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An Exploratory Study of the Relationship between Computational Thinking and Creative Attitudes among University Students

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ABSTRACT

This study aimed to explore the relationship between the computational thinking scale (CTS) and the creative attitudes scale among university students. A total of 93 university students were tested on the CTS ("creativity," "algorithmic thinking," "cooperativity," "critical thinking," and "problem solving") and the scale of creative attitudes ("flexibility," "analytical problem solving," "entrepreneurship," "perseverance," "imagination," and "co-operation"). The results show a significant correlation between the majority of CTS factors and creative attitudes. However, imagination and co-operation are only correlated with one or two CTS factors. Therefore, we identified factors of CTS and the creative attitudes that are related to each other.

KEYWORDS

computational thinking, creativity, creative attitudes, university students, empirical study

1. INTRODUCTION

1.1. *Purpose of This Research*

This study aimed to explore the relationship between computational thinking and the creative attitudes of university students and obtain basic knowledge for future class design.

1.2. *Background of This Research*

The information environment is advancing further, with the increase of advanced information technology and artificial intelligence (AI) and the Singularity's predicted arrival (Kurzweil, 2005).

In education, many projects have been conducted, including implementing programming education and training AI engineers. Therefore, the importance of fostering computational thinking has been emphasized (Wing, 2006).

The term computational thinking was first used by Papert (1980), however, Wing's essay led to the recognition of computational thinking as a basic problem-solving skill useful to all (Wing, 2014). Computational thinking is a set of problem-solving methods that involve expressing problems and their solutions that can be executed by a computer. Other definitions of computational thinking include the International Society for Technology in Education (ISTE) and the Computer Science Teachers Association's (CSTA) operational definition (2011) and more (e.g., Selby & Woolard, 2014). Because many of the current definitions commonly used computational thinking as defined by Wing (Shute et al, 2017), it has been used in this study.

For example, in the U.K., computing is a subject that focuses on developing computational thinking (Gov.UK: Department for Education, 2013). It consists of skills in problem-solving formulations, logical organization, and data analysis using computers and other tools, confidence in handling complexity and perseverance in tackling challenging problems, and thinking and expression of abstraction and algorithm design. These skills are not demonstrated when creating programs, however it can be applied to problem solving in all aspects of life. Moreover, many practices enhance computational thinking. For instance, computing at school led to the creation of teacher resources and implementation of many practices (Computing at School, 2015). There are many other practices to foster computational thinking (Fagerlund et al., 2020; Grover & Pea, 2015; International Society for Technology in Education (ISTE), n.d.). Moreover, Computational Thinking with Scratch by Harvard University focused on its development using Scratch and suggested evaluation methods (Harvard University, n.d.; Brennan & Resnick, 2012). In the U.K., progression pathways were proposed (Computing at School, 2015a).

In addition, it was highlighted that creativity is related to computational thinking (e.g., Doleck et al., 2017; Rotem et al., 2020). In this study, we focused on enhancing creativity and computational thinking. The possibility of enhancing creativity by increasing computational thinking or enhancing computational thinking by increasing creativity, makes computational thinking training promising. Therefore, the implementation of classes that realize computational thinking and creative development is necessary for future education.

1.3. *Identification of Problems*

The relationship between creativity and computational thinking was determined (Hershkovitz et al., 2019) in several studies. In addition, there are various ways to assess creativity and computational thinking, such as evaluating portfolios and artifacts, measuring creativity directly with creativity tests, and examining the relationship between computational thinking and creativity using psychological scales.

However, for students who never demonstrated creativity or who had not experienced any education to enhance creativity, it is essential to understand whether they have an attitude to solve problems before attending computational thinking or special classes to demonstrate creativity. It is crucial to understand the relationship between computational thinking and creativity as readiness, and also to develop an attitude of creativity that is independent of a specific problem.

A creative attitude implies not following a set method or pattern of problem solving, however it requires posing questions, being curious and unafraid to constantly improve and create something new out of failure (Schank & Childers, 1988).

Subject matter can be developed, and appropriate lessons designed based on the understanding of the relationship between creative attitudes and computational thinking. Therefore, understanding this relationship is fundamental. However, no previous studies have addressed this.

In this study, we explored the relationship between computational thinking and the creative attitudes of university students as primary data for designing classes to enhance computational thinking and creativity.

2. RESEARCH METHOD

2.1. Survey Targets and Procedure

In November 2021, a survey was administered to second-year university students majoring in game development in Japan in a class taught by one of the authors. In the survey, responses were obtained from 93 participants (average age: 19.24, SD = 0.71, 88 males, 5 females). The effective response rate was 100.0%. The duration of the survey was approximately 15 min. As ethical consideration, in conducting the survey, there were no questions on personally identifiable information such as name, initials, e-mail address, or student ID number. The survey content was explained to the respondents prior to administration. Furthermore, they were advised that they should respond to the survey, only if they agreed with its content, and that their responses would be considered as their consent. The acquired data are encrypted and stored in a lockable location at the applicant's institution with restricted access.

2.2. Measurement Scales

To measure computational thinking, we prepared five factors and 29 items on the computational thinking scale. (Bando & Motozawa, 2021). This scale is a Japanese translation of the computational thinking scale developed by Korkmaz et al. (2017). Hereafter, the Japanese version of the computational thinking scale is denoted as “CTS.” These five factors are: creativity, algorithmic thinking, cooperativity, critical thinking, and problem solving. The CTS is shown in Table 5 in the Appendix.

In addition, creative attitudes were measured using a revised version of the creative attitudes scale (Shigemasu et al., 1993) that contained six factors and 74 items. These six factors are: flexibility, analytical problem solving, entrepreneurship, perseverance, imagination, and cooperation. The measurement scale of creative attitudes is shown in Table 6 in the Appendix.

A five-point Likert scale (1–5) was used: “5: Strongly Agree, 4: Agree, 3. Undecided, 2: Disagree, 1: Strongly disagree.”

Both of these scales were used in surveys of university students, and their usage is valid for this study.

2.3. Analysis of Procedure

First, descriptive statistics of the computational thinking scale and creative attitudes were calculated. Subsequent to confirming normality, the correlation coefficients between the factors and CTS items and creative attitudes were calculated.

3. RESULTS

3.1. Descriptive Statistics

Tables 1 and 2 show the results of the descriptive statistics of the computational thinking scale and creative attitudes. These results showed that the mean scores for all items and factors were above a medium score of 3.00.

Table 1. Descriptive Statistics of the Computational Thinking Scale

	Mean	*S.D.*
creativity	3.52	0.65
algorithmic thinking	3.19	0.81
cooperativity	3.72	0.90
critical thinking	3.23	0.73
problem solving	3.01	0.70

(n = 93)

Table 2. Descriptive Statistics of Creative Attitudes

	Mean	*S.D.*
flexibility	3.01	0.62
analytical problem solving	3.33	0.63
entrepreneurship	3.51	0.66
perseverance	3.51	0.69
imagination	3.44	0.60
cooperation	3.36	0.48

(n = 93)

3.2. Normality Test for the Computational Thinking Scale and Creative Attitudes

We tested the normality of each of the CTS and creative attitude factors using the Shapiro-Wilk test. The results are shown in Table 3.

Table 3 shows that in the CTS, normality was observed in creativity (W = 0.99, *n.s.*), algorithmic thinking (W = 0.98, *n.s.*), critical thinking (W = 0.98, *n.s.*), and problem solving

(W = 0.99, *n.s.*), but not in cooperativity (W = 0.95, p < .01). Normality for creative attitudes was found: flexibility (W = 0.99, *n.s.*), analytical problem solving (W = 0.98, *n.s.*), entrepreneurship (W = 0.98, *n.s.*), perseverance (W = 0.99, *n.s.*), imagination (W = 0.97, *n.s.*), and co-operation (W = 0.97, *n.s.*). These results indicated that only cooperativity factor did not show normality. We applied parametric analysis because the sample size was close to 100 and there was one factor that did not show normality.

Table 3. Results of the Normality Test of the Computational Thinking Scale and Creative Attitudes

		W	
Computational Thinking Scale	*creativity*	0.99	
	algorithmic thinking	0.98	
	cooperativity	0.95	**
	critical thinking	0.98	
	problem solving	0.99	
Creative Attitudes	*flexibility*	0.99	
	analytical problem solving	0.98	
	entrepreneurship	0.98	
	perseverance	0.99	
	imagination	0.97	
	cooperation	0.97	

**p <.01 (n = 93)

3.3. Correlation between Computational Thinking Scale and Creative Attitudes

Pearson's correlation coefficient was used to calculate the correlation coefficient, as shown in Table 4.

We focused only on the relationship between CTS and creative attitudes, and items with correlation coefficients greater than 0.40. The results showed significant associations between creativity and the following: flexibility, analytical problem solving, entrepreneurship, and perseverance. Moreover, we determined the significant associations between algorithmic thinking and the following: flexibility, analytical problem solving, entrepreneurship, and perseverance. We found the same results for cooperativity and co-operation. Moreover, there were significant associations between critical thinking and the following: flexibility, analytical problem solving, entrepreneurship, and perseverance. The correlation coefficients between problem solving and all factors of creative attitudes were less than 0.40.

4. DISCUSSION

The creativity of CTS was related to creative attitudes of flexibility, analytical problem solving, entrepreneurship, and perseverance. Previous research showed a relationship between creativity and computational thinking.

Flexibility and analytical problem solving, entrepreneurship and perseverance correlated with creativity, critical thinking, and algorithmic thinking. This suggests that it is adequate to focus on these relationships in order to design activities that enhance creative attitudes and computational thinking. Similarly, focusing on the relationship between entrepreneurship and perseverance may enhance creative attitudes and computational thinking.

However, imagination did not correlate with all factors of creative attitudes, and co-operation correlated with cooperativity only. Therefore, activities that aim to increase the imagination and co-operation of creative attitudes to enhance computational thinking may not be efficient.

The participants of this study were enrolled in a course that dealt with game development. Many of them were students aiming to create new games. In addition, they had numerous programming classes, and typically performed programming using Python and Unity.

When creating a game of a certain scale, it is necessary to focus on the relationship between the whole and its parts, such as how to create modules, consider the overall design, and proceed with development in a structured manner. This suggests that algorithmic thinking is related to an analytical attitude toward problems and a participant's attitude.

Moreover, problem solving in CTS is making several choices or aiming to solve problems collaboratively. With the COVID-19 pandemic, tasks are often performed individually and there is limited development within teams, thus, it is assumed that there is no relationship between problem solving and several factors of creative attitudes. The same applies to cooperativity in CTS.

Thus, it is unlikely that a unique curriculum focusing on each CTS factor can be developed to enhance CTS's creativity, critical and algorithmic thinking. Moreover, to improve the cooperativity and problem solving of CTS, it is necessary to consider an individual's curriculum. Fostering cooperativity and problem solving independently through

Table 4. Correlation between Computational Thinking Scale and Creative Attitudes

	creativity	*algorithmic thinking*	*cooperativity*	*critical thinking*	*problem solving*	*flexibility*	*analytical problem solving*	*entrepreneurship*	*perseverance*	*imagination*	*cooperation*
creativity	1.00										
algorithmic thinking	0.55**	1.00									
cooperativity	0.20	0.08	1.00								
critical thinking	0.60**	0.63**	0.07	1.00							
problem solving	0.17	0.20	0.22*	0.15	1.00						
flexibility	0.61**	0.62**	0.22*	0.69**	0.22*	1.00					
analytical problem solving	0.56**	0.58**	0.13	0.69**	0.22*	0.67**	1.00				
entrepreneurship	0.59**	0.44**	0.18	0.55**	0.05	0.55**	0.68**	1.00			
perseverance	0.60**	0.46**	0.21*	0.63**	0.09	0.57**	0.69**	0.59**	1.00		
imagination	0.28**	0.37**	0.00	0.24*	-0.21*	0.41**	0.38**	0.53**	0.32**	1.00	
cooperation	0.07	-0.02	0.46**	-0.05	0.24	0.10	0.07	0.14	0.13	-0.12	1.00

**p < .01, *p < .05 (n = 93)

activities that enhance creative attitudes and computational thinking is necessitated.

Table 4 shows that the items other than co-operation were related to each other in each factor of creative attitudes. In developing subjects, it is essential to create subjects and practices that foster computational thinking and creative attitudes in a well-balanced manner, not by correlating items.

5. SUMMARY AND FUTURE WORK

This study explored the relationship between CTS and the creative attitudes of university students to obtain basic knowledge for designing classes to enhance computational thinking and creativity. Although the relationship between computational thinking and creativity was determined, we focused on creative attitudes and creativity as readiness and clarified that the relationship between computational thinking and creative attitudes provides essential knowledge for future lesson design. Results in this study demonstrated a correlation, however participants of the survey were students specializing in game development and programming. Therefore such a cohort would likely have the requisite skills and attitudes surveyed.

However, there are some limitations which should be addressed in future studies. First, there is a need to expand the number of survey participants. It is assumed that university students from other departments have different tendencies toward CTS than those surveyed in this study.Consequently, it is necessary to survey various students to understand the relationship between CTS and creative attitudes in more detail. In addition, the number of participants in this study were 93, which was not large. A larger sample is required to examine the validity and reliability of these factors.

Second, correlations with scores of other creativity tests, such as the S-A is essential. The creative attitudes psychological scale is sufficient for understanding creative tendencies, however students' creativity is not easily understood. Therefore, it is necessary to use a creativity test to examine the relationship between CTS and creativity.

In the future, these problems should be resolved, and practices should be developed based on the survey results. Practices that enhance computational thinking and creativity should be implemented.

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Appendix

We denote the computational thinking scale (CTS) and creative attitudes in Tables 5 and 6.

Table 5. The Factors and Items of the Computational Thinking Scale

Factor 1: Creativity	
1	I like the people who are sure of most of their decisions.
2	I like the people who are realistic and neutral.
3	I believe that I can solve most of the problems I face if I have sufficient amount of time and if I show effort.
4	I have a belief that I can solve the problems possible to occur when I encounter with a new situation.
5	I trust that I can apply the plan while making it to solve a problem of mine.
6	Dreaming causes my most important projects to come to light.
7	I trust my intuitions and feelings of "trueness" and "wrongness" when I approach the solution of a problem.
8	When I encounter with a problem, I stop before proceeding to another subject and think over that problem.
Factor 2: Algorithmic Thinking	
9	I can immediately establish the equity that will give the solution of a problem.
10	I think that I have a special interest in the mathematical processes.
11	I think that I learn better the instructions made with the help of mathematical symbols and concepts.
12	I believe that I can easily catch the relation between the figures.
13	I can mathematically express the solution ways of the problems I face in the daily life.
14	I can digitize a mathematical problem expressed verbally.
Factor 3: Cooperativity	
15	I like experiencing cooperative learning together with my group friends.
16	In the cooperative learning, I think that I attain/will attain more successful results because I am work.
17	I like solving problems related to group project together with my friends in cooperative learning.
18	More ideas occur in cooperative learning.
Factor 4: Critical Thinking	
19	I am good at preparing regular plans regarding the solution of the complex problems.
20	It is fun to try to solve the complex problems.
21	I am willing to learn challenging things.
22	I am proud of being able to think with a great precision.
23	I make use of a systematic method while comparing the options at my hand and while reaching a decision.
Factor 5: Problem Solving	
24*	I have problems in the demonstration of the solution of a problem in my mind.
25*	I have problems in the issue of where and how I should use the variables such as X and Y in the solution.
26*	I cannot apply the solution ways I plan respectively and gradually.
27*	I cannot produce so many options while thinking of the possible solution ways regarding a problem.
28*	I cannot develop my own ideas in the environment of cooperative learning.
29*	It tires me to try to learn something together with my group friends in cooperative learning.

*invert scale

Table 6. The Factors and Items of the Creative Attitudes

Factor 1: Flexibility	
1*	I am not good at making analogies.
2	I enjoy talking about a wide variety of topics.
3	I am good at finding common characteristics among dissimilar things.
4	Even when I encounter a difficult problem, I can usually find a solution.
5	I am knowledgeable about many different subjects.
6	Other people often say that I think of ideas that are different from the ideas of others.
7	I can think of many related ideas.
8	I think of many different ideas at the same time.
9	I enjoy participating in intense discussions.
10	I can easily think of alternatives when I have difficulty in solving a problem.
11	Other people often ask me how to solve a problem.
12	I can think of several different ways to solve a problem at the same time.
13	I usually view a situation from several different perspectives.
14	I often have several different views about a phenomenon.
15	I can easily divert myself.
16	Other people consider me to be unusual.
17	I am good at understanding things.
18	I always consider the possibility that other people's ideas may be wrong.
19*	I dislike unusual people.
20	I am able to understand other people's feelings.
21	I often wonder what the world will be like in the future.
22	It is easy for me to ask others for help.
23	I prefer to solve problems in my own way.
24*	It is difficult for me to voice opinions that are different from the majority.
Factor 2: Analytical Problem Solving	
25	I think about the structure of a problem before I begin to solve it.
26	I often consider the fundamental basis of things.
27*	It is difficult for me to understand structure of a problem.
28	Before starting to do something. I usually think about the process.
29	I can easily divide a problem into several subproblems.
30	After I solve a problem, I continue to try to find more beautiful solutions.
31	When I think of a new idea, I also think of how to implement it at the same time.
32	I believe in my ability to understand the fundamental nature of things.
33	I enjoy making detailed observations.
34	I am not interested in ordinary things.
35*	I tend to make judgements intuitively, rather than logically.
Factor 3: Entrepreneurship	
36	I want to create new and beautiful things that have never been made before.
37*	I dislike things that are new and unusual.
38	I am very curious.
39	I am interested in learning about things that are not related to what I am doing.
40	I want to create beautiful things.
41	I am interested in many different things.
42	I want to create things that are better than those made by other people.
43	I like to create new things that make life more convenient.
44	I have a good understanding of what makes art and music beautiful.
45	I am good at making things.
46	I like to take things apart.
47	I start working on a new idea, even when I don't yet know how to do it.
Factor 4: Perseverance	
48	I have strong opinions that usually do not change.
49	I do not like to leave things unfinished.
50	During a discussion, I usually do not change my opinions.
51	I usually accomplish what I set out to do.
52	I tend to stick to my old ideas.
53	When I concentrate, I am not aware of things around me.
54	I do not give up easily.
55	I find it difficult to understand things that are inconsistent and illogical.
56	I become frustrated when I cannot solve a problem.
57	It is easy for me to keep working on the same task for a long time.
58	I am confident that if I think I will succeed, I will succeed.
Factor 5: Imagination	
59	I daydream often.
60	I can easily imagine things that do not exist.
61	Thinking about something new makes me happy.
62	Rather than concentration on one task, I prefer to move back and forth from one task to another.
63	I think that I am very different from other people.
64	I have strong emotional feelings several times a day.
Factor 6: Cooperation	
65	I often consider the group consensus when I work with others to solve a problem.
66	The approval of people in authority is important to me.
67	I often work in cooperation with others.
68	I usually consult others when I don't know how to solve a problem.
69	When I see someone who is having difficulty, I usually try to help them.
70	I want to try to do things that are good for both myself and society.
71*	I see unusual aspects of common occurrences.
72*	I am reluctant to share my ideas with others.
73*	I think I will be more creative when I work by myself, rather than when I work with others.
74*	I care about what others think about me.

*invert scale