

Analysis of Task Commitment Types of Science Learning in High School Students' Biology Classification

Won-Jung Kim · Jung-Ho Byeon · Yong-Ju Kwon*

Korea National University of Education

Abstract: The purpose of this study was to analyze task commitment types of science learning in high school students' biology classification. Thirty students were selected as the representatives of five task commitment types according to task commitment type inventory scores. They participated in think-aloud biology classification task. To analyze the procedural characteristics of task commitment, a coding scheme and think-aloud task were developed. Characteristics of respective task commitment types were identified from the result of the think-aloud protocol coding analysis. They are TGC(task goal commitment) type, LGC(low goal commitment) type, CC(conditional commitment) type, SC(suspended commitment) type, and DC(delayed commitment) type. Findings gained from this study are expected to serve as the foundation of task commitment enhancement strategies and as the information on the characteristics of each task commitment type. Also, future studies are required to investigate the commitment-related properties not only in biology classification but also in other science learning situations.

Key words: task commitment type, science learning, task solving process, biology classification, think-aloud

I . Introduction

1. Necessity and Purpose of Study

Task commitment is defined as the tendency to persistently attend to a high-level task until one reaches the task's goal (Kim *et al.*, 2013; Renzulli, 2002). Task commitment is the focal determinant of student success related to confronting unstructured high level tasks (McCayk *et al.*, 1987). Students need to learn how to persevere when confronted with a challenging task. Students are bound to have different task commitment types because they have unique and diverse experiences and interests. These differences lead students to develop different types of task commitment. Understanding these types will help teachers and educators to identify and apply the proper strategy to enhance and maintain student task commitment.

When students perceive the given task as challenging but achievable, they have an

opportunity to increase task commitment (Elliot *et al.*, 1999; Elliot & Thrash, 2001; Greene & Miller, 1996; Meece *et al.*, 1988). In this term, tasks inducing commitment entertain unclarified problematic situations with high-level goal. Task performers do not know the proper solution and face difficulty and uncertainty.

The concept of task used in this study can be related to the concept of "problem" often used in the phrases, "problem solving process" or "problem based learning" (Ferreira & Trudel, 2012; Gagne, 1980). This kind of task features uneasy situations waiting to be solved. It requires task performers to maintain a focused attention and commitment. The task solving process, generally called the problem solving process, is characterized by four steps: task identification, solution planning, solution realization and evaluation (Mioduser & Kipperman, 2002). Task performers obtain, establish and apply a diverse set of knowledge during the task solving process. This is the process of declarative and procedural knowledge

*Corresponding author: Yong-Ju Kwon (kwonyju@gmail.com)

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generation. In other words, the task solving process is the learning process (Barrows & Tamblyn, 1980; Kim & Cho, 2008).

Especially with regard to learning biology, Prokop *et al.* (2007) found that students reported difficulty and decreased interest when performing the biological classification task. They said that this perceived difficulty might have caused some students to be reluctant when learning biology and may have decreased learning motivation. In order for students to overcome such obstacles, task commitment is necessary. In order to classify objects, students must design, apply, and confirm the scientific and objective criteria. This is the process of knowledge generation and application, which is essential for students to resolve the current and potential tasks. Students need to learn how to persevere when confronted with a challenging task. Thus, it is figured that students would exhibit the task commitment when they conduct the biology classification. Students will develop different characteristics of task commitment according to their task commitment types.

On the other hand, task commitment types of science learning can be found through the task commitment type inventory (Kim *et al.*, 2013). The inventory examines three components of task commitment: high goal setting, self confidence, and focused attention. These three components serve as the three factors of the inventory. Students show different score means on those three factors and the difference will reveal as the different types of task commitment. They found out five types of task commitment of science learning through cluster analysis. Such a typology, however, still has a question: how differently students develop the task commitment during the learning situation? Using the task-commitment-type-inventory, teachers and researchers get to know which commitment types students or subjects have. However, inventory scores would not fully explain how different respective types are. Thus, this study tries to find which characteristics are

revealed in each task commitment type when students are given the biology classification task as the science learning task.

2. Literature Review

Type Determinants of Task Commitment

In this study, type determinants of task commitment are defined as the factors deciding the task commitment types. They are created through the interaction of the task commitment components with the task solving process. The procedure extracting type determinants is shown in Figure 1-1. Four types of determinants can be expressed through different behavior types. This variation will cause the difference in task commitment type. These determinants are combinations of task commitment sub-components and task solving steps.

Task commitment is composed of three components and their sub-components (Kim *et al.*, 2013). Three components are high goal setting, self confidence, and focused attention. Sub components of 'high goal setting' are task goal exploration, self goal set, self goal clarification, self goal attainment. Sub components of 'self-confidence' are self confidence by successful mastery experience, self confidence on the goal achievement, self confidence on the strategy and performance, and self confidence from the goal achievement. Sub components of focused attention are attention toward task identification, attention toward the goal of task, attention on strategy and performance, and attention on goal achievement. Task commitment component levels differ among individuals. This is why task commitment presents itself differently among individuals. These components and their sub-components develop in different patterns along the process of task solving. Hence, components must be considered in light of each task solving process when investigating task commitment types.

Task solving process includes four steps:

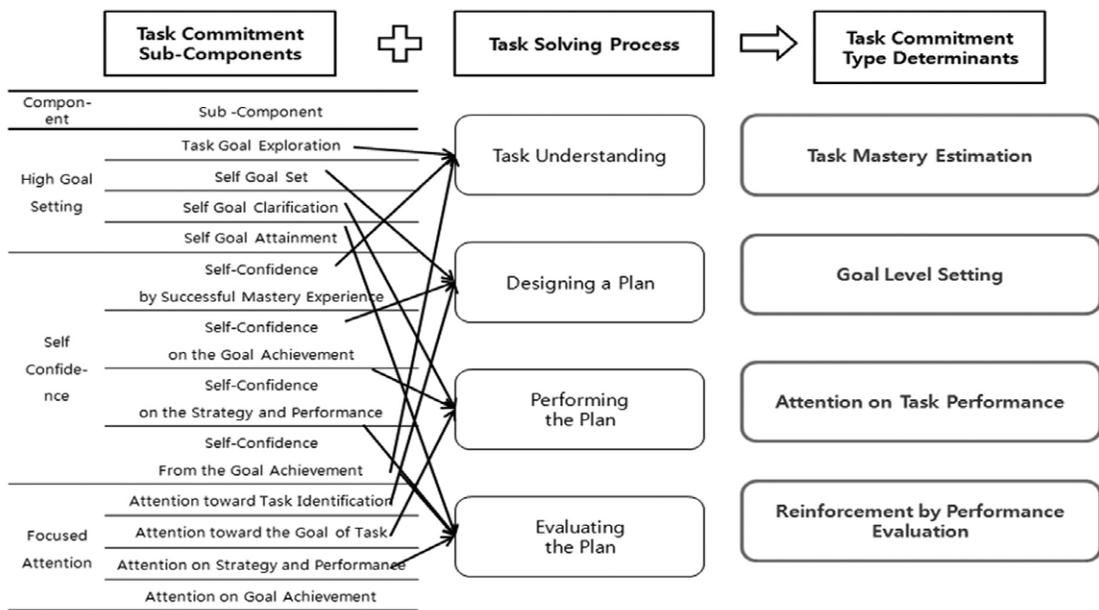


Fig. 1-1 Comparison between tiered tests (tiered-scoring) and conventional multiple-choice tests (partial-scoring)

understanding a task, designing a plan, performing the plan and evaluating the plan. Daiber *et al.* (1991) describe the process moves on task understanding, devising a plan, carrying out the plan and looking back. Sub-components of task commitment were paired with the proper step of the task solving process so as to construct the type determinants. Through the combination, four type determinants were extracted. They are task mastery estimation, goal level setting, attention on task performance, and reinforcement by performance evaluation.

Behavioral Types of Each Determinant

Four type determinants entertain four behavioral types each. These behavioral types of each determinant interact each other in order to establish one’s task commitment type. The first determinant, task master estimation means estimating whether one can succeed in task mastery through investigation on task contents. Performers reveal varied behaviors in the aspect

of task mastery estimation. They can estimate they will master the task or reach to the goal (Zimmerman, 1990). They might estimate task is hard to complete (Bandura, 1997), or they would not figure out whether to succeed or not (Tuckman, 1990). People hesitate to take necessary and decisive actions when they are not sure of task success and have little confidence (Shawer, 2010). Thus, task mastery estimation shows different behavior types: positive estimation, reserved estimation and negative estimation.

The second determinant, goal level setting reveals when designing a plan, which is the second step of task solving. It requires performers to set the goal level (Harkins & Lowe, 2000), have the confidence on goal achievement (Bandura, 1997), and attend to the task’s goal (Overton & Macvicar, 2008). These behaviors are all integrated toward goal setting (Vedder-Weiss & Fortus, 2012). Therefore, the second determinant was named ‘goal level setting’. Which level of goal one chooses to pursue causes

the discrepancy in learners' commitment. Performers can exhibit three types of goal level setting: task goal setting (Anderson *et al.*, 2010; Locke & Latham, 2006), lower goal setting (Alexander & Jetton, 2000), and no goal setting (Hijzen *et al.*, 2007). Here the task goal means highly challenging but achievable goal expected by given task.

Attention on task performance, the third determinant appear when performing the plan of task solving. During this step, performers are actively committed to task with clarified self goal (Locke & Latham, 2002), confidence (Linnenbrink & Pintrich, 2003) and attention on strategy and performance (Schraw & Moshman, 1995).

The last determinant, 'reinforcement by performance evaluation' is presented when evaluating the performance. During the performance evaluation, performers gain feedback and reinforcement. Zimmerman (2002) pointed out the importance of self monitoring and evaluation when learners strive to perform a challenging task and achieve the goal. Learners can reveal different responses to the performance evaluation. Reinforcement by performance evaluation includes four types: sustaining goal and performance (Greene & Azevedo, 2007), achieving task goal (Boekaert *et al.*, 2000; Butler & Winne, 1995), achieving low goal (Meier & Albrecht, 2003), and giving up performance (Meier & Albrecht, 2003).

Each determinant of task commitment interacts one another and the interaction causes difference in task commitment style (Locke & Latham, 2002; Shernoff, 2003; Hall & Foster, 1977). Based on these findings on the interaction of determinants and behavior types, this study hypothesized that subjects of different commitment types would represent heterogeneous commitment behavior during task performance in the aspect of task mastery estimation, goal level setting, attention on task, and reinforcement by evaluation.

II. Methodology

1. Subjects

Thirty high school second graders from Daejeon city participated in this study. They were selected as the representatives of five task commitment types among students who answered to the task commitment type inventory. In other words, six students per each type were chosen as the subjects to perform the biology classification task. They conducted the shell and seed classification task while thinking aloud. Their verbal protocols were converted to the coded protocol based on the coding scheme.

2. Analysis on Characteristics of Each Commitment Type

The process analysis on characteristics of each commitment type has three steps: coding scheme/task development, data acquisition and data analysis. In order to design the coding scheme, literature analysis was conducted and type determinants and behavioral types of each determinant were extracted. At the same time, the think-aloud task was developed. Coding scheme and thinking aloud task items took the content validity test.

2.1. Development of Coding Scheme and Thinking Aloud Task

Coding Scheme Development

Four type determinants were extracted and used as the coding scheme categories. Further literature analysis focused on the behavioral sub-types within each determinants. The developed coding scheme is introduced in table 2-1. This coding scheme was confirmed with a validity test by two science education experts. They tested the every code definition and example through coding scheme test sheet. They scored the validity from 5 to 0 according to the level of validity. This process continued until the

Table 2-1
The developed coding scheme

Determinant	Behavior Type	Code	Predicted Protocol
Task Mastery Estimation	Positive Estimation	EsP	<ul style="list-style-type: none"> · I know how to do task such like this. · It looks interesting. · It might be solved if I do it as I did before · It looks possible if I once do it.
	Reserved Estimation	EsR	<ul style="list-style-type: none"> · I am not sure and just I need to start. · Let' s do it once then I would figure it out. · I don' t know whether I can do this well or not.
	Negative Estimation	EsN	<ul style="list-style-type: none"> · It looks boring. · It is too difficult to succeed. · It's impossible to make it. · Ah... I cannot do this.
Goal Level Setting	Setting Task Goal	SeTG	<ul style="list-style-type: none"> · I will do this until I will complete the task demands. · Let' s do it to the end. · Since I have to reach to the goal..
	Setting Lower Goal	SeLG	<ul style="list-style-type: none"> · It is likely that I can find two keys and more than two is.. not necessary. · Finding three clues is easily possible.
	Setting No Goal	SeNG	<ul style="list-style-type: none"> · I don' t know which goal I have to make. · Just, (without specific goal setting) · I don' t know how many keys I can find
Attention on Task Performance	Attention on Task Relevant Elements	AtTR	<ul style="list-style-type: none"> · Applying this key. · From that part (of given information) · Because this key can be applied to them.. · This is possible as a classification key...
	Attention on Task Goal Approach	AtGA	<ul style="list-style-type: none"> · How closely am I coming for the task completion? · Am I coming in the right direction? · How many things are remained before completion?
	Attention on Task Irrelevant Elements	AtNT	<ul style="list-style-type: none"> · What is the sound out there? · Is the lunch time outside? · I am too hungry to do this.
Reinforcement by Performance Evaluation	Sustaining Goal and Performance	SuGP	<ul style="list-style-type: none"> · Maybe my solution would not be right, so let's do it differently. · If trying in another aspect · If viewing this with another key
	Achieving Task Goal	AcTG	<ul style="list-style-type: none"> · This is the best what I can do. · I met the goal task expected.
	Achieving Low Goal	AcLG	<ul style="list-style-type: none"> · Ok, I met the goal I set. · Anyway, I made it even though it is lower than task demand.
	Giving up Performance	GuP	<ul style="list-style-type: none"> · I cannot do this and just want to stop it. · I am sorry but I want to give it up. · I cannot do it as much as I planned.

code got the score of 5 from both of the experts. The first determinant, ‘task master estimation’ involves three behavior types. They are positive estimation, reserved estimation, and negative estimation. Codes representing each of the types are EsP, EsR, and EsM respectively. The second determinant, ‘goal level setting’ includes three behavior types. They are setting task goal, setting low goal, and setting no goal. Codes for each are SeTG, SeLG, and SeNG. The third determinant, ‘attention on task performance’ involves three behavior types of attention on task relevant elements, attention on goal approach, and attention on task irrelevant elements. Codes for each are AtTR, AtGA, and AtNT in turn. The last determinant, ‘reinforcement by performance evaluation’ has four behavior types of sustaining goal and performance, achieving task goal, achieving low goal, and giving up performance. Codes for each are SuGP, AcTG, AcLG, GuP.

Thinking Aloud Task Development

Two conditions should be concerned with regard to think-aloud task (van Someren *et al.*, 1994). First, the task should be difficult enough. Subjects must experience challenge of the given task without it being neither too easy nor too difficult. Second, the task must provide an opportunity for subjects to represent their cognitive process. In the case of this study, students must exhibit task commitment through their science task solving process.

In order to choose the objects, previous studies were referred. Objects used in previous studies include bird feathers, pollen, seeds, shells and so on (Kwon *et al.*, 2007; Kwon & Lee, 2010; Park *et al.*, 2010). Among these, shells and seeds were selected as the objects of classification task through expert consultation and pilot test. Three conditions were considered. Objects must be tangible and identifiable with eyes. Also, objects should be difficult enough to generate task commitment.

Accordingly, subjects were asked to “find as many scientific classification keys as possible

while speaking aloud everything that goes through your mind.” They were also asked to “express your goal level and task mastery estimation whenever they occurred in your mind.” These requirements were recited using a written script. Researchers introduced the thinking aloud session, by reading out the script. The content validity of the think-aloud test was also tested by two science education experts and three current middle school teachers.

2.2. Data Acquisition

Among 462 students who participated in inventory survey, thirty participants were selected as the subjects of think-aloud task. They were included in one of five task commitment types of science learning. Six subjects per each type took part in the thinking aloud task. They participated in the main task after their training session.

During the task, participants generated potential classification keys and confirmed whether the keys were proper or not. The process was paralleled with thinking aloud. The entire processes participants conducted the task were audio/video taped. The researcher interviewed subjects to confirm missed or omitted thought fragments after thinking aloud. The researcher asked, “What did you mean with this thinking aloud?” or “Did you have any other thought between these?”

2.3. Data Analysis

The verbal protocols were transcribed by two independent researchers so as to secure the reliability of transcription. Transcribed protocol was segmented into the meaning unit. Segmented protocol was coded based on the coding scheme. Coding was done by two independent researchers in order to ensure the reliability. If their codes were splitted each other, they discussed till they were agree to the most appropriate code. The code structure of each type was visualized and compared to one another so that the researcher could distinguish the

characteristics of each task commitment type present in the science learning task.

III. Results and Discussions

1. Characteristics of Task Goal Commitment Type

Type A was the group that showed the highest mean score in task commitment type inventory. This type was named 'task goal commitment (TGC)' type because the six subjects of type A commonly reached the task goal with sustained attention. The coded protocol of the six subjects were integrated in the following sequence: (EsN → EsR → **EsP** → (SeNG → SeLG →) **SeTG** → {**AtTR** ⇌ (AtGA) ⇌ **SuGP**}*N → **AcTG**. These subjects showed three commitment characteristics during the classification task.

1.1. TGC type subjects showed the combination, [EsP → SeTG].

A-3, A-4 and A-5 started both tasks and set their task goals with a positive estimate. With sustained attention paid toward the task, they achieved their task goals.

A-3: 6 keys the most if I do it well? Let's make it once. Ok, I will find six keys.

A-4: Oh, it looks very difficult. Hm, but there are many cues so I think I can find the most. I have to stick to it, right?

The other subjects did not start with a positive estimate, but they developed a positive sentiment gradually. They upgraded their goal, determined to find as many solution keys as possible.

A-1: (When he found 6 classification keys during the shell task), I feel better now and it is interesting to find and apply keys. I think I can do it more.

A-2: (Starting the shell task), I never know how I do this and I cannot set up the goal. I

just want to start...

(When he found three keys), I think I can make it.

They revealed the 'EsP SeTG' combination in the beginning or middle of the task solving process. Butler and Winne (1995) support this trait. They describe committed learners pull out knowledge and confidence to analyze the task requirements. Based on that analysis, they set goals. Goals lead these learners to update strategies and practice it until they succeed in task mastery.

TGC type set challenging but achievable goals when they had self confidence. Self confidence preceded the high goal setting. This order is backed by the finding that one's confidence is a precursor to goal choice (Greene *et al.*, 2004). Locke and Latham (2002) described characteristics of committed learner with high goal and self confidence. This type of learners attempts various activities and exerts more efforts. They also reveal perseverance through harder effort and manipulate more effective strategies. Such a series of committed actions was also reported by Hijzen *et al.*, (2007). They said that achieving learners tend to focus on completing the task in a successful and responsible manner based on the solid goal pursuit and positive attitude.

1.2. They continued the task until they reached the goal [AtTR ⇌ SuGP → AcTG].

All subjects showed consistent attention toward the task performance until they completed the task. Most of the task time was invested in completing the task. They searched for the classification keys, applied them to each object, and confirmed those keys were right to apply or not. If one key was not applicable to every object, then the key was canceled and they found another key. In total, they found 5~11 classification keys. A-2's following protocols are one example demonstrating attention on task-relevant elements:

A-2: Whether the pattern is regular or not, 3, 10, and 9. These objects have irregular patterns on the surface regardless of the texture. But, 11, 4, 1, 8, 5, 2, 7, 13, 6 have the regular pattern. Yes, this can be one.

By confirming the suitability of keys, subjects are able to continue the task. This is SuGP, sustaining goal and performance. In this study's classification task, subjects would find more keys than expected, in order to generate the maximum number of possible keys. Also, the protocols of SuGP include the statements on the observation required to continue the performance.

A-4: And then, green... green. (Looking at each shell)

A-5: Let's classify one more time within clam shells. This, yes. I am comparing the ratio of length and width. Ok. Then, I will classify in this way.

The number of keys subjects made varied because of individual perceptions of task difficulty. However, a commonality among the six subjects' goal setting was that they targeted the challenging goal level or they heightened the goal level along the performance so that they could meet the task goal.

(Ending the seed task),

A-1: I was determined to find 7 keys but I found two more keys and that was the maximum. I am finished.

A-2: These are the best I can. Here is finished.

During retrospective interview, A-5 and A-6 even pointed out that they could find more if other measuring tools were offered.

A-5: I did my best. It would be better if I could confirm more keys. For example, I can weigh or drop some solvent on the shells.

A-6: I think I can find more, but the tools are

necessary. At this condition, I find the maximum.

1.3. Subjects utilized the attention on the goal approach while attending to the task and sustaining the goal [AtTR \Leftrightarrow (AtGA) \Leftrightarrow SuGP].

All subjects except A-2 presented attention on the goal approach in the middle of the task performance. They checked to see how many classification keys they made and whether those keys were objective and acceptable. It is perceived that the subjects evaluated their progress and encouraged themselves to stick to the task until it was achieved.

A-3: Smooth or rough? But, I think this seems hard to be objective key. Let's see another distinctive key.

It seems that I found 6 keys as I planned. Let's look back. Yes, those are pretty objective.

A-5: No, this is not proper. It must be objective.

I have one key to classify subjectively. But that's neither scientific nor objective. I am trying hard not to make improper key.

2. Characteristics of Low Goal Commitment Type

Type B demonstrated the second highest mean score of task commitment type inventory, so they were expected to demonstrate a moderately high level of goal setting, attention to task, and confidence. Type B was named 'low goal commitment (LGC)' type since the subjects of this type set a low-level goal, and tended to stop the task once they reached that low-level goal. General traits shown in the six subjects of this type are characterized in two ways.

2.1. They set a low-level, rather than completing the task, and then terminated the task once they met the low goal [SeLG \rightarrow AcLG].

Subjects in type B set a low-level goal compared to the task goal. The goal of this task was to find the maximum number of objective classification keys, but subjects in this type set easily attainable goals.

Whether the goal was easily attainable or challenging enough cannot always be revealed by the protocol itself, but the retrospective interview offered information on the perceived goal level. Protocols in square bracket are gained from the retrospective interview.

B-2: I predict that I can find only one key. [I was embarrassed because task such like this is the first time for me. I could not figure out the commonness from these items.]

B-4: Firstly, three? Three seems possible.

B-6: It looks not easy. Size, color, and pattern. Three is possible.

Subjects first scanned the items of the given tasks and then figured out how many possible classification keys existed. Therefore, keys generally included the size, color, pattern, or shape which were superficial and qualitative. They terminated task performance when they met their low-level goal. They put more value in attaining their goal than in completing the given task.

This type is close to the students whose goal is to demonstrate one's existing ability (Greene & Miller, 1996; Meece *et al.*, 1988; Sawtelle *et al.*, 2012; Somers & Birnbaum, 1998). They tend to set easily attainable goal to show their own perceived faculty rather than challenge toward high-leveled task. They are reported to show shallow processing strategies when compared to students who take mastery goal, or task goal named in current study (e.g., Elliot & Thrash, 2001; Elliot *et al.*, 1999; Greene & Miller, 1996; Meece *et al.*, 1988). Therefore, they set their goal as highly as possible to easily solve. This becomes a lower goal than challenging goal that task offers.

2.2. Attention on task relevant elements was split by non-task elements or negative estimate on the task mastery.

Comparing to the subjects of type A, those of type B revealed the split form of 'AtTR \rightleftharpoons SuGP' combination. This is comparative to the TGC type which showed no such separation. It is worth considering why the 'AtTR \rightleftharpoons SuGP' combination was split. There were two cases dividing the 'AtTR \rightleftharpoons SuGP' combination: when attending to the non-task relevant elements or when estimating negatively about ability to master the task.

First, attention toward task relevant elements was interfered by attention paid to the non-task relevant elements. Here, non-task relevant elements include embracing improper key applications. B-5 established a subjective classification key after he found three objective ones. He reported in the retrospective interview that he thought he could not find more so he chose to apply a subjective solution even though it was less proper. Whether one has had the item might not be appropriate as the objective key of classification because it depends on one's personal experience.

B-5: [I was eager to find more but nothing appeared so I decided to use this.] This time, I will classify according to whether I have ever eaten or not. This is bean and I have eaten this before. I am not sure about 'j' then, it seemed that I ate it once. I don't know 'c'. 'a' is what I have eaten. So 'f' is. Remainders are not familiar as food for me.

Next, negative estimations on task mastery ability in the middle of the task performance distract attention from the actual task. It places more attention on one's perceived ability levels and less on completing the task.

B-1: (While searching for the key), they look similar. It is too complicated to distinguish.

Speaking out alone is also uneasy.

B-6: (After finding one key), it looks hard to classify. They are too different to find the similarity.

3. Characteristics of Conditional Commitment Type

Type C demonstrated the middle level scores of the three factors. Thus, it was estimated that this type's subjects would demonstrate mid-range of levels of goal setting, attention to task and self-confidence. Type C was named the 'conditional commitment (CC)' type because their performance tended to be contingent on the perceived difficulty or demand of the given task. In short, CC type subjects resulted in different outcomes. When they felt the task was easy to complete, they progressed smoothly, achieved their goal. However, if they saw the task was difficult to master, they stopped working. Three traits of the CC type were discovered:

3.1. Subjects of the CC type set a low goal, just as subjects of the LGC and SC type did.

All six subjects of CC type set the goal that one can achieve with ease. Setting an easily attainable goal in this classification task is categorized as SeLG (low goal setting). This task requires students to strive to find the maximum number of classification keys. The mission was hardly perceived as easy one. If a subject internalized the mission of the task and tried to find as many keys as possible for as long as possible, the person was considered to be committed to the goal. Even if the subject initially set a low level goal, he or she could upgrade the goal level if they achieved the easy goal. Task goal setting was featured as the TGC type's goal setting behavior.

Meanwhile, the CC type was geared toward setting an easily attainable goal or a seemingly possible level of goal. A stepwise upgrade of goal level was not seen in this type. Low goal setting was the trait of LGC and SC types. Thus, it can

be found that LGC, CC, and SC types share the common trait of low goal setting, but they develop different levels of commitment along the task solving process.

Protocols of goal setting accompany those of the task mastery estimate. Following protocols are examples of protocols about goal setting and task mastery estimate in the case of CC type subjects. Parentheses introduce the codes of respective protocols.

C-1: I don't know much about this. (EsN, Negative estimate)

5? Finding 5 keys seems quite easy. (SeLG, Setting Low Goal.)

Shape, size, texture, color, hm.... those I have eaten or not.

C-6: Finding six keys seems possible for now. (SeLG + EsP)

In the case of C-3 and C-4, whether they set the easy goal had to be confirmed by the retrospective interview.

C-3: [*Retrospective interview*: When I decided to find six keys, it seemed not burdensome because some keys were already seen then.] (SeLG)

C-4: [*Retrospective interview*: I don't know about seeds or shells so I thought it would be less embarrassing if I did not struggle to find the maximum. But I knew that I had to do this.] (SeLG)

3.2. CC type subjects reveal conditional commitment resulting in low goal achievement and ceased performance.

CC type subjects either achieved the low goal or otherwise ceased the performance. To which outcome one reaches should be considered in the respective subjects' commitment process. It depended on the perceived difficulty of the task and how the goal was approached. They commonly reported that the seed task was more confusing than the shell task and that they

knew little about the seeds. This caused them to cease task performance during seed task.

C-1: (Ending shell task), I am done. I think I found some.



(Ending seed task), I meant to find five at first. But I think I cannot find more. They are confusing. There would be more but, I am not sure.

C-4: (Ending shell task), I am done. Am I doing well? I found four.



(Ending seed task), I know little about this. There must be more. But, this is making me shrunk now. So I want to quit this.

C-5: (Ending shell task), (*He decided to find four keys and finally found four keys and said*) I am done.



(Ending seed task), I am done. It seems that I am finishing too quickly but I know little information on seeds. They are not sure. So... I am done. now.

When subjects quit the task, they mainly reported that there was a lack of information and a lack of sureness in the keys they made, both of which were germane factors in their low level of self confidence. These caused an irregular behavioral outcome in CC type.

3.3. The combination of three codes, [AtGA ⇔ AtNT ⇔ EsN], was dominant in CC type subjects' protocols.

Compared to the TGC or LGC types, the CC type demonstrated a divergent code procedure. It was because attention to goal approach, attention to non-task elements and negative estimate interrupted the combination of [AtTR ⇔ SuGP]. Of course, CC type also represented the [AtTR ⇔ SuGP] pairs like TGC or LGC types. However, the split of the combination was

dominant in this CC type.

The statements on the AtGA were especially connected to the EsN or AtTR. This is quite different from the TGC type in which AtGA was linked to task goal achievement. This indicates that AtGA manifested differently in the TGC and CC types. AtGA is the attentive behavior related to the questions, "how well am I doing?" or "Where am I?" The TGC type uses the AtGA to succeed in the task. However, the CC type tended to be wavered by AtGA and linked to the EsN or AtNT.

C-1: I don't know. I am messed. (EsN)

Sound when the cup was shaken? (AtNT)

No, it must be objective. Ha..... (AtGA)

C-2: No, no . it must be scientific. (AtGA)

How about stickers on the surface? (AtNT)

What can be there? Difficult... (EsN)

The CC type features low goal setting and a split combination of AtTR and SuGP by the AtGA, AtNT, and EsN. Moreover, the level of reinforcement by performance evaluation was heterogeneous as two kinds, AcLG or GuP.

4. Characteristics of Suspended Commitment Type

Type D gained the second lowest score means. From this statistic result, the researcher predicted that subjects of type D would exhibit a moderately low level of commitment during the classification task. Type D was named 'suspended commitment (SC)' type because they ceased task performance even though they did not accomplish the goal of the task with digression to task-irrelevant elements and lowered confidence. This type revealed two common traits.

4.1. SC type showed the combination of [EsN ⇔ SeLG].

The SC type set a low goal based on a negative estimate of task mastery or vice versa. Even the one subject who started with a positive estimate,

developed a negative one during the performance. This dominant combination of [EsN \rightleftharpoons SeLG] is unique to the SC type. Generally, the TGC, LGC, and CC type showed arbitrary pattern related to the task mastery estimate. This trait is also different from the SC type who reveals the strong linkage of negative estimate (EsN) and no goal setting (SeNG).

D-1: I will try it once so that even one keys I can discover. (SeLG)

(After finding one key), The more I do the more it is susceptible. It is difficult to be sure on my choice. (EsN)

D-2: These seeds are not likely to be classified. (EsN)

Then, I will make two keys. (SeLG)

D-4: I have done similar task before, then it didn't work, so. (EsN)

3? seems possible for now. (SeLG)

4.2. SC type showed the combination of [EsN \rightleftharpoons GuP].

A negative estimate was not only linked to low goal setting but also to quitting. Even those who started with a positive estimate developed a negative estimate of success and ended up giving up on the task.

Therefore, the combination of [SeLG \rightleftharpoons EsN \rightleftharpoons GuP] characterized the SC type. Negative estimate is related to a low level of confidence. Low goal setting is linked to lowered motivation. This led to a lack of performance completion. Thus, giving up on one's task would feed back negatively on one's commitment. This cyclic interaction starts from EsN or SeLG. Thus, educational intervention is required in order to enhance the confidence and goal level of SC type. This finding corresponds to the conclusion reached by Greene et al. (2004). They reported a feeling of low competence can lead to task avoidance and performance withdrawal. Learners become disengaged from the task if they recognize they did not progress as well as they thought they would and if they feel the

obstacles are heavily encountered (Butler & Winne, 1995).

D-3: Then, how can I make it into the objective key? Colors are not matched neither. I feel nervous now. (EsN)

(After finding one key), I want to finish here. (GuP)

D-5: Finding objective keys is too difficult. (EsN)

I want to stop here. (GuP)

D-6: I am observing now, but I am not convinced with my solution. (EsN)

Ah, I stop here. Embarrassing. (GuP)

5. Characteristics of Delayed Commitment Type

Type E scored the lowest means of three factors. Based on the result, it can be predicted that subjects of type E would exhibit a low level of commitment during the classification task. Type E was named the 'delayed commitment (DC)' type due to their hesitation and reluctance to begin the task. They commonly revealed integrated sequences such as 'EsN \rightarrow SeNG \rightarrow (AtTR \rightleftharpoons AtGA \rightleftharpoons AtNT) \rightarrow GuP.' They set no goals and even made no classification keys satisfying the task condition. The six subjects in this type revealed the following characteristics.

5.1. All DC type subjects negatively estimated their ability to complete the task successfully, set no task goal and gave up on the task. The linkage [EsN \rightarrow SeNG \rightarrow GuP] was obvious.

Subjects in this type set no goal at first and did not upgrade the goal level. The other four types often started the task with no goal, but they naturally set the goal along the performance process. Such goal level transformation was not discovered in this type.

E-1: This is too hard. How can I compare these? (EsN)

(Goal setting behavior was not presented)
(SeNG)

With the number of stickers? ([bserving the items])

Boring.. I cannot do this. (GuP)

E-6: I don't know. I feel I cannot make it. (EsN)

Familiar things and otherwise.

Then, size.. Ah.....(making no protocols)

(After researcher's urging), I, I. Can I stop here? (GuP)

5.2. AtTR(attention toward task relevant elements) were seldom connected to SuGP (sustained goal and performance).

The other four commitment types revealed the interaction between AtTR and SuGP. This is the process of classification key finding. When discovering the key, they applied it to the items, and confirmed the key. However, the combination of AtTR and SuGP seldom occurred in the DC type. E-3 made one key during the seed task. E-6 discovered one key during shell task. They were, however, hesitating to apply their 'possible keys'. Some subjects observed the items and questioned themselves, saying "Size? Size can be the key?" Other students even stated "Colors are different" or "This is sharp-edged." The main difference between the DC type and the other four types was that they hesitated to apply the key.

When compared to the subjects of the SC type, who each tried the given task at least once, the subjects of this type made few attempts to complete the task. In the training session, they displayed a normal performance in thinking aloud but when conducting the main task, they delayed in completing the task. Therefore, the SC type must be evaluated based on task commitment, not intelligence or verbal ability.

The SC type's hesitation or reluctance can be interpreted in several ways. They might have been less motivated, less focused, or less confident. This behavioral trait should be understood through an educational perspective. Strictly speaking, this type cannot be said being committed because it hardly demonstrates the sign of commitment.

However, they at least tried to pay attention to task-relevant and sometimes task-irrelevant elements. In short, they made an observation. Observation is the antecedent process of classification. Every subject of the DC type conducted an observation whether it was related to the task or not. This information indicates how and when teachers can intervene to enhance the commitment of DC type students. In the case of the classification task, for example, teachers can lead students to participate in an observation first and encourage them to generate varied information through the observation. This would be the starting point where hardly-committed students transform their commitment type to a more enhanced form.

Based on the qualitative analysis, this study identified the traits of commitment types appearing in the seeds and shells classification task (Table 3-6). Identified traits of each type were extracted from the common codes appearing throughout the six subjects of each type.

IV. Conclusions and Implications

This study aimed to investigate task commitment types during biology classification tasks. Five types of task commitment were named after its procedural characteristics revealed in the subjects' biology classification task performance. Characteristics of respective task commitment types were identified from the result of the think-aloud protocol coding analysis. Five types were equated to five types of task commitment. They are TGC(task goal commitment) type, LGC(low goal commitment) type, CC(conditional commitment) type, SC (suspended commitment) type, and DC(delayed commitment) type. TGC type exhibited a positive estimate on task mastery, sustained the attention, and achieved the task goal. LGC type set a low-level goal and paid attention to task until they just achieved the low goal. CC type demonstrated conditional commitment according to the perceived difficulty of task and the

Table 3-1
Characteristics of the physics test for eleventh graders

Type	Task Commitment Process Characteristics
TGC (task goal commitment)	$(EsN \rightarrow EsR \rightarrow) EsP \rightarrow (SeNG \rightarrow SeLG \rightarrow) SeTG \rightarrow \{AtTR \rightleftharpoons (AtGA) \rightleftharpoons SuGP\} * N \rightarrow AcTG$ <ul style="list-style-type: none"> • Positive estimate and high goal setting revealed by combination of [EsP → SeTG] • Continuing the task until they reach to the goal. [AtTR ⇌ SuGP → AcTG] • Attending on the goal approach while attending to the task and sustaining the goal level [AtTR ⇌ (AtGA) ⇌ SuGP]
LGC (low goal commitment)	$(EsP \rightarrow EsR \rightarrow) EsN \rightarrow SeLG \rightarrow \{AtTR = SuGP\} * N1 \begin{matrix} \rightarrow AtNT \\ \rightarrow AtGA \end{matrix} \rightarrow \{AtTR = SuGP\} * N2 \rightarrow AcLG$ <ul style="list-style-type: none"> • Setting low-level goal than task goal and terminating the task when they met the low goal [SeLG → AcLG]. • Attending on task relevant elements was split by non-task elements or negative estimate on the task mastery.
CC (conditional commitment)	$(EsP \rightarrow EsR \rightarrow) EsN \rightarrow SeLG \rightarrow \{AtTR \rightleftharpoons \begin{matrix} AtGA \rightleftharpoons \\ AtNT \rightleftharpoons \end{matrix} SuGP\} * N \begin{matrix} \rightarrow AcLG \\ \rightarrow GuP \end{matrix}$ <ul style="list-style-type: none"> • Setting low goal • Conditionally committed, resulting in low goal achievement or ceased performance • Combination of three codes, [AtGA ⇌ AtNT ⇌ EsN]
SC (suspended commitment)	$(EsP \rightarrow EsR \rightarrow) EsN \rightarrow SeLG \rightarrow \{AtTR \rightleftharpoons \begin{matrix} AtGA \rightleftharpoons \\ AtNT \rightleftharpoons \end{matrix} SuGP\} * N \rightarrow GuP$ <ul style="list-style-type: none"> • Interaction between negative estimate and low goal setting [EsN ⇌ SeLG] • Interaction between negative estimate and Performance give-up [EsN ⇌ GuP]
DC (delayed commitment)	$EsN \rightarrow SeNG \rightarrow AtTR \rightleftharpoons AtGA \rightleftharpoons AtNT \rightarrow GuP$ <ul style="list-style-type: none"> • Negatively estimating their success in task, setting no goal and giving up the task [EsN → SeNG → GuP] • Disconnection between task-oriented attention and sustained performance

process of task solving. SC type set a low goal, but ceased performance in the middle of the task with a negative estimate on successful performance. DC type subjects delayed performance initiation and set no goal with a negative estimate on performance success.

This study identified the typological properties of commitment in the biology classification task. Findings gained from this study offer several educational implications. First, characteristics of

each commitment type serve as the foundation designing task commitment enhancement strategies. This study adopted the vertical typology rather than the horizontal one. In other words, the respective types are not equal in their commitment levels. TGC is the most committed type while DC is the opposite. The reason this study chose to elaborate on vertical typology is to gain information on the educational strategy of task commitment enhancement. From

findings on each type's characteristics, a stepwise strategy can be formulated. The differentiation among five types offers a clue for the task commitment enhancement strategy. The transformation from DC type to SC, CC, LGC, or TGC type is plausible. For example, the DC type first needs to attempt like the SC type and the LGC type needs to upgrade its goal level in order to upgrade to the TGC type. However, this stepwise transformation does not always seem easy for students to make by themselves. Students can develop their commitment through positive task-related experiences, stepwise goal setting and achievement. Teachers can then use this to help increase confidence and to provide feedback tailored to each learner. The properties of the TGC type, in particular, can furnish researchers with precise commitment processes and strategies. The type features the internalization of the task goal, confidence, high goal setting, and task-oriented attention. The internalization of the task goal is necessary for students to commit themselves to science learning (Butler & Winne, 1995; De Corte, 1996). Furthermore, increased self confidence heightens the goal level and the individual's involvement in the task (Hall & Foster, 1977). Once learners select goals, they pay attention to reach those goals (Anderson et al., 2010; Butler & Winne, 1995). This finding on the order of task commitment implies the possible strategy for task commitment enhancement.

Especially, the conditional commitment of the CC type indicates that the task itself should be taken into account as a part of the strategy. The CC type features a wavering commitment level. This reflects the task's effect on one's commitment. Therefore, science learning tasks targeted to foster one's commitment should be developed.

Findings gained from this study are expected to be the foundation of task commitment enhancement strategies and as the information on the characteristics of each task commitment type. Also, future studies are required to

investigate the commitment-related properties not only in biology classification but also in other science learning situations.

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