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Combination of Creative Thinking to Enhance Team Creativity and Team Performance: Analysis Result of the Survey to Graduate Students in the Project-Based Learning Class

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Abstract

Organizations rely on creative thinking to create knowledge and use knowledge creatively in today's business environment. The purpose of this study is to indicate the points in combining the four kinds of creative thinking (divergent, convergent, experiential, and rational thinking) of team members to enhance Team Creativity and Team Performance. We conducted a qualitative and quantitative analysis of the survey with graduate school students participating in a team collaboration project-based learning class for four months in one team. The survey was conducted three times; just after the team was organized, two months later, and two weeks before the final presentation. We analyzed the survey result in four points and identified three suggestion points. The first is to include members who self-evaluate themselves to have sufficient "rational" and "divergent" thinking in the team from the initial phase. Secondly, we suggest each member keep making efforts to control "divergent" and "convergent" thinking according to situations of the team and to be evaluated positively by other team members at the final phase of the project. Also, the team members should improve their creative thinking positively through team collaboration activities to achieve higher performance as a team.

Keywords: knowledge creation, team creativity, team performance, creative thinking

1 Introduction

To ensure continuity and implement survival strategies in today's global competitive business environment, organizations rely on creative thinking (CT) to find creative solutions [1][2][3]. It is indicated that based on a knowledge-based economy, creativity has an important role [1][4]. Encouraging creativity in organizations or teams, not just in individuals, is necessary [5][6].

Also, the world experiencing the pandemic has relied on the knowledge management process to create, share and apply knowledge [1]. Basadar & Gelade [7] indicated that innovative organizations make a habit of using knowledge creatively not just spreading it.

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In this study, we aim to propose specific ways to encourage CT which leads to a team's higher performance and creativity. We consider that the team's performance and creativity are the results of creating new knowledge or using knowledge creatively in the team collaboration process.

The 2-axis of CT was one of the parts of the method designed and proposed in the previous studies [8][9][10], which aims to enhance the performance and creativity of the team. CT is defined as a combination of the four kinds of thinking; divergent, convergent, experiential, and rational thinking. 2-axis of CT visualizes individuals' CT balance. The 2-axis was designed based on the consideration that "that the good balance of the roles in the team leads to good performance when all the members have acceptance of others" [8][9]. Since the purpose of the 2-axis of CT is to visualize the CT balance, those previous studies did not indicate how and when to encourage CT leading to higher performance and creativity of the team.

In particular, the purpose of this study is to indicate the combination of the four kinds of CT mentioned in Akaki et al. [8][9][10] should the team members be encouraged to enhance team creativity (TC) and team performance (TP). In this study, TC is defined as "teams producing novel ideas and solutions to maintain firm's competitive edge". [11]. The lesson from this study should be useful for individuals in teams who aim to organize and collaborate with the team members to create knowledge and use knowledge creatively by analyzing and visualizing each team member's CT.

We asked seventy-two students who attended a four-monthly team collaboration project-based learning class, such as a Design Project class in a Graduate School to answer the survey three times, just after the team was organized, two months later, and two weeks before the final presentation. We visualized the recognition of the behavior of themselves and the team members by the Creative Thinking Map (CTM) which is consisted of two kinds of 2-axis of CT based on the proposal in Akaki et al. [8][9][10].

We analyzed the result of the survey in four points; adding perspectives and analysis points indicated by Akaki & Ioki [12]. First, four functions of the map to enhance self-acceptance (SA) were clarified by analyzing the free descriptions of the examinees who were led to SA by receiving the CTM according to the final survey. SA is defined as a positive evaluation of oneself according to Kawagishi [13]. Secondly, the correlations among the three key factors, such as SA, TC, and TP score at the final survey were analyzed. The analysis result indicated that there is a significant correlation between SA and TC, and TC and TP [12]. Third, the correlations among the four kinds of CT and the three key factors mentioned above were analyzed. Finally, we focused on the top and bottom three teams in TP to analyze the changes that occurred to self-evaluation and evaluation by others on CT among the first, mid-term, and final surveys. The result is discussed from the perspective that the efficacy of creativity leads to a positive performance as a team.

Through the qualitative and quantitative analysis, two kinds of combinations and timing of CT that the team members should encourage during projects in order to enhance SA, TC, and TP are indicated. First is the combination of rational and divergent thinking. As for the timing, it is suggested to include members who self-evaluate themselves to have sufficient rational and divergent thinking in the team from the initial phase. The second is the combination of divergent and convergent thinking. As the timing, it is suggested each member start making efforts to control divergent and convergent thinking according to the situation of the team from the beginning stage of the project. The member's level of divergent and convergent thinking should be sufficient enough to be evaluated by other team members not only self-evaluation at the final phase of the

four months project. In this study, a sufficient level is defined as the level to be evaluated by oneself or other members that one is demonstrating strengths utilizing CT [12]. In order to analyze further the timing to improve CT, we compared the changes that occurred to CT between the top and bottom three teams in TP. The result indicated that the development of the rational and convergent thinking, which is utilized to narrow down the idea to the best one, stops earlier that the divergent and experiential thinking that is used to create knowledge widely and openly. Also, by interpreting higher evaluation of CT as efficacy on creativity, we indicate that creative self-efficacy and collective-efficacy will lead to positive TP as the evaluation on CT gradually improve through team collaborations.

Section 2 summarizes the previous studies. Section 3 describes the items we analyzed. Section 4 describes the result of the analysis. Section 5 discusses the result of the analysis. Section 6 concludes by describing future research topics.

2 Literature Review

(1) Creative Thinking and Knowledge Management

Shamsi [2] described that the quality of knowledge management is affected primarily by the ability to enforce CT in daily life. CT is explained as “the process of breaking down and building up our knowledge about an issue while gaining new insights about it” [2]. Through the analysis result, Shamsi [2] indicated that CT mediates the effect of management skills on knowledge management. On the other hand, Ismael & Sağsan [3] indicated that there was not a direct significant relationship between the knowledge management process and CT but organizational culture mediates the relationship between them. Since the direct or indirect relationship between CT and knowledge management is indicated in previous studies, we focus on CT for knowledge creation and using knowledge creatively.

Kareen et al. [1] found that the environments, resources, personal characteristics, and SECI are the factors to improve creativity. In previous studies, several factors and points to enhance TC or collective intelligence are indicated. For instance, Pirola-Merlo et al. [14], indicated that "team creativity at a particular point in time could be explained as either the average or a weighted average of team member creativity". Also, Wooley et al. [15] identified the factors, such as social sensitivity, more equal distribution of conversational turn-taking, and the proportion of females, related to collective intelligence in groups. In this study, we focus on four kinds of creative thinking (divergent, convergent, experiential, and rational thinking) and their combination to enhance TC and TP.

(2) 2-axis of Creative Thinking

The 2-axis of CT was used in the previous studies [8][9][10] to make each member able to recognize and unleash the strong points they have in CT in order to enhance the performance of the team. The 2-axis of CT was included in the advice sheet proposed by Akaki et al. [8][9][10] that can be utilized to promote collaboration inside the team by enhancing the self-acceptance (SA) of the team members. In the previous studies [8][9][10], the effects of the advice sheet were indicated. For instance, according to the experimentation conducted in Akaki et al. [10], the advice sheet had a positive effect on 70% of the examinees' TC. However, the previous studies did not

apply the advice sheet from the beginning stage of the project and could not indicate the changes that might occur to the individual team members and the teams as the project proceeds.

Figure 1 shows the 2-axis of CT. The reason for selecting the 2-axis is explained as below by Akaki et al. [8][9].

" only convergent does not create new ideas, only divergent does not refine or narrow down to the best idea, only logical thinking does not generate empathy, and only emotional intelligence does not explain things logically to convince others."

We consider the combination of the four kinds of CT leads to higher performance and creativity of teams.

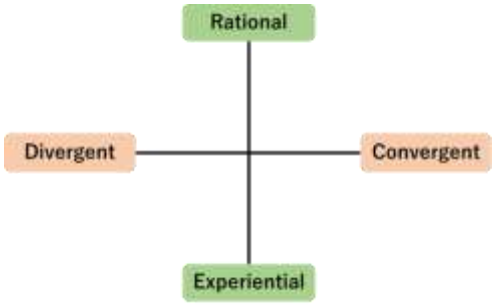

Figure 1: 2-axis on the advice sheet [10]

Saito [16] defined CT as the integration of divergent & convergent thinking and experiential & logical thinking. According to the previous studies, we define the vertical axis as "rational" & "experiential", and horizontal axis as "divergent" & "convergent". Table 1 shows the definition of each kind of CT.

Table 1. Definition of CT [10][12]

Kind of thinking	Definition
Divergent	Performed at the process to diffusely generate many unique ideas.
Convergent	Performed at the process to logically and precisely summarize ideas.
Experiential	Holistically, automatically, and concretely process information based on experimental intuition.
Rational	Analytically, consciously, and abstractly process information based on logic.

(3) Design Project

The examinees of this study are the students participating in the Design Project in 2019, which is one of the core curriculums of the Graduate School of System Design and Management, Keio University in Japan. Graduate School of System Design and Management (Keio SDM) was established by Keio University in April 2008. The objective of establishing Keio SDM was "to build the System Design and management science (SDM science), a discipline system to creatively design and thoroughly manage the large-scale complex systems, and to provide graduate school education to train people who are capable of leading the construction and operation of large-scale complex system" [17].

Design Project has been conducted for first-grade master students and takes the project-based learning structure. Through project-based learning classes, students are provided with the opportunity to participate in real problem-solving and knowledge construct in an authentic professional context [18]. The students struggle with their team members to design solutions to 'real world' business or social problems that proposal companies are facing. We consider that the team collaboration in the Design Project is close to the ‘real world’ business situation although it is held in a schooling context.

In addition, according to Watanabe et al. [19], Design Project "was aimed at enhancing presentation, team work abilities, leadership skills, technological knowledge, and creativity". CT in a team collaboration situation is necessary to achieve a higher performance in the Design Project class.

Although the previous studies of Design Project mainly focus on the course design and methods utilized in the project, we focus on the teams and team members' way of thinking.

3 Analysis Method

Examinees are the seventy-two students belonging to the first grade of Keio SDM, who participated in the Design Project class. Many students work in the private and public sectors besides their research activities. The students were divided into fourteen teams consisting of five or six members. Table 2 shows the course schedule for the fiscal year 2019 [12]. The students will prepare a presentation every two weeks about a solution with innovative values to the proposer company, which gives specific issue or problem they need to solve. We conducted the survey four times. The result of the survey on CT will be analyzed and its result will be visualized by the CTM. CTM is sent to each student via e-mail a week after the survey was conducted to refer to during the team collaboration. The details of CTM and the items for analysis are indicated in this chapter.

Table 2: Schedule of Design Project class 2019. [12]

Date	Team activity	survey
May 4	Team formation	First Survey
May 18	1st presentation	
June 1	2nd presentation	
June 15	3rd presentation	Mid-term Survey
June 29	4th presentation	
July 13	5th presentation	
July 27	6th presentation	Final Survey (creative thinking)
August 10-11	7th presentation	Final Survey (key factors)

(1) Creative Thinking Map

We use the CTM in this study which is presented at Akaki & Ioki [12]. Figure 2 shows the CTM. We visualized the recognition of the behavior of themselves and the team members by two kinds of 2-axis of CT [8][9][10].

As the vertical axis, we utilized the rational and experiential engagement by Information-Processing Style Inventory [20] on a five-point scale. This scale is used since the items measure the logical understanding as "rational" engagement items, and emotional expressivity in

"experiential" engagement items according to Pacini & Epstein [21]. Divergent and convergent thinking is measured by the Creative Attitude Scale [16] on a five-point scale. Guilford [22] defines that divergent and convergent thinking is necessary for creativity. Saito [16] invented the scale to measure the creativity of Junior High School students.

CTM describes the "Individual" map, which visualizes how each one of them and other team members observe the individuals' attitude, and the "Team" map, which visualizes how all the team members' attitudes are observed mutually [12]. The points to observe the map is written under the map to encourage interpretation of the 2-axis [12].

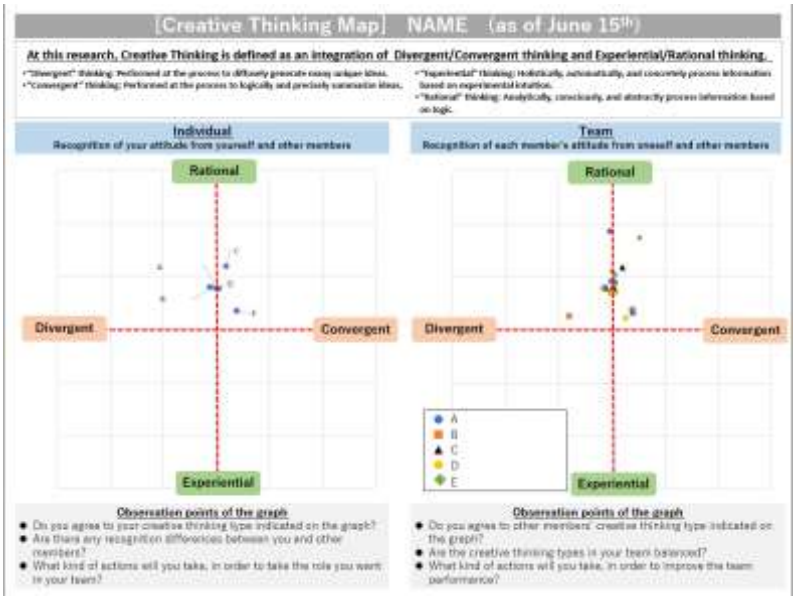

Figure 2: Creative Thinking Map [12]

(2) Items for Analysis

In this chapter, we indicate the four points analyzed in this study. First, we analyzed the free descriptions written about the effects of the CTM to improve SA by “Open coding”. Three steps are identified by Kobayashi et al. [23] to implement "Open coding".

Step 1: View the free descriptions on the final survey and pick out the descriptions of the examinees who answer that the map positively affected SA. Set the viewpoint for Affinity Diagram grouping (Step 2). It was set in this study as "improvement of SA by the map" in order to clarify the necessary functions of the map.

Step 2: Searching, the aforementioned viewpoint, the descriptions for the method that seems to be related, and sort them into groups.

Step 3: Write titles for each group that summarizes the essence of the group, at a slightly higher level of abstraction (called "Open coding results" in this study).

This study ensured the validity of the analysis by taking a review from one researcher skilled in qualitative research methods [24].

Second, we analyzed the correlations between the three key factors, such as SA, TC, and TP of the final survey. The scale developed by Uemura [25] was used to measure SA on a seven-point scale. In order to measure TC, the scale developed by Zhou & George [26] on a seven-point scale was used, which indicates that expressions of the voice of the team members are important to improve TC. The direct effect of SA on TC is analyzed in Akaki & Ioki [12] since the direct relationship between SA and TC or TP had not been indicated in previous studies. Several studies indicated that accepting the ideas and plans of others leads to organizational creativity [27][28][29]. Also, SA commonly affects positively to individual creativity when researchers analyzed the relationship between California Psychological Inventory and Subjective Well-being factors and creativity [30][31][32]. TP is defined as the evaluation result of the faculty members of the Design Project class, which is the summary of the evaluation of the presented solution from eight points; Understandability, Novelty, Innovativeness of the Problem Definition, Creating New Value to the Society, Innovativeness of the Solution, Preference, Passion to the Solution, and Team's Attainment.

Third, in order to clarify the combination and timing of four kinds of CT that the individuals should enhance, the correlations among the four kinds of CT and the three key factors were analyzed. The four kinds of CT scores were measured in two ways, such as self-evaluation and average evaluation by other team members.

Finally, in order to further analyze the timing to improve the four kinds of CT, we compared the top and bottom three teams' changes that occurred to CT while the project proceeds. The top and bottom three teams were identified by their TP score. We analyzed it in two ways. First, we classified the thirty-one students belonging to the top and bottom three teams into four groups according to when and how their self-evaluation and evaluation by other team members changed. We compared the ratio of students in each classification between the top and bottom three teams. Secondly, we conducted a paired t-test between the top and bottom three teams on how much their scores on CT changed among the first, mid-term, and final surveys.

4 Analysis Result

(1) Free description analysis affecting Self-Acceptance

Twenty-eight examinees out of seventy-two (38.9%) answered "strongly agree" or "partly agree" that the CTM promoted SA [12]. In order to figure out the reason why those examinees felt the promotion of SA, we analyzed the thirty comments of the free descriptions explaining the reasons for the enhancement of SA by Open coding. We clarified the four functions of CTM which promote SA in Table 3. The first function "enhance self-understanding and promote conscious behavior" was mentioned by 33.3% of the examinees who realized the positive effect to SA. The second function "give different perspectives" and the third function "confirm the similarities of the cognition among oneself and team members" were both raised by 20.0% of the examinees. The number of examinees who raised "support and help oneself to keep a positive attitude towards the activities" was the least; 16.7%.

Table 3: The main results of open coding

The function of the Creative Thinking Map	Number	%
Enhance self-understanding and promote conscious behavior	10	33.3%
Give different perspectives	6	20.0%
Confirm the similarities of the cognition among oneself and team members	6	20.0%
Support and help oneself to keep a positive attitude towards the activities	5	16.7%
Others	3	10.0%
TOTAL	30	100.0%

Table 4 shows the detailed descriptions for each function. The number of examinees who mentioned that they recognized how they should behave to the team through the CTM was the highest (26.7%) among other comments. Also, 16.7% of the examinees commented that they recognized how other members were observing their behavior from a different perspective to objectively understand themselves. Also, 13.3% of the examinees commented that they noticed that their recognition is similar to other team members' by noticing other members' evaluation. Other comments were raised by examinees less than 10% and classified into the four functions.

Table 4: Open Coding results (the ratio of the number of people)

Functions	Comments	Number	%
Enhance self-understanding and promote conscious behavior	I recognized how I should behave	8	26.7%
	I understood myself deeply	2	6.7%
Give different perspectives	I recognized how other members are observing my behavior	5	16.7%
	I acquired an objective perspective on my attitude	1	3.3%
Confirm the similarities of the cognition among oneself and team members	I noticed that my recognition is similar to other team members	4	13.3%
	I agreed to the situation visualized on the 2-axis	2	6.7%
Support and help oneself to keep a positive attitude towards the activities	It helped me, indeed	2	6.7%
	I became confident	2	6.7%
	It helped me to perceive the activity positively	1	3.3%
Others		3	10.7%
TOTAL		30	100.0%

(2) Correlations among the key factors

As Akaki et al., [12], Table 5 shows the result of the correlation analysis among the key factors. SA and TC had a significant correlation; the correlation coefficient was 0.263 ($p<0.05$). Also, TC and TP had a significant correlation; the coefficient was 0.457 ($p<0.01$). Direct correlations between SA and TP were not indicated.

Table 5: Correlations among the key factors. [12]

	Self-Acceptance	Team Creativity	Team Performance
Self-Acceptance	-	.263*	-0.001
Team Creativity	.263*	-	.457**

(p<0.05*, p<0.01**)

(3) Correlations among team members' Creative Thinking and the key factors

As Akaki et al. [12], Table 6 shows the result of correlation analysis among the self-evaluation (SE) and the average of evaluation by other team members (EO) on four kinds of CT and the three key factors. The correlation factors highlighted gray in Table 6 were significant (p<0.05* or p<0.01**). SE of the divergent and rational thinking and SA had significant positive correlations. SE of the divergent and convergent thinking and EO of all four kinds of CT had positive correlations between TC. At the first survey, significant negative correlations were identified between EO of the divergent, convergent, and experiential thinking and TP. In contrast, the correlations between EO of the divergent, convergent, and rational thinking and TP were significantly positive at the mid-term and final survey.

Table 6: Correlation analysis of four kinds of creative thinking and three key factors.

	Creative Thinking	Self-Acceptance	Team Creativity	Team Performance
First-SE	Divergent	.306**	0.156	-0.148
	Convergent	0.222	0.150	-0.151
	Experiential	0.099	-0.048	-0.047
	Rational	.389**	0.194	0.006
First-EO	Divergent	0.161	-0.129	-.256*
	Convergent	0.129	-0.177	-.274*
	Experiential	-0.002	-0.184	-.326**
	Rational	0.142	-0.031	-0.043
Mid-term-SE	Divergent	.326**	0.119	-0.071
	Convergent	0.113	0.105	0.055
	Experiential	0.129	-0.164	-0.156
	Rational	.343**	0.178	0.008
Mid-term-EO	Divergent	0.213	0.134	.273*
	Convergent	0.090	0.230	.328**
	Experiential	-0.016	-0.036	-0.119
	Rational	0.100	0.202	.252*
Final-SE	Divergent	.322**	.326**	0.035
	Convergent	.258*	.414**	0.151
	Experiential	.261*	0.080	0.153
	Rational	.363**	0.178	0.117
Final-EO	Divergent	0.079	.245*	.309**
	Convergent	0.035	.264*	.337**
	Experiential	-0.010	.390**	0.120
	Rational	0.042	.252*	.268*

(p<0.05*, p<0.01**)

(4) Changes occurred to the top and bottom three teams

Table 7 shows the result of the classification of the thirty-one students belonging to the top and bottom three teams into four groups according to when and how their self-evaluation and evaluation by other team members changed. Seventeen students belong to the top three teams and fourteen students belong to the bottom.

We classified the students whose CT evaluation improved at both the first and mid-term and mid-term and final survey to Classification 1 (C1). Classification 2 (C2) shows the students whose CT improved between the first and mid-term survey but dropped between mid-term and final survey. In a contrasting situation, Classification 3 (C3) shows the students whose CT dropped between the first and mid-term survey but improved between the mid-term and final survey. We classified the students whose CT dropped between both first and mid-term and mid-term and final survey to Classification 4 (C4). The largest numbers of each classification are highlighted gray in Table 7.

As the result regarding SE on four kinds of CT, the most of the examinees belonging to the top three teams were classified to C1 on divergent (52.9%), convergent (70.6%), and experiential (41.2%) thinking. On the other hand, the score of the examinees belonging to the bottom three team tends to drop between mid-term and final survey compared to the top three team members. Most examinees belonging to both top and bottom three teams were classified to C3 for rational thinking (top 3: 47.1% and bottom3: 35.7%).

Regarding EO, more than 60% of the examinees belonging to the top three teams were classified to C1 for divergent (64.7%) and experiential thinking (76.5%). For convergent and rational thinking, more than half of the examinees belonging to the top three teams were classified to C2 (convergent: 64.7% and rational: 58.8%). The examinees belonging to the bottom three teams tend to experience a drop between first and mid-term surveys on divergent (42.9%), convergent (42.9%), and rational thinking (50.0%).

Table 7: Changes in creative thinking comparing the top and bottom three teams

	Creative Thinking	Teams	C1 Mid-First>0 Final-Mid>0	C2 Mid-First>0 Final-Mid<=0	C3 Mid-First<=0 Final-Mid>0	C4 Mid-First<=0 Final-Mid<=0
SE	Divergent	Top 3 teams	52.9%	23.5%	17.6%	5.9%
		Bottom 3 teams	28.6%	35.7%	35.7%	0.0%
	Convergent	Top 3 teams	70.6%	17.6%	5.9%	5.9%
		Bottom 3 teams	42.9%	21.4%	28.6%	7.1%
	Experiential	Top 3 teams	41.2%	23.5%	35.3%	0.0%
		Bottom 3 teams	14.3%	50.0%	14.3%	21.4%
	Rational	Top 3 teams	17.6%	17.6%	47.1%	17.6%
		Bottom 3 teams	14.3%	21.4%	35.7%	28.6%
EO	Divergent	Top 3 teams	64.7%	29.4%	0.0%	5.9%
		Bottom 3 teams	35.7%	0.0%	42.9%	21.4%
	Convergent	Top 3 teams	29.4%	64.7%	5.9%	0.0%
		Bottom 3 teams	28.6%	7.1%	42.9%	21.4%

	Experiential	Top 3 teams	76.5%	11.8%	5.9%	5.9%
		Bottom 3 teams	14.3%	42.9%	28.6%	14.3%
	Rational	Top 3 teams	17.6%	58.8%	23.5%	0.0%
		Bottom 3 teams	35.7%	0.0%	50.0%	14.3%

Table 8 shows the mean score and the p values (the result of a paired t-test between the top and bottom three teams on how much their scores on CT had changed) among the first, mid-term, and final surveys. Regarding SE, the changes of experiential thinking between the mid-term and final survey were the only item that had a significant difference between the top and bottom three team members (p values: 0.016). More items had significant differences between the top and bottom three team members regarding EO. The changes of divergent (p values: 0.000), convergent (p values: 0.000), and rational (p values: 0.026) thinking scores between first and mid-term and the changes of divergent (p values: 0.002), convergent (p values: 0.001), and experiential (p values: 0.012) scores between the first and final survey were significantly different.

Table 8: Mean score and p values of changes in the creative thinking of top and bottom 3 teams

	Creative Thinking		Top 3 teams mean score	Bottom 3 teams mean score	p values
SE	Divergent	Mid-First	1.000	0.286	0.635
		Final-Mid	2.000	0.929	0.582
		Final-First	3.000	1.214	0.385
	Convergent	Mid-First	2.235	-0.857	0.189
		Final-Mid	1.941	1.214	0.605
		Final-First	4.176	0.357	0.127
	Experiential	Mid-First	0.429	1.334	0.492
		Final-Mid	0.951	-1.561	0.016*
		Final-First	1.379	-0.227	0.321
	Rational	Mid-First	0.005	-0.500	0.232
		Final-Mid	0.162	0.284	0.797
		Final-First	0.167	-0.217	0.437
EO	Divergent	Mid-First	4.238	-0.607	0.000**
		Final-Mid	0.800	1.304	0.534
		Final-First	5.038	0.696	0.002**
	Convergent	Mid-First	5.053	-0.964	0.000**
		Final-Mid	-0.344	1.357	0.043*
		Final-First	4.709	0.393	0.001**
	Experiential	Mid-First	0.763	-0.098	0.095
		Final-Mid	0.889	0.208	0.157
		Final-First	1.652	0.110	0.012*
	Rational	Mid-First	0.566	-0.352	0.026*
		Final-Mid	-0.153	0.270	0.130
		Final-First	0.413	-0.082	0.273

($p<0.05$*, $p<0.01$**)

5 Discussion

(1) Result of the Open Coding

According to Akaki & Ioki [12], four functions of the CTM to enhance SA were clarified by the result of the Open coding.

From the comments “I recognized how I should behave” and “I understood myself deeply”, Akaki & Ioki [12] identified the function; “Enhance self-understanding and promote conscious behavior". By promoting deeper self-understanding through the map, SA was enhanced and led to individuals' conscious behavior.

From the comments "I recognized how other members are observing my behavior" and "I acquired an objective perspective to my attitude”, Akaki & Ioki [12] identified the function; “Give different perspectives”. Through the map, the individuals can acquire the perspectives from other team members and the third person making the map. These perspectives contribute to the individuals’ objective self-understanding and enhance SA.

From the comments “I noticed that my recognition is similar to other team members” and “I agreed to the situation visualized on the 2-axis”, Akaki & Ioki [12] identified the function; “Confirm the similarities of the recognition among oneself and team members”. By offering logical proof to individuals’ recognition, they can be confident in their behavior and conversations during team collaboration, which will lead to SA.

From the comments “It helped me, indeed”, “I became confident” and “It helped me to perceive the situation positively”, Akaki & Ioki [12] identified the function; “Support and help oneself to keep a positive attitude towards the activities”. By visualizing the situation through the map without any concrete advice as Akaki et al. [8] [9][10], the result indicates that the map has the function to make the individuals' minds positive and enhance SA.

(2) Relation among the key factors

Akaki & Ioki [12] found a significant correlation between SA and TC, and TC and TP. Although the direct relationship between SA and TC is not indicated in the previous studies, the result indicates that SA can significantly affect TC, however, the correlation is weak. It can be predicted that mediation by other factors enhances the positive relation between SA and TC. Also, TC significantly affect TP in the four-month project-based learning class as other previous studies indicate the positive relations between TC and TP.

(3) The relationship among team members' Creative Thinking and the key factors

Akaki & Ioki [12] clarified the combination and timing of the four kinds of CT the team members should encourage to enhance SA, TC, and TP.

a) SA: Since SA is defined as a positive evaluation of oneself according to Kawagishi [13], self-evaluation on CT had significant correlations to SA instead of evaluation of other team members. Self-evaluation of divergent and rational thinking of the first, mid-term, and final survey and SA had a significant correlation. The team members who evaluate themselves as divergent and rational from the initial phase of the project tend to have a higher SA during the four months project [12].

b) TC: The result of the final survey on CT, which is the self-evaluation and evaluation by other team members after understanding each other deeply in four months team collaborations, had a positive impact on TC. This result also indicated that it is difficult to predict how the TC would be at the final phase from the evaluation of CT at the first or mid-term of the project. According to Akaki & Ioki [12], this result indicates that the team members who acquired the skill to control divergent and convergent thinking through the four months of teamwork affect the final TC.

In addition, evaluation by other team members of all four kinds of CT and TC had a significant correlation at the final survey, which implies the validity of measuring these four kinds of CT to encourage TC [12].

c) TP: The evaluation by other team members on CT had significant correlations between TP. The result indicates that the behaviors related to the specific CT have to be recognized by other members and its level has to be high enough to be evaluated positively by others to lead to better performance as a team.

The team member, who are evaluated by other members to have sufficient rational and divergent thinking, and can control divergent and convergent thinking affects the final TP [12]. Additionally, the result that evaluation of other members on rational, divergent, and convergent thinking at the first survey and the TP had a significant negative correlation indicates that it is difficult to recognize each other's thinking from the beginning stage of the team [12].

(4) Changes occurred to creative thinking comparing the top and bottom three teams

We reinforce the result of the correlation analysis by comparing the difference between the top and bottom three teams in TP on how and when their CT changed. The top three team's team members tend to experience positive changes through team collaboration activities.

a) Changes on self-evaluation: Concerning the most numbers of students belonging to top three teams, three kinds of CT except rational thinking score improved between both the first and mid-term and mid-term and final survey. However, most of the students belonging to the bottom three teams experienced drops in either timing. Paired t-test result shows a significant difference between the top and bottom three teams' score changes occurred between the mid-term and final survey on experiential thinking. This result shows that the bottom three team members lose their confidence in their experiential thinking utilizing their experiences or intuitions at the later part of the project while at the same time top three team members increase confidence.

The most of the students' rational thinking scores dropped between first and mid-term but increased between mid-term and final survey. The result reflects that confidence in rational thinking takes time to improve compared to other kinds of CT.

We interpret those positive changes in self-evaluation on CT reflect the enhancement of creative self-efficacy which leads to higher individual creativity and TC. In this study, we identified that the positive changes in creative self-efficacy positively affect TP by comparing the top and bottom three teams. This result could be explained by the previous studies. According to Seo et al. [32], creative self-efficacy influences individual creativity through individual absorptive capacity, exploration, and exploitation. However, as Park et al. [33] indicated, excessively high creative self-efficacy of team members affects TP negatively, the result may become different if the project continued longer.

b) Changes in evaluation by other team members: Divergent and experiential thinking scores of more than half of the students belonging to the top three teams improved among first, mid-term, and the final survey. On the other hand, the convergent and rational thinking score of more than half of the students belonging to the top three teams increased between the first and mid-term survey but did not between the mid-term and final survey. This result indicates that the development of CT to logically narrow down the idea to the best one stops earlier than the CT to spread the ideas experientially to broaden the possibilities. As well as self-evaluation scores, most of the students belonging to the bottom three teams experienced a decrease in CT scores evaluated by other team members. Paired t-test result indicates that students belonging to the top three teams tend to evaluate other team members' CT more positively while the project proceeds.

By interpreting the positive evaluation by team members as collective-efficacy, we confirmed that collective efficacy positively affects TP. This result is explained by the previous studies identifying the relationship between collective efficacy and TP. According to Katz-Navon and Erez [34], collective-efficacy influenced TP when "a highly interdependent task required team members to closely interact and coordinate their efforts". Also, Kim and Shin [35] indicated that "under conditions of low task interdependence cooperative group norms and group positive affect were positively associated with TC, and that collective efficacy mediated these relationships."

6 Conclusions

In order to enhance SA, TC, and TP, two kinds of combinations and timing of CT that the team members should encourage during the team collaboration project are indicated.

First is the combination of "rational" and "divergent" thinking. As for the timing, Akaki & Ioki [12] suggest organizing the team with members who self-evaluate themselves to have sufficient "rational" and "divergent" thinking in the team from the initial phase. This is because rational and divergent thinking had positive correlations with SA from the first survey. As SA and TC have a positive correlation, we consider that higher SA will lead to voices in the team which lead to creativity. TP is affected when other members evaluate that the member is demonstrating "rational" and "divergent" thinking, not just self-evaluation [12]. Also, since rational thinking takes more time to acquire confidence, it is effective to include members with high self-evaluation from the initial phase.

The second is the combination of "divergent" and "convergent" thinking. As the timing, Akaki & Ioki [12] suggest each member start making efforts to control "divergent" and "convergent" thinking according to the situation of the team when the team is organized. The member's level of "divergent" and "convergent" thinking needs to be sufficient enough to be self-evaluated and evaluated by other team members at the final phase of the four months project [12]. Also, in order to achieve higher TP, the team members' evaluation of each other should turn more positive as the team collaboration proceeds.

The limitation of this study is that the number of examinees who felt the effect of SA by receiving CTM was limited to 38.9%. The 2-axis of CT is only a part of the advice sheet proposed in the previous studies [8][9][10] that aim to enhance SA leading to team's higher performance and creativity. We consider that with other components of the advice sheet, for instance, the advice from the advice writer outside the team, SA would be enhanced stronger than by only showing the 2-axis of CT. Although Akaki & Ioki [12] indicated the direct significant positive correlations between SA and TC, it can be predicted that CTM was not the only factor affecting the SA of the

examinees. However, it was valuable to clarify the functions of CTM to positively affect SA through the qualitative analysis to further recognize the value of the 2-axis of CT. Also, regarding the quantitative analysis, we could not conduct anything further besides correlation analysis and paired t-test since the number of examinees was limited to seventy-two graduate school students.

As future research topics, it is necessary to analyze the changes that would happen by applying the two points we indicate in this study to the actual business collaboration situation cases. It can be utilized not only in knowledge creation but other knowledge management phases, for instance, when the team is working to build effective consensus. Also, further researches on a combination of four kinds of CT is possible. In particular, we identified that experiential thinking has different characteristics since there were no positive significant correlations between TP.

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