daily life.	4.54	0.63
I am ready to teach AI education with AIoT.	4.31	0.91
I think this platform is appropriate for the solution AI education.	4.54	0.50
I need to have materials for teaching and learning AI.	4.00	0.88
I want to learn advanced AI concepts in the next training.	4.46	0.63
I will bring this training can apply to teach students.	4.92	0.27

Note: 1.00–1.50 = strongly disagree, 1.51–2.00 = disagree, 2.51–3.50 = moderately agree, 3.51–4.50 = agree, 4.51–5.00 = strongly agree.

In addition, the 3 teachers' interview reported positive perceptions about this new technology combination of AI and IoT to apply in the AI educational contexts.

- Teacher 1: *"I think AI competency is an important aspect of performance in AI education, but in my opinion, it abstracts concepts and advanced content. On the other hand, after attending this training, I am not having difficulty understanding; it also makes me understand and connect how to use it in real life."*
- Teacher 2: *"In education, AI concepts may be complex and challenging to teach. I am anxious about teaching students. They may be misconceptions or negative toward learning AI. Nevertheless, hands-on learning activities can be attached to students' interests and motivation."*
- Teacher 3: *"The training activity is fantastic; I learned about basic AI used in an actual situation, not abstract; it taught me how to teach students about AI. I am ready to participate in the next training, and I hope that advanced AIoT in another situation will be brought into activity."*

6 CONCLUSIONS

To promote artificial intelligence education, we proposed the artificial intelligence of things professional development (AIoT-PD) training to enhance the teachers' AI competencies and promote their positive perception of AI education. This professional development was to make explicit connections between AI concepts and IoT activity. The teachers can understand and apply the teaching approach to their classroom. The first research question was raised to investigate the development of teachers' competencies in AI. The study's results determined that the AIoT-PD training statistically significantly increased teachers' competency in three domains (AI knowledge, AI skill, and AI attitude). In addition, the second research question was raised to evaluate teachers' perception of training, showing teachers' positive responses: confidence, intention, and readiness to teach AI.

Admittedly, this study is subject to limitations. The sample only included participants from one college and not from other institutes. Thus, this sample is different from participants from Thailand. However, this training course focuses on the changing world of work and shifting demands regarding knowledge and skills for teachers. This study revealed several limitations and challenges of AI teachers' competencies that impact the use of AI for teaching their students in the future in Thailand.

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9 AUTHORS

Pornchai Kitcharoen is a Ph.D. candidate in Mechanical Engineering Education at the Department of Teacher Training in Mechanical Engineering in the Faculty of Technical Education, King Mongkut's University of Technology North Bangkok, Thailand (E-mail: P.kitcharoen@email.kmutnb.ac.th).

Suppachai Howimanporn is an Associate Professor at the Division of Mechatronics and Robotics Engineering, Department of Teacher Training in Mechanical Engineering in the Faculty of Technical Education, King Mongkut's University of Technology North Bangkok, Thailand (E-mail: suppachai.h@fte.kmutnb.ac.th).

Sasithorn Chookaew is an Associate Professor at the Division of Mechatronics and Robotics Engineering, Department of Teacher Training in Mechanical Engineering, Faculty of Technical Education, King Mongkut's University of Technology North Bangkok, Thailand (E-mail: sasithorn.c@fte.kmutnb.ac.th).