Maze and Mirror Game Design for Increasing Motivation in Studying Science in Elementary School Students

The case of Maze and Mirror Workshop in Shimada elementary school of Japan

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Abstract. The research project discussed here, examines attempts to increase the motivation of elementary school students in basic science by the means of designing a science game. To realize this goal, the maze and mirror game was designed and a workshop was held based on the game which teaches the concepts of light and reflection during joyful group play. The game was initially designed for this research consisted of a maze pattern, mirrors and bases, a buzzer and a laser. The results of the game were evaluated by three types of questionnaires and showed improvement in all aspects. The questionnaires revealed that 91% of students liked the game very much and 81% favored having these kinds of games in their science classes. The main achievement of this game for students can be categorized into four main areas: Creating thinking and independent learning, playful learning atmosphere, a chance to learn in group activities, and a feeling of accomplishment.

Keywords: Game design · Maze and mirror game · Science workshop · Playful learning · Real time video

1 Introduction

Love for and/or interest in science begins in elementary schools (Spencer and Walker 2012). Younger children tend to be more curious and motivated to learn. The pipeline for increasing the number of people interested in science fields begins in these formative years. Efforts on designing games and combining them with science workshops will provide a unique chance for children to enjoy these games broadly, while their motivation and enthusiasm for learning science may increase and help them to face the challenges or learning sciences such as physics in high school and later.

In this research, by designing a game and a game-based science workshop including reflection by RTV, we prepare a situation for students to enter a game, and enjoy, learn and share their experiences while they're studying about light, mirror and reflection. One of the steps of this workshop is preparing Real Time Video (RTV) which is taken simultaneously during the workshop. During the workshop two camera men take photos and videos, and at the same time make a 4-minute video of the game. At the end of the

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workshop, this clip is shown to participants which reflects the students, their group and the other groups' activities. In this game, the RTV allowed children to understand their strong and weak points and consider them in the possible next steps, giving them a good chance to improve their learning of science achieved in the game and for the researchers to study their reaction to the designed game.

2 Method

2.1 Maze and Mirror Game Concept

Children at birth are natural scientists, engineers, and problem-solvers (Tony 2011). They consider the world around them and try to make sense of it the best way they know how: touching, tasting, building, dismantling, creating, discovering, and exploring. For kids, this isn't education. It's fun. Children's play is not "supplemental" to their learning. It is their learning. (Renee 2011). According to Einstein "Play is the highest form of research". Fred Rogers said "Play is often talked about as if it were a relief from serious learning, while for children, play is serious learning. Play is really the work of childhood".

Resnick (2007) in "All I really need to know (about creative thinking)" argues that the kindergarten approach to learning - characterized by a spiraling cycle of Imagine, Create, Play, Share, Reflect, and back to Imagine - is ideally suited to the needs of the 21st century, helping learners develop the creative-thinking skills that are critical to success and satisfaction in today's society. The materials and the creations vary, but the core process is the same." He thinks of it as a spiraling process in which children imagine what they want to do, create a project based on their ideas, play with their creations, share their ideas and creations with others, and reflect on their experiences – all of which leads them to imagine new ideas and new projects (Fig. 1). Considering these aspects, an indirect educational atmosphere based on a designed game can allow children to think, play and discover actively. Children will be motivated if they have the chance to do something by themselves and feel that they did it! In this research, two methods were considered for sharing. One involved sharing through consultation time in group work, and the other sharing through reflection by RTV. The case of light, mirror and reflection were considered and a Maze and Mirror Game was designed to be used with the research subjects.

This Maze and Mirror Game creates a unique possibility for students to communicate in groups, share and strengthen their ideas, and experience playful learning. There is the possibility of direct, hands-on learning and self-evaluation by seeing their interactions in their own groups and by seeing how other groups interact through reflection by RTV, integrating better learning with fun. It is expected that the learning procedure will increase their interest, activate their minds, and what they have learned will be retained longer (Fig. 2).

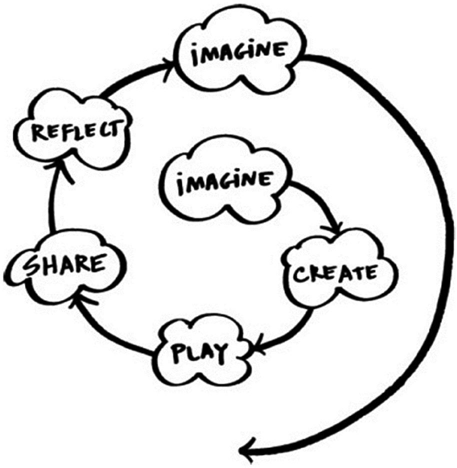

Fig. 1. The kindergarten approach to learning (Mitchel 2007)

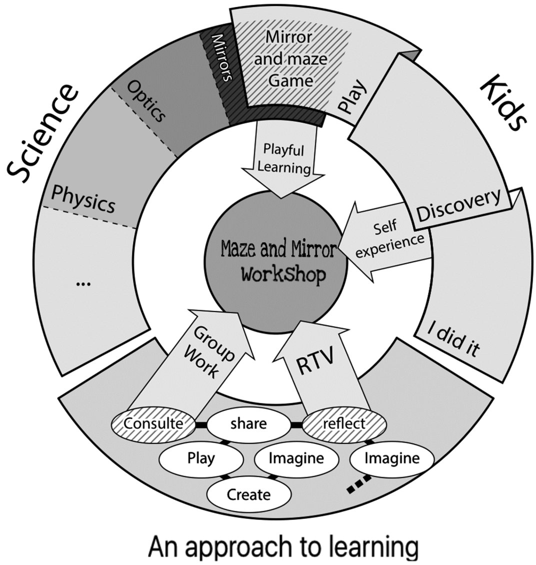

Fig. 2. Maze and Mirror Game design

2.2 The Steps of Maze and Mirror Workshop

Following the inspiration of Mitchel Resnick's spiraling process, the workshop steps were designed as seen in Fig. 4. In the preparatory step, the workshop and what students will do are explained to students. Then a questionnaire about light and mirror is distributed among the students to collect information about their basic knowledge of the science that will be presented. After that, students gather in the workshop area for about 15 min for an ice-breaker that helps them to warm up mentally and become prepared for the main part of the workshop. The next step is the first round of the game in which the first two groups of students start to play the Maze and Mirror Game, competing with each other. The group which finishes first is the winner of the game. Each round of the game takes about 20 min. After the first round, the students fill in the same questionnaire to check their knowledge progress. Then a time is allocated to groups for consultation about what they have done, their experiences and ideas about how they should continue in order to win the game. This is followed by the second round of the game in which the other two groups of students participate and the first two groups are spectators. A third round follows in which all four groups enter the game and compete with each other to check on students' progress compared to their first rounds. After that, the RTV which reflects what students did during two hours of activity is shown for about five minutes. In the RTV students will see their own and other groups' experiences. The last step is answering a questionnaire about the game, the workshop and RTV which asks about students' feelings and understanding. In this workshop, there were two facilitators to help the students know what to do in each step, to motivate them, to help them to understand their feelings, and to ask them questions during question time as it is difficult for children to answer the questionnaires by themselves (Figs. 3 and 4).

Fig. 3. Workshop's steps

2.3 Maze and Mirror Game Design

This game was initially developed for this research as an educational aid product in 2012 (Fig. 5). It is basically a conventional maze which is solved with light instead of a pen on paper. It is designed to teach students about light and reflection while playing an enjoyable game.

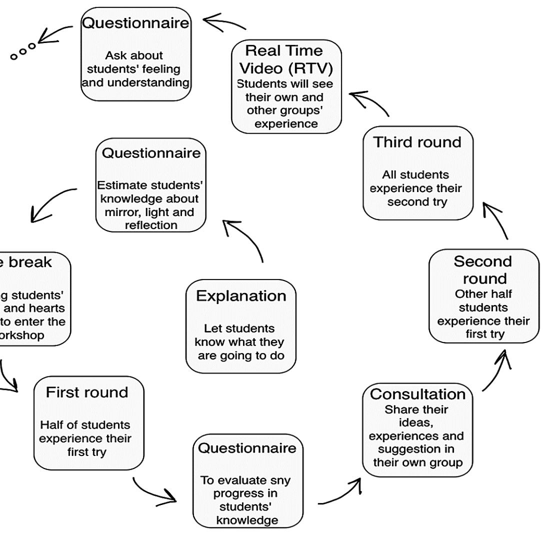

Fig. 4. The spiral of workshop steps inspired from Mitchel Resnick's approach

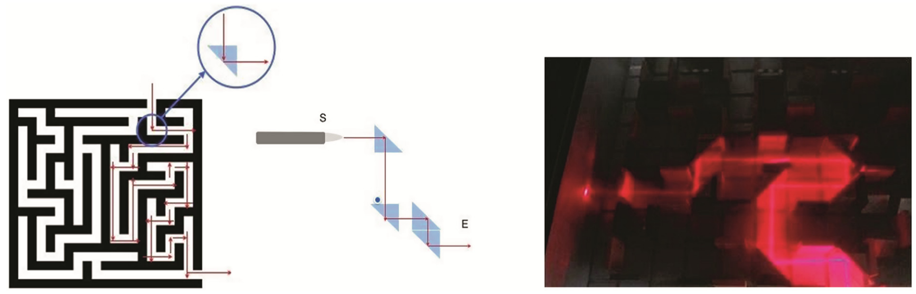

Fig. 5. Maze and Mirror Game's concept

A laser beam emits from the starting point and players direct it toward the correct path by using a mirror or prism, putting the reflective devices at the correct point with the proper orientation to divert the Laser beam to the right path and continue this manipulation until they reach the final goal.

This set is made of a wooden board covered with 3 × 3 cm flat cubes used to construct a passage (Fig. 6). By fixing the flat cube pieces at different points along the passages, it is possible to make different maze patterns on the board. The board is colored silver and the pieces are dark grey and pink. There is also a laser as the light source, small mirrors with wooden stands and a fog producer (fogger or recurrence) that makes the laser beam visible.

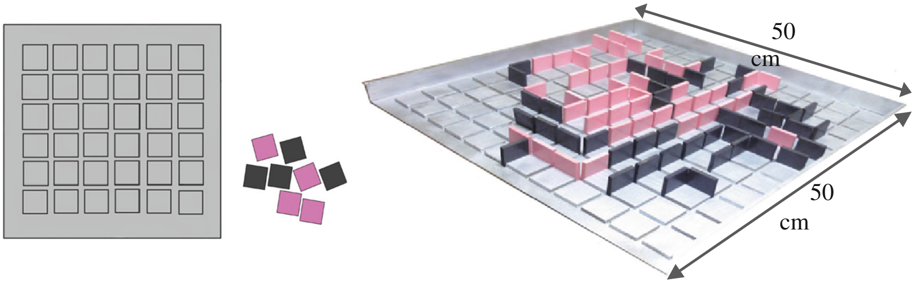

Fig. 6. Maze and Mirror Game's design (Color figure online)

2.4 Maze and Mirror Game as a Workshop

A larger version of the game was redesigned to be used as a workshop. The game is played in a semi-dark room to make the laser beam visible, yet allowing for enough light to take videos for RTV.

This version consists of the following elements:

(1) Fogger (American DJ) to make the laser beam visible (Fig. 7a)

Fig. 7. (a) Fogger (b) Game sets (c) Maze pad in the game set

(2) Maze pad, which is a 3 × 3 m printed sheet of a maze pattern (Figs. 7b, c). A maze pattern was downloaded from a maze generator website with ten turns. The pattern was redrawn in the illustrator at a resolution quality that enabled printing the design on a 3 × 3 m plastic sheet. The maze pattern was divided into three parts and each 1 × 3 m part was printed and connected from the backside.
(3) High power laser pointers (to meet the need of multiple reflections)
(4) Mirrors, A4 size (size considered necessary to make the reflection in ten mirrors in one game set reach its best usability.)
(5) Innovative mirror bases made of cardboard sheets designed to allow the mirrors to rotate around a horizontal axis ten centimeters from the ground, as well as rotate around the central vertical axis allowing the students to adjust the laser beam freely (Fig. 8).

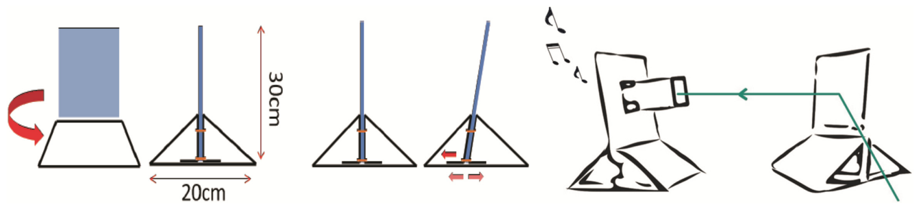

Fig. 8. Mirrors and sensor's base and their rotations and the set's function

(6) An optical buzzer assembled as a goal which beeps when a laser beam is detected and announces the successful end of the game. It is located on an A4 size sheet and its base is the same as the base used with the mirrors. A tetrahedron passage placed around the sensor on the board prevents other lights from triggering the sensor, thus preventing a continuous beep from the buzzer (Fig. 8).

2.5 Implementation of the Game in Shimada Elementary School

This game was implemented in the Shimada Elementary School, (Osaka, Japan) on September 2013. A total of 44 students from two 6th grade classes attended. 6 graders were considered because they matched to the game usability best as an elementary school students. They were divided into four groups. Two groups, A1 and B1, competed in the first round, the other two groups, A2 and B2, competed in the second round, and all four groups competed in the third round. In each group, one person was responsible for fixing the laser pointer, one for the fogger and the others for placing the mirrors (10 mirrors had been prepared for each group). The workshop consisted of explanation, questioner time (1), break, first round, questioner time (2), consultation time, second round, third round, reflection by RTV and questioner time (3). Students' prior formal exposure to light and mirrors before the workshop was in third grade of elementary when they had a lesson named the nature of light (let's investigate the sunlight).

3 Result

3.1 Students' Interactions with the Game and Contents

The game set was successful and students could accomplish the game through three rounds of the game. Despite of uncomplicated theory of the game, practically transferring light through mirrors and fixing mirrors' angles was challenging for students and let them to be familiar with the concept of light and reflection as they revealed in their questioners. The performance of laser, maze sheet, mirrors, sensor and fogger was convenient. Music sound of the sensor that was played right after light reached to the end point was resulted in children's excitement about the game's accomplishment. Just there was a need for a base for laser to be fixed on and move up and down freely. This will be helpful for more accuracy considering that light getting to the end point of the maze through several mirrors, and millimeter movement of laser can disrupt everything.

An analysis of student answers to the questionnaires about light and reflection, as well as to the general questionnaires, yielded the following results. Eighty-one percent of students expressed interest in having these kinds of workshops in their science classes, as one of them expressed that "It would be a good chance to have workshops like this once a month". Analyzing students' answers in the questioners generally revealed that what was motivating them in this research can be summarized in some main areas. One of them indicated as hands-on experiences. Students enjoyed moving their bodies while studying and being engaged in some tasks like changing mirrors' position. The other one can be presented as self-confidence. They enjoyed expressing their ideas and watching that they worked, they had the possibility to cope with their responsibilities in their groups, and they could find some new capabilities in themselves. Group-work is another case students enjoyed and benefited quite much of it. Thinking together, learning while cooperating and winning all together were some of their beliefs on benefits of group-work through this game. Also the feeling of accomplishment like as when they had been trying their best and with excitement were arranging the last mirror of the game was another achievement of this game in students' point of view. Having fun and atmosphere related items such as wide space and teacher's tension also helped them to increase their motivation. These finding demonstrate the success of the game in motivating students' interest in science (Fig. 9).

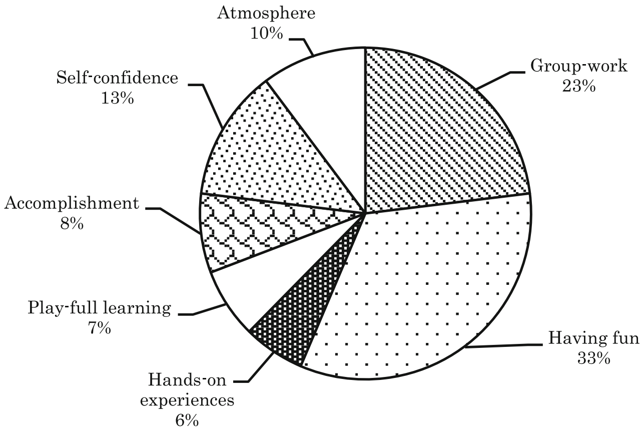

Fig. 9. Motivating factors through students' answers in the questioner

3.2 Real Time Video (RTV) Questionnaire

Regarding to the questions related to the RTV, students when they requested to describe their facial expressions through the RTV, 26% answered happy, 26% answered serious, and others answered with other replies like normal and I couldn't understand. Their feelings about themselves were mostly a combination of happy and serious. Through the RTV, they could see which part they did well and where they could try harder. Also they could study interactions in both their own groups and the other groups while the positive points in themselves and their own groups will increase their self-confidence and positive points in other groups will help them to learn new aspects of learning, feeling and interacting, which may help them in their future interactions (Fig. 10).

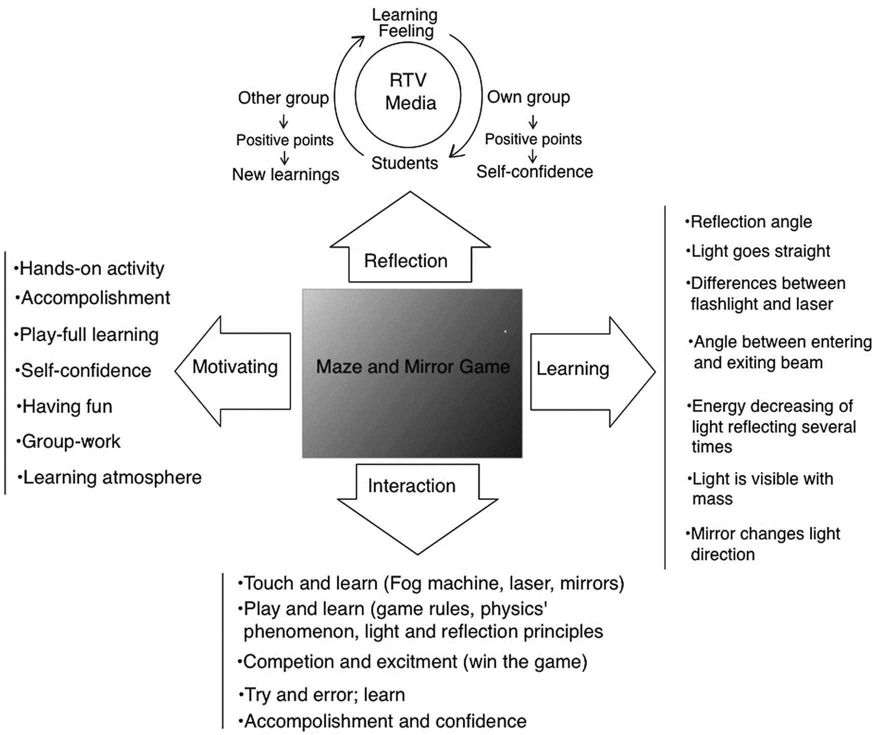

Fig. 10. Maze and Mirror game and concluding factors considering students' interaction with the game

4 Conclusion

The Maze and Mirror Game was initially designed for this research in 2012 with the purpose of motivating elementary school students in science, specifically physics. This game was redesigned in 2013 on a bigger scale to be held as a workshop for students to study its effect on student motivation for science leaning. The game in the Shimada elementary school in Japan was studied and the results revealed that students were impressed by the game as a new atmosphere in which to learn while they are playing. They learned more than what was expected from this game in terms of both theoretical physics and its practical application. For example, students learned that a laser beam enters and exits a mirror at the same angle. They also learned that when a laser beam is reflected by several mirrors, the beam becomes thinner. This is something that can only be learned through practical or hands-on experience. They enjoyed working with their hands with new things in a new learning atmosphere as much as they enjoyed working together, doing something by themselves and watching themselves through the RTV. They had useful suggestions to create a better game and believed that advantages of the game-based workshop over their normal science classes are the possibilities of learning while having fun, learning in person rather than studying books or taking notes, studying and interacting in a bigger space than their classroom, cooperating with classmates, discussing their opinions and, being involved in the learning process, which one of them expressed by saying “I felt the game with my body”. They also had the chance to evaluate themselves in a Real Time Video (RTV). Their answers to the RTV questionnaire showed their attention in all aspects, their feelings, their facial expressions and the extent to which they where successful encountering with the game and how they believed they could improve. It will be great if there is a chance to study same group over a one-year period of time to study students’ further interactions considering the game.

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