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Analysis of Gender Differences for Enhancing Learners' Computational Thinking Ability– From the Personal Characteristics and Coding Preference Point of View

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Abstract

Even though the effort to reduce the gaps between genders, gender differences still exists in many fields. Computer programming area is not an exception. In order to enhance students' computational thinking ability, this paper analyzes the gender differences in personal characteristics such as abstract thinking ability. Also, it analyzes computer programming factors how they differently affect the students' program understanding ability from the gender point of view. By analyzing students' attitudes toward programming, we can help educators to increase their students' computational thinking ability.

Keywords: *Gender difference, Computational thinking, Abstract thinking, Programming factors, Coding preference*

1. Introduction

Recently, computational thinking ability has been regarded as an essential ability that is needed in 21st Century. Various studies have been conducted so far, and many researchers mentioned that automation and abstraction are treated as the key components in computational thinking ability [1][2][3][4]. Also, a lot of researchers have developed the meaningful results about what to teach their students with new pedagogical approaches and technologies. However, there still exist many considering aspects in how to teach even though many methods have already been published. In this paper, we focus on the analysis of gender differences in order to develop instructional method more accurately [5][6].

On the other hand, from the previous our research [7][8], we found that there existed a statistically significant difference in abstract thinking ability that is represented in terms of the Behavior Identification Form Index, shortly BIF [9][10], between male and female high school students. According to the previous works [7][8], the mean value of the male students' abstract thinking ability was higher than that of the female students.

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The existing research usually insisted that higher abstract thinking ability is helpful to solve problems. However, this may not always be true.

In this paper, we analyze personal characteristics and figure out if there exists any gender difference in them in order to develop a better educational way to enhance students' computational thinking ability. In order to achieve our research objectives, we surveyed 286 high school students who learned the Python programming language with the RUR-PLE from the same teacher. We gave 5 programs and requested them to draw the result of each program.

The rest of our paper is organized as follows. In section 2, we describe the Behavioral Identification Form and the computer programming problems that were used in the paper. In section 3, we present the research results related to the gender difference in abstract thinking and difficulty levels of programming components while coding. Also, we describe the experimental results how students' coding preference affects their programming understanding ability. Finally, we conclude our paper in section 4.

2. Backgrounds

The action identification theory [9] is the theory that people's actions can be figured out by their thinking styles. According to the theory, there are two styles in people's thinking; one is abstract (global) thinking style and the other is concrete (local) thinking style [9]. The thinking styles can affect teenagers' academic achievement differently. Many research works have been done to measure people's thinking levels [9][10][11].

One of them is the Behavioral Identification Form, namely BIF [9][10]. The BIF was developed by Vallacher and Wegner, and it consists of 25 items to measure a person's action identification level. Each question has two alternatives; one is abstract and the other is concrete [10]. We can calculate a person's abstract thinking value by giving 0 point for the concrete alternative and giving 1 point for the abstract alternative. We can get the abstract thinking level with the sum of the scores of the items.

For this research, we developed 5 RUR-PLE programs. We defined the programs in terms of the lines of codes, the number of selection commands, and the number of iteration commands shown in [Table 1]. The scores on which students have solved the 5 problems became dependent variables in our experiment.

Table 1. The 5 RUR-PLE programs

Factors	Program1	Program2	Program3	Program4	Program5
The lines of codes	11	15	22	14	17
The number of iterations	0	1	2	6	10
The number of selections	0	0	4	0	3

3. Experimental results

In this section, we describe the experiment results that contain the gender differences in the degree of difficulty while using commands of the RUR-PLE and contain how different abstract thinking levels of genders affected the program understanding ability. Also, we examined how learners' coding preferences affect their program understanding ability.

First of all, we examined if there was any gender difference in the degree of difficulty when the students use the RUR-PLE commands. As shown in [Table 2], for the 3 command groups, the female students felt more difficulty than the male students when they used commands. The basic command group was the exception. However, there was no difference in the students' total scores statistically. From this result, educators have to encourage female students more to have self-esteem when they use their computer programming language for enhance their automation skills.

Table 2. The gender difference in the degree of difficulty about the command groups

Command Groups	Gender	Mean	SD	*t*-test for Equality of Means				
				t	df	Sig. (2-tailed)	Mean Difference	SD
Condition	Male	1.65	.85	-3.71	266	<.001	-.41	.11
	Female	2.06	.95					
Selection	Male	2.63	1.16	-5.60	283	<.001	-.74	.13
	Female	3.36	1.07					
Iteration	Male	2.67	.95	-3.29	245	.001	-.37	.11
	Female	3.04	.82					

Next, we examined if there was any difference in the abstract thinking level and program understanding ability between two genders. As shown in Table 3, there was a gender difference in the abstract thinking level. The mean difference between gender was 2.36, the $t = 4.15$. The male students had the higher level of abstract thinking than the female students. On the contrary, the female students thought more concretely than the male students did.

Table 3. The gender differences in the abstract thinking value and the program understanding ability

Problem	Gender	Mean	SD	*t*-test for Equality of Means				
				t	df	Sig. (2-tailed)	Mean Difference	SD
Problem 1	Male	1.94	.26	2.17	233.91	.031	.10	.05
	Female	1.84	.49					
Problem 2	Male	1.85	.52	1.25	284.82	.211	.08	.07
	Female	1.76	.60					
Problem 3	Male	.92	.99	-2.22	286	.027	-.26	.11
	Female	1.18	.96					
Problem 4	Male	1.53	.79	-.45	286	.654	-.04	.09
	Female	1.57	.72					
Problem 5	Male	.88	.78	.30	286	.764	.03	.09
	Female	.85	.82					

This difference can affect the interpretation of programs. In fact, the male students solved the Problem 1 better, which contained simple sentences, whereas the female students solved the Program 3 better, which contains if-elif statements and is more complex. From this result, we figured out that when the students read programs, concrete thinking is helpful to understand the program's result.

Also, we examined if there was any difference in program understanding ability between the students who had the lower abstract thinking ability and the students who had the higher level abstract thinking ability. The mean value of the abstract thinking

for all the students was between 13 and 14. Thus, we divided the students into the group with abstract thinking value of 13 points or less and the other group with abstract thinking value of 14 points or more. There was no difference in the abstract thinking level as shown in [Table 4]. It seemed that abstract thinking level did not affect the students' program understanding ability. However, in order to make our analyses more accurate, we divided the data with gender and then examined again if there was any difference between two abstract thinking level.

Table 4. The differences in the program understanding ability between two abstract thinking levels

Problem Type	Abstract Thinking Level (ATL)	Mean	SD
Problem 1	Lower	1.89	.42
	Higher	1.89	.37
Problem 2	Lower	1.79	.59
	Higher	1.82	.54
Problem 3	Lower	1.02	.98
	Higher	1.10	.98
Problem 4	Lower	1.55	.74
	Higher	1.55	.80
Problem 5	Lower	.85	.80
	Higher	.90	.80

As a result, we found that in the Problem 5, the male students had a partial difference in program understanding ability between two abstract thinking level (See also Table 5). Besides, for the Problem 2, the Problem 3, and the Problem 4, the students who had the higher abstract thinking level solved the problems better than those who had the lower abstract thinking level.

Table 5. The differences in the program understanding ability between two abstract thinking levels with two data sets divided by gender

Problem Type		*t*-test for Equality of Means				
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Problem 5	Male	-1.78	134	.078	-.23	.13
	Female	.95	148	.343	.13	.14

Finally, we examined if there existed any interaction effect between the students' coding preference level and gender. We asked students to rank whether they like to write code, namely coding preference, or to read code. If a student preferred to write code, then the student's coding preference level was set to high. Otherwise, the student's coding preference level was set to low. For other problems except the Problem 1, the students who had the high coding preference level also understood the programs better (significantly different). However, in the Program 3, the effect size of gender (.02) was higher than that of coding preference (.01). And, there was no interaction effect between coding preference and gender. In summary, the students with the high coding preference level and the female students have solved the Problem 3 better than the others. Also, for the other problems, there were no interaction effect between coding preference and gender. And, the coding preference factor's effect size was bigger than gender. In some types of programs, gender can play the more important key factor for understanding programs.

4. Conclusions

In this research, we have analyzed the personal characteristics of the teenagers based on their understanding of the RUR-PLE computer programs to find out better educational methods for developing their computational thinking skills. In particular, this paper focuses on gender differences analysis. By performing these, we can contribute to develop more appropriate educational methods for the students. As a result, the female students felt more difficult when they use the RUR-PLE commands while programming even though their program understanding abilities were not different from those of the male students. And, only for the iteration command such as repeat, the male students at the high abstract thinking level understood the program better than the male students at the low abstract thinking level. On the contrary, the female students at the low abstract thinking level understood the program better. It means that concrete thinking was helpful to the female students, whereas abstract thinking was helpful to the male students for the same problem. Educators need to be aware of gender differences in analyzing problems and to teach them to think in different ways for their better understanding the problems.

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