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MCY-Mentoring Activities by Creating and Communicating Mathematical Objects[1]

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In recent years, an increasing number of viewpoints hold that students should be engaged in a learning environment where understanding and knowledge transfer take place. This study introduces Mathematics Created by You (MCY)-mentoring program, which allows students to construct *artefacts* that are required to learn. This program is online-based and so can be shared by several people and mathematics leaning takes place through interactions within this carefully designed environment. Also, MCY intends to provide students a series of sequential activities related to creative play, creative learning and creative inquiry based on a Constructive and interactive environment. Furthermore, a creative activity- constructing a creative product using building blocks- was presented as an example. Finally, we investigate the pedagogical implications and suggest directions for the further development.

Keywords: MCY-mentoring, constructionism, creativity, mathematics, artefact

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INTRODUCTION

It is widely accepted by many researchers that active learning approaches such as asking questions, searching for constructions and creating abstract concepts should be adopted in order for students to understand and transfer the knowledge when they learn mathematics and science. There has been recently a growing interest toward the technology-based learning which requires students to actively participate in their learning by developing simulation activities. At the same time, numerous studies have demonstrated the efficiency of technology-based learning. (Jonassen, 1991; Mayer, 2002; de Jong *et al*, 2010)

The Science Crated by You (SCY) project is currently underway in Europe to address this matter. This project reflects the spirit of constructionism which believes knowledge construction takes place when students are engaged in building objects. In fact, SCY learners are supposed to work on missions by producing ‘emerging learning objects (ELOs)’ that are created by them. In order to accomplish these missions, students are required to be equipped with integrated knowledge of different domains (*e.g.*, physics and mathematics, or biology and engineering). In these activities, students perform like scientists who are exploring and creating science. Their productive learning activities include designing a plan and stating a hypothesis, doing experiments, analyzing data and discussing the results. In this study, we propose Mathematics Created by You Mentoring (MCY-mentoring) which applies mathematics to SCY principles and discuss the pedagogical implications of MCY by investigating the examples that were posted on a mentoring program website (http://mentoring.snu.ac.kr).

The Mathematics Created by You (MCY) is a online-based program, it is basically connected with mathematics, but it is not limited just mathematics. It is, in fact, not only connected with LEGO games, but also it can be applied to mathematics learning and exploring. In addition, MCY program intends to provide students an environment where they can perform like mathematician by creating mathematics and communicating with peers and they can experience creative mathematics through this program.

THE MCY-MENTORING PEDAGOGICAL APPROACH

As there has been a change in cognitive science, it is now granted that cognition is not a passive reflection of the universe (Lakoff & Núñez, 1997). Instead, it is resulted from the interactive relationship between a physical body and environment. Such change has resulted in a new stance that human body, brain and environment should be reconsidered. This stance holds that mind should be understood as an interactive function of human brain, body and environment and it led to the view of embodied cognition. To support this point of view, a number of studies have demonstrated that physical condition has influence on human's mind, just like laugh can make people happy. For example, Lakoff & Núñez (2000) described embodied cognition from the mathematics perspective. They stressed that mathematical concepts can be formed using body sense and brain, while it can be build up by our mind. In other words, mathematics is conceptualized by both our body and mind.

As this cognition paradigm shift, the relationship between mind and brain has been attracted much attention in the field of cognitive psychology. Consequently, it called for a need to change educational environment into a place where experience and operational activities are emphasized. Radford (2005) claimed that sensorimotor experience in the first stage of Piaget's theory will be the foundation of the higher cognition in the future. MCY-mentoring, therefore, is developed based on interactive learning which fairly considered the interactive relationship between Constructionism and environment.

Constructionism-based environment where can create specific artefacts

Constructionism proposed by Papert is based upon Piaget's constructivism, but it is more pragmatic because it contains specific methods and strategies. As Ackermann (2004) pointed out, both Papert and Piaget's theories hold the same view, while Papert's constructionism focuses more on the role of media. Papert's constructionism, in other words, holds that learning occurs when 'physical construction' like building artefacts transforms to 'mental construction' through media. This notion has been well explained by Kafai & Resnick (1996).

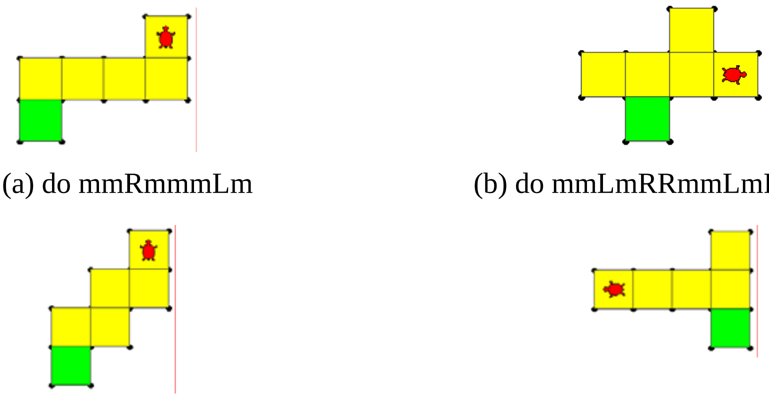
MCY-mentoring program is basically inspired by Constructionism theory. It helps learners build specific artefacts in media context that aims to boost the idea of 'learning by making, learning by design'. We believe MCY-mentoring program which is based on constructionism theory will help learners acquire metacognitive knowledge as well. Anderson & Kraftwohl (2001) illustrated different levels of knowledge: factual knowledge, conceptual knowledge, procedural knowledge, meta-cognitive knowledge. He addressed that factual knowledge and conceptual knowledge seemed to be like knowledge fragmentation that can be collected and classified, while procedural knowledge and metacognitive knowledge were identified as the ability that can collect, arrange, process, evaluate, integrate and analyze the lower level knowledge such as factual knowledge and conceptual knowledge. In this sense, procedural and metacognitive knowledge are more emphasized in our MCY program, rather than factual or conceptual knowledge. For example, let's take a look at an activity which asks students to construct a regular tetrahedron. Traditional Instructionism learning theory will ask students to explore the properties of the tetrahedron by providing pictures and definitions. However, in MCY activities, students were exposed to the experience that can help them understand how this object is consisted and what each side looks like before starting to explore its properties. The specific experience refers to the process that intellectual curiosities and thoughts are triggered after observing and operating the structure, rather by watching videotapes. In this way, learners' knowledge about a tetrahedron does not stay in fragments or disassociated. Instead, the whole process how they built knowledge about the object is branded in their minds. They will consider what if they change angles of folding papers in the previous stage. Therefore, this learning experience will lead to learners' metacognitive knowledge that can reflect and transfer learner's thoughts. We believe learners will make good use of the artefact which has been created by triggering their thoughts and intellectual curiosities in MCY activities and the artefact will also serve as a good material and tool when they learn and explore mathematics, also it can be a tool of communication and evaluation as well.

Interactive learning based learning environment which allows learner-object and learner-learner interactions

It has been acknowledged that promoting the learning approach which can engage students in inquiry-based learning activities to enhance problem solving skills and self-directed learning skills is necessary, since this approach will help students develop communication skills, information application skills, self-directed learning skills and problem solving skills (Lobry de Bruyn, Lisa, 2004). Hoppe at al (2005), for example, proposed a new channel: communication through the artefact, which claims that shared workspaces with visual objects can enrich human-human communication. In a related matter, online-based learning environment just functions as shared workspaces and it enables interactions between learning materials and individual learner as well as among several learners. As Bates (1990) stated that these two kinds of interactions have significant influence on the learning results.

By applying communication through the artefact principle, our MCY-mentoring program has an online-based shared workspace where learners can construct their own artefacts. There are three kinds of interactions: individual interaction taking place between artefact and learner; interactions between artefact and other people and person-to person social interaction.

In MCY-mentoring program, artefacts are represented by action symbols. Thus, artefacts made by learners are identified as semiotic symbols and visual objects which correspond to each other. It means semiotic symbols remind learners of visual objects, and vice versa, learners will notice the semiotic symbols when they see visual objects. Semiotic symbol- forward and rotate, are Logo-based action symbols. Figure 1 shows the process how to construct a regular hexahedron using semiotic symbols. As can be seen in Figure 1, the turtle is constructing a block with three action symbol commands- m(moving forward), L(rotating to left), and R(rotating to right), and the green facet is the initial position where the turtle starts to construct an object.



(a) do mmRmmmLm

(b) do mmLmRRmmLmRRmLm

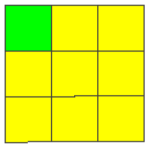
(c) do mmRmLmRmLm

(d) do mmmRRmRmmm

Figure 1. Development figures of constructing a regular hexahedron using action Symbols

Semiotic symbols represent the process how to construct an object, while visual objects show the result. In Table 1, there are four different types of semiotic symbols that can construct the same 3*3 quadrangle. M1 constructs in zigzag pattern and M2 rotates from outside to inside in a spiral pattern. In M3 case, the turtle constructs a facet starting from left bottom to upward using symbol '[ ]' which means the turtle remembers its position and then branches out to the right to make two more facets. Also, we can see the basic module in M3 'm[Rmm]' has been replaced by a simple one- A in M4. In this way, learners' thought process can be investigated by analyzing the symbols since those symbols reveal the whole process.

Table 1. Diverse symbol expressions that construct the same visual object

visual product	symbolic process
	(M1) do mmmRmRmmLmLmm (M2) do mmmRmmRmmRmRm (M3) do m[Rmm]m[Rmm]m[Rmm] (M4) A='m[Rmm]' do AAA

Moreover, the semiotic symbol-based artefacts can lead to the connection between ‘aretefact-learner’ and ‘artefact- third party’. For instance, the main subjects-‘learners and artefacts’- can interact each other because learners can reflect their thoughts by observing the visual objects and correct mistakes by operating the symbols. ‘Artefact-third party’ interaction is noticeable along with ‘artefact-learner’ interaction. ‘Third party’ which refers to peer students or mentors can perceive that how the learner developed thinking when constructing an artefact by only considering the semiotic symbols. This indicates that social communication is taking place since other people can evaluate the outcomes or give feedback. This social interaction is exactly reflected in our MCY-mentoring program. In this sense, social interaction can provide scaffolding that leaner’s inner communication is lack of. In addition, social interaction is more specific and accurate than usual interaction since it occurs among people mediated by symbol-based artefacts and also it may derive more fruitful communication related to learning.

DESIGH PRINCIPLES OF MCY-MENTORING

So far we have reviewed two pivot environments – constructionism environment and interactive environment, which serve as an educational basis of MCY-mentoring program environment. In this chapter, we want to demonstrate the designing principles of MCY-mentoring program. Basically, MCY-mentoring is consisted of three principles: Building a cognitive environment which promotes creative thinking; Being approachable and practical at the same time; Developing a learner-centered evaluation system and boosting interaction between learners.

A cognitive environment which promotes creative thinking

MCY-mentoring program aims at engaging students in creative mathematics beyond simple mathematics. Hence, the tasks in this program should be developed as cognitive tools that can promote creative thinking. As Jonassen (2000; 2006) claimed, learning tools should function as mind tools and trigger learners' cognitive thoughts. We expect the artefact created by students in MCY-mentoring program can be thinkable model (Lawler, 1996) which can promote new ideas. Consequently, we propose the following three designing principles based on creativity.

-Including domain-general vs domain-specific, creative procedure and creative results

In Kim & Lee (2007)'s study on mathematics and creativity, they analyzed mathematical creativity in terms of domain and evaluation. From the perspective of domain, they classified mathematical approach and creativity approach, which are domain specific and domain general matters respectively. Meanwhile, thinking process approach and divergent product process has also been classified from the view of evaluation. Each of these approach has also been classified into Mathematics-Thinking process (McTd)-approach, Mathematics-Divergent product (MctD)-approach, Creativity-Thinking process (mCTd)-approach and Creativity-Divergent product (mCtD)-approach according to their focus on different approaches. Although some research on creativity such as Torrence (1987) has emphasized the importance of divergent product, creativity that are introduced in school mathematics is more focused on content knowledge and thinking process rather than creativity itself. In this sense, this kind of creativity is McTd and the reason of this problem is because school knowledge tries to apply creativity to the mathematical knowledge. As a result, the characteristic of mathematics itself stands out. In order to avoid this problem, MCY-mentoring program aims to guide students to explore mathematical elements when conducting creative activities. Therefore, MCY-mentoring program takes a different approach from McTd approach. Basically the approach we use in this program starts from mCtD to attain McTd goal.

- Problem posing and problem solving should take place alternately

As Cropley(2004) mentioned, intelligence refers to the problem solving skill whereas creativity means the ability of finding problems. When solving a certain problem, we need the existed knowledge and intelligence. However, it requires creativity when finding a new problem in the existing problems. Besides, finding problems can take place when we actively explore given problems. In this matter, MCY-mentoring enables students to explore artefacts quite freely. Take a polygon-related MCY activity as an example, students can construct an octahedron by themselves and turn it over in different directions and observe it from divergent angles. It is unlike the way we observe an octahedron, since it has been laid down we can see a brand new shape of a octahedron. Also, students will keep asking what would it be like after adding regular tetrahedrons in each side of a octahedron. Hence MCY enables students to foster both problem posing and solving skills.

- Divergent thinking and Convergent thinking as well as lateral thinking and vertical thinking should take place alternately

Guilford (1950) argued that creativity and intelligence should be distinguished and he classified thinking into two different types: convergent thinking and divergent thinking. The former one refers to the traditional concept of intelligence and the latter one refers to creative cognition. In other words, the difference mainly lies in their focus: convergent thinking values the one and only excellent answer, whereas divergent thinking means the ability to develop original ideas and then come up with a new idea. Therefore, convergent thinking ability is required when carefully considering a problem or making an important decision. On the other hand, divergent thinking is a crucial ability to invent a new thing or come up with a novel idea to solve problems.

In a related manner, De Bono (1970) proposed vertical thinking and lateral thinking and he stressed the significance of lateral thinking to foster creative thinking. He also stated that vertical thinking refers to the traditional thinking which follows a strict hierarchical and logical system, while lateral thinking is more unconventional because it creates novel ideas that are unique and enables us to try different perceptions to lead to an unexpected result.

As we explained so far, there are a couple of different types of thinking which has diverse functions. However, it’s not proper to say a certain type of thinking is above another one. Instead, all these types of thinking abilities should be coordinated since the integrated thinking skills are required in studying. So that MCY-mentoring program does not emphasize a certain thinking ability, but it enables several thinking abilities to take place alternately in order to build up creative knowledge.

Being approachable and practical at the same time

Papert (1980) suggested that learning process should be natural and authentic. He also claimed communicating with computers should not be like learning a foreign language in the classroom, but it should be like acquiring French in France. Moreover, a related issue has also been highlighted by Skemp (1987). He argued that since the most meaningful part in learning mathematics is schema, learning through games should be applied to the mathematics teaching. It is noteworthy that the exploring mathematics is way much more meaningful than taking an exam. Therefore, we believe our students should be exposed in an environment where they can enhance their creative thinking, and game-situated teaching should be promoted.

MCY-mentoring program was developed by adopting Resnick & Silverman (2005)’s ‘Low floor & wide wall’. The merits of our program are: it is game-based program which means easy to approach; it can be applied widely and deeply to other related subject matters. MCY- mentoring program is meaningful because mathematical materials-3D building block and polyhedron that can be well applied to mathematics learning are introduced. Students are easy to get familiar with these materials and then the materials will turn out to be their exploring tools. In our program, we name the sequence Creative Play(CP), Creative Learning(CL), Creative Inquiry(CI) respectively. The reason we put "creative" in each term is our goal is to foster students' creativities. Each sequence has been developed according to the ten domains presented by National Council of Teachers of Mathematics (NCTM) and six cognitive levels of Bloom's taxonomy. Taking 3D building block activity for example, there are a lot of activities: creating a creative 3D product with blocks, communicating with 3D object in CP stage; proving figurate number using blocks, measuring the surface area and volume of the object in CL stage; investigating Euler's characteristics of 3D objects, investigating the reflective pattern of construction in CI stage.

As can be seen in Figure 2, the activity which measures surface area and volumes of 3D object in CL stage belongs to *measurement* in math category, while it is categorized into *understand* and *apply* in cognitive process. Meanwhile, the activity which investigates Euler's characteristics is under *problem solving* and *reasoning & proof* within the category of math, but it lies in *apply* and *analyze* in cognitive process as well. This phenomenon can be explained that a certain activity can be included in two or three different math categories and cognitive process.

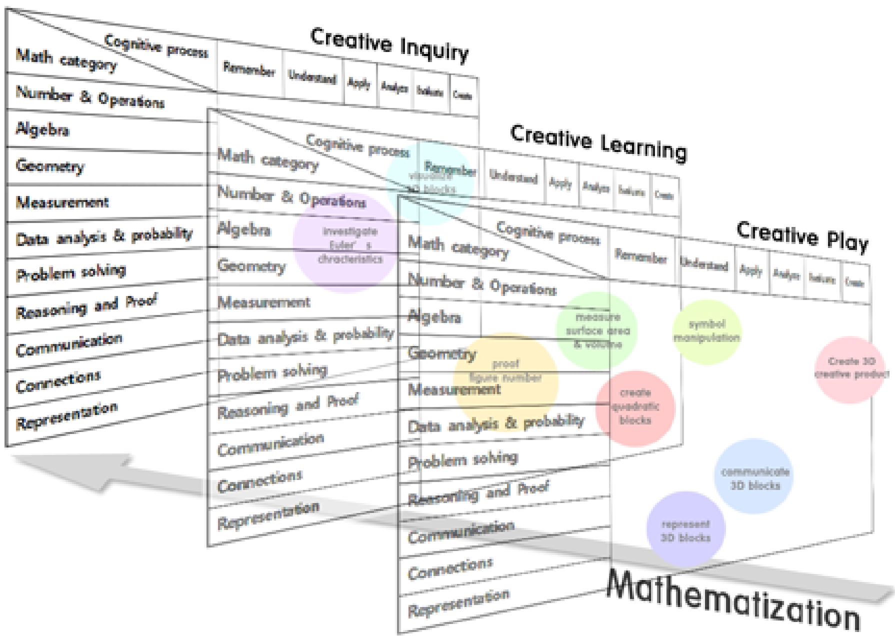


Figure 2. The Constitution of MCY Contents

An environment which allows Learner-centered evaluation and interaction

The previous two design principles are about contents, while the third one deals with the basic concept how MCY-mentoring program actually works and is evaluated. MCY-mentoring is basically taking place with the artefact created by learners and learning, communication and evaluation are all possible in this context. Constructing these artefacts is not a matter of momentary process. Instead, it's continuous process which contains sequence, so MCY-mentoring is built in an e-portfolio environment. This is to say that saving, correcting and evaluating learner's products are all available in MCY-mentoring program.

Meanwhile, e-portfolio is an effective way to conduct formative evaluation. This is because e-portfolio, as a storing place of learning evidence-artefacts and an evaluation tool which enable students to reflect the learning process, plays a significant role in this program (Bhattacharya & Hartnett, 2007; Barbara, 2009).

As Barbara (2009) stated, moreover, "Another value of e-portfolio is continuous improvement that it can offer a student. A student does not see the work as definitive but can steadily improve it over the learning period." She also stressed that teacher-student interaction and student-student interaction can facilitate students to acquire a meaningful knowledge. Besides Barbara (2009), Black & William (1998) proposed four pillars (metacognition, authentic tasks, contextual feedback, student responsibility) as the features of e-portfolio. The focus of the e-portfolio also satisfies those educative models based on exploratory dialogue and guidance as a source of cognitive change (Whitelock, 2006). Accordingly, learner-centered development, self evaluation and peer evaluation as well as collaborative learning all can be found in MCY-mentoring program since it shares a similar structure with e-portfolio.

FIRST MCY-MENTORING MISSION: Constructing creative products with blocks

In an effort of embedding creative thinking, MCY-mentoring is designed to engage students in an environment where they can explore mathematics by playing games. Students from S city participated in our program and conducted constructing creative products with blocks activities by accessing mentoring website (http://mentoring.snu.ac.kr). This activity belongs to the Creative Play (CP) stage and it includes three different categories: representation, problem solving and create. To conduct this activity, it requires both math and cognitive categories, such as representing mathematical object using semiotic symbols, fulfilling a given task and creating a new product. This activity is designed to facilitate easier access to the following activities, since students can get more experience to deal with blocks in this stage. The product of this task is the object created by students with a full use of commands they learned.

82 students who are 12 to 13 years old participated in our program and they all did individual work. Students were asked to accomplish a total number of three submissions in a period of three weeks and the whole mission lasted for one month. In addition, students' final products were submitted at the last week. Also, their products were posted on-line including command languages and explanations.

First, we posted useful information for the first mission on the website and students were required to acquire the basic action symbols and command languages before conducting the 1st submission. Figure 3 shows five given information which is necessary to accomplish the first mission.

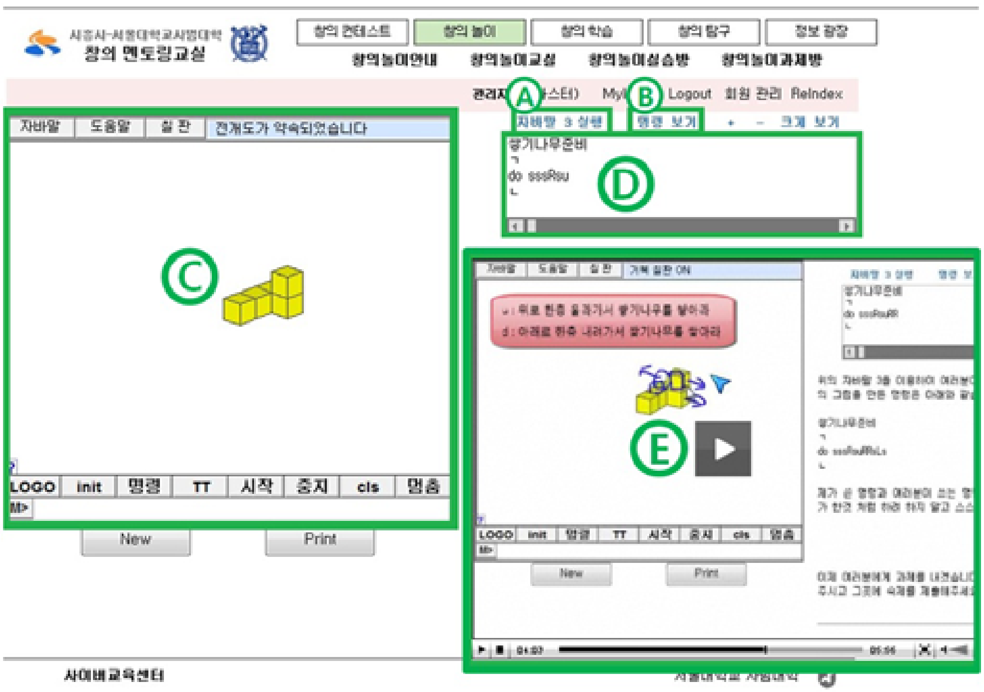


Figure 3. MCY-mentoring environment

As presented in Figure 3, there are four different buttons:
(A) executing commands,
(B) Checking saved commands,
(C) execution board,
(D) command operation board,
(E) flash video.

The required knowledge is provided as flash and literally explained.

For the first step, the flash videos helped students operating commands, they put the command languages they just learnt and press JavaMAL button, and then the products which are created following their commands were shown on the board. It means students can get spontaneous reflection by operating and learning at the same time. In this way, students' mistakes can be reduced and acquiring command language will become easier and effective.

After learning the basic command languages, students started working on three sub-missions. We introduced new command languages that are needed for next mission and then we gave them two tasks. One is a given task, the other one should be created by students themselves. At first, students tried hard to finish the given task after understanding the instructions about command languages. Also, they developed their ideas and tried to apply their prior experiences to their new task when working on their own products, in order to create more complicated ones.

A detailed process of students' work is presented in Figure 4. It shows an example of a student working on the second submission. The second submission is to ask students to create a fan as a given task after acquiring the command languages-rotating, and then create another product by applying the knowledge about rotating. The product in (A) is a wind generator which was given as a common task and then the student developed the former product and made a more complicated wind generator for use in developed countries, as can be found in (B).

Figure 4. MCY activity developed for promoting divergent thinking

Figure 4 is well shown how a student developed divergent thinking in MCY mentoring context and built up the ideas successfully.

First paragraph: This is the common task object-fan.

Second paragraph: It's just a wind generator. It's easy, isn't it?

Third paragraph: This wind generator is a complicated one which for use in developed countries. It looks hard to make, right? I was so amazed that I could make it by myself.

Students seemed to perform very well in submission activities, but they did have troubles. The good things are they could figure out problems by themselves or shared ideas with peers and tried to solve them together. These strategies contribute to the characteristics of MCY-mentoring program in which students can get self-reflection immediately. Also, we found some students tried to find solutions by analyzing the symbols they made or posted on-line questions to get feedback from others. For example, one student had trouble in conducting *rotating* command language when he tried to create a helicopter which runs through rail tracks. At that time, he asked he called for help and eventually he figured out problems with the help of the mentor and peer students.

Ah(learner): Is it rotating well?

Koh(peer): No.

Koh(peer): Did you put the command dd_n on; dd_n [ ] after ㄴ?

Koh(peer):... I think the number should be 70 when I put n …

Yang(mentor): You don't need to use *off* if you used engine

Ah(learner): Thank you.

Moreover, we could see interactions among students taking place as well. They pointed out other's problems using posted comments in order to get better results. For example, peers reminded a student who was making a globe that the earth's axis is tilted 23.5 degrees. Taken other's advice, the student searched more information and learnt from other's work and finally he could create a more elaborated product.

Namu(peer): Wow!

Ahn(peer): The earth's axis is tilted 23.5 degrees

Lim(learner): Sorry, but I'm still having trouble with angles. If I put ddv=23.5 as command, then I cannot make a globe. Help me…

Saram(peer): The earth is tilted 23.5 degrees and as it revolves around the sun.

Yang(mentor): Please check the hint given on the bulletin board.

Lim(peer): Wow, great. Thank you.

Wan(peer): Now, the globe rotates perfectly.

Duck(peer): Could we see the angle of 23.5 degrees?

Spongesong(peer): It's just like a real globe.

yang(mentor): The reason you couldn't make a perfect globe is that you used m and o as command language. I see you used do o and repeat 72 {do m<} a lot as command languages, you should reduce it with repeat command, try this command repeat 36 {do o 72{m<}}. Actually, the command language you used is overused for 36 times which caused some facets are overlapped. Only 36 times is enough to make a perfect globe. Do you know why? I'd like to give leave you this question as problem of inquiry. I also see you used the command- do (ccv=#DCDCDC)RRs[>s>s>s>s>s>s >s>s>s>[dd]suu[s]uRRssssds]RRsss- to make this axis. What should you do to make this axis symmetric?

Lim(learner): Thanks. *^^*

Lim(learner): I've got the answer to the problem of inquiry. It's because I set rry as 5 degree, if I rotate 36 times, it turns to be be 180 degrees and consequently I can make a circle.

A student who just learnt the command '[ ]' presented the following final product (Figure 5). In this activity, this student constructed a wheel first and made symmetrical commands using rotation which is shown in (A). We also can see from (B) that he used the command '[ ]' twice to make the whole command language simple. This implies that learning tool, which refers to learning '[ ]' in this case, played a role of mind tool of the student and this mind tool functioned as thinkable model which can generate cognitive thinking.

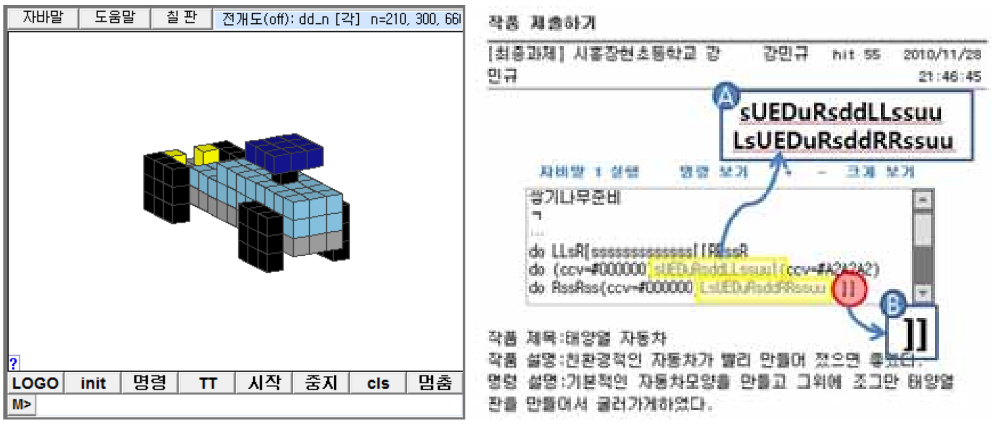


Figure 5. Using symbols as mind tool

As described above, students were asked to acquire the action symbols and command languages by accomplishing submissions and they submitted their final products in the end. The evaluation on the artefact from first mission contains both artefact and explanation about it.

Moreover, we introduced two domains of pedagogical approach-constructionism and interactive learning- as the basis of evaluation. Constructionism-based evaluation is composed of two parts. One focused on artefact's function and appearance which indicates mCtD-approach. In the first mission, the function and appearance of the artefact had been mainly considered in evaluation since the product is the creative building blocks. Then the product was evaluated in terms of fluency, creativity, adaptability and elaborateness.

The other evaluation is from the perspective of McTd-approach, which values commands and thinking process. Play in CP stage in MCY-mentoring program does not mean simple activities using tools. Instead, it indicates the activities which can foster students' mathematical thinking and creative thinking through playing games. We expect students' thinking process can be traced using command languages made by students. In this sense, ability that can use creative command language, diversity, organizing ability and elaborateness had been taking into consideration when evaluating students' thinking process and the above four standards were presented as originality, adaptability, elaborateness and systemicity.

On the other hand, interactive learning based evaluation was considered from two parts: quantity and quality. As mentioned above, students can observe and evaluate others' products in MCY-mentoring program. The distinctive feature which allows peer students and mentors to provide scaffolding is utilized in the evaluation system. The performance of giving feedback and conducting self-reflection can also be taking into consideration as a significant evaluation standard. As a result, we concluded that many students performed beyond our expectation considering the above three evaluation standards. In addition, the portfolio presents the continuous improvement of each student.

CONCLUSION

In this study, we propose an online-based MCY-mentoring program which was developed on the basis of Constructionism and Interaction. The purpose of developing this program is to support math education, but it is not limited to only math. In fact, it aims at engaging our students in a creative mathematics learning environment where they can play games and explore mathematics at the same time. Also, MCY-mentoring was designed under the three principles: Building a cognitive environment which promotes creative thinking; Being approachable and practical at the same time; Developing a learner-centered evaluation system and boosting interaction between learners. According to the first principle, MCY requires creative thinking and creative products, and it enables problem posing and problem solving to take place alternately. Also, divergent thinking and convergent thinking as well as lateral thinking and vertical thing can take place alternately in MCY. The second principle was set to connect Creative play, creative learning and creative inquiry and further to fulfill Resnick & Silverman (2005)'s low floor & wide floor. Finally, the third principle reveals that each product should be sequential which can show the learner's continuous improvement and conduct a learner-centered evaluation. Moreover, the purpose of promoting interaction between peer student and the mentor is presented in the third principle.

Furthermore, the first mission activity- construct creative products with blocks- has been explained as an example of MCY. The learning process describes how to deal with problems and troubles by utilizing self-reflection and peer feedback. When students fulfilled missions, they were so surprised by the products they created.

MCY-mentoring has revealed, to a certain extent, the positive effect on mathematics education, yet it is not without limitations. For instance, the activity example what we presented above belongs to the CP stage and more activities from CL and CI stages should be investigated by considering how to navigate our students embedded with mathematical thinking. Therefore, further research would benefit from systemizing the current activities what we introduced and developing a MCY curriculum using the current frame work. We do believe MCY will become an effective diagnosis tool to guide students to conduct the proper activities in the future.

What's more, there are some shortcomings need to be supplemented in terms of technique and management. Although MCY provide students an environment where they can present the products, it cannot serve as a smart teaching guide technically. 'Customized' technical support that helps learners manage themselves without peers or mentors could be considered. Also, it is necessary to elaborate the current e-portfolio system. It could be better to set up an automatic database according to the students and activities. Regarding to the management, more efforts can be made to encourage students' volunteer participation and enhance on-line management. Hence, unique and interesting tasks and missions should be developed and discussions about how to attract students actively participate in MCY is needed like establishing a reward system for outstanding students may work.

Even MCY is still in an early stage, it is a promising project since it proposes creative mathematics to the students who are lack of creative activity experiences. Overall, MCY activities that enable students to enhance creative thinking should be expanded and developed.

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