

Ability to Solve Complex Social Problems of Prospective Teachers according to Gender and Computational Thinking

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Abstract

In the 21st century, computational thinking has become an essential skill all students must have. This research aims to determine the influence of gender on learning outcomes to solve social problems, the relationship between gender and the level of Computational Thinking, and the influence of the level of Computational Thinking on learning outcomes to solve social issues. This research uses mixed methods. This study employs descriptive verification methods, quantitative analysis, case study methodologies, and in-depth interview approaches. The use of in-depth interviews was employed to gather additional data from specific informants to enhance the analytical rigor of the research beyond the scope of quantitative analysis. The research subjects were 256 Faculty of Teacher Training and Education, Sebelas Maret University students. The quantitative data analysis is based on the results of computational thinking ability tests using the Wilcoxon Test. The results of this research show that there is an influence of gender on social problem-solving learning outcomes, there is no significant relationship between students' computational thinking level and gender, and there is a substantial influence of students' computational thinking level on learning outcomes for solving social problems. This research shows that the two factors above play a significant role in influencing student learning outcomes. These capabilities work in synergy with the computational level of thinking. With the right efforts, developing computational thinking skills can improve students' abilities to solve various learning problems. A more in-depth analysis was carried out using K-Mean clustering analysis, and new questions were found that there were other things that influenced learning outcomes. Through in-depth interviews, another factor influencing learning outcomes was literacy skills, especially writing and digital literacy.

Keywords:

Computational Thinking, Gender, Social problem, Problem Solving Ability

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INTRODUCTION

Computational thinking is a thinking skill that enables students to make decisions in solving their problems (Harangus & Kátai, 2020). Computational thinking skills include Critical Thinking, Algorithmic Thinking, Problem Solving, Cooperativity, and Creativity (Varela et al., 2019). Students need computational thinking to learn not only related to mathematical problems but also social problems (de Paula et al., 2018) (Akbar, 2021)(John Lemay et al., 2021). Learning various strategies in the digital era will become more meaningful with the computational thinking skills that students have. Computational thinking in the context of this research is not the result of thinking but rather a thinking process (Tsai et al., 2021).



Students have a variety of unique learning styles (Alfonseca et al., 2006); (Gu, 2012);(Hamilton-Ekeke, 2015). Learning complexity is an internal process that involves prior knowledge, motivation, cognitive aspects, and the environment, which influence each other (Mohd et al., 2019)—created a new definition of the cognitive domain as the meeting point between cognitive process dimensions and knowledge dimensions (Heer, 2012). Cognitive processes are explained in various concepts according to various theories, including behaviorist, connectivist, and humanist theories (Behlol & Dad, 2010); (Carro & Sanchez-Horreo, 2017). However, everyone agrees that learning at school does not happen by chance, even though students will also learn many unplanned things both in and outside the classroom (Pritchard, 2009).

Problem decomposition thinking skills in dealing with problems are cognitive abilities that can be optimized to provide a better learning experience (Selby & Woollard, 2016). This can be done through thought-provoking learning activities (Santosa et al., 2020), by art (Chacón-López & Maeso-Broncano, 2023), collaboration (Laal & Ghodsi, 2012), as well as healthy student social life (Zimmerman, 1989). Computational thinking is an essential skill that students must have in the current digital era. The importance of this ability in education was first investigated by Seymour Papert and popularized by Jeannette M. Wing in 2006 (Lodi & Martini, 2021). According to (Korkmaz & Bai, 2019), computational thinking is the ability to think innovatively in identifying phenomena and providing various solutions to the problems faced. So, computational thinking is a problem-solving skill that is expected to be possessed by the young generation who are critical and innovative (Shanmugam & Nadesan, 2019). Computational thinking is also a skill developed to improve children's abilities from an early age in terms of solving problems, designing systems, and understanding human behavior when using basic computing concepts (Espino & González, 2016).

An efficient learning strategy to make students acquire computational thinking skills is incorporating problem-solving steps into learning with relevant strategies (Avcı & Deniz, 2022). Collaborative problem-based learning is one learning strategy that can potentially improve systematic thinking skills as an essential element of computational thinking (Jones et al., 2013) (Santosa et al., 2020). Apart from that, other strategies improve algorithmic thinking and problem decomposition skills, such as project-based learning (Bell, 2010), collaborative problem-solving (Ghosh et al., 2012); (Santosa et al., 2020), and so on. With exemplary efforts, the growth of computational thinking skills can increase students' abilities to solve various learning problems (Rosali & Suryadi, 2021).

Research (Espino & González, 2016) concludes that gender influences the level of computational thinking. (Tsai et al., 2021) concluded that boys have more computational thinking skills than female students, especially in decomposition thinking when dealing with problems. Research (Angeli & Georgiou, 2023) confirms the research above that gender influences the level of computational thinking. A study (Hsu et al., 2017) in group model learning found differences in performance when men were grouped separately and women separately. Variations However, the above conclusions need to be challenged in other research.

This research highlights the gender factor, one of the essential factors influencing computational thinking skills, and its influence on learning outcomes.

(Chongo et al., 2020) The relationship between computational thinking skills and learning achievement was significant, while gender differences were insignificant. However, (Jiang & Wong, 2022) found that, on the contrary, gender differences did not have a significant effect on students' computational thinking levels. Still, at the students' age level, it was more effective. The differences in the findings above need further clarification and testing.

Initial research was conducted on the class through observation and assessment of student activity in discussion sessions on factual social cases. In direct discussion sessions, male students tended to be more active in expressing their opinions on various problem-solving questions than female students. However, in the formative evaluation session, it was found that the problem-solving learning outcomes of female students were, on average, higher than those of male students. Therefore, based on the description above, this research aims to determine the influence of gender differences on social problem-solving learning outcomes, the differences in students' computational thinking levels based on gender, and the impact of students' computational thinking levels on social problem-solving learning outcomes. It is also necessary to deepen the relationship between each group of students' computational thinking levels and gender on learning outcomes to solve social problems. The questions above will be answered in this research.

METHODS

This research uses mixed methods. This research combines descriptive verification, quantitative analysis, case study methods, and in-depth interview techniques. In-depth interviews were used to obtain more data from certain informants to sharpen research analysis that quantitative analysis could not answer.

In the descriptive verification method, the variables used are adjusted to primary data, namely gender and students' level of computational thinking—meanwhile, the affected variable results from learning to solve social problems. The course for social problem-solving material is Pancasila Education. The number of respondents to this research was 256 students from the Faculty of Teacher Training and Education, Universitas Sebelas Maret.

The instrument used to measure students' level of computational thinking in this research is a modification of the tool developed by (Korkmaz et al., 2017). The questionnaire consists of 19 statements translated from the original language, namely English, into Indonesian. After carrying out a validity test, it was found that r calculated $\geq r$ table, which means that the instrument was declared valid.

Quantitative analysis based on computational thinking ability test results. Data analysis used the Wilcoxon test because the data was not normally distributed. Further analysis was carried out using Orange software, which has the K-Means clustering method. The reason for using this software is that it is open-source software. Further analysis of this research uses K-Means for clustering. Meanwhile, Spearman's rho was used to analyze the relationship between variables because the data was not normally distributed.

Data was collected by sending a Google form link to the WhatsApp group of students taking the Pancasila Education course. The data was collected from May

20, 2023, to June 20, 2023. The sampling technique used was a nonprobability incidental technique.

In the case study method with in-depth interview techniques, informants are male and female students with high computational thinking and learning outcomes. In-depth interviews were conducted with two respondents from each gender group. This in-depth interview aims to gather complete information regarding the respondents' attitudes, knowledge, and views regarding various social problem-solving questions. The in-depth interview was conducted on June 19, 2023. The key questions asked were "How do you answer the complex social case posed?" and "Why did you answer that?". These two fundamental questions will evolve as needed.

RESULTS & DISCUSSION

The results of data analysis to answer the question of the influence of gender on learning outcomes to solve problems are as follows:

Table 1. Wilcoxon Gender Test Results and Learning Outcomes

Test Statistics ^a	
	Hasil Belajar
Mann-Whitney U	6609.500
Wilcoxon W	12387.500
Z	-2.292
Asymp. Sig. (2-tailed)	.022

a. Grouping Variable: Jenis Kelamin

Learning Outcomes	
Mann-Whitney U	6609.500
Wilcoxon W	12387.500
Z	-2.292
Asymp. Sig. (2-tailed)	.022

a. Grouping Variable: Gender

Table 1 above shows the U value of 6609.5 and the W value of 12387.5. When converted to a Z value, the value is -2.292. The Sig value or P value is $0.022 < 0.05$. If the p-value is $<$ the critical limit of 0.05, then there is a significant difference between the two groups, which means H1 is accepted. This shows that the learning outcomes of male and female students have substantial differences. Furthermore, it can be seen that the average learning outcomes of female students are higher than male students.

The results of data analysis to examine the relationship between the level of computational thinking and gender can be seen in Table 2 below:

Table 2. Wilcoxon Test Results for Computational Thinking Level and Gender

Learning Outcomes	
Mann-Whitney U	7679.500
Wilcoxon W	18705.500
Z	-411
Asymp. Sig. (2-tailed)	.681

The table above shows the U value of 7679.5 and the W value of 18705.5. When converted to a Z value, the value is -0.411. The Sig value or P value is 0.681 > 0.05. If the p-value is > the critical limit of 0.05, then there is no significant difference between the two groups, which means H1 is rejected. This shows no significant difference in the computational thinking of men and women.

The results of data analysis measuring the correlation between computational thinking and learning outcomes can be seen in Table 3 below:

Table 3. Spearman's Rho Test Results for CT Levels and Learning Outcomes

			Computational Thinking	Hasil Belajar
Spearman's rho	Computational Thinking	Correlation Coefficient	1.000	.862**
		Sig. (2-tailed)	.	.000
		N	255	255
	Hasil Belajar	Correlation Coefficient	.862**	1.000
		Sig. (2-tailed)	.000	.
		N	255	255

**Correlation is significant at the 0.01 level (2-tailed).

		Computational Thinking	Learning Outcomes
Spearman's rho	Computational Thinking	Correlation Coefficient	1.000
		Sig. (2-tailed)	.000
		N	255
	Learning Outcomes	Correlation Coefficient	.862**
		Sig. (2-tailed)	.000
		N	255

**Correlation is significant at the 0.01 level (2-tailed)

Based on the correlation calculation between computational thinking variables and learning outcomes, a correlation coefficient value of 0.862 was obtained with a significance of 0.000. From these results, a significance value of 0.000 < 0.05 (smaller) was obtained, so the researcher's hypothesis was rejected. Then, it can be concluded that there is a significant relationship between the computational thinking variable and learning outcomes. A positive coefficient number indicates a positive relationship; if computational thinking increases, then learning outcomes will improve. On the other hand, if computational thinking goes down, then Learning Outcomes will go down too.

Further analysis will use k-means clustering analysis to see groups in the data. The analysis steps can be seen in the following picture:

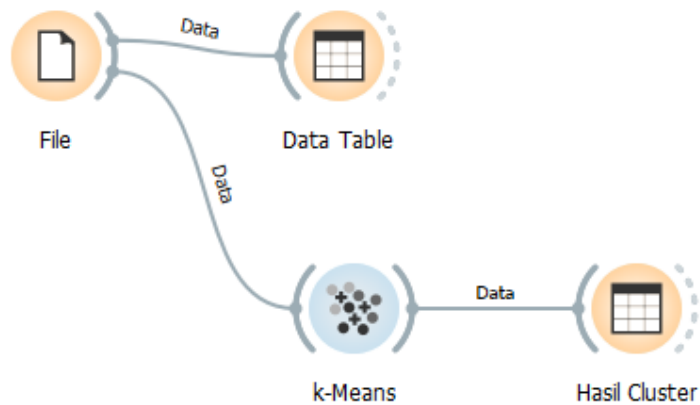


Figure 1. K-Means Clustering Analysis Steps

The results of further analysis using k-means for gender groups, computational thinking level, and learning outcomes can be seen in Figure 2 below:

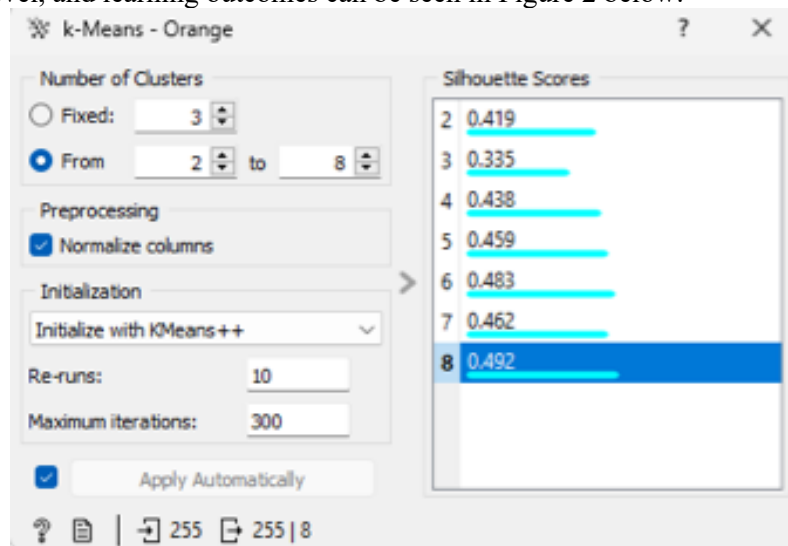


Figure 2. K-Means Clustering Test Results

From the Silhouette Score, it is recommended that there are eight clusters. Each cluster has different characteristics. Cluster 1 is a group of female students with a medium level of computational thinking and medium learning outcomes. Meanwhile, Cluster 2 is a group of male students with a high level of computational thinking and high learning outcomes. Next, Cluster 3 is a group of female students with a medium level of computational thinking and high learning outcomes. Next, Cluster 4 is a group of male students with a medium level of computational thinking and medium learning outcomes. Cluster 5 is a group of female students with low levels of computational thinking and low learning outcomes. Cluster 6 is a group of male students with a high level of computational thinking and high learning outcomes. Cluster 7 is a group of female students with a high level of computational thinking and increased learning outcomes. The last cluster is cluster 8, a group of male students with low levels of computational thinking and expected learning outcomes.

Based on the clustering results above, two students were selected from Cluster 6, a group of male students with high levels of computational thinking and high learning outcomes. Furthermore, Cluster 7, a group of female students with a high level of

computational thinking and increased learning outcomes was also selected by two students. Each of them then became informant 1 (one) and informant 2 (two) for the male students with high levels of computational thinking and increased learning outcomes. Informant 3 (three) and Informant 4 (four) are female students with high levels of computational thinking and high learning outcomes. Each informant was then subjected to an in-depth interview. Interviews to obtain in-depth information on how informants answer questions asked about complex social problems and why they answer that way. The results of the in-depth interview analysis can be seen in the following table 4:

Table 4. Interview analysis results

INFORMANT	HOW?	WHY?	ANALYSIS
Informant 1	Answers are more complete and precise than answers in written exams	He is less able to convey his thoughts in writing	Low writing literacy
Informant 2	Answer clearly and structured the same as written exam answers	Able to share his thoughts in writing	High writing literacy
Informant 3	Answers are the same as written exam answers. Search for answers from search engines (Google)	He can convey his thoughts in writing and is skilled at searching for various digital sources	High writing literacy and digital literacy
Informant 4	Answers are the same as written exam answers. Search for answers from Artificial Intelligence (ChatGPT) chatbots	He can convey his thoughts in writing and is skilled at searching for various digital sources	High writing literacy and digital literacy

Computational thinking is a student's cognitive, affective, and conative process in applying systematic concepts and methodologies to create solutions to existing problems (Sovey et al., 2022). Many studies link the level of computational thinking with learning outcomes (Shanmugam & Nadesan, 2019); (Chongo et al., 2020) (Angeli & Georgiou, 2023). Apart from that, computational thinking is also widely seen from a gender perspective (Espino & González, 2016). The research has tested the relationship between the level of Computational thinking, gender, and learning outcomes to solve social problems.

According to research (Sovey et al., 2022) shows that gender and computational thinking factors influence the ability to provide solutions to problems. It was confirmed in this research that there is a correlation between learning outcomes and gender. It was found that female students had better learning outcomes in solving social problems than male students. This shows that women can use a systematic and logical methodology to solve social issues they face. This ability develops with increasing age and maturity of thinking (Jiang & Wong, 2022).

This research also found no significant difference in the level of Computational thinking between male and female students. This means that the potential of each student to solve problems based on Computational thinking is relatively equal. Each gender group has a high, medium, or low level of Computational thinking. The Computational thinking

of each group of students is not determined by gender or age factors but rather by the level of maturity of each individual's scientific thought (Angeli & Valanides, 2020); (Espino & González, 2016); (Jiang & Wong, 2022). However, the findings of this study differ from the opinion (Angeli & Georgiou, 2023), which states that the level of computational thinking between men and women is significantly different. The story of men's computational thinking is higher in various ways than women's; this may have happened because the research was conducted on children aged between 5 and 6 years, so intervention factors before learning were more dominant (Sovey et al., 2022). Meanwhile, this research was conducted on students between 19 and 21 pursuing higher education.

The research results show that computational thinking and learning outcomes are significantly correlated. This means that the level of computational thinking determines the learning outcomes of social problem-solving. These findings confirm the research findings of previous researchers, which linked computational thinking with algorithmic thinking abilities and problem decomposition (Yadav et al., 2017); (J. Moon et al., 2020); (Rosali & Suryadi, 2021).

However, this research found from the clustering analysis results that the female gender group with moderate computational thinking had high learning outcomes in solving social problems. This is different from cluster 4 from the male gender group, where the results of computational thinking are moderate, and the learning outcomes are also reasonable. So, it was found that at the level of computational thinking, the learning outcomes of men and women differed. Based on these results, it is suspected that other factors support learning outcomes besides the level of computational thinking of students in the female gender group. Other factors that may influence are the level of self-regulated learning (Santosa et al., 2020), learning style (Yuzela et al., 2023), level of critical thinking (Sola et al., 2017), level of internet self-affiliation (Santosa & Sarwanta, 2021), or other related internal and external factors. It is necessary to conduct more in-depth research on other factors determining the level of learning outcomes in solving social problems.

Based on qualitative analysis from in-depth interviews, it was found that other factors besides students' level of computational thinking influence learning outcomes in solving complex social problems, namely literacy skills. Literacy abilities consist of reading and writing skills (B. Moon, 2014). This research shows that the two factors above play a significant role in influencing student learning outcomes. This ability works in synergy with the computational level of thinking (Tsai et al., 2021) (Zapletal et al., 2023).

The findings of this research show that students' writing and digital literacy skills play a role in improving learning outcomes. Previous researchers also found that digital literacy skills can increase motivation and learning outcomes (Lilian, 2022). This ability enables students to get useful information to solve various problems (Purnama et al., 2022). Meanwhile, this study's results show no significant difference in the level of Computational thinking between male and female students. This research also found that computational thinking and learning outcomes were significantly correlated. Based on these two premises, other factors influence learning outcomes. This factor is literacy skills, especially writing literacy and digital literacy.

CONCLUSION

The conclusions of this study answer the research questions that have been asked. The research results show that there is an influence of gender on learning outcomes to solve social problems. In this study, it was found that female students had higher learning outcomes than male students.

The second conclusion is that there is no significant relationship between students'

level of computational thinking and gender. This means that there is no significant difference in the level of computational thinking of male and female students. In other words, gender does not conclusively influence levels of computational thinking.

The third conclusion is that there is a significant influence on students' level of computational thinking on social problem-solving learning outcomes.

More in-depth analysis was carried out using K-Mean clustering analysis. The results of the K-Mean clustering analysis in this study found 8 clusters. A unique thing was found in cluster 3: the group of female students with moderate computational thinking skills had high learning outcomes. Meanwhile, cluster 4, namely the group of male students who have moderate computational thinking abilities, only has moderate learning outcomes. This raises the question of whether there are other factors that cause female students to have a moderate level of computational thinking. Therefore, they obtain high results in learning to solve problems. After conducting in-depth interviews with four students, it was found that another factor that influences learning outcomes is literacy skills, especially writing and digital literacy.

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