



Patterns of Computational Thinking Skills for Elementary Prospective Teacher in Science Learning: Gender Analysis Studies

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ABSTRAK

Hasil data PISA menunjukkan kemampuan berpikir komputasional masih kurang. Kemampuan berpikir komputasional salah satunya dipengaruhi oleh gender. Penelitian ini bertujuan untuk menganalisis pola computational thinking skill calon guru SD berdasarkan pada gender di 8 Universitas Pendidikan di Indonesia. Pada penelitian ini komponen computational thinking skill yang dianalisis adalah abstraksi, berpikir algoritma, dekomposisi, dan pengenalan pola. Penelitian ini merupakan penelitian mix method dengan subyek penelitian sebanyak 234 calon guru SD pada 8 lembaga perguruan tinggi kependidikan di Indonesia. Instrumen yang digunakan adalah tes dan wawancara. Teknik analisis data yang digunakan adalah teknik analisis data kuantitatif menggunakan SEM PLS untuk analisis data kualitatif menggunakan miles dan Huberman. Hasil penelitian menunjukkan bahwa computational thinking skill pada proses pembelajaran IPA masih rendah karena pada komponen dekomposisi dan pengenalan pola masih rendah. Berdasarkan hasil uji SEM PLS menunjukkan kemampuan berpikir komputasional berhubungan dengan Gender. Secara umum computational thinking skill mahasiswa wanita sedikit lebih tinggi pada semua sub indikator dibandingkan computational thinking skill pria dan terdapat perbedaan pola computational thinking skill antara calon guru SD pria dan wanita. Kemampuan calon guru SD wanita dalam menjawab lebih detail dan lebih terstruktur, sedangkan jawaban pada calon guru pria lebih singkat dan kurang menyeluruh. Rekomendasi pengembangan kemampuan berpikir komputasional calon guru SD dengan mengembangkan pembelajaran yang berbasis masalah, berbasis proyek

kontekstual dan pembelajaran berbasis STEAM.

ABSTRACT

The PISA data results show that computational thinking abilities are still lacking. Computational thinking ability is influenced by gender. This research aims to analyze patterns of computational thinking skills of prospective elementary school teachers based on gender at 8 universities in Indonesia. In this research, the components of computational thinking skills analyzed are abstraction, algorithmic, decomposition, and pattern recognition. This research is a mix method research with research subjects as many as 234 prospective elementary school teachers at 8 higher educational institutions. The instruments used were test and interviews. The data analysis technique used is a quantitative data analysis technique using SEM PLS and for qualitative data analysis using miles and Huberman. The research results show that computational thinking skills are still low on the decomposition and pattern recognition components. Based on the SEM PLS test results, it shows that computational thinking abilities are related to gender. In general, the computational thinking ability of female students is slightly higher in all sub-indicators than men and there are differences in the pattern of computational thinking ability between male and female elementary school teacher prospective. The ability of prospective female elementary school teachers to answer in more detail and more structured, while the answers of male prospective teachers are shorter and less comprehensive. Recommendations for developing computational thinking skills by developing problem-based learning, contextual project-based learning and STEAM based learning.

1. INTRODUCTION

Education must be able to develop the skills needed to welcome the Era of Society 5.0. One skill that needs to be developed is Computational Thinking (CT). Computational thinking is one of the basic skills needed by society in the 21st century for everyone, not just computer scientists but also in various

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fields (Bilbao et al., 2021; Vourletsis & Politis, 2022; Wing, 2006). Computational thinking includes creative, algorithmic, critical and problem-solving thinking skills, establishing communication and collaboration (Lee, Tak Yeon et al., 2014; Riley, D., & Hunt, 2014; Wing, 2006). Computational thinking skills is the ability to understand and solve complex problems with firm reasoning, imaginative, open and the ability to work together to be simple to get learning solutions that are effective, efficient and optimal (Ansori, 2020; Korkmaz et al., 2017; Vourletsis & Politis, 2022). CT is defined as a thinking process that involves the ability to formulate problems and develop approaches to solving these problems by means of computer working principles. Computational thinking is a complex cognitive function for developing a solution to a complex problem by utilizing programming concepts such as abstraction, iteration and recursion (N. I. Azizah et al., 2022; Chan et al., 2021; David Lemay et al., 2021). This skill can be implemented in students' learning activities related to information processing, identifying a problem that has been presented. Computational thinking skills can influence student learning abilities and student learning outcomes (Haseski et al., 2018; Korkmaz et al., 2017; David Lemay et al., 2021).

Computational thinking skills has 4 techniques of them according to previous study, such as: (a) decomposition, which is problem solving by simplifying complex problems into small parts that are easy to understand; (b) pattern recognition, namely the stage that aims to identify similarities in the causes of problems that arise; (c) abstraction, which focuses on identifying important information in the problem and (d) algorithms, namely designing the stages in solving a problem (Wing, 2006). Computational Thinking consists of the ability to formulate problems in a way that allows using computers and other tools to organize data logically, analyze them, represent data through abstraction, automate solutions, identify, analyze. The ability to solve problems in learning is a fundamental part (N. Azizah, 2023; Budiarti et al., 2022; Kamil et al., 2021).

Computational thinking skills are very important and must be developed in science learning. However, in reality, students have not yet mastered this computational thinking ability. There are still many students who are not yet optimal in computational thinking according to the results of the Program for International Student Assessment (PISA) test in 2018 which states that Indonesian students' abilities are ranked 73rd out of 79 participating countries. The results of the survey analysis of PISA test scores in the field of science explain that 52% of Indonesian students are still in the low level competency group (Lestari & Roesdiana, 2023; Marchelin et al., 2022). Students are only able to recognize or differentiate explanations of simple scientific phenomena, differentiate simple cause and effect relationships and interpret graphic and visual data which only requires low level cognitive abilities. Students are still not able to develop their cognitive abilities at a high level (Dian et al., 2023; Yuntawati et al., 2021). The survey results are a stimulus that requires efforts to improve science learning, especially students' problem-solving abilities. Solving this problem is related to computational thinking skills.

Several studies have been conducted regarding computational thinking abilities in students in Indonesia. Furthermore, based on research results, computational thinking abilities are influenced by several factors, including competence, learning comfort, learning motivation, intrinsic motivation and attitudes towards science and mathematics (Atmatzidou & Demetriadis, 2016; Durak & Saritepeci, 2017). Computational thinking abilities have different patterns based on gender differences. Several studies state that gender plays a role in computational thinking skills (Dilla et al., 2018; Kumala et al., 2022; Sun, L., Hu & Zhou, 2022). Gender causes different ways of thinking and learning influencing a person's habits and characteristics. The selectivity model suggests that gender is a factor that influences information processing and learning. There are three differences in the cognitive abilities of men and women, namely: 1) higher verbal abilities, 2) higher spatial abilities, 3) higher arithmetic abilities. This is also related to students' computational thinking abilities based on gender.

Previous studies support the notion that women are more thorough in processing information than men. Important correlations have been found between gender, information processing, and information utilization. Men tend to excel in mathematical reasoning tests. Some studies also state that gender differences are very small (Y. Zhao et al., 2022). Women's performance in the information processing speed factor is superior (Allen & Caviola, 2022). The two groups showed small differences in cognitive patterns. Other study state men are superior in understanding mathematical concepts (Kusumaningsih et al., 2019). Women's HOTS abilities are higher than men's. Students' computational thinking abilities are closely related to teachers' computational thinking abilities. Based on this, it is very important to carry out a comprehensive survey study of computational thinking skills for teachers so that based on this data it can be used as a basis for developing computational thinking skills for students. The results of the analysis of research studies show that there has been no research that examines the computational thinking abilities of prospective elementary school teachers in Indonesia based on gender. Data on computational thinking skills based on patterns of gender differences can help policy makers and

practitioners to facilitate the needs of prospective teachers in developing computational thinking skills according to the gender characteristics of men and women.

Based on this, the aim of this research is to analyze the computational thinking abilities of prospective elementary school teachers based on gender at several universities in Indonesia. It is hoped that the research results can be used as a basis for developing and facilitating the computational thinking skills of prospective elementary school teachers in Indonesia. So it is hoped that it can be used as an alternative in developing students' computational thinking abilities, especially in elementary schools more broadly.

2. METHOD

The approach used in this study is a mix method approach, where research data is obtained from several methods. The methods used are observation and interviews to collect data qualitatively and questionnaires are used to measure computational thinking skills quantitatively (Cortini, 2014). Quantitative data analysis using SEM and qualitative data analysis using Miles and Huberman. The subjects in this study were 234 prospective elementary school teachers and 8 science teaching lecturers in elementary schools from 8 universities in Indonesia including Muhammadiyah Magelang University, PGRI Kanjuruhan Malang University, Yogyakarta PGRI University, Tribhuwana Tungga Dewi University, Trunojoyo Madura University, Sebelas Maret University, Bhinneka PGRI University, Sidoarjo Muhammadiyah University. The research instrument used a test and interviews. Further lattice Computational Thinking Skills component instruments are described in Table 1.

Table 1. Computational Thinking Skills Instrument Grid

No	Indicators	Sub-Indicators	Code
1	Decomposition	Observe important information related to the problem given.	K1
		Identify the information requested from the problem given.	K2
2	Abstraction	Focus important information and ignore less relevant information.	K3
		Describe general patterns related to differences and similarities in the problems presented.	K4
		Conclude the pattern that exists in the problem.	K5
3	Pattern recognition	Understand patterns related to similarities and differences in problem solving	K6
4	Algorithms	Describe the stages in solving a problem.	K7

The data analyzed using SPSS crosstab and SEM PLS. The data obtained from the SPSS 26 crosstab analysis results are quantitative data used to describe the characteristics of teachers prospective computational thinking, while SEM PLS 8.80 is used to measure the relationship between teachers' prospective computational thinking and gender. The criteria used to measure results are the index at the Chi-square point, $RMSEA \leq 0.08$, $CFI \geq 0.95$, $NFI \geq 0.90$, $RMR \leq 0.05$ and t value > 1.96 . Another instrument used besides the test is the interview. Interviews were conducted with lecturers and prospective elementary school teachers as research subjects at 8 TTI universities in Indonesia. The results of the interview were then subjected to qualitative analysis (Miles et al., 2014).

3. RESULT AND DISCUSSION

Result

Based on the results of research that has been carried out regarding computational thinking in general it is shown in Figure 1.

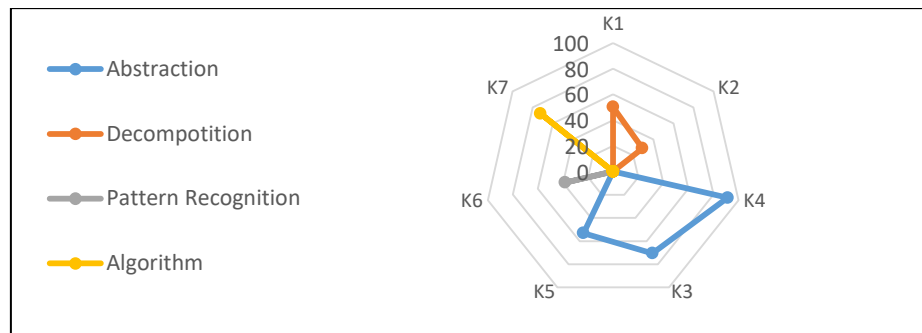


Figure 1. Computational Thinking Skills for Elementary School Teacher Prospectives

Based on Figure 1, it can be seen that the value of the ability of elementary school teachers on the decomposition indicator which consists of sub-indicators of known information identification obtained a value of 50.2% and the identification of the problems asked obtained a value of 29.7%. The abstraction indicator consists of stating the general pattern of similarities and differences in a problem at 91.4%, focusing information at 70.6%, drawing conclusions at 53.11% and the pattern recognition indicator at 38.3% and the algorithm indicator at 72.28 %. It was also concluded that the ability to think computationally was low on the problem identification sub-indicator being asked and pattern recognition ability. In this ability, elementary school teacher perspectives have difficulty in compiling a question from a problem, while in the problem pattern recognition sub-indicator, in general, elementary school teacher perspectives are less able to show patterns from alternative solutions that are developed. This happens due to a lack of learning training to develop solutions not just one step. So far, learning training still refers to learning to develop an alternative solution. This is in accordance with the results of interviews with lecturers regarding the ability to think computationally of prospective elementary school teachers. This is in accordance with the results of interviews conducted with several research subject lecturers. According to several lecturers, this ability has not been comprehensively trained in learning. A variety of learning problems have never been presented so that prospective elementary school teachers have never determined patterns, focused on problems, carried out abstractions and analyzed the possibilities of a problem. This causes the solutions developed to also not be varied because prospective elementary school teachers do not know the pattern of these problems and in general are not able to determine the characteristics of the problems they are facing.

If based on gender, the computational thinking abilities of prospective elementary school teachers are shown in Figure 2.

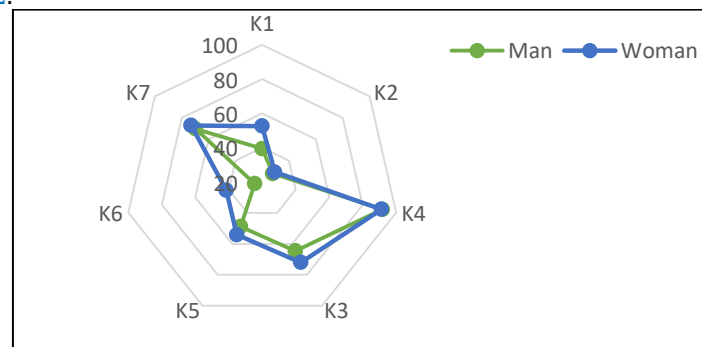


Figure 2. Data on Computational Thinking Abilities of Prospective Elementary School Teachers Based on Gender

Based on Figure 2, it can be seen there is a difference in computational thinking ability in women of 52.6% and men 39.5%. The pattern recognition indicator found an indicator difference of 41.44% for women and 24.41% for men. The third indicator, which is almost 8% adrift, is the abstraction indicator, the sub-indicator focusing on information. The same indicators and sub-indicators for male and female gender are found in the problem identification indicators asked by men, 29.34% and 27.9%. The sub-indicator abstraction indicator states that the general pattern of similarities and differences has slight differences, where for women it is 91.3% and for men it is 91.86%. Furthermore, based on calculations on the PLS SEM, it can be seen that the model is fit, judging from the SMSR value (0.119) > 0.08, VIF < 5, rms Theta (0.161) > 0.1. In brief, data on computational thinking skills based on gender is shown in Table 2.

Table 2. Computational Thinking Based on Gender

	Original Sample (O)	Sample Means (M)	Standard Deviation (STDEV)	T Statistics (O/STDEV)	P Values
CT (M) -> Male	0.601	0.670	0.092	6.524	0.000
CT (W) -> Women	0.666	0.696	0.073	9.073	0.000

Based on Table 2, it can be seen that computational ability is influenced by gender, both men and women are shown in t count > t table with a t-table value of 1.996, with a P Value <0.05. Next, to find out the pattern of computational thinking abilities based on gender for each sub-indicator, it can be observed in Table 3.

Table 3. Computational Thinking Indicator Data Based on Gender

	Original Sample (O)	Sample Means (M)	Standard Deviation (STDEV)	T Statistics (O/STDEV)	P Values
L <- Male					
LK1 <- CT (L)	0.612	0.516	0.246	2,484	0.013
LK2 <- CT (L)	0.408	0.390	0.159	2,558	0.011
LK3 <- CT (L)	0.387	0.408	0.249	1,555	0.121
LK4 <- CT (L)	0.340	0.300	0.216	1,576	0.116
LK5 <- CT (L)	0.561	0.487	0.268	2,097	0.037
LK6 <- CT (L)	0.717	0.656	0.146	4,919	0.000
LK7 <- CT (L)	0.380	0.335	0.234	1,622	0.105
P <- Female					
PK1 <- CT (P)	0.498	0.491	0.145	3,428	0.001
PK2 <- CT (P)	0.578	0.574	0.112	5,162	0.000
PK3 <- CT (P)	-0.579	-0.554	0.163	3,559	0.000
PK4 <- CT (P)	-0.183	-0.164	0.216	0.844	0.399
PK5 <- CT (P)	0.772	0.759	0.081	9,498	0.000
PK6 <- CT (P)	0.699	0.680	0.115	6,065	0.000
PK7 <- CT (P)	0.539	0.528	0.146	3,687	0.000

Based on Table 3, it can be interpreted in general that women have a greater influence on computational abilities than men. If visualized based on the path coefficient and t value, it is shown in Figure 3.

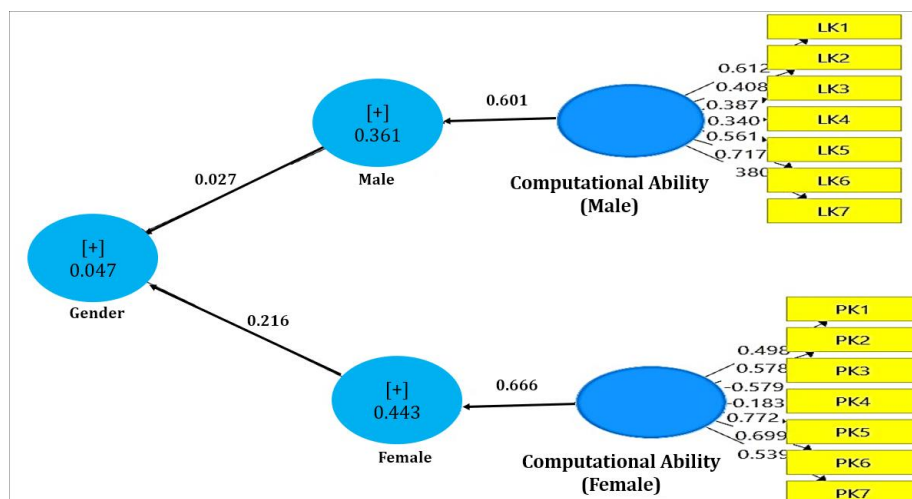


Figure 3. Path Coefficient and T-Value of the Relationship between Gender and Computational Thinking for Elementary School Teacher Prospective

If it is observed in Figure 3 it can be concluded that for men the influence of gender on scores for each sub-indicator of computational thinking ability is highest to lowest at K6-K1-K5-K2-K3-K7-K4 and for women it is at least high to lowest is K5-K6-K3-K2-K7-K1-K4. So based on the PLS SEM test it can be seen that computational thinking ability is influenced by gender. Where in this study the value of women's

computational thinking ability was slightly higher than the value of computational thinking ability in men. The results of the analysis of the path coefficient and the comparison of the analysis data on the work of prospective elementary school teachers are shown in Table 4.

Table 4. Patterns of Computational Thinking Ability of Elementary Teacher Prospectives

Code	Indicator	Sub-Indicators	Patterns of Computational Thinking Abilities of Prospective Elementary School Teachers
K1	Decomposition	Identify known information	The K1 indicator for men is considered to be moderately influenced by gender and for women it is not sufficiently influenced by gender. The percentage of male and female K1 is almost 13% different. Based on the answers from the prospective elementary school teachers, the results were quite varied. For the answers, the female elementary school teacher candidates could identify more fully and provide more diverse information, while the male elementary teacher candidates tended to be shorter and the information provided was more limited to one answer.
K2	Decomposition	Identify the problem being asked	In this sub-indicator, male and female gender have the same position in influencing this indicator. The values shown are also almost the same between male and female genders, only 2% apart. However, the abilities shown by both genders are quite low. If observed based on the results of the work of male and female elementary school teacher candidates, it shows that prospective elementary school teachers are still lacking in terms of analyzing the questions from the problems that have been presented. In general, the questions developed by men and women are almost the same, with 1-2 questions. Only a few prospective female elementary school teachers were able to ask detailed questions.
K3	Abstraction	Mention general patterns of similarities/differences in the problems presented	Based on the results of the PLS SEM on gender, this sub-indicator has quite a lot of influence. If we look at the percentage scores of male and female elementary school teacher candidates, there is not much difference, only 0.5%. This can also be seen from the results of assignments by men and women which are almost the same and show quite high scores. Prospective male and female elementary school teachers are able to show the differences and similarities of the problems that have been presented.
K4	Abstraction	Focus important information	Based on the path coefficients for men and women, this sub-indicator is the least influenced by gender. This data is in accordance with the data on the percentage of computational thinking ability which shows a slight difference in computational thinking ability between men and women. This is in accordance with the answers given by female and male elementary school teacher candidates where on average elementary school teacher candidates are able to focus on around 3-5 pieces of information. The pattern of answers for elementary school teacher candidates was almost the same, the answers were not so detailed between men and women. Based on this, it can be analyzed that the answers of female and male elementary school teacher candidates are almost the same so that this sub-indicator is not influenced by gender.
K5	Abstraction	Able to draw conclusions from patterns found in the given problem.	This indicator for women is very influenced by gender, while for men it also has quite an influence. If identified based on the percentage of male and female elementary school teacher candidates, the difference is almost 6%.

Code	Indicator	Sub-Indicators	Patterns of Computational Thinking Abilities of Prospective Elementary School Teachers
K6	Pattern recognition	Pattern recognition	<p>This means that the differences shown are not far enough. As shown by the results of the work of elementary school teacher candidates, male elementary school teacher candidates showed quite a variety of answers. Male elementary school teacher candidates were quite able to show 2-3 conclusions, but quite a lot showed that their conclusions lacked detail. For prospective female elementary school teachers, there is also quite a variety, some are able to provide 3-4 conclusions in detail, but there are also those who only show one conclusion or the answer is not appropriate. In general, female elementary school teacher candidates are more detailed in preparing answer conclusions.</p> <p>The sub-indicator that is most influenced by male gender is this indicator. In this indicator, female gender also has quite an influence on the second position. The percentage difference in scores on this indicator between men and women is around 17%. In this indicator of pattern recognition, male elementary school teacher candidates are not quite able to determine the problem patterns that have been presented, some male elementary school teacher candidates' answers show only one or two answer patterns, for example the pattern shown is a pattern of learning problems related to the use of media and learning models. The answers from prospective female elementary school teachers that emerged were quite diverse and were able to show problem patterns in several aspects of learning in terms of media use, IT use, learning models, learning environment, student motivation and students' ability to learn.</p>
K7	Algorithm	The ability to formulate steps to solve problems	<p>This indicator shows that the values for male and female gender get almost the same score when viewed from the percentage, only 3% difference. This indicator shows that prospective elementary school teachers have been able to develop alternative solutions to problems by compiling 2-3 alternative solutions to the learning problems presented. However, there are obstacles in the selection of alternative solutions to the problem. The alternative chosen is still not effective enough because prospective elementary school teachers are generally only able to provide one solution, both male and female gender.</p>

Based on [Table 4](#), it can be concluded that the fourth, third and seventh sub-indicators have almost the same pattern because based on SEM PLS calculations these sub-indicators show that they are not influenced by gender. For the sixth and fifth sub indicators are influenced by gender. This is also in accordance with the results of the thinking abilities of prospective elementary teachers which are quite different on these indicators and the patterns of answers of prospective elementary teachers are different.

Discussion

Based on the research results, it can be seen that students' abilities are in determining patterns, focusing on problems, abstracting and analyzing the possibilities of a problem. This causes the solutions developed to not vary because prospective elementary school teachers do not know the pattern of the problem and are generally unable to determine the characteristics of the problems they face. These problem solving skills are not trained enough by students in the learning process. So far, problems only refer to how to overcome the solution to a problem, not yet focused on analyzing problem patterns. Analysis of problem patterns and their solutions will be able to determine the root of the problem and select the most appropriate solution so that problems with the same pattern do not occur.

Computational thinking skills and problem solving training are important and interrelated. Computational Thinking relates to a person's skills in solving problems, compiling abstractions, algorithmic thinking, logical thinking, analytical thinking, creative thinking, and using basic concepts in processing data or information (Konstantinidou & Scherer, 2022; Lee, Tak Yeon et al., 2014). Computational Thinking Skills and problem solving skills, learning outcomes and the depth of one's thinking can be improved (Ansori, 2020; L. Zhao et al., 2022). Computational thinking skills can be easily and permanently improved through activities related to problem solving. The ability to solve problems in learning includes the ability to find important information, know the amount of information needed, create mathematical forms, create solution procedures, and explain and show that the resulting solution is correct (Rijke et al., 2018; Yunus & Mitrohardjono, 2020). The four steps to problem solving consist of recognizing the problem, making a plan to fix the problem, carrying out the plan to fix the problem, and reviewing.

The ability to solve problems and develop various alternative solutions is very much needed, so that prospective elementary school teachers are able to solve problems easily in various contexts. So that prospective teachers can be more adaptive in developing teacher professionalism and abilities in dealing with daily problems. This ability is also closely related to HOTS thinking abilities (Darmayanti et al., 2022; Fanny, 2019). The role of computational thinking skills in learning is: 1) provide direct experience. 2) can be used in species classification with explicit "If-Then" logic. 3) improve computational thinking skill models through existing problems. 4) create (program) computational models, practice learning directly.

Computational thinking skills can be improved by using the STEAM model (Çiftçi & Topçu, 2023), problem solving-based learning (Latifah et al., 2022), game-based learning (Cheng et al., 2023), Generative AI (Yilmaz et al., 2023) and curriculum policy (D. Lemay et al., 2021). The development of computational thinking can be carried out through several scenarios which consist of concept illustrations, integration of computational thinking skills in all scientific disciplines, application of learning in the classroom and other environments. Familiarization with computational thinking skills can train students naturally to always apply computational thinking skills. In developing computational thinking, it is very important to consider the psychology and behavioral characteristics of students (Konstantinidou & Scherer, 2022; Qian & Choi, 2022). Data on computational thinking abilities based on patterns of gender differences can help policy makers and practitioners to facilitate needs according to the gender characteristics of men and women.

In the pattern aspect of students' computational thinking abilities is according to gender. This is also in accordance with the results of the thinking abilities of prospective elementary school teachers which are quite different on these indicators and the answer patterns of prospective elementary school teachers are different. Where the answer patterns of male elementary school teacher candidates are shorter and more concise, in contrast to female elementary school teacher candidates who show more detailed answer patterns in explaining things that are considered important so that the explanation of the answers is clearer. This is because women's verbal abilities are better than men. Women were found to score higher than men in terms of mathematical sentences and mathematical reasoning. This advantage is associated with the verbal superiority that women have compared to men. men perform better in geometry, probability, and statistics, this is related to men's advantage in visual-spatial strategies (Aristawati et al., 2018; Pewkam & Chamrat, 2022). Women are able to explain in detail, while men are briefer and clearer.

The implications of the research results can be the basis for developing a prospective teacher education curriculum at the elementary level. Curricula that integrate computational thinking skills can improve preservice teachers' readiness to teach science. Aspiring teachers need to be given appropriate training to develop their computational thinking skills, and research results can help design appropriate training programs. This research may be limited to certain populations and contexts, so the results may not be directly applicable to different situations. Factors outside the control of the study, such as the educational environment and support from schools or universities, may have an impact on the results of the study.

4. CONCLUSION

The ability of prospective elementary school teachers in computational thinking skills on decomposition and pattern recognition indicators is still low, while on abstraction and algorithmic thinking indicators is quite good. In general, if we look at gender, female students' computational thinking abilities are slightly higher than male students. The difference in the pattern of computational thinking abilities between male and female prospective teachers lies more in the delivery of explanations which causes the explanations and answers to be less detailed in revealing the computational thinking abilities of prospective elementary school teachers. Female teacher candidates' explanation abilities are more

detailed and structured, while male teacher candidates' answers shorter and less comprehensive. So the analytical skills of male teacher candidates are less detailed and tend to be shorter than female teacher candidates. Analytical skills are the basis for computational thinking skills. Developing computational thinking skills can be trained through the development of problem-based learning and project-based learning for prospective elementary school teachers.

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