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A Systematic Review of Teachers' Preparedness towards Computational Thinking Integration in Mathematics

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ABSTRACT
As earlier studies highlighted the importance of teachers' preparedness to develop computational thinking (CT) for students in school education, this study aims to explore the teaching areas involved in the mathematics teachers' preparedness to integrate CT in classrooms, as well as to investigate the considerations for effective training or professional development activities to prepare mathematics teachers in teaching CT. A total of 16 journal articles from 2015 to 2020 were reviewed in this study. The findings indicated that not all the teaching areas (i.e. classroom management, teaching methods, subject knowledge, technology, planned curriculum, assessing students, and choosing teaching materials) were involved in the teachers' preparedness for each study. Several considerations for effective training or professional development had been proposed. The results can be utilized to inform initial teacher education plans and ongoing professional development opportunities to better prepare the teacher to teach CT in the mathematics classrooms.

KEYWORDS
Systematic review, teachers' preparedness, computational thinking, mathematics

1. INTRODUCTION
Teachers from all levels require educational experience to prepare them to teach CT concepts effectively (Rich, Yadav, & Schwarz, 2019). Chalmers (2018) findings maintain for teachers to be able to successfully integrate and teach CT in classrooms, they need to have increased knowledge and awareness of the subject and its concepts, only when the teachers are confident can they deliver meaningful knowledge to the students. This further highlights the importance of the preparedness of teachers. Thus, this study intends to conduct a systematic review of teachers' preparedness towards CT integration in mathematics. Two following research questions guide this systematic review:

a) What are the teaching areas involved in the mathematics teachers' preparedness to integrate CT in classrooms?

b) What are the considerations for effective training or professional development activities to prepare mathematics teachers in teaching CT?

2. LITERATURE REVIEW
Teachers' preparedness was defined by Gonzales (2018) as "[t]he state of "being ready for some purpose, use or activity" (p. 15) before having to accomplish an activity. Ondimu (2018) described teachers' preparedness as individual and collective knowledge, ability, skills, perceptions, and attitudes of teachers to support the enactment of curricula. The teacher's level of preparation is measured according to the teacher's views on the following seven teaching areas: (1) classroom management, (2) teaching methods, (3) subject knowledge, (4) technology, (5) planned curriculum, (6) assessing students and (7) choosing teaching materials (Lu, 2005).

Courses or training are implemented to meet the need for teacher preparation. Earlier studies (e.g. Angeli and Jaipal-Jamani, 2018) revealed that the training given to the pre-service teachers was able to develop pre-service teachers' CT skills and better prepare them to teach CT in the classrooms. Besides the teacher education courses or training, the CT professional development courses were also implemented for in-service teachers. For example, Yadav, Gretter, Good, and McLean (2017) executed a study with 76 in-service teachers in a program that included two 39-hour courses. The findings revealed that participants have a better understanding of CT concepts and practices, and have made improvements in three of the four knowledge-related dimensions related to technical knowledge content.

3. METHOD
The method utilized in this systematic review was based on the method of performing systematic reviews in the social sciences by Petticrew and Roberts (2006). Five scientific databases were employed to execute systematic review, namely Scopus, Web of Science, Science Direct, LearnTechLib, and ProQuest Education database. We used several combinations of search terms to find the relevant articles for this systematic review, i.e. "computational thinking" AND ("math" OR "mathematics") AND ("teacher"). The initial search resulted in a total of 156 articles.

The inclusion criteria for this systematic review were including (a) The article published in the last five years, i.e. between 1st January 2015 and 31st December 2020 as the field of CT in the mathematics teacher education was only being developed in recent years; (b) The article published in the peer-reviewed journals; (c) The article reported on the empirical evidence of the research, involving qualitative or quantitative, and mixed-method; (d) The article presented the CT in the mathematics teacher education; (e) The participants must be mathematics in-service teachers or pre-service teachers; and (f) The article published in the English language. Meanwhile, the exclusion criteria were including (a) The article published

in the book chapter, book series, and conference proceedings; (b) The article that only reported on the literature review, opinion, and framework or model; and (c) The article did not relate CT in the mathematics in-service teachers or pre-service teacher education. Using the above inclusion and exclusion criteria, 16 articles were included in this systematic review.

4. FINDINGS

4.1 Teacher Preparation

To review the math teachers' preparation to integrate CT in classrooms, we adapted Lu's (2005) seven teaching areas. It includes (1) classroom management, (2) teaching methods, (3) subject knowledge, (4) technology, (5) planned curriculum, (6) assessing students, and (7) choosing teaching materials (see Table 1).

Table 1. Teacher preparedness in seven teaching areas in the reviewed articles

No	Authors & Year	1	2	3	4	5	6
1	Li (2020)					/	
2	Piedade, Dorotea, Pedro, & Matos (2020)		/	/			
3	Reichert, Barone, & Kist (2020)			/	/		
4	Araujo, Floyd, & Gadanidis (2019)		/	/	/	/	
5	Papadakis & Kalogiannakis (2019)			/	/		/
6	Masfingatin, & Maharani (2019)						/
7	Rich, Yadav, & Schwarz (2019)			/			
8	Tuhkala, Wagner, Iversen, & Kärkkäinen (2019)				/		
9	Yuan, Kim, Hill, & Kim (2019)				/	/	
10	Chalmers (2018)		/	/	/		/
11	Günbatar, & Bakırcı (2018)				/		
12	Valentine (2018)		/		/	/	
13	Wang, Utemov, Krivonozhkina, Liu, & Galushkin (2018)		/				
14	Gadanidis (2017)				/	/	/
15	Gadanidis, Cendros, Floyd, & Namukasa (2017)			/	/	/	/
16	Leonard et al. (2017)	/		/	/		

*(1) classroom management, (2) teaching methods, (3) subject knowledge, (4) technology, (5) planned curriculum, (6) assessing students and (7) choosing teaching materials

4.2 Teacher Training and Professional Development

Yadav et al. (2017) concluded that teacher training and professional development activities are vital as it was observed that teachers only had a basic understanding and knowledge of CT. They found that the current training being provided to teachers is not enough, so 'training needs to begin early on in the teacher preparation programs to allow pre-service teachers to understand how computational thinking ideas are related to their content areas' (p. 217).

According to Chalmers (2018), a big part of the professional development practices should be, 'a greater awareness of computational thinking concepts, practices, and perspectives would increase teachers' understanding and confidence to embed computational thinking and robotics into primary school classrooms' (p. 97). Wang et al. (2017) shed light on access methodological resources like flipped classrooms, as a driving force to increase the teachers' motivation levels.

Valentine (2018) discussed how increasing chances for pre-service teachers to experience and interact with concepts and tools of math and CT and viewing them as doers or makers is an important consideration for professional development training. She adds that this lays a strong foundation and cultivates a habit of active thinking with respect to what to teach and how to teach those math and CT concepts in the classrooms. 'Future work might consider creating opportunities for pre-service teachers to plan their own constructivist-oriented mathematics lessons and try these out with classmates and in their field placements' (p. 16). Pre-service teachers would benefit significantly from STEM content courses taught in an integrated way since pre-service teachers tend to apply an integrated method to STEM teaching after they have been taught in such a way.

5. CONCLUSION

Research question one explored the level of mathematics teachers' preparedness to integrate CT in classrooms. The results revealed not all the seven teaching areas were covered for teachers' preparedness in each study. Most of the studies (11 studies) investigated the use of technology, followed by subject knowledge (8 studies), planned curriculum (6 studies), teaching methods (5 studies), assessing students (5 studies), classroom management (1 study), and choosing teaching materials (1 study).

Research question two investigated the considerations for effective training or professional development activities to prepare mathematics teachers in teaching CT. Several considerations for effective training or professional development activities were including the importance of introducing the teacher preparation programs early, imbue in a greater awareness of CT concepts, practices, and perspectives, access methodological resources, as well as experience and interact with concepts and tools of math and CT.

There is a need for teacher professional development and ongoing training for the pre-service and in-service teachers who integrate CT in their mathematics classrooms. This systematic review can be useful for teachers, educators, and researchers seeking to greatly improve the quality of training or professional development programs to enhance the teachers' preparedness of teaching CT in mathematics lessons.

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