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Preservice Teachers' Views of Computational Thinking: STEM Teachers vs non-STEM Teachers

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ABSTRACT

This study was performed to explore the views of preservice teachers of computational thinking (CT) through a pilot survey. A total of 329 preservice teachers from the National Institute of Education Singapore took part in this pilot survey. These preservice teachers were trained to teach STEM and non-STEM subjects. The overall findings showed that the preservice teachers do not yet have an adequate understanding of CT. Most of them perceived CT as logical thinking or reasoning. This is followed by no idea or no understanding or not sure, using ICT or computer, coding or programming, problem-solving and so forth. Besides that, STEM preservice teachers had different views of CT compared to non-STEM preservice teachers. These initial views of CT among the preservice teachers can serve to inform the design of teacher preparation programs, policies and syllabus materials to support the preservice teachers to infuse CT into their future teaching practices.

KEYWORDS

computational thinking, preservice teacher, view, pilot survey

1. INTRODUCTION

In Singapore, developing computational capabilities is one of the key enablers for the Smart Nation initiative. Several programs have been conducted to introduce and enhance computational thinking (CT) skills and coding abilities among the Singaporean, from pre-school students to adults. Nevertheless, one of the main concerns is how to best prepare and support teachers to incorporate CT into their teaching in the classroom (Yadav, Hong, & Stephenson, 2016). We are a research group that explores the design of new programs to train the preservice teachers and in-service teachers in CT. A recent program that has been implemented was CTFest: Sharing and Learning about CT which sponsored by a grant from the Google Data Centre Community Fund. During the CTFest, featured talks and discussions were held for the teachers to learn about the best practices in the teaching of CT. The attendees included teachers of computer science, computer programming and applications, computing, design and technology, and computing-related Applied Learning Programmes; colleagues from Curriculum Planning & Development (CPDD) of MOE, polytechnics lecturers and Singapore Science Centre. Industry partners were also invited to exhibit their work in computing education.

Educational experiences are needed for the teachers from all levels to prepare them well to teach CT concepts effectively. Knowing the standpoints of preservice teachers towards CT can serve as applicable resources for creating teacher preparation programs, policies, and syllabus materials to support the teachers to integrate CT into their teaching practices (Rich, Yadav, & Schwarz, 2019). Thus, this study is intended to determine preservice teachers' views of CT through a pilot survey. It is led by these research questions:

(a) How do preservice teachers view computational thinking?

(b) What are the differences in the view of computational thinking between STEM and non-STEM preservice teachers?

2. LITERATURE REVIEW

CT has the potential to promote problem-solving skills and capabilities among the students as they start to think in new ways (Yadav et al., 2014). Therefore, the students should be taught to understand computational procedures and develop skills for representing and abstracting information (Lu & Fletcher, 2009). Hemmendinger (2010) also claimed that the aim of teaching CT was "to teach them how to think like an economist, a physicist, an artist, and to understand how to use computation to solve their problems, to create, and to discover new questions that can fruitfully be explored" (p. 4). Yadav et al. (2011) asserted that teacher education was one discipline where CT would have a noteworthy effect on K-12 education. This was because if the preservice teachers were able to present their CT ideas in the teaching, the students would have the superior experience of computing in general.

Some works have been executed to determine how preservice teachers view CT. For instance, Chang and Peterson (2018) accomplished a study to identify the perceptions of CT among preservice teachers. The preservice teachers define CT as an important literacy, with elements of thinking in a logical series and steps, thinking for solution and creating strategies, and demonstrating thinking. Furthermore, Bower and Falker (2015) conducted a study to investigate the understanding of CT among preservice teachers. The results indicated that almost one-third of the preservice teachers regarded CT as problem solving using technology, and utilizing technology. Another study was done by Yadav et al. (2014) to evaluate the understanding of CT among preservice teachers. The preservice teachers perceived that CT as heuristics and problem solving, algorithms, use of computers or technology, and critical thinking.

3. METHOD

3.1. Respondents

329 preservice teachers in the National Institute of Education, Singapore who participated in this study. They had just completed their year-long teaching training courses, and were about to go to school for their practicum before graduation as a teacher. They were trained to teach at least two subjects. Most of them (*n*=147, 44.7%) had the curriculum subject of English Language / Literature / General Paper. This is followed by the subjects of Mother Tongue (*n*=92, 28%), Mathematics (*n*=82, 24.9%), Science (*n*=59, 17.9%), History / Social Studies / Geography / Economics (*n*=76, 23.1%), Art / Music / Drama (*n*=21, 6.4%), Computer Applications (*n*=3, 0.9%), Principles of Accounts (*n*=3, 0.9%), Elements of Business Skills (*n*=2, 0.6%), Character and Citizenship Education (*n*=2, 0.6%), Social Studies (*n*=1, 0.3%), and French (*n*=1, 0.3%). 121 of them were trained to teach STEM subjects including Mathematics, Science, and Computer Applications. We considered them as STEM preservice teachers if they were trained and prepared to teach at least one STEM subject. Meanwhile, 208 of them were trained in teaching non-STEM subjects. All of these preservice teachers were required to attend a one and half hour long CT introductory session as part of their Beginning Teacher Orientation Programme.

3.2. Pilot Survey

At the beginning of the session program on CT, the respondents had to complete a pilot survey which consisted of two questions. The first question was in multiple-choice format, and the second question was open-ended. The first question was "What subject areas have you been prepared to teach?" and the second question was "What is your current understanding of computational thinking?" The respondents answered the questions using google forms. The responses of the second question were analyzed using an open coding approach to identify the preliminary analytic categories. If the responses contained multiple features, they were put under two or more categories, for instance 'Problem solving with the use of computers' was included in the categories of 'problem-solving' and 'using ICT/computer' (Bower & Falkner, 2015).

4. FINDINGS

4.1. Preservice Teachers' Views of CT

Table 1 presents the views of CT among preservice teachers. In Table 1, we notice that the majority of the preservice teachers perceived that CT was logical thinking or reasoning with a total frequency of 80. It was surprising that a number of preservice teachers (*n*=43) did not have any idea or understanding of CT. Most of them (*n*=38) also regarded CT involve the use of ICT or computer. 32 of the respondents viewed CT as coding or programming. Besides that, the preservice teachers also thought that CT was related to problem-solving, with a frequency of 30 and CT was systematic or systematic thinking with the frequency of 19. They deemed that CT was thinking or thinking process (*n*=13), computation or calculation (*n*=10), and algorithm (*n*=10). This is followed by mathematics (*n*=8), analytical thinking or analytical thinking (*n*=8), and programming (*n*=8). Six of the respondents conceived that CT was step by step and thinking like a computer. Methodical thinking and analysis were perceived as CT with a frequency of 4 respectively. Furthermore, CT was also considered as computing skills or principles (*n*=3), sequencing or sequential thinking (*n*=3), artificial intelligence (*n*=3), structured or structured thinking (*n*=2), and using software (*n*=2). The other CT views with a frequency of 1 were including stepwise thinking, thinking like a bot, thinking like a coder, rational thinking, IT-related thinking, engineering-related and so on.

Table 1. Preservice Teachers' views of CT

No	CT Views	Frequency
1	Logical thinking/reasoning	80
2	No idea/No understanding/Not sure	43
3	Using ICT/computer	38
4	Coding/Programming	32
5	Problem solving	30
6	Systematic/Systematic thinking	19
7	Thinking/Thinking Process	14
8	Computation/Calculation	10
9	Algorithm	10
10	Mathematics	8
11	Analytical/Analytical thinking	8
12	Steps/Step by step	6
13	Thinking like a computer	6
14	Methodical thinking	4
15	Analysis	4
16	Computing skills/principles	3
17	Sequencing/Sequential thinking	3
18	Artificial intelligence	3
19	Structured/Structured thinking	2
20	Using software	2
21	Algorithmic thinking	1
22	Strategy	1
23	Robots	1
24	JavaScript	1
25	Out of box thinking	1
26	Recursion	1
27	Stepwise thinking	1
28	Giving instructions	1
29	Rational conclusions	1
30	Commands	1
31	Thinking like a bot	1
32	Thinking like a coder	1
33	Thinking like a machine	1
34	Numbers	1
35	Higher order thinking	1
36	Excel	1
37	Statistics	1
38	Permutation	1
39	Combinations	1
40	Configurations	1
41	Decision making	1
42	Directions for machines	1
43	Computer terminology	1
44	Technical	1
45	Algebraic thinking	1
46	Binary codes	1
47	Iterations	1
48	Processing thoughts effectively	1

49	Thinking procedurally	1
50	Procedure	1
51	Mathematical thinking	1
52	Rational thinking	1
53	Memory work	1
54	Managing complexity	1
55	Using models	1
56	Proactive thinking	1
57	ICT lesson	1
58	IT-related thinking	1
59	Optimization	1
60	Function	1
61	Graph theory	1
62	Standardized thinking	1
63	Solutions	1
64	Making teaching easier	1
65	Engineering-related	1

4.2. *Comparison of the view of CT between STEM and non-STEM preservice teachers*

Based on Table 1, the views of CT that had a frequency of 2 or more than 2 were included in the analysis to compare the differences in the view of CT between STEM and non-STEM preservice teachers. From Table 2 and Figure 1, it can be observed that more STEM preservice teachers (28.9%) viewed CT as logical thinking or reasoning than non-STEM preservice teachers (21.6%). Most of the non-STEM preservice teachers (15.9%) did not know about CT compared to that of STEM preservice teachers (8.3%). When compared to non-STEM preservice teachers, the STEM preservice teachers were more likely to consider CT as coding or programming (10.7%), systematic or systematic thinking (8.3%), thinking or thinking process (5.0%), computation or calculation (5.0%), mathematics (2.5%), analytical or analytical thinking (3.3%), steps or step by step (3.3%), thinking like a computer (2.5%), methodical thinking (1.7%), and using software (0.8%). The percentage for the non-STEM preservice teachers for these ten CT views was 9.1%, 4.3%, 3.8%, 1.9%, 2.4%, 1.9%, 1.0%, 1.4%, 1.0%, and 0.5% respectively. In the contrast, the STEM preservice teachers were less likely to regard CT as using ICT or computer (10.7%), algorithm (1.7%), analysis (0.8%), computing skills or principles (0.8%), and sequencing or sequential thinking (0.8%). The percentage for non-STEM preservice teachers was higher than STEM preservice teachers for these five CT views, i.e. 12%, 3.8%, 1.4%, 1.0%, and 1.0%. Both STEM and non-STEM preservice teachers deemed CT as problem-solving which had the same percentage of 9.1%. Non-STEM preservice teachers considered CT as artificial intelligence and structured or structured thinking with a percentage of 1.4% each, but there was 0% for the STEM preservice teachers.

Table 2. Comparison of views of CT between STEM and non-STEM preservice teachers

CT Views	STEM	Non-STEM
Logical thinking/reasoning	28.9	21.6
No idea/No understanding/Not sure	8.3	15.9
Using ICT/computer	10.7	12
Problem solving	9.1	9.1
Coding/Programming	10.7	9.1
Systematic/Systematic thinking	8.3	4.3
Thinking/Thinking Process	5	3.8
Computation/Calculation	5	1.9
Algorithm	1.7	3.8
Mathematics	2.5	2.4
Analytical/Analytical thinking	3.3	1.9
Steps/Step by step	3.3	1
Thinking like a computer	2.5	1.4
Methodical thinking	1.7	1
Analysis	0.8	1.4
Computing skills/principles	0.8	1
Sequencing/Sequential thinking	0.8	1
Artificial intelligence	0	1.4
Structured/Structured thinking	0	1.4
Using software	0.8	0.5

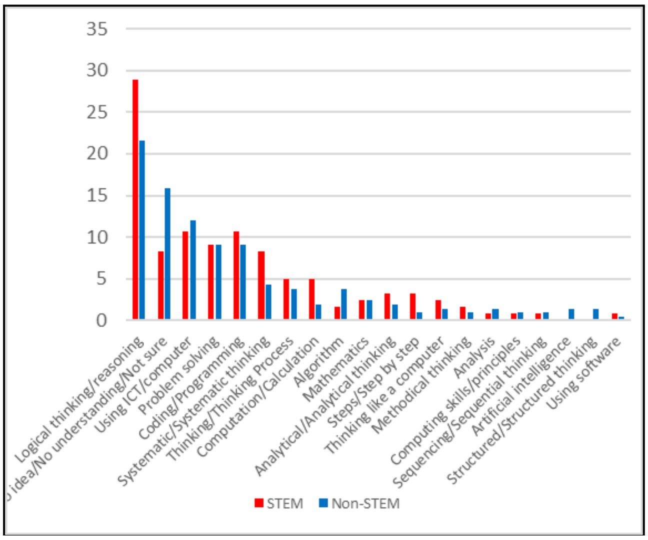

Figure 1. Comparison of views of CT between STEM and non-STEM preservice teachers

5. DISCUSSIONS AND CONCLUSION

The overall findings demonstrated that preservice teachers did not have a sufficient understanding of CT. This indicated that a lack of awareness of how CT skills can be incorporated into their teaching practices, thus implying that more work needs to be put in to expose them to knowledge and practices about the integration of CT in the classrooms. The majority of preservice teachers perceived that CT as logical thinking which is analogous with the result of a study from Chang and Peterson (2018) where CT is seen as thinking in logical steps. The preservice teachers had comparable responses with the study of Sands, Yadav and Good (2018) where CT involved problem-solving, logical thinking, thinking like a computer, mathematics, using ICT or computer, coding or programming, and algorithm. CT was regarded as problem solving and mathematics which is also consistent with the finding of Rich, Yadav and Schwarz's (2019) study. The preservice teachers were capable to determine the types of thinking connected with CT, such as analytical thinking, mathematical thinking, logical thinking, and structured thinking, which is compatible with the study of Bower and Falkner (2015). By referring to Table 1, some of the preservice teachers were able to identify the concepts and elements that related to CT, for example, algorithmic thinking, iterations, function, using models, sequencing or sequential thinking, and thinking procedurally. However, there were some responses in Table 1 that did not relate to CT or had no clear meaning, such as JavaScript, configurations, memory work, solutions, and graph theory.

Preservice teachers, regardless of STEM and non-STEM, ought to have similar thoughts about CT. However, in this study, it was found that the STEM preservice teachers had different views of CT compared to non-STEM preservice teachers. Unlike the non-STEM preservice teachers, the STEM preservice teachers were more likely to perceive CT as logical thinking or reasoning, coding or programming, systematic or systematic thinking, thinking or thinking process, computation or calculation, analytical or analytical thinking, steps or step by step, thinking like a computer, methodical thinking, and using software. On the other hand, the STEM preservice teachers were less likely to regard CT as using ICT or computer, algorithm, analysis, computing skills or principles, and sequencing or sequential thinking. More non-STEM preservice teachers did not have an idea or understanding concerning CT. This is most likely because STEM preservice teachers may have more exposure to Computing courses in their tertiary education before joining the preservice teaching course. Both STEM and non-STEM preservice teachers had the same response for CT as problem-solving. Two remarkable differences of view of CT between STEM and non-STEM preservice teachers were the artificial intelligence and structured or structured thinking as none of the STEM teachers gave these responses. This could attributed to non-STEM teachers perception that CT is related to the use of technology.

In some countries such as the United Kingdom, efforts have been made to integrate CT into all subjects at all levels, If teachers have pre-conceptions of CT that differ from the concepts of CT, it would be difficult to require teachers to integrate CT into the curriculum, Our findings of this study can serve as useful resources to help create teacher preparation programs, policies, and syllabus materials to help the preservice teachers to embed CT into their future classrooms. It is proposed to implement more teacher preparation programs on CT for the preservice teachers to help them to be more familiar with the CT concepts and have a better grasp on how CT can be employed in their future teaching. The teacher preparation programs play an important role in making a large-scale shift towards embedding CT into K-12 education. Hence, preservice teachers should have opportunities to experience CT during their preservice courses. During the course, tangible or practical examples of how to integrate CT into different subject areas should be provided. Future research needs to include a bigger sample of participants with diverse demographics. Besides, this pilot survey does not tell us much about the views of preservice teachers in detail. In future research, we can further investigate where the teachers are getting their ideas about CT from through in-depth interviews and elaborate on them.

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