AN ANALYSIS OF TEACHER-STUDENT INTERACTION PATTERNS IN A ROBOTICS COURSE FOR KINDERGARTEN CHILDREN: A PILOT STUDY

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ABSTRACT
Compared with other media, programmable bricks provide children with the opportunity to create their own product and, through this process, to express creative thinking. Studies have found that learning robotics or integrating programming bricks into courses can help to develop students' problem-solving abilities and enhance their learning performance. This study attempted to develop a one-to-one Topobo robotics course for kindergarten children and to explore teacher-student interaction patterns. This study used a creative thinking spiral as the framework for the Topobo robotics course. The research sample included a five-year-old child and a preschool teacher. Topobo, the programmable bricks, was the main learning tool in this course, and the sequential analysis method was used to identify teacher-student interaction patterns. Based on the frequency of the teacher-student interactions, this study found that two behaviors, the student's "play" and the teacher's "guidance," appeared most frequently. Moreover, the results of sequential analysis and content analysis of the videotaped learning process indicated that the teacher's guidance helped the student to assemble or play with the Topobo bricks. The teacher's questions encouraged the student to express and share his ideas or identify and solve problems. This study proposes suggestions for future studies on this issue.
Keywords: Topobo, Creative thinking spiral, Teacher-student interaction, Sequential analysis

INTRODUCTION

Many new technologies, such as games and robots, have been applied to educational fields (Chen, Chiang, Liu, & Chang, 2012; Feng, Lin, & Liu, 2011; Lin et al., in press; Liu, 2011; Liu & Lin, 2009; Miller & Robertson, 2010; Nelson, Erlandson, & Denham, 2011), and the concept of media literacy, which includes the ability to use new technology, has received increasing attention (Chang & Liu, 2011; Chang, Liu, Lee, Chen, Hu, & Lin, 2011; Chang, Shieh, Liu, & Yu, 2012; Liu, Lin, Jian, & Liou, 2012). Programmable bricks provide children with the opportunity to create their own products and to express creative thinking (Lin, Liu, & Huang, 2012; Lin, Liu, Kou, Virnes, Sutinen, & Cheng, 2009; Liu, Lin,& Chang, 2010). Liu (2010) interviewed forty-eight elementary school students about their perceptions of robots and found that students tend to perceive learning of robotics as a way to high technology. Some studies have found that integrating educational robotics or programming bricks into courses could improve students' problem-solving abilities and enhance their learning performance (Chang, Lee, Wang, & Chen, 2010; Chang, Lee, Chao, Wang, & Chen, 2010; Liu, Lin, & Chang, 2010). Most of these studies have focused on primary school, middle-high school students, and even higher education students, but few studies have examined how to design robotics course for kindergarten children and how children learn in these courses (Bers, 2007; Levy & Mioduser, 2008; Virnes & Sutinen, 2009).

The five stages of creative thinking spiral model proposed by Resnick (2007) can illustrate both how children develop their creative thinking and how teachers interact with their students. These five stages are illustrated within the context of a robotics course: imagining (e.g., guiding students to imagine the product of a robotics course), creating (e.g., assembling bricks in a robotics course), playing (e.g., playing with the products in a robotics course), sharing (e.g., sharing and expressing ideas in a robotics course) and reflecting (e.g., identifying and solving problems in a robotics course).Through the above process, learners may share their new ideas, develop assembly skills and solve problems in a robotics course. Moreover, creative behaviors have been viewed as the performance of creative thinking. The period of creative behavior starts with motivation and proceeds to the accomplishment of forming a product (Harris, 1998; Lubart, 2001). In the past, although the participants mentioned by Resnick were elementary students, Resnick's original concept was based on lifelong kindergarten (Resnick, 1998). Moreover, Virnes and Sutinen (2009) also designed a robotics course for kindergarten students using Topobo developed by Raffle, Parkes and Ishii (2004). In this pilot study, we attempted to design a one-on-one kindergarten Topobo robotics course to encourage learners to share new ideas, develop assembly skills and solve problems; we also designed the course to explore possible teacher-student interaction patterns.

Teacher and student interaction is understood to be an important issue in education, and teacher-student interaction is beneficial for students' learning. Flanders (1970) developed an analytical system for teacher-student interaction and identified seven categories of teachers' behaviors: clarifying feelings, praising, using students' ideas, asking questions, lecturing, giving directions, and criticizing. Amidon (1959) indicated that teachers could help to develop students' ideas by asking questions. Liu and Elicker (2005) found that when teachers asked specific questions or asked for students' help, children felt more confident and secure. Two roles can be identified among teachers and students: parallel and inclination. When teachers and students perform parallel roles, they have equal status. When teachers and students perform inclination roles, they interact as educators and the educated (Liu & Elicker, 2005). For teachers, behaviors such as playing with children and expressing their experiences were related to the parallel role, and behaviors such as directing and asking questions were related to the inclination role. During teacher-student interactions, teachers can use strategies such as denomination, correction, and expansion to reconceptualize the information provided by the children (Rosemberg & Silva, 2009). While a few studies have investigated teacher-student interactions, most previous studies have been conducted in a classroom context where one teacher was responsible for several children. Chi, Siler, Jeong, Yamauchi and Hausmann (2001) suggested that in a one-to-one context, instructors could provide suitable support according to students' needs, thereby enhancing students' motivation and learning performance. This study uses a quantitative content analysis of video recordings and a sequential analysis method to explore teacher-student interaction patterns; these methods are applied to a situation in which children learn by using programmable bricks via the creative thinking spiral model (Resnick, 2007). The teacher-student interaction patterns are evaluated to determine the effectiveness of the Topobo robotics course as a pilot study.

METHOD

Participants and course design

To explore the application of Topobo for instruction and teacher-student interactions, this study conducted an empirical, exploratory case study with an observation and analysis of a videotaped teaching case to understand teacher-student interaction patterns. The participants in this study were one five-year-old child and a kindergarten teacher. Topobo, the programmable bricks invented by Raffle, Parke and Ishii (2004), were used as learning materials. The detailed background and characteristics of the student and the teacher are shown in Figure 1.

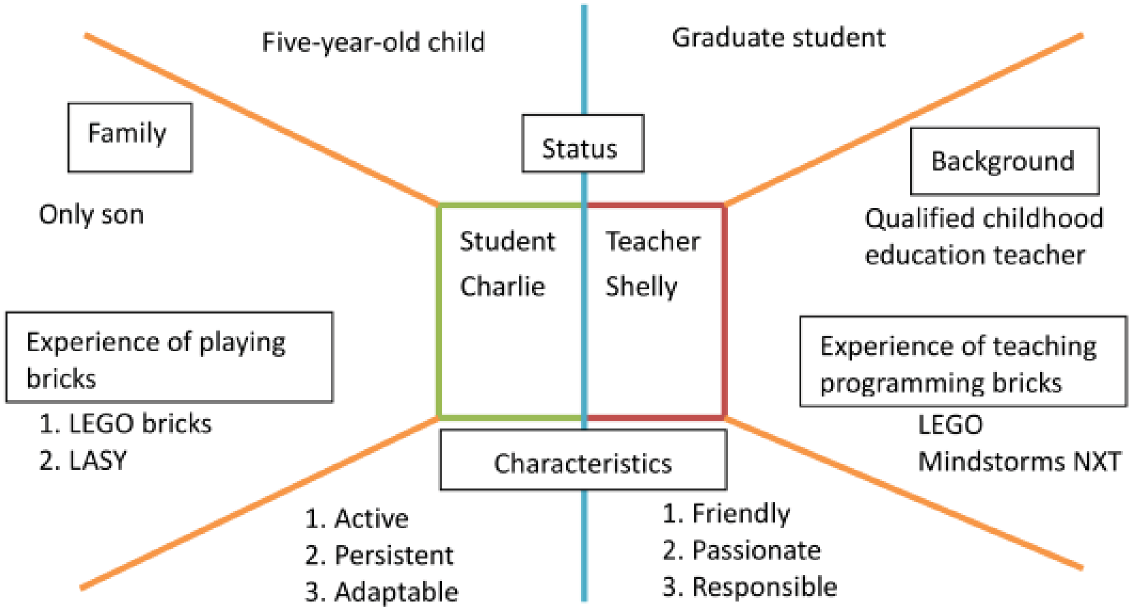

Figure 1: Characteristics of the student and the teacher

This course had three purposes or goals: 1. encouraging the student to propose and share new ideas; 2. developing the student's assembling skills and playing with programming bricks; and 3. helping the student to identify and solve problems. The course structure is shown in Figure 2. The design of the robotics learning course was based on the creative thinking spiral model proposed by Resnick (2007). Five elements were included in this course: imagining, creating, playing, sharing and reflecting.

In the imagining stage, the teacher gave the child a treasure-hunting map and explained the task. The student explored the map and collected the bricks he needed. In the creating stage, the student assembled the bricks to create products for different tasks. In the playing stage, the teacher and the child used the products to complete the task. In the sharing stage, the teacher and the child shared their experiences, feelings, and ideas. Finally, in the reflecting stage, the child identified some problems with his products and attempted to redesign or add functions to his products.

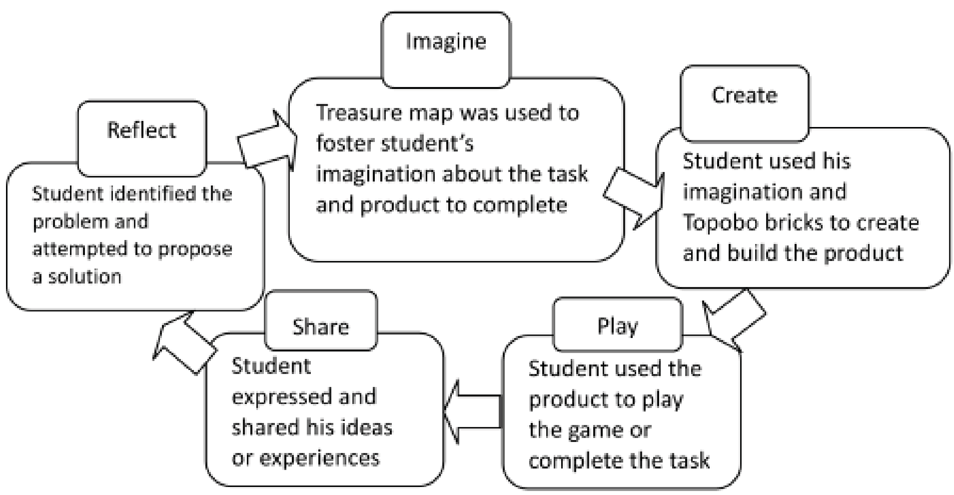

Figure 2: Topobo robotics course structure

The Topobo robotics course is a four-hour, one-to-one course that includes seven tasks. Task 1 to task 3 asked the child to use one motor in his products, and task 4 to task 7 asked the child to use two or more motors in his products (Table 1). The student had to assemble Topobo robotics to solve the assigned learning tasks on the map.

The study field was a semi-closed space. There was only one door, at the front of the classroom, and one video camera was set up in the front of the classroom to record the teacher-student interactions.

Table 1: The task list in the Topobo robotics course

Task1: Snail	Single motor
Task2: Dragonfly	
Task3: Penguin	
Task4: Ant	Two motors
Task5: Shepherd dog	
Task6: Elk	
Task7: Dinosaur	

Materials

Topobo

Topobo was designed by Raffle, Parkes, and Ishii in 2004. The Topobo programmable bricks are based on the concept of 3D construction. Topobo includes two kinds of bricks, active and passive. Passive bricks include straight-, T-, L- (90^0), and tetra- (108^0) shaped bricks. The active bricks are egg-shaped objects that are able to record and play back movement (Figure 3). In this course, we provided Topobo bricks for the student to create different kinds of products.

Figure 3: Actives (left) and passives (right) in Topobo system

The teacher-student interaction coding scheme

The teacher-student interaction coding scheme was based on a design from previous studies (Flanders, 1970; Perraton, 1987). Seven codes were included in this coding scheme: T1 (providing guidance), T2 (correcting mistakes), T3 (asking questions), S1 (assembling bricks), S2 (playing with the products), S3 (sharing and expressing ideas), and S4 (identifying and solving problems) (Table 2).

Table 2: Coding scheme for teacher-student interaction in robotics learning activities

Code	Actor	Dimension	Description
T1	Teacher	Providing Guidance	The teacher explains how the activity proceeds.
T2	Teacher	Correcting mistakes	The teacher identifies the student’s mistake and provides direction.
T3	Teacher	Asking questions	The teacher asks questions to guide the student.
S1	Student	Assembling bricks	The student assembles bricks independently. The teacher and the student assemble the bricks together.
S2	Student	Playing with the products	The student plays with the product independently. The student and teacher play with the product together.
S3	Student	Sharing and expressing ideas	The student shares his experience with the teacher. The student shares his ideas with the teacher.
S4	Student	Finding and solving problems	The student identifies problems. The student proposes solutions to the problems.

For content analysis, each interaction behavior was coded by three educational researchers. Coding the four-hour robotics learning activities produced 432 codes. The value of the Kappa coefficient was .92 ($p<.001$), indicating that the data had very good inter-rater reliability.

Lag sequential analysis

Lag sequential analysis was used to explore whether significant teacher-student interaction patterns existed. We also provided supplemental qualitative information for the significant interaction patterns during the Topobo robotics course. Lag sequential analysis is a useful tool for researchers to analyze relationships and extract patterns in behavior streams. It also allows the researchers to examine whether certain sequences of behaviors reached statistically significant levels (Bakeman & Quera, 1997). Lag sequential analysis has been applied in educational studies to explore knowledge construction patterns in online discussion forums. The sequential analysis software Multiple Episode Protocol Analysis 4.8 (MEPA 4.8), designed by Gijsbert Erkens, was used in this study.

RESULTS AND DISCUSSION

Descriptive statistics of teacher-student interactions

The distribution of coded interaction behaviors during the four-hour robotics learning activities is shown in Figure 4. The results indicate that S2 (playing) was the most frequent behavior (n=108, 25.00%), followed by S3 (sharing and expressing ideas: n=83, 19.21%) and T1 (guidance: n=80, 18.53%). The frequencies of the three codes (T2, S3, and S4) were much lower than the frequency of S2. T2 (correction) constituted only 6.02% of all interaction behaviors during the robotics learning activities. It is worth noting that in the robotics learning activities, the teacher rarely corrected the student's errors directly (6.02%), and the child was encouraged to play with Topobo (25.00%). Additionally, T1 (guidance) was an important interaction behavior for the child, who often shared his ideas with the teacher during the robotics learning activities.

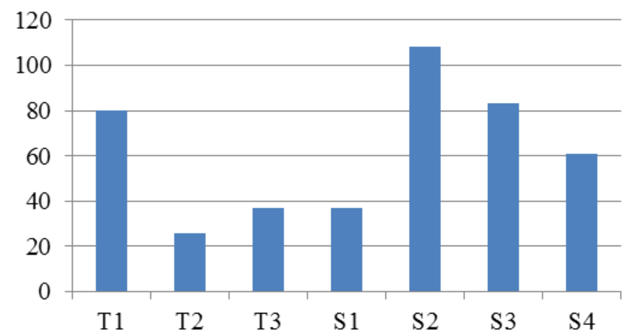

Figure 4: Distribution of quantitative content analysis of interaction behaviors in robotics learning

Lag sequential analysis of teacher-student interactions

To further investigate whether significant interaction patterns were present during the robotics learning activities, calculations of sequential transfer matrixes were performed. The adjusted residual table of sequential analysis was then inferred (as shown in Table 3). Table 3 indicates that the seven sequences that reached a significant level during the robotics learning activities were T1→S1, T1→S2, T3→S3, T3→S4, S3→S2, S4→T1, and S4→T2 (Figure 5).

Table 3: Adjusted residuals table of sequential analysis (lag=1)

	T1	T2	T3	S1	S2	S3	S4
T1	-2.78	-1.02	0.06	3.34*	2.46*	-0.44	-1.58
T2	-0.86	-0.48	0.55	-0.88	-0.21	0.00	1.84
T3	-2.01	-1.63	-1.95	-0.72	-2.61	4.87*	3.23*
S1	0.51	1.29	-0.11	1.73	-2.25	1.18	-1.07
S2	1.62	-0.24	-0.52	-0.52	-2.01	1.87	-0.39
S3	-0.07	0.00	1.80	-0.99	2.77*	-4.02	0.45
S4	3.07*	2.02*	-0.12	-2.16	0.81	-2.29	-1.44

*P<0.05

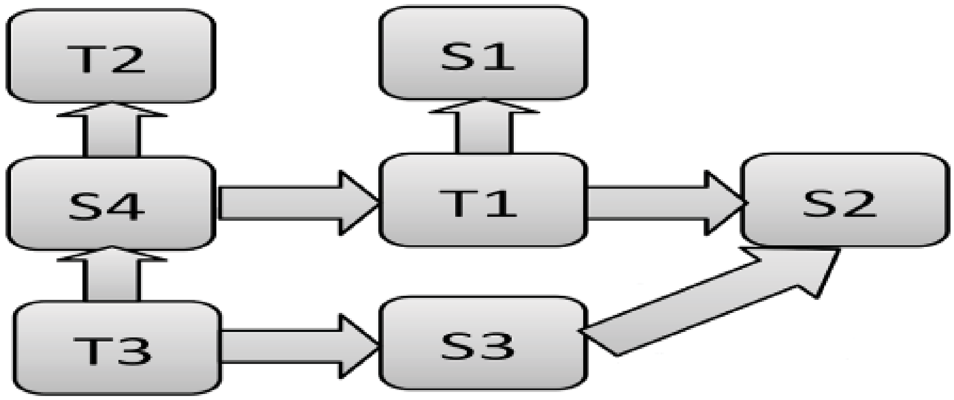

Figure 5: Lag sequential-analysis diagram of teacher-student interaction in robotics learning activities

This study found that the student's behaviors of identifying and solving problems were significantly followed by the teacher's questions (T3→S4). The results indicated that the teacher's questions triggered the student's reflection. After analyzing the student's behaviors in this sequence, it was found that 50% of the student's behavior involved proposing solutions and 42% involved solving problems independently. These results suggest that teachers' questions can encourage students to reflect on problems and attempt to identify possible solutions. However, S4 (finding and solving problems) did not occur repeatedly, indicating that the student could not identify and solve problems by himself and required the teacher's support. Furthermore, the student's behavior of expressing and sharing his ideas significantly followed the teacher's questions (T3→S3) ($z=3.23$, $p<.05$), indicating that the teacher's questions triggered the student's reflection and expression. The content analysis showed that the student shared his new ideas most frequently and that the teacher's questions triggered the student's imagination and willingness to share his ideas. Additionally, the teacher often asked the student questions to identify his reasons for performing certain behaviors. The following excerpts of dialogue from the content analysis of the video demonstrate that the questions provided the opportunity for the student to explain the motivation behind his behavior.

Teacher: The snail walks very slowly. Can we help him?
Student: Yes!
Teacher: How?
Student: We can assemble a whipping top!
Teacher: How can a whipping top help the snail?
Student: The whipping top can spin fast, and it can help the snail move faster.
(20110130-S3-1-I006)

The sequence T1→S1 achieved significance($z=3.34$, $p<.05$), indicating that the teacher's guidance gave the student direction in assembling the programmable bricks. This sequence suggests that providing suitable support (such as helping to assemble the tiny components or explaining the task) helps the child to assemble the bricks independently. However, the results of the sequential analysis demonstrated that after the student finished assembling (S1), the action that sequentially connected to other behaviors showed no significant sequences. This result indicated that the assembling behavior did not extend to other creative thinking activities, such as playing (S2), sharing (S3) or problem solving (S4). Additionally, the sequence T1→S2 reached a statistically significant level ($z=2.46$, $p<.05$), suggesting that the student's play behavior often followed the teacher's guidance. Clearly introducing the course rules and objectives would help the teacher and student to achieve consensus and to cooperate in the game. After the student finished S2 (play), the sequential connection of this action to other behaviors showed no significant sequences. Thus, in the Topobo robotics course, play behaviors did not occur spontaneously, and the teacher's guidance was important. The results indicate that the teacher's guidance triggered the student's building and playing behaviors. Furthermore, the teacher's questions may trigger the student's sharing and problem-solving behaviors. This result suggests that the teacher's support was important to the student in this course.

To provide adequate support and maintain the student's engagement in the course, the teacher paid attention to the student's problems and attempted to provide appropriate support. Two sequences, S4→T2 ($z=2.77$, $p<.05$) and S4→T1 ($z=3.07$, $p<.05$), reached statistically significant levels, indicating that when the student had problems during the robotics learning activities, the teacher provided guidance. This behavioral transition showed that the teacher cared about the student's problems and provided guidance for the student during the Topobo robotics course.

The sequence S3→S2 achieved a statistically significant level, suggesting that before the child played with the programmable bricks or assembled products, he expressed and shared his ideas with the teacher. In Resnick's model (Resnick, 2007), children shared their experiences or ideas only after they had the play experience. However, in this study, the student shared his ideas before he played the game to clarify the rules and goals of the task.

The relationship between course objectives and teacher-student interaction

In this section, we examine the relationship between the course objectives and the teacher-student interactions.

Objective 1: Encourage the student to propose and share new ideas.

One of the objectives of this course was to encourage the student to propose new ideas. Therefore, when the student proposed ideas, the teacher responded positively or by asking questions to allow the student to express his ideas. The lag sequential analysis indicated that the sequence T3→S3 (i.e., from the teacher's question to the student's sharing behavior) reached a significant correlation ($z=4.87$, $p<.05$). Through positive responses and questioning, the teacher encouraged the student to express new ideas. Furthermore, the sequence S4→T1 achieved a significant level. Following this sequence, when the student had problems, the teacher provided ideas for the student. After the discussion and sharing process, the student was able to generate more ideas. The following excerpt of dialogue from the content analysis of the video demonstrates these findings:

> *Student: I want to use the flag to distract the monster.*
> *Teacher: I think….how about using the whipping top?*
> *Student: Mm……Oh, I got it. I want to assemble a whipping top to defend against the monster's attack. (20110130-T1-3-I115)*

Learning to share and express ideas is a very important skill. Through the process of creating new products and sharing ideas, the student engaged in the creating process (Resnick, 2007). In this course, we encouraged the student to share and express his ideas through the teacher's questions. The result of the sequential analysis showed that the sequence T3→S3 reached a significant level ($n=19$, $z=4.87$, $p<.05$), indicating that the teacher's questions were a useful strategy to encourage the student to express his ideas. When the teacher asked questions, the student had to organize his thoughts and attempt to express them clearly. Through a series of questions, the teacher helped the student clarify his ideas, and the student was able to explain his thoughts and motives more clearly. The following excerpts of dialogue from the content analysis of the video demonstrate these findings:

> *After student assembled a fish:*
> *Teacher: ……Why are the fins of the fish not the same size?*
> *Student: Because the fish is sick…* *(20110130-T3-R159)*

> *Student: Now, someone wants to steal their treasure.*
> *Teacher: Who?*
> *Students: This small green monster.*
> *Teacher: The green monster again? He usually comes to steal the treasure when people sleep. Why is he so bad?*
> *Student: Because he wears a mask.*
> *Teacher: So we cannot identify him?*
> *Student: Yes.* *(20110130-S3-1-P192)*

Objective 2: Develop the student's assembling skills and play with the programming bricks.

In this course, we provided programmable bricks, Topobo, for the student to develop his assembling skills. Because the student lacked experience assembling the programmable bricks, the teacher guided the student systematically in an attempt to motivate the student to assemble the bricks. The result of the teacher-student interaction analysis indicated that the teacher's guidance enhanced the student's assembling behavior (i.e., T1→S1) ($z=3.34$, $p<.05$). In the process, the student learned to identify which kinds of bricks and motors he needed and how to analyze his mistakes. After analyzing the student's assembling behaviors, it was found that the student assembled the bricks independently. As Figure 6 shows, the student gradually developed his motivation and ability to assemble the programmable bricks and completed a series of products to achieve the learning tasks. Play was an important objective in this course, and we hoped that the student would be able to apply his own motivation to complete the tasks. The student had to learn to control the motor and construct the product in accordance with his imagination and design. Therefore, the teacher clearly explained the operation of the motor to the student. The sequential analysis showed that the sequence T1→S2 reached a significant level, indicating that guidance on the control and operation of the motor was useful for the student and allowed him to continue and complete the tasks.

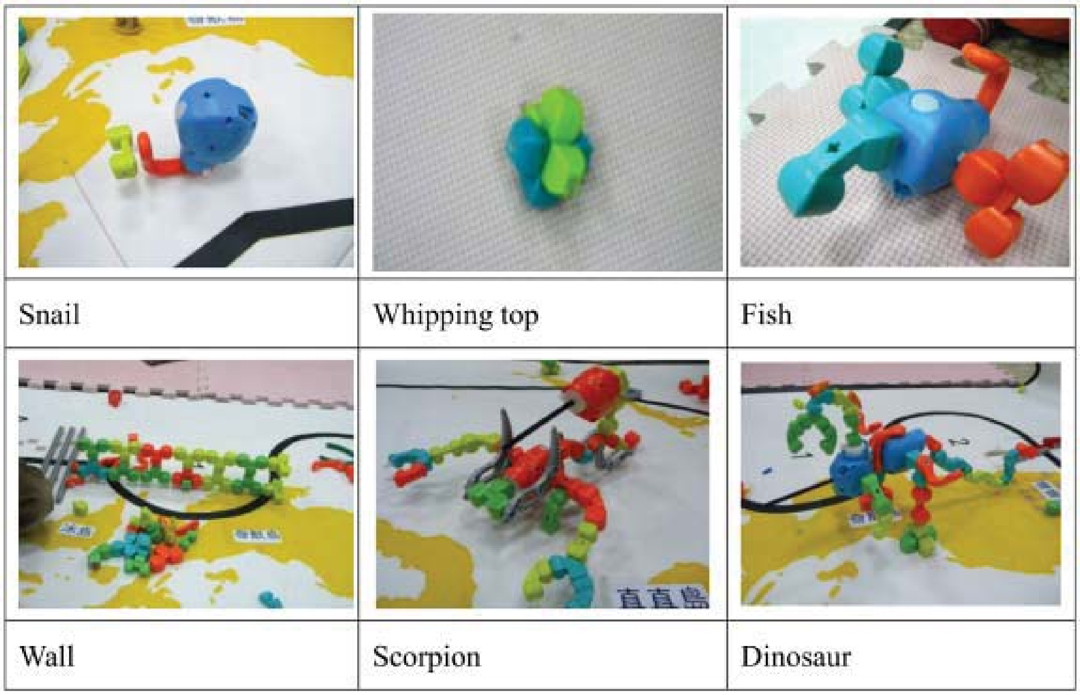

Figure 6: The child's six products

Objective 3: Discussion to help the student identify and solve problems.
Reflection is an important element of the creative thinking spiral. Reflection helps a student to evaluate his products according to certain standards or rules and to choose suitable strategies to solve problems. A goal of this course was to encourage the student to develop the ability to identify problems, test possible solutions, attempt to fix the problem, solve the problem, and then attempt to refine his work. The sequential analysis showed that the sequence T3→S4 reached a significant level ($n=12$, $z=3.23$, $p<.05$), indicating that the teacher's questions helped the student to identify problems and consider possible solutions.

CONCLUSIONS AND SUGGESTIONS

This study examined whether a child developed assembling abilities, willingness to share ideas, and the ability to identify and solve problems during the Topobo robotics course. The main purpose of this study was to develop a robotics course for kindergarten children and to investigate the patterns of teacher-student interactions to evaluate the effectiveness of the course. In this study, the child developed assembling ability, willingness to share his ideas, and the ability to identify and solve problems. Interestingly, the teacher's guidance or support was very important for the children, and different strategies had different effects on the child's behavior. Providing children with concrete rules and guidance is beneficial for their ability to assemble and play with the programmable bricks. Additionally, by asking children questions, teachers can help students to identify problems, propose solutions, and share their ideas. This study found that the teacher was an important element in enhancing the child's learning and engagement in the robotics learning activities. Even in a constructivist learning environment, the role of teacher remains essential. By providing various suitable strategies, the child could use his imagination and could identify and solve problems. Programmable bricks were a new learning material for this kindergarten child, and the teacher's support was necessary. Based on the results of this study, we suggest that teachers should provide different supportive strategies, such as providing guidance or asking questions, to help children develop their ability to assemble the programming bricks, identify and solve problems, and increase their willingness to propose and share their ideas.

Although the teacher's support allowed the child to identify and propose solutions to problems, the child's ability to identify and solve problems did not occur repeatedly. The student did not develop the habit of identifying and solving problems independently. Chi, Siler, Jeong, Yamauchi and Hausmann (2001) suggested that in a one-to-one context, instructors could provide suitable support according to students' needs. However, in such a context, children might feel that they are in an unequal position in relation to the teacher and rely on the adult's help. Peer interaction is also an important element of a learning environment, but in a one-on-one context, the child had no peers to interact with and fewer opportunities to learn by observing, so he relied more on the teacher's support. Because the programming bricks were a new technology for the child, concrete examples during the learning process that allow the child to observe or imitate would decrease the child's difficulty in identifying and solving problems.

This work has some limitations that should be addressed in future research. A robotics course for kindergarten children was developed in this study is a one-on-one context. In future research, teacher-student interactions in a classroom context should be explored. Moreover, the teacher-student interaction patterns and peer interaction patterns could be compared to provide more information about how students interact with teachers or peers in a learning environment using programmable bricks. Furthermore, the design of the robotics course was based on the creative thinking spiral model, which includes five elements: imagining, creating, playing, sharing, and reflecting. The micro-view perspective was applied to evaluate the effectiveness of the robotics course by exploring teacher-student interaction patterns. More empirical studies are required to identify the sequence pattern of the five elements in the robotics course and to provide more information about how kindergarten children develop their creative thinking during this type of course.

ACKNOWLEDGEMENT
This study was supported by the National Science Council, Taiwan, under contract numbers NSC 101-2631-S-008-001, NSC 100-2511-S-008-017-MY2, and NSC 100-2511-S-008-006-MY2.

REFERENCES

Amidon, E. J. (1959). Dependent-prone students in elementary learning situations.Unpublished Phd. Thesis.University of Minnesota.

Bakeman, R., & Gottman, J. M. (1997). *Observing interaction: An introduction to sequential analysis* (2nd Ed.). Cambridge, UK: Cambridge University Press.

Bers, M. U. (2007). Project Inter Actions: A multigenerational robotic learning. *Journal of Science and Technology Education, 16*(6), 537-552.

Chang, C. S., & Liu, E. Z. F. (2011). Exploring the media literacy of Taiwanese elementary school students. *Asia-Pacific Education Researcher, 20*(3), 616-623.

Chang, C. S., Liu, E. Z. F., Lee, C. Y., Chen, N. S., Hu, D. C., & Lin, C. H. (2011). Developing and validating a media literacy self-evaluation scale (MLSS) for elementary school students. *Turkish Online Journal of Educational Technology, 10*(2), 63-71.

Chang, S. L., Shieh, R. S., Liu, E. Z. F., & Yu, P. T. (2012). Factors influencing women's attitudes towards computers in a computer literacy training program. *Turkish Online Journal of Educational Technology, 11*(4), 177-187.

Chang, C. W., Lee, J. H., Chao, P. Y., Wang, C. Y., & Chen, G. D. (2010). Exploring the possibility of using humanoid robots as instructional tools for teaching a second language in primary school. *Educational Technology & Society, 13*(2), 1-24.

Chang, C. W., Lee, J. H., Wang, C. Y., & Chen, G. D. (2010). Improving the authentic learning experience by integrating robots into the mixed reality environment. *Computers & Education. 55*(4), 1572-1578.

Chen, S. T., Chiang, I. T., Liu, E. Z. F., & Chang, M. (2012). Effects of improvement on selective attention: Developing appropriate somatosensory video game interventions for institutional-dwelling elderly with disabilities. *Turkish Online Journal of Educational Technology, 11*(4), 409-417.

Chi, M. T. H., Siler, S. A., Jeong, H., Yamauchi, T., & Hausmann, R. G. (2001). Learning from human tutoring. *Cognition Science, 25*, 471-533.

Feng, H. C., Lin, C. H., & Liu, E. Z. F. (2011). Parents' perceptions of educational programmable bricks for kids. *British Journal of Educational Technology, 42*(2), E30-E33.

Flanders, N. A. (1970). *Analyzing teaching behavior*. Reading, MA: Addison-Wesley.

Harris, R. (1998). *Introduction to creative thinking*. Retrieved January 31, 2010, from, http://www.virtualsalt.com/crebook1.htm.

Levy, S. T., & Mioduser, D. (2008). Does it "want" or "was it programmed to…"? Kindergarten children's explanations of an autonomous robot's adaptive functioning. *International Journal of technology and Design Education, 18*, 337-359.

Lin, C. H., Liu, E. Z. F., & Huang, Y. Y. (2012). Exploring parents' perceptions toward educational robots: Gender and socioeconomic difference. *British Journal of Educational Technology, 43*(1), E31-E34.

Lin, C. H., Liu, E. Z. F., Chen, Y. L., Liou, P. Y., Chang, M., Wu, C. H., & Yuan, S. M. (in press). Game-based remedial instruction in mastery learning for upper-primary school students. *Educational Technology & Society*.

Lin, C. H., Liu, E. Z. F., Kou, C. H., Virnes, M., Sutinen, E., & Cheng, S. S. (2009). A case analysis of creative spiral instruction model and students' creative problem solving performance in a LEGO robotics course. *Lecture Notes in Computer Science, 5670*, 501-505

Liu, E. Z. F. (2010). Early adolescents' perceptions of educational robots and learning of robotics. *British Journal of Educational Technology, 41*(3), E44-E47.

Liu, E. Z. F. (2011). Avoiding internet addiction when integrating digital games into teaching. *Social Behavior and Personality, 39*(10), 1325-1336.

Liu, E. Z. F., & Lin, C. H. (2009). Developing evaluative indicators for educational computer games. *British Journal of Educational Technology, 40*(1), 174-178.

Liu, E. Z. F., Lin, C. H., & Chang, C. S. (2010).Student satisfaction and self-efficacy in a cooperative robotics course. *Social Behavior and Personality, 38*(8), 1135-1146.

Liu, E. Z. F., Lin, C. H., Jian, P. S., & Liou, P. Y. (2012). The dynamics of motivation and learning strategy in a creativity-supporting learning environment in higher education. *Turkish Online Journal of Educational Technology, 11*(1), 172-180.

Liu, J., &Elicker, J. (2005). Teacher-child interaction in Chinese kindergartens: An observational analysis. *International Journal of Early Years Education, 13*(2), 129-143.

Lubart, T. I. (2001). Models of the creative process: Past, present and future. *Creativity Research Journal, 13*(3), 295-308.

Miller, D. J., & Robertson, D. P. (2010). Using a games console in the primary classroom: Effects of "Brain Training" programme on computation and self-esteem. *British Journal of Educational Technology, 42*(1), 88-100.

Nelson, B.C., Erlandson, B., & Denham, A. (2011).Global channels of evidence for learning and assessment in complexgameenvironments. *British Journal of Educational Technology, 42*(1), 88-100.

Perraton, H. (1987). *The role of theory and generation in the practice of distance education* (Report No. CE049375). Hagen, Oktober: Zentrales Institut fur Fernstudienforschung. (ERIC Document Reproduction Service No. ED290015)

Raffle, H., Parkes, A., & Ishii, H. (2004). *Topobo: A constructive assembly system with kinetic memory*. In Proc. CHI 2004, 647-654.

Resnick, M. (2007). Sowing the seeds for a more creative society. *Learning and Leading with Technology, 35*(4), 18-22.

Resnick, M. (1998). Technologies for lifelong kindergarten. *Educational Technology Research & Development, 46*(4), 43-55.

Rosenberg, C. R., & Silva, M. L. (2009). Teacher-children interaction and concept development in kindergarten. *Discourse Processes, 46*, 572-591.

Virnes, M., & Sutinen, E. (2009). *Topobo in kindergarten: Educational robotics promoting dedicated learning*. Proceedings of the 17th International Conference on Computers in Education, 690-697.