Long, Y., Sun, Y., Yang, Y., & Wei, L. (2019). Investigating teachers' pedagogical practices and beliefs regarding developing creative thinking in training institutes offering robotics education. Paper presentation at the *2019 Knowledge Building Summer Institute: Knowledge Building Practices and Technology for Global Hubs of Innovation.* March 15-16, 2019, Beijing, China.

Investigating Teachers' Pedagogical Practices and Beliefs Regarding Developing Creative Thinking in Training Institutes Offering Robotics Education

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Abstract: In robotics education, teachers serve as facilitators, guiding students to complete challenging tasks. However, although teachers' pedagogical practices and beliefs are crucial to the development of students' higher-level abilities, previous studies have paid little attention to these topics. This study aims to investigate teachers' pedagogical practices and beliefs as they pertain to robotics education and the development of primary school students' creative thinking skills. Ten teachers from training institutions offering robotics education participated in this study. Semi-structured interviews were used to collect data. Qualitative analysis of the teachers' interviews revealed that most of the teachers motivated their students using positive reinforcement, viewed themselves as encouraging students to approach tasks independently, believed that students' logical thinking can be developed through robotics education, and stimulated students' creative thinking in a process of discovery. This study has important implications for teachers and researchers devoted to helping students improve their higher-order thinking.

Introduction

Developing students' higher-order thinking skills, especially their creative thinking, has drawn increasing attention from researchers and educators. However, which pedagogical practices can lead to creative learning outcomes remains unclear, both in theory and in practice.

As a new form of educational practice and an emerging research subject, robotics education shows great potential in helping students develop their creative thinking and creative design skills. Robotics education is a multi-disciplinary subject incorporating computer science and integrating mechanical, electrical, and electronic engineering (Nemire, Jill, Larriva, Ceser, Jawaharlal & Mariappan, 2017). In robotics education classes, students are expected to devise original solutions to real problems under the guidance of their teachers. In this context, students develop their capacities in creativity, teamwork, and problem-solving by facing challenging tasks (Gerecke & Wagner, 2007). Alimisis (2013, p. 63) also pointed out that robotics education, which is based on interesting activities and hands-on experiences, can create an engaging, attractive, and interactive learning environment. In recent years, the Chinese government has promoted various projects to promote this new form of educational practice. However, robotics education in China is still at an initial stage, characterized by a shortage of professional and experienced teachers and a lack of research. However, some studies on robotics education have established that teachers' pedagogical practices and beliefs play a vital role in the development of students' creative thinking (e.g., Brickhouse, 1990; Clark & Peterson, 1986; Hashweh, 1996; Nespor, 1987). Therefore, research in this area helps provide teachers with training that can improve their practice. This study is conducted in the context of teacher training institutions and analyzes teachers' pedagogical practices and beliefs as they pertain to robotics education and the development of creative thinking in primary school students. Specifically, the study aims to address the following two questions.

(1) Is creative thinking an intended learning outcome of robotics education?

(2) Which pedagogical practices and beliefs are visible among training institutions' teachers, and are they designed to help students develop their creative thinking?

Method

Research context and subjects

This research was carried out in two districts of Wuhan, Hubei Province, China. Ten teachers from selected training institutions participated in the study. Table 1 shows the details of the interviewees.

Table 1: Background information on 10 interviewees. ✔ means "teacher graduated from key university." ✘ means "not from key university." B means "Bachelor's degree." N/A means "unclear."

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
Gender	Male	Female	Female	Female	Male	Male	Male	Male	Male	Male
Years of teaching	4 years	2 years	N/A	1 year	3.5 years	0.5 years	6 years	2 years	2.5 years	2 years
Key university	✘	✔	✔	✔	✔	✔	✘	✔	✘	✘
Degree	B	B	B	B	B	B	B	B	B	B
Major	Information management	Foreign trade	N/A	Educational technology	Mechanical automation	Mechanical automation	Building equipment engineering	E-commerce	Computer network technology	Pharmaceutics

Data collection and analysis

Semi-structured interviews were used to investigate the sampled teachers' pedagogical practices and beliefs regarding robotics education. Each interview lasted for around 1 hour and was conducted face-to-face or online. The questions in the pre-designed outline are listed below.

A1 Please describe in detail the course, teaching objectives and contents of the whole semester in your class.

A2 How do you motivate students in your class?

A3 What do you do when students can't operate educational robots or complete programming task in robotic education?

A4 To give us a deeper understanding of your classroom teaching, can you describe in detail your teaching steps during classes? What do you do in each step and what are the main teaching methods used?

B1 How do you understand robotics education?

B2 What is the significance of robotics education, and what is the key to teaching it?

C1 In your opinion, what is the main influence on students' creative thinking?

C2 What can be done to help students improve their creative thinking in robotics education course?

Figure 1. Pre-designed interview outline.

Upon consent, each interview was audio recorded and transcribed verbatim. The teachers' answers to the questions were classified according to the following categories: pedagogical practices, learning outcomes, and practices and beliefs regarding creativity. Sawyer's themes (2017, p105) were adopted and refined for data analysis. First we conducted a thorough analysis of each interview, followed by a comparison of all of the teachers' interviews.

Findings: emergent themes

Six themes emerged from the interviews and were grouped into three clusters: pedagogical practices (three themes), learning outcomes (one theme), and beliefs and practices related to creativity (two themes). Table 2 presents a detailed analysis of each interviewed teacher in all six aspects.

Table 2. Each teacher's practices and/or beliefs associated with themes. ✔ means "matched." ✘ means "unmatched." N/A means "unclear."

Description of the themes	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
1. Class content is closely related to daily life.	✔	N/A	✔	✔	✔	✔	✔	N/A	✔	N/A
2. Motivating students using positive reinforcement.	N/A	✔	N/A	✔	✔	✔	✔	✔	✔	✔
3. Guiding students to approach tasks independently.	✓	✔	✖	✔	✔	✔	✔	✔	✖	✔
4. Believing that robotics education can develop logical thinking.	✔	✔	✔	N/A	✔	N/A	✔	✔	✔	N/A
5. Believing that students' creative thinking is primarily influenced by their own horizons and their teachers' guidance.	N/A	✔	✔	✔	✔	✔	✔	✔	✔	✔
6. Stimulating students' creative thinking in a discovery process.	✓	✔	✖	✖	✔	✔	✔	✔	✔	✔

Pedagogical practices

Class content is closely related to daily life (Theme 1). Most of the robotics education teachers related class content to daily life, with students being expected to apply their own insights about life to learning in the classroom. Two teachers commented that "connecting with life can enrich the class, divert students' thinking, and promote their knowledge acquisition" (T6; T7). As T1 mentioned, "When explaining infrared sensors, students are expected to draw inferences about their potential use in the anti-pinch function of elevators, for example, and the obstacle avoidance function of sweeping robots." He explained how mastering an infrared sensor is related to solving problems in life. T4 and T9 also pointed out that "students should know how to cope with problems in life." Some of the teachers expected students to reflect on their classroom knowledge from the perspective of daily life. As T5 explained to students, "the lower the center of gravity, the more stable." He advised students to experience this sensation when taking a bus.

Motivating students using positive reinforcement (Theme 2). Most of the robotics education teachers praised their students frequently and offered material rewards as incentives. In addition, most of them awarded points to each student based on their performance, which, to heighten their enthusiasm, could be exchanged for gifts (T1; T2; T4; T7; T8; T10). Two teachers pointed out that "some of the older students don't need material rewards and are highly motivated by the course itself and the personal interactions with teachers" (T1; T2). T5 encouraged students to show their parents their completed projects to strengthen their sense of achievement. T6 also commented that "teachers and parents' recognition of students' accomplishments is the most effective [incentive]."

Guiding students to approach tasks independently (Theme 3). Most of the robotics education teachers viewed themselves as facilitators, enabling students to reflect on their mistakes, solve problems, and work independently. T1 mentioned that "Our teachers can't simply give directions to students, because the purpose of the class is to have students develop their own problem-solving skills. Therefore, when a problem surfaces, the teacher ideally guides students to reflect on why they made mistakes." T2 offered the following example: "when students struggle with parameter settings, they are supposed to think independently about the problem, with teachers guiding them toward their goals." T7 and T10 also emphasized that "students should identify the source of the problem and determine how to fix it." T5 pointed out that "teachers should guide students in a way that they can understand." He gave an example of explaining how to build a washing machine model in class. "Firstly, it is important to highlight the vital parts of the structure, such as the main engine, before analyzing the structure as a whole." Finally, regarding building models, he pointed out that "The idea is not to issue step-by-step instructions, but rather to inform students about the general sequence of assembly and items the needing attention so that they can work independently." T9 also said that "students can only understand which kind of bridge is most stable when building a model bridge."

Learning outcomes

Believing that robotics education can develop logical thinking (Theme 4). T1 commented that "students of robotics education can develop logical thinking by engaging in design, assembly, programming, and operations." Other teachers pointed out that "students can train their own logical thinking skills during programming, specifically when deciding on the order and combination of cards that activate different robot functions" (T2; T3; T5; T10). T3 explained that "robotics education is a comprehensive discipline for training logical thinking." T5 said that "students can develop their thinking skills by deducing problems in a robot's structure or programming according to the robot's performance." T7 mentioned indirectly that "students' thinking skills develop along with the degree of complexity involved in building models and in programming." Robotics education also has the potential to develop

other related abilities. Here, some teachers referred to creative thinking (T1; T4; T6). T4 explained that "teachers simply present the basic goals, giving students a lot of space to build and create." T6 also pointed out that "sparking creative thinking is vital in robotics education. With no drawings or templates to constrain students, they can use their imaginations and create spontaneously." Students' comprehensive practical ability, manipulative ability, problem-solving ability, and psychological endurance were mentioned by other teachers (T5; T7; T8; T9; T10).

Beliefs and practices about creativity

Believing that students' creative thinking is primarily influenced by their own horizons and their teachers' guidance (Theme 5). Some teachers said that "the more things students touch and the more they think, the more ideas they generate. Creative thinking reflects the accumulation of comprehensive ability." The teachers also mentioned that students, counseled by teachers, gradually develop their own ideas (T6; T7; T9; T10). T2 stated that "students' creative thinking depends on their own original ideas and their teachers' new ideas." This statement suggests that students' imagination is unrestrained and should not limit their ideas when solving problems. T5 also said that "students have their own thinking process, and teachers serve more as facilitators in the discovery process." He further pointed out that "when children have [creative] ideas, [the teacher] must provide constant guidance. It's quite demanding for the teacher to be able to understand the student and provide immediate and targeted guidance."

Stimulating students' creative thinking in a discovery process (Theme 6). Many of the teachers stimulated students' creative thinking by referring to the structure and function of building models. T1 said, "If we want to be creative with a model car, I will inspire students by showing the car's potential for transportation, emergency services, or engineering. Students can then base their design on the function." T5 pointed out that "teachers' explanations need to be open, wide-ranging and divergent." He gave an example of making a model of a washing machine: "students are expected to think about how to make the model run silently and how to reduce friction." He also inspired students to consider their responses to sudden and unexpected situations such as a power failure. Some teachers often raised questions to inspire students. T3 explained that "at the start of a class, teachers raise questions to elicit students' examples and encourage the application of knowledge." He explained that "asking more questions can help students think creatively." T10 also said that "posing questions inspires students to think about the principles that can activate and train their creative thinking."

Conclusion

In this study, we found that in robotics education training institutions, teachers' beliefs and practices were positive and nurtured students' creative thinking. Most of the teachers connected their classes with daily life (Theme 1) and motivated students using positive reinforcement (Theme 2). Although only a few teachers regarded creative thinking as a significant learning outcome (Theme 4), they emphasized that their guidance in the discovery process helps develop students' creative thinking (Theme 3; Theme 6). This may relate to their belief that students' creative thinking is influenced by their own horizons and their teachers' guidance (Theme 5). This study, which interviewed teachers to explore emergent themes in robotics education, provides a foundation for our research on the pedagogical beliefs and practices that are conducive to students' creative thinking.

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Acknowledgments

This research was partly supported by a grant from Central China Normal University (Grant No. 201810511044), and partly and financially supported by self-determined research funds of CCNU from the colleges' basic research and operation of MOE.