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In 2016, the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) established a council to organize education in the fields of logical thinking, imagination, problem solving and computer programming at the elementary school level. This began MEXT's consideration of the relationship between programming education and problem solving ability. Discussion about programming education in elementary school has been ongoing.

This paper reviews the discussion of the council, and considers computational thinking in comparison with the ideas of Art thinking as proposed by present author Ariga, and considers the impact of these on education.

Computational Thinking, art thinking, STEAM Education

II. INTRODUCTION

In 2016, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) established a council to organize education in the fields of logical thinking, imagination, problem solving and computer programming at the elementary school level [1], and started to consider the relationship between programming education and problem solving ability. Later, through a second meeting that was held in May 2016, MEXT published an article titled "The way of programming education in elementary school level" [2]. In the publication, it says that programming education is aimed at teaching computational thinking by introducing students to the knowledge of how to program algorithmically to process information, and experience programming, a necessary skill regardless of what kinds of career the student will choose. This paper considers computational thinking, and compares the similarity of that idea with Art thinking as proposed by Ariga, and considers the impact of these on education.

III. COMPUTATIONAL THINKING SELECTING A TEMPLATE

From the discussion at the council, computational thinking (CT) is described as an ability to think logically using symbols that have individual functions, combining such symbols, and modifying the combinations in a planned way of working. Also, the council commented that the definition is clearly defined based on computational thinking and its relation with programming and logical thinking.

Computational thinking is proposed by Wing and has been the key concept in international computing education which includes programming education [3].

In 2011, CSTA (Computer Science Teachers Association) and ISTE (International Society for Technology in Education) defined the operational definition in CT to be used for elementary education. The definition contains the following thinking and attitudes:

CT1: An ability to convert the variety of real-world problems into a format that a computer can read and problem solve.

CT2: An ability to analyze and organize the data logically.

CT3: An ability to use data as variable to convert into model or to run a simulation.

CT4: An ability to build a problem solving process using algorithms.

CT5: An ability to find and run a solution for the best way to solve the problem.

CT6: An ability to apply a solution from a certain problem so that it can be used in a variety of general problems.

CT7: An ability to approach open-ended problems creatively.

CT8: An ability to communicate with others and cooperatively solve problems together.

CT9: An attitude to approach complicated problems with confidence.

CT10: An attitude to approach and strive with persistence to solve complicated problems.

CT11: An attitude to approach unclear problems.

In contrast, the clarity of the definition of CT is viewed as a problem in the field of education. This paper refers to the definition written in Nikkei Kids (2017) [4] as the main ability involved in CT.

- Abstraction: An ability to see things in the abstract. An ability to find what similar things have in common.
- Decomposition: An ability to think and organize from a structure into pieces in order to understand the essence and composition of things.
- Algorithmic Thinking: An ability to think in proper order.
- Evaluation: An ability to evaluate methods.

- Generalization: An ability to generalize things.

CT emphasizes that programming education isn't for the sake of educating programmers, but for educating people in order to work in any career field in the future. Also, programming education under the council is aiming at credentials and ability through education as described in Fig. 1.

Below are the details of Fig. 1:

1. Intelligence, skills. To notice there is a path for solving problems, when a computer is used, at least in elementary education, and in daily life.
2. Ability to think, judge and express. To educate the CT in a certain stage of childhood development.
3. Ability to learn, humanity. To cultivate the attitude of using the computer for quality of life and better society in a certain stage of childhood development.

Those criteria and abilities are based on the proposal of the Central Council for Education. This proposal is still being continued even now from the MEXT, as per the article "Improvement of the class with active and communicative learning." Therefore adherents of CT can say it is focusing on cooperative problem solving.

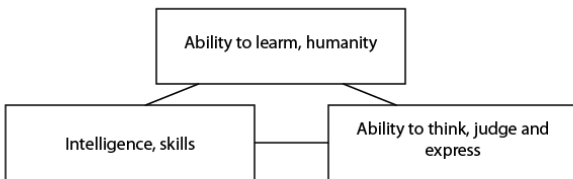


Fig. 1. Criteria for ability to learn through programming education [2]

IV. ART THINKING

Art thinking occurs in a mind that imagines and realizes a future [5], and an ability to solve the gap creatively between social and personal thought [6]. Ariga Minatsu, who proposed art thinking, emphasizes that art thinking is altruism [7].

The creative process in art thinking by Murayama is shown in Fig. 2 [6].

The creative process in art thinking contains 4 phases.

1. Notice the gap. The gap occurs when the real and image, self and other, and environment around the person don't match up together. This is the phase in which the art thinker may notice the gap.
2. Affirm the gap. To recognize the gap the person is going to deal with.
3. Express your image. Expressing a positive image for the future by affirming the gap. Receive feedback

and communicate with outside by comparing your expression with reality.

4. Resolve the gap. Join self and other with the surrounding environment to resolve the gap together. Communication from a self and its exterior (in the previous phase) innovates the new structure.

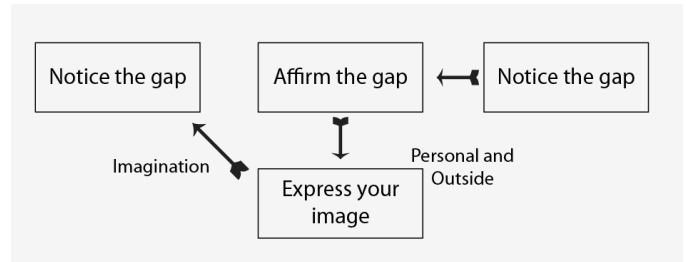


Fig. 2: Creative process in art thinking [6]

V. CT AND ART THINKING

Both theories share one aspect, which is that creative and logical thought both lead to problem solving. Declaration to be the World's Most Advanced IT Nation and E-government Policy, which was revised in June 2018, claims the importance of programming education for elementary education. It focuses on organizing the content, to attract students, and to approach problems creatively by means of IT. The Ministry of Internal Affairs and Communications claims the importance of educating programmers and possibility of improving the logical thinking through studying programming [8]. According to the ministry, the improvement in problem solving, self-motivation, programming skill, creativity, understanding the origin of the computer are all effects of programming education. These are based on the following:

- Creativity improves because students can choose and realize what they want to create.
- Creativity improves by experiencing the joy of creativity.

Also, educating programmers a in step-by-step way that contains logical thinking and recognition, the important roles are shown below [8].

TABLE 1. EDUCATING PROGRAMMER IN STEP-BY-STEP PROCESS THAT CONTAINS LOGICAL THINKING AND RECOGNITION [8].

Stage	Typical teaching method	Main materials / tools
(1) Before logical thinking (From approx. 3 years old to 9 years old)	(a) Experience programming: While trying graphics operation, check the result and get familiar with programming through experiences.	Viscuit

	(b) Creativity development: Use the visual programming environment which can be operated simply, and cultivate creativity through creation of animation. Study through play and expression, extend individuality.	Viscuit
(2) When logical thinking can be done (around 9 years old)	(a) Autonomy development: Use a visual programming environment that requires a logical configuration. The educator only conducts basic support.	Scratch, visual language, EV3 Lego mindstorms
	(b) Learning Skills: Learn visual programming using Scratch etc. (1) Learning material learning, (2) Original development, (3) Step up such as presentation sessions. Could be school type, multiple event type. Systematized curriculum and teaching materials (original text, commercial text).	Scratch, visual language
	(c) Problem setting and problem solving: Setting the goal or the final program and use Scratch and other tools to realize the plan. Gain problem solving skills and planning skills.	Scratch, visual language, blueprint, planning sheet
	(d) Collaborative skills: Communication between children. Educators focus on lending support. To educate about collaborative skills and expression.	Scratch, visual language, viscuit
	(e) Patience and problem solving: Be able to concentrate on the problem when encountered. Teach patience and problem solving skills.	Scratch, visual language, EV3 Lego mindstorms
(3) When the text type language can be used	(a) Learning Skills Come from 3 steps; (1) Understanding of basic concepts, (2) Overall composition and practice	Java, Objective-C, HTML5, text language

	(3) Original application development.	
	(b) Motivation: Encourage self-motivation through communicating with the mentors. Also, to feel the connection with outside such as releasing the application.	Java, Objective-C, text language
	(c) Problem setting and problem solving: Plan what kinds of program to make in advance, and then think how to.	text language

Also, Ozaki [9] showed the technical information modeling capabilities which are necessary for CT, as shown below.

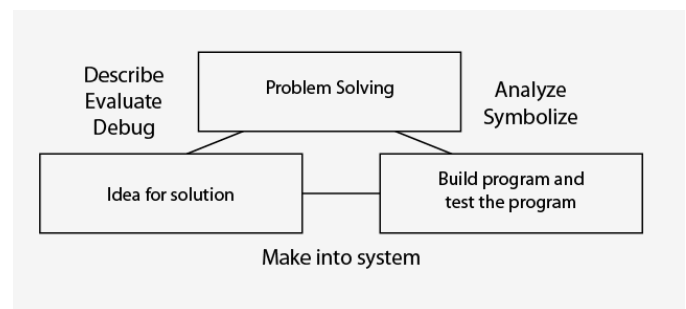


Fig. 4. Technical information modeling capabilities necessary for CT [9]

Looking at CT as a form of problem solving, specifically the processing of content for problem solving, there is a need for context in order to understand the meaning of learning and its connection to the real world and life in society [9].

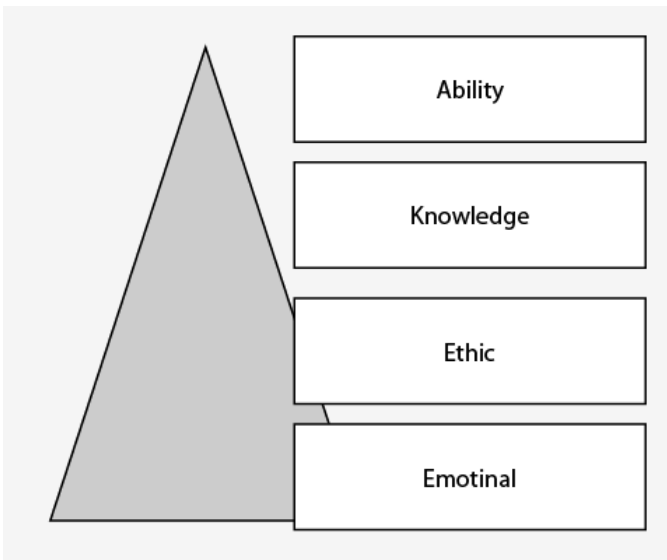
By contrast, in art thinking, Sakai and others define the approach of visualizing [10] and the structure of intellectual ability [11]. According to Sakai and others, intellectual ability is a combination of intelligence and three abilities, namely (deduction, induction, and adaptation).

1. Deduction. Logical thinking with premise. A kind of Critical thinking.
2. Induction. Scientific thinking with evidence.
3. Creative thinking with resonance.

Also, ethical activity and stable emotion for the basis of attitude are given as components of intellectual ability (shown in picture 5).

Fig. 5. Component of intellectual ability and visualization [10]

Sakai and others claim that ethics and stable emotion within adaptation as creative thinking are difficult to teach. One of the ways to educate these components at once is to use art thinking [10].



In contrast, the key difference between CT and art thinking is in finding the problem. CT proceeds in problem solving by using logical thinking, reading the problem just like in coding programs, but instead in the real world and society. Art thinking presents a new meaning to the gap between the personal and world by communicating and noticing the intrapersonal dimension. So, finding the problem in CT is matching the real world and the society. However, art thinking is not only matching the real world and the society but affirming the gap and solving the gap. Therefore, art thinking has a role in CT and it can be said that art thinking motivates art-related creative development.

As a detailed educational practice, Ariga holds a workshop that focuses on the development of abilities that are involved in art therapy. What follows are some details with the analysis of multiple intelligences theory.

A. About art therapy

Art therapy is one kind of psychotherapy that is used as a communication tool to express one’s emotion through the creative process in art. Therefore, regardless of skill level or art technique ability, it focuses on reading the thought and emotion expressed within the process of creation.

Wadeson claims six advantages of art therapy [12]:

1. **Mental property:** Unlike language, art therapy can reflect a sudden image externally. So, clients have the advantage of expressing their principal emotion that can’t be described verbally.
2. **Reduction of defensiveness:** Linguistic communication that is used daily can be defensive, and decorative to hide true emotions.
3. **Objectification:** Some people may show the resistance to forms of counseling that use language. It is sometimes difficult to face yourself in such a session. Communicating through art increases the possibility of

expressing the emotion and clients often feel that it is easier to communicate.

4. **Permanence:** Artwork remains as is, so it is easier to go back and reflect on yourself. Also, the artwork sometimes expresses the emotions of the client and is an easier way of sharing problems with the counselor.
5. **Coexistence:** Linguistic communication doesn’t occur all at the same time, requiring both a listener and speaker. They don’t both speak at the same time, with a one-by-one order. However, art contains the emotions put in one spot, so it may be possible to read the unconscious mind of the author after the fact.
6. **Creative energy:** While creating artwork, the client feels fulfilled by increased creative energy.

B. Multiple intelligences

Multiple Intelligences Theory is a theory proposed by Howard Gardner in 1983. “An intelligence is the ability to solve problems, or to create products, that are valued within one or more cultural settings.” [13][14]. Gardner further defined the theory as below [13]. He lists and categorizes each intelligence shown in the table 1 [13][14][15]:

TABLE 2. 8 INTELLIGENCES IN MULTIPLE INTELLIGENCES THEORY

	Intelligence	Description
1	Verbal-linguistic	An ability to learn, communicate, write, read and use language.
2	Logical-mathematical	Analyze problems, manage numbers in a mathematical way, solve problems in a scientific way.
3	Musical-rhythmic	An ability to play musical instruments, and compose songs.
4	Bodily-kinesthetic	Create and solve problems by using the body.
5	Visual-spatial	Analyze, manage and recognize patterns in spatial terms.
6	Interpersonal	Understand other people and maintain good relations between them.
7	Intrapersonal	Control yourself and understand yourself to live in an effective way.

8	Naturalistic	Recognize categories of phenomena and understand species.
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10:10	Clean up
10:15	Look at the finished artwork
10:20	After-research survey
10:30	End of the 1st class
10:40	Start the 2nd class
11:40	End of the 2nd class

C. Minatsu's practice

Minatsu Ariga held a workshop that contains the essence of art therapy to stimulate the development of the participant's MI. The workshop confirms the transformation and the change in the emotion of the participants from step (2) Affirm the gap to step (3) Express your image.

1) About workshop

The workshop "Become a friend with a sleepy bear" was held on June 2017, in Tsuruoka City, Yamagata, Japan. This workshop is to come up with a friend for the characters drawn in the picture book *The Three Little Ones and the Golden Mane* [16]. In detail, the children are given a paper that has an illustration of the bear. Using the prepared materials, children decorate the bear and give a description of the physical characteristics (Shown in picture 5).

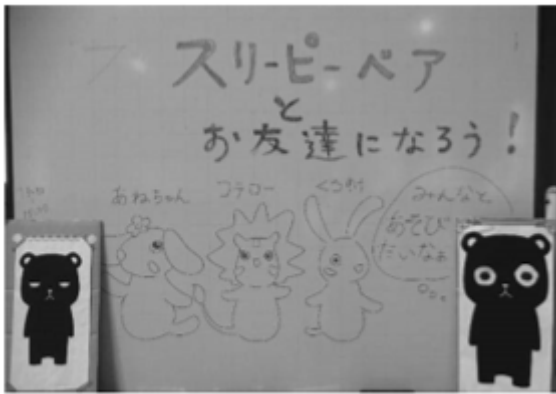


Fig. 5. Explanation of the characters from the picture book

2) The process

The author, Ariga, carried out the workshop in a 62-person classroom, with supporting staff of 3 people. Time Schedule is shown in Table 2.

TABLE 3. WORKSHOP TIME SCHEDULE

9:30	Introduction and pre-research survey
9:40	Explanation of how to make today's artwork
9:45	Start working Introduce the character to others

10 minute of SAN Scale emotional analysis, 10 minute of multiple intelligences analysis survey has done before and after the workshop for 62 participants. Those participants took all the tests seriously.

3) SAN emotional analysis

SAN emotional analysis is a 7-level scale in which emotion is expressed by means of the face of an illustrated rabbit. Participants of the workshop select the level of their feeling. Also, the participants express their feeling by writing inside the speech balloon (picture 6).



Fig. 6. SAN emotional analysis

The participants chose one from among the 7 different emotions. They are only allowed to choose one. The efficiency of the use of the picture to let participants pick the emotion, especially when the participants are still below level of using words, is reported under other pieces of research [17][18].

4) Multiple Intelligences analysis survey

There are many reports about the use of Multiple Intelligences theory in the educational field that indicate it is positive to expand and be able to have a variety of class types [19], which

is also the basic educational strategy in the Netherlands. However, when it comes to measuring the efficiency, there is no survey that is used to analyze the statistical result. The simplified version of the multiple intelligences test by Thomas Armstrong that contains 80 questions [20] isn't enough to prove its validity.

This survey is organized into 48 questions through factor analysis based on Armstrong's report of statistical verification checklist [21]. The result of the validity is verified [22] and done with a 4 point scale.

5) *Analysis*

The result of SAN emotional analysis after the workshop is below (Table 3).

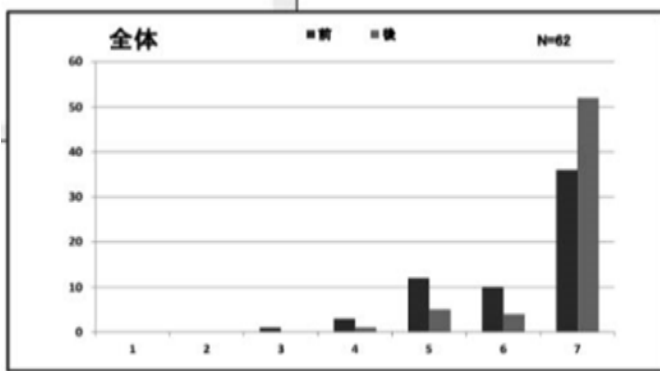


Fig. 7. The result of SAN emotional analysis

The average of SAN emotional analysis before was 6.24 and after was 6.73.

Research team observed the increase in overall average, and reported the participants enjoyed the workshop, and were willing to repeat it if they had the chance again.

The result of the Multiple Intelligences analysis survey is in Table 4. The survey is done in self-evaluation with a 4 point scale.

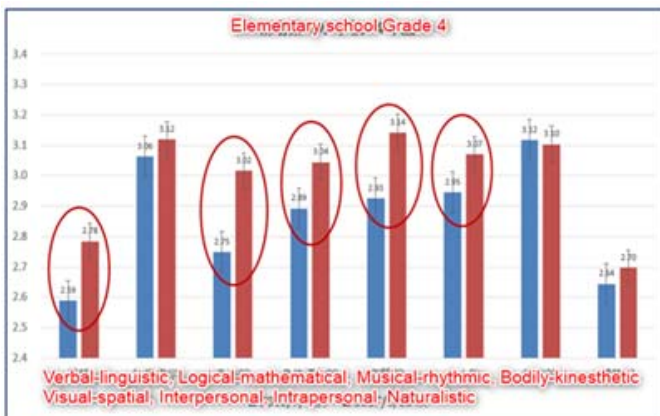


Fig. 8. The result the Multiple Intelligences analysis survey before and after

From the result of the survey, the research team concluded that verbal-linguistic, musical, bodily-kinesthetic, spatial, and

interpersonal intelligences had improved. Also, the result of correlation analysis done from before and after the survey showed the next trait.

1. Interpersonal before workshop x Verbal-linguistic after workshop = 0.627
2. Verbal-linguistic before workshop x Interpersonal after workshop = 0.621
3. Intrapersonal before workshop x Verbal-linguistic after workshop = 0.591

6) *Discussion*

It is obvious that the students demonstrated improvement in all kinds of intelligences, except for Interpersonal. In his work, Gardner claims that if all of the 8 intelligences are focused on achieving artistic goals, then there is a possibility that all the intelligences could be improved. The present research results agree to what Gardner had claimed [23]. Speaking within the concept of art thinking, it seems that if the individual's self-esteem is strongly functioning, then one does develop an intelligence that is necessary when art therapy moves to step (3) Express your image from step (2) Affirm the gap.

According to the such movement, the author, Ariga, tests the relationship between the workshop and the Multiple intelligences as below.

- Consider the connection of story and the characters (logical-mathematical, Verbal-linguistic).
- Imagine the traits of the character, provide a chance to think about its originality (Intrapersonal).
- Share the completed work with friends (Interpersonal).

With this educational intention, the other intelligences are developed accordingly. Any of the learning process has a choice of method [24]: (1) the Aesthetic, (2) the Narrative, (3) the Logical/Quantitative, (4) the Foundational, (5) the Experiential.

In reality, the author, Ariga, asked the children who named the bear very quickly, "What is bear good at?" and the children replied "To read a book!" then start drawing some books around the bear. In a different case, the child drawing a bear standing on the ground wearing a big brown hat said, "This bear is an adventurer named Johnny. He is at a mountain." The bear holds a country flag, and the student used the example of glass to describe the mountain. Those who had curiosity and were able to reflect their own ability onto the bear had a great experience.

The result of the workshop before and after the Multiple Intelligences showed that differences among individuals in how they understand the others rely on the positive relationship with society, especially when it involves the communication through words. Actually, Ariga observed there are some students talking to the other students who are slow in

creating the artwork in the workshop about caring for each other.

In preceding studies, the children who understand and care about others have higher level of skills in society [25], take a longer time to communicate with friends, and gain reputation [26][27]. In their communications, the children with underdeveloped function have difficult times developing relationships with friends [28]. Also, after adolescence, people who can understand others have a higher possibility of cooperating with others voluntarily [29]. Those factors could imply that the efficiency of art therapy is dependent on the development of the mental factors in the individual.

VI. CONCLUSION

Regarding the two modes of thought, art thinking and CT could be said to share the same field of deductive reasoning. When looking at art therapy as one of the approaches to development by art, there is a possibility for developing the Multiple Intelligences as proposed by Howard Gardner. This is due to logical-mathematical thinking being one of the abilities that can be developed through art education. The reason why art thinking has the possibility to develop the eight intelligences is because art thinking covers the field of 'A' (art and design) in STEAM education.

When it comes to art curriculum in schools, it should not merely be a free elective course. It is not only about focusing on design and sense, but is really about thinking, the main purpose of school education. It is necessary to design curriculum around Art considering the subject to be not only drawing, painting or some sort of visually related subject, but rather Art must be treated and designed to be a comprehensive, required subject.

We are grateful to JSPS for providing this research with the Grants-in-Aid for Scientific Research 16K04798.

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