

RESEARCH NOTES

Stories of Tomorrow: Practice in Elementary School and Its Reflection

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Abstract : A pilot program in Europe, Stories of Tomorrow, STEAM education and ICT-using problem-solving practice for upper elementary school students, was conducted with one class of 6th-grade students in the Faculty of Education, Wakayama University, and one class of 3rd-grade students in the Faculty of Education, Mie University, on the theme of travel and migration to Mars. We tried it out by making use of the time for integrated studies and other activities. We did not just implement this task as is, but also carried out it from the perspective of curriculum design to see how it could be used in the Japanese classroom. We found that the moderately difficult task of being on the borderline between what the students know and what the students do not yet know, materials that were easy-to-operate for the students, and the creation of classroom relationships filled with a collaborative atmosphere led to success of problem-based learning. We were able to learn from the students' feedback that through problem-solving, the spirit of collaboration, the spirit of overcoming failure, and the deep understanding of scientific research and technology development has been nurtured.

Keywords : Integrated studies, Problem-solving learning, International collaboration, ICT, STEAM, Stories of Tomorrow

1. Introduction: Stories of Tomorrow

How can students' creativity flourish? To address this question, Stories of Tomorrow, an interdisciplinary, going beyond science alone, computer-aided educational practice project began in 2017 as an experiment in Europe with funding from the European Commission ^[1]. Several schools from each of the five European countries, Portugal, France, Germany, Greece, and Finland have participated in the project, and in 2018, Japan also participated. The call from the Stories of Tomorrow was given by Hidehiko Agata, director of the outreach and education office, National Astronomical Observatory of Japan, through the mailing list of the Japanese Society for Education and Popularization of Astronomy on September 3, 2017. In response,

Tomita, one of the authors, called on elementary school teachers in Japan, and around December 2017, two elementary schools attached to Faculty of Education of Wakayama University and Faculty of Education of Mie University were invited to participate.

The Stories of Tomorrow is a problem-solving exercise based on a hypothetical challenge of traveling and migrating to Mars. The original task was to create a multimedia e-picture book about a journey and migration to Mars and to evaluate each other's collaboration in the process, the science, technology, and artistry of the contents. The practice was designed for sixth-grade students. In the creation of the Stories of Tomorrow e-picture book, a working website was developed using the game engine UNITY (fig. 1; in this project, we call it the platform).

The picture storytelling with animation reminds us of PowerPoint, but the platform was highly functional in terms of audio, video, and animation, and it was also highly compatible with augmented reality. This is a good example of the use of ICT.

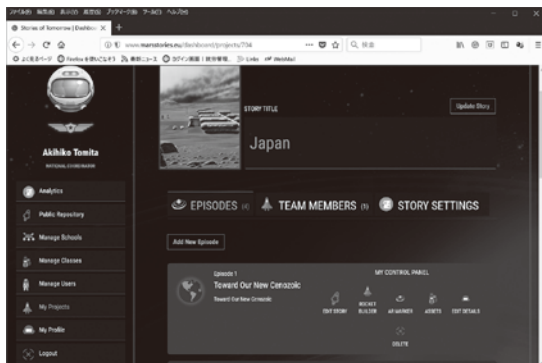


Fig. 1 Sample screenshot of the Stories of Tomorrow platform (also available in Japanese).

The theme of Mars gives a strong impression of the subject of science, but it can be seen as an integrated study with various research studies, technical exercises, storytelling, and collaborative work in the process, when students investigate the journey to Mars, migration, and life on Mars. This is a good example of STEAM (Science, Technology, Engineering, Art/Arts, Mathematics) education. In addition to the storytelling activity, consideration of sustainable communities, food procurement, human relationship building, habitation, and flying body designing on the computer will incorporate much of the content of expression activity, food and shelter, community, and construction, and will be relevant to the subjects of home economics, health and physical education, social studies, Japanese language, arts and crafts, math, music, English, and morals, and will contribute to international understanding, information education and programming education. It is so comprehensive that it does not only fit into the framework of STEAM education. Although this is an elementary school practice, this kind of multifaceted problem-solving setting is expected to lead to the enrichment of integrated inquiry-based and problem-solving research projects required in senior high schools.

The summer school was held as a training and exchange session with teachers of five European countries, in which all the authors participated [2]. While some of the training was technical, such as technical training in the creation of e-picture books and training in AR and other functions, it also offered

direct interaction between teachers. It was a very valuable opportunity for the participating Japanese teachers to interact directly with each other from many countries, and it was useful for them to build an international collaboration network in the future (fig. 2).



Fig. 2 A summer school discussion (Maeda, one of the authors, is a little to the right in the center of the picture, in the foreground).

The Guidelines for the Course of Study in Japan, which were revised in March 2017 and fully implemented in elementary schools from the 2020 school year, aim to nurture the ability to not only “what to learn,” but also “become what you can do” (how to use what you can do and how to relate to society and the world) through “proactive, interactive, and deep learning” (how to learn), using the perspectives and ideas of each subject. Besides, it aims to “enhance foreign language education,” “enhance computer-based learning activities,” “foster programming thinking,” “address contemporary issues: sustainable development initiatives, natural disasters, etc.,” and “enhance the connection between out-of-school informal education and formal education.” What the Stories of Tomorrow aims to do, and what the Stories of Tomorrow can do, can be used to enrich this content that elementary schools are trying to address in the Guidelines for the Course of Study.

2. Practice of the Stories of Tomorrow in Japan

In the two schools in Japan, the two teachers participating in the study (the authors, Kubo and Maeda) implemented the project in their classrooms. It was implemented in one class of 6th graders at elementary school attached to Faculty of Education of Wakayama University and in one class of 3rd

graders at elementary school attached to Faculty of Education of Mie University. Tomita served as the contact person in Japan to the Stories of Tomorrow's headquarters and was also responsible for researching and consulting with the two schools on various environments, including computer systems. Doran coordinated the international network of the Stories of Tomorrow and was in frequent contact with Tomita to connect Japan with the rest of the world.

The original design of the Stories of Tomorrow was described in section 1. However, as described below, there were some difficulties in implementing it in Japan. Firstly, the Stories of Tomorrow was originally prepared as practice for 40 hours per year. Considering the situation in Japan, it was not realistic to use 40 hours per year, even with the discretion of the homeroom teacher. Nevertheless, in both schools where it was practiced, the teachers made use of time for integrated studies and science classes to carry out the practice.

In addition, creating an e-picture book was not an easy task even for the upper grades of elementary school students. In particular, we should have considered how to incorporate the spirit of the Stories of Tomorrow into the third-grade students of the Mie school.

The platform prepared to support the creation of the e-picture book was excellent, but it required a high level of computational power. The computer room environment was not sufficiently conducive to the preparation of e-picture books, even at the two university-attached schools, at the time of its implementation.

In the original plan, the e-picture book was to be evaluated by the teacher according to eight perspectives: scientific content and knowledge (20%), storyline (10%), artistry and creativity (10%), narrative originality (10%), collaboration (10%), effective presentation (10%), inclusion of problem-solving content (20%), and relevance to the theme of travel and migration to Mars (10%). In this international collaborative project, respect for the language and culture of each country was also well-considered, and the e-picture book was created in each country's native language. It would have been wonderful if the e-picture book was created as originally intended and if we could have had a deep exchange of the work with the other participating countries, but we could not achieve that much this time because it was a task that was introduced only

during this year and just a one-year project.

In spite of these problems explained above, we decided to implement the Stories of Tomorrow from the perspective of curriculum design, pursuing how the elements of integrated studies, problem-solving learning, international collaboration, ICT application, and STEAM education that the Stores of Tomorrow had could be incorporated in the Japanese classroom. This was the purpose of our research. The practices in the two schools are described in sections 3 and 4 below, respectively.

3. Practice at Mie University Elementary School: Integrated education of science and programming using Lego with the theme of exploration on Mars and foreign language activities

The Stories of Tomorrow, including the level of computer handling, was originally developed for sixth-grade students, therefore, it could not be used directly in the third graders of Maeda's class. Maeda decided to use the spirit of the Stories of Tomorrow, instead of just creating an e-picture book, making use of what students had learned in the classroom with the theme of the Mars expedition, and improving the English education to cooperate with people around the world for scientific exploration.

In considering the creation of a "class that ignites students' minds," Maeda have felt that with themes that aim at the boundary between "I know" and "I don't know yet," materials to support the activity, and human relationships in the classroom, students will be able to pursue tasks proactively and freely. The Stories of Tomorrow's contents were a perfect challenge for such a theme, therefore, in the third term of the school year of 2018 (January to March 2019), using a total of 12 hours of integrated studies classes and science classes, Maeda planned a unit with the aim of "Let's build a Mars rover to detect metal". In a simulated Martian environment made of cardboard, placing a piece of metal on it, the students tried to search for the piece of metal with a simulated Mars rover they created (Figs. 3, 4, and 5). This rover was a robot made from Lego bricks. Through programming, the students made it work. For the metal detection, the students proactively and interactively developed a robot with batteries, wires, and a miniature light bulb in a group activity, and when the rover passed over a piece of metal, the miniature light bulb turned on. The robot's shape

and weight had to be carefully considered to be able to cope with the unevenness of the simulated Martian surface. The development of the robot was carried out through trial and error. This practice is shown on the official Lego Education website as a challenge, “Let’s build a metal detecting probe” for the unit of “Pathway of electricity” for the third grader’s science curriculum ^[3].

In a series of lessons, from the students’ feedback: “It was so refreshing to see the light bulb shine when the rover’s nail (part of the simulated Mars rover’s equipment) hit the metal and it made the miniature light bulb shine, I almost forgot the frustrating incident when I was assembling it”, “The research activity was full of failures, disagreements and quarrels during the activity, but we got the light on at last.” The feedbacks were filled with the joy of achievement and a moralistic mind. In particular, the latter feedback was such that one would think that this was a story from the actual development of a real Martian rover. Besides, some of the students returned feedbacks with a proactive mind in discovering new ideas and admiring the device development, such as “We have made a rover that lights up when it finds a metal object, but it can only find it, not take it back to Earth, so I want to make something that can take it back to Earth”, “The rover can’t climb up a step and it stopped, so I want to make a lighter and more compact rover that can climb up a step,” etc. These are exactly what are currently being researched and developed for the real Mars rover. We can say that the actual scene of research and development is the exploration of science by adult professionals with the mind of children. There are feedbacks with full of challenging spirit and a deep understanding of scientific research and technological development, such as “I’ve learned that rovers fail too, and if I fail something in the future, it’s better not to give up”, “I was amazed that researchers continue to study Mars, despite repeated failures and revising the programs” ^[4]. One of the reasons for the success of this activity was the use of a robot created from Lego bricks, a teaching material that is easy for the students to manipulate. Maeda also incorporated electronic storytelling activities using Keynote, which runs on a tablet device and is easy for the students to operate, rather than the Stories of Tomorrow platform.

In addition to the Lego programming education, using the Stories of Tomorrow as a scientific



Fig. 3 The rover making and metal detecting challenge in the Maeda class.



Fig. 4 Creating a well-balanced LEGO robot requires a lot of trial and error. The size of the batteries also needs to be considered. This is where the students’ collaborative work comes in.

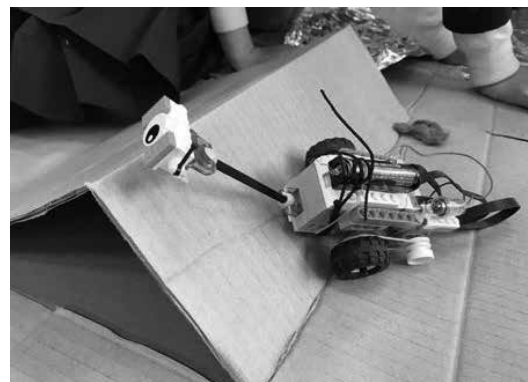


Fig. 5 Successfully overcoming obstacles requires a lot of ingenuity and trial and error. This is where the students’ collaborative work comes in.

exploration in cooperation with people from all over the world, Maeda also focused on English language education with international understanding as the theme from a cross-curricular perspective. The students sent a video message in English to introduce their school life, after receiving a video message from a French teacher whom Maeda had met at the summer school. Maeda's classroom used mind maps to expand the English vocabulary and practiced the students' ability to introduce their school in English. These activities were the result of direct interaction between teachers at the summer school.

4. Practice at Wakayama University Elementary School: Creating electronic picture books based on mutual learning in groups

During the second and third terms of the school year of 2018 (September 2018 to March 2019), Kubo used integrated studies time to practice the activity in the 6th-grade class. First, the students have researched on Mars in the literature and internet, then they created the e-picture book using the platform developed for the Stories of Tomorrow through the group activity. To access the platform over the internet, the students visited Wakayama University twice (on 11 and 20 December 2018) as an off-campus field trip: on 11 December from 1:00 to 2:30 p.m. and on 20 December from 12:00 to 2:30 p.m. This was a practice of elementary school-university direct collaboration (Figures 6, 7, and 8).

The elementary school's computers were 32-bit Windows 7 machines at the time, therefore, the platform did not work well. The computers at the Wakayama University Academic Information Center were also Windows 7 machines at the time, however, they were 64-bit machines. The platform managed to work, though it was somewhat unstable. In the activities with advanced ICT utilization, there was the issue of the need for adequate hardware and software. We can have a research task for the development of a system with greater versatility and operability for students.

The class was divided into seven groups to create a draft of the e-picture book. At first, Kubo asked the students to think about the structure of the book in relation to the Japanese language classes' storytelling. After that, each group came up with a draft, and then they worked proactively and collaboratively



Fig. 6 E-book production at Wakayama University.



Fig. 7 A screenshot of the work in progress to create an e-picture book using the Stories of Tomorrow platform.

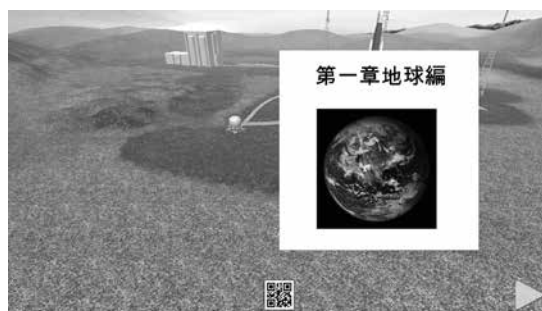


Fig. 8 Example of an e-picture book cover that the students created.

to revise the draft. The three themes of Earth, Space, and Mars were included in the e-picture book in accordance with guideline of the Stories of Tomorrow project. Some groups had a high level of imagination, and the students incorporated topics which they researched into the story, and other students tried to pursue the original story, some of the characters were quite original. Kubo had hoped that the story could be developed into a play as well, but it was a little too far for the students. However, many groups were left with a dull script. In addition, because we were too busy thinking about the use

of ICT and grasping the system, the important part of the project, Mars, was not so well incorporated. As for the creation of the e-picture book itself, it did not produce sufficient results. Nevertheless, Kubo felt that the students were able to further develop their ability to work together, gather information, and express themselves through the process of creating the e-picture book. Each group was able to assign their responsibility for the project and make good progress. In terms of inter-disciplinary point of view, the students had not only the connections with the Japanese language subject in relation to the storytelling, but also the connections with the arts and crafts subject in relation to the representation of the pictures, and with the science subject in relation to the communication of the research.

Some of the students looked back on the project as an opportunity to think about Mars, which they had never thought about before, relating to the global environmental issues. We got feedbacks, such as "Though the task was difficult for me, I felt a sense of accomplishment when it was completed," "I could cooperate with group member." Although manipulability was a little difficult for elementary school students, it was the moderate difficulty of the task that led to such collaborative feedback from the students. We can say that we should prepare an environment in which the operation is easy and the task is moderately difficult. This is similar to the strategy of aiming for the boundary between "I know" and "I don't know yet" in the Maeda class.

5. Reflections of the practice of the Stories of Tomorrow in Japan

The Stories of Tomorrow originally aimed at the creation of electronic picture books, and through the activity, we expected to improve the students' ability to work together, to integrate the various things they had learned, and to apply them to the task.

When we look back at the practice in Japan, where we did not focus too much on the e-book creation work, nor on securing 40 hours strictly, but firmly incorporated some of the ideas from the Stories of Tomorrow, we can conclude that we were able to provide students with the ability to work together, to integrate the various things they learned, and to apply them to the task. First, the foundation of student's skills and competencies have been nurtured, then the Stories of Tomorrow challenge

came in, which led to a successful problem-solving activity. Rather than having a single, comprehensive, general-purpose task that could be decisive, these skills and competencies have been gradually developed in a variety of classes, activities, and lives, and these new tasks have further improved them. From the perspective of curriculum design, which is becoming more important in Japan, the Stories of Tomorrow has been used well. The key to success in problem-solving learning is a moderately difficult task that lies on the border between "I know" and "I don't know yet," teaching materials that are easy-to-handle for the students, and the creation of human relationships in the classroom that are filled with an atmosphere of collaboration. Through problem-solving, we can see from the feedbacks from the students of this project that a spirit of collaboration, a challenging spirit, and a deep understanding of scientific research and technological development are fostered.

We can use the electronic picture book system as a form of recording of various activities, rather than being limited to creating an electronic picture book; for example, spending time in the spacecraft (physical education in relation to training, music and reading in relation to relaxation in life, arts and crafts in relation to spacesuit design), spending time on Mars (integrated studies in relation to vegetable farming, home economics in relation to diet and nutrition, math and arts and crafts in relation to the building), Mars exploration in relation to programming education. Thus, we can use the electronic picture book as a tool for inter-disciplinary reflection.

6. Conclusions

1. From the practice of the Stories of Tomorrow in Japan, we confirmed what is accepted that the key to success in problem-solving learning is a moderately difficult task that lies on the border between "I know" and "I don't know yet," teaching materials that are easy-to-handle for the students, and the creation of human relationships in the classroom that are filled with an atmosphere of collaboration.
2. From the practice of the Stories of Tomorrow in Japan, we confirmed what is accepted that through problem-solving, we can see from the feedbacks from the students of this project that a spirit of collaboration, a challenging spirit, and

a deep understanding of scientific research and technological development are fostered.

- It was found that it is possible for third-grade students to practice STEAM education using ICT on the theme of travel and migration to Mars through adequate development of tasks, teaching materials, and classroom atmosphere. This is the great result of the practice at Attached Elementary School, Faculty of Education, Mie University.

Acknowledgments

We would like to thank all those who have guided us into the wonderful world of the Stories of Tomorrow. We would like to thank the elementary schools attached to Faculty of Education of Wakayama University and Faculty of Education of Mie University for sharing the significance of this practice and for their cooperation and encouragement to implement it in their schools. It was Dr. Hidehiko Agata, director of the outreach and education office, the National Astronomical Observatory of Japan, who encouraged and called for the implementation of this educational practice in Japan. From 1 to 6 July 2018, we participated in the Summer School (<https://stories.ea.gr/>) of the Stories of Tomorrow at the Golden Coast Hotel and Bungalow, facing Marathon Bay in Attica, Greece, which brings together teachers from schools in different countries in the world. It was a great opportunity for us from Japan to interact directly with teachers from Europe. We are particularly grateful to the lead school, Ellinogermaniki Agogi (<http://www.ea.gr/>) in Greece, and to NUCLIO (<https://nuclio.org/>), the global organization for teacher training (Rosa Doran is the president of NUCLIO). Prior to the implementation of the Stories of Tomorrow in Japan, a briefing session was held at the National Astronomical Observatory of Japan on 10 and 11 March 2018, together with the teacher training program GTTP (<http://galileoteachers.org/>), under the arrangement by Dr. Hidehiko Agata (Rosa Doran is the president of GTTP). On 15 March 2018, a Portuguese team from the Stories of Tomorrow visited Attached Elementary School, Faculty of Education, Mie University, where they observed classes and interacted with students. On the next day 16th, the team visited Attached Elementary School, Faculty of Education, Wakayama University,

where they also had the opportunity to attend classes, observe the school, and interact with the students. On the following days, 17th and 18th, we had a GTTP session and the Stories of Tomorrow pre-training at Attached Elementary School, Faculty of Education, Wakayama University (fig. 9). Throughout the year 2018, the Stories of Tomorrow's European team kindly supported Japanese practice over the internet. Tomita was supported in part by a Grant-in-Aid for Scientific Research (18K02937, PI: Akihiko Tomita).

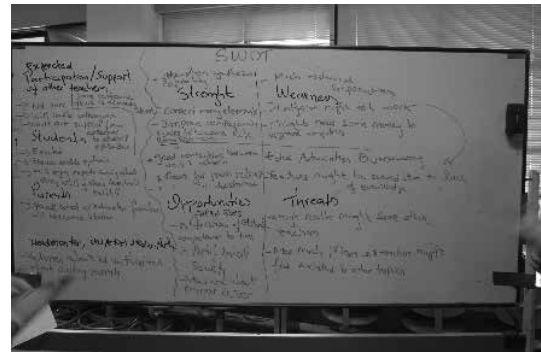


Fig. 9 Whiteboard at the pre-training session.

- Stories of Tomorrow website:
<http://www.storiesoftomorrow.eu/>
- Stories of Tomorrow Summer School website:
<https://stories.ea.gr/>
- "Let's build a metal detecting probe" (Masashi Maeda, published in September 2018), which is available on Lego Education's "downloadable lesson plan website for use as-is in the classroom."
<https://legoedu.jp/lessonplan/?p=101>
The teaching plan, practical classroom slides, and worksheets, and classroom scenes are available there.
- "Programming Education in Third Graders in Elementary School through the Building of a Mars Rover" by Masashi Maeda, at the 9th Meeting of Small Satellites for Science Education, 26-27 September 2020 (invited talk, online).

This manuscript was based on two meeting proceedings and discussion at the meetings: "Stories of Tomorrow: Elementary School-University Collaboration in STEAM Education" by Akihiko Tomita, Fumihito Kubo, and Masashi Maeda at the 32nd Annual Meeting on Astronomical Education (6 August 2018, Keio University, Hiyoshi Campus, Yokohama, Japan), and "Stories of Tomorrow: An integrated Practice with Interdisciplinary Integration, ICT Usage and International Collaboration in Elementary Schools" by Akihiko Tomita, Fumihito

Kubo, and Masashi Maeda at the 2018 Annual Meeting of the Collaborative Project for the Faculty of Education, Wakayama University (16 February

2019, Faculty of Education, Wakayama University, Wakayama).