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# Use of Mobile Technologies to Promote Scientific Discovery Learning in Elementary School

## Abstract

The purpose of the study was to identify educational effects of a new learning method that integrates mobile-technology-based science learning with activity-oriented discovery learning. The major finding of the study was that the mobile-technology-based Science program enabled students to learn scientific knowledge through associated activities and creatively apply their knowledge to complete the mission of the learning. Also, the study found that the use of tablet PCs and SNS for scientific inquiry activities facilitated students to learn in fun ways, to collaborate with other students, and to share what they have learned with each other.

**Keywords:** *mobile technology, discovery learning, Smart Science*

## Introduction

Children, unlike adults, prefer learning by concrete operations and physical activity. This is children's natural tendency in the process of cognitive development. Piaget (1929) argued in his theory of cognitive development that children's cognitive development requires providing them with rich and diverse experiences and facilitating smooth teacher-student and student-student interactions. Many science education experts say that discovery learning is a teaching method that facilitates children's cognitive development and helps them deeply understand scientific phenomena (Hammer, 1997; Kipnis, 2007; Kirschner, Sweller & Clark, 2006; Matthews, 2002; Mayer, 2004). Discovery learning, which is a voluntary and active intellectual activity, involves developmental changes in the learner's conceptual system. From science teachers' point of view, therefore, discovery learning is a teaching strategy that can help students discover and learn scientific concepts by themselves through their active participation in the learning process.

With the development of Information Technology (IT), computer-based discovery learning methods have been researched. The existing computer-based learning methods use desktop computers, whereas there are various attempts to integrate mobile technology into the learning process as IT is rapidly developing. One of the merits of using mobile-based personal learning devices is that students can have classes anywhere, even on the move (Naismith, Lonsdale, Vavoula, Sharples & 2006; Pachler, 2007). Teachers who use mobile devices in learning spaces well-equipped with wireless internet access can provide diverse and rich educational content to their students while in motion and students can access necessary information regardless of where they are. Therefore, such learning methods can greatly contribute to providing classes on sensorimotor experiences, such as combining learning with physical activity (Rudd, 2008; Lave & Wenger, 1991). This means that discovery learning can take place not only in typical classrooms but also in other places where students can learn more effectively.

In this context, this study aims at applying creative activity-oriented discovery learning to mobile-technology-based science classes for elementary school children and exploring the educational effects of the learning method. This study was conducted based on the implementation of the 'SMART Science' project supported by the National Smart Education Plan in Korea. This project conducted activity-oriented discovery learning by using tablet Personal Computers (PCs) and social networking services (SNSs) for science classes in an elementary school equipped with wireless internet access.

## The Overview of the SMART Science

### The Objective of the SMART Science

The OECD Programme for International Student Assessment (PISA) results have shown a consistent trend over the last decade: according to the PISA's international survey results for student academic skills, Korean students' academic achievements in science have been at the top while their level of interest in science has been at the bottom. What is behind this trend is the country's age-old practice of learning by rote specifically geared towards college entrance exams. Although a certain degree of direct instruction by the teacher is necessary for science education, putting too much emphasis on it, as Korea has been doing for a long time, discourages students from taking interest in science and, subsequently, makes it difficult to carry out education to help students enjoy the exploration and discovery of scientific phenomena.

The National Smart Education Plan introduced by the Ministry of Education and Science of Korea in 2011 aims at integrating IT into teaching and learning processes as a way to overcome the shortcomings of learning by rote and to transform the current education system into a learner-oriented creative education system. In particular, it includes key action plans to use mobile technology in education including installing wireless internet in elementary and middle schools and creating learning environments that enable the use of mobile devices in class.

As part of the policy, the 'SMART Science' project for elementary school children aims at facilitating students' understanding of scientific knowledge and their interest in science by extending learning spaces from typical classrooms to various places outside classrooms and carrying out innovative teaching techniques that have not been available in elementary schools, focusing on students' active participation and inquiry.

The 'SMART Science' project was conducted in a Smart School equipped with wireless internet access where the students and teachers used tablet PCs (Galaxy Tab) in class. In this educational environment, students could experience activity-oriented learning by freely moving in and out of their classrooms and exploring various places in the school. This project was designed to facilitate the students' physical activity and their active participation in creative scientific inquiry activities.

### The Overall Structure of the SMART Science

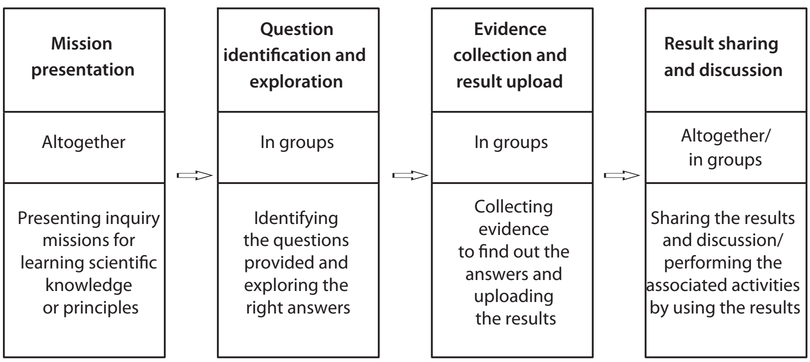
The 'SMART Science' is a program composed of four missions for enhancing sixth graders' science knowledge, domain knowledge, inquiry ability, and creative thinking ability. Each mission comprises seven questions. After completing each mission, the students conduct various activities that associate major subjects such as science, Korean, English, and social studies as well as character and creativity education by using the results of their mission performance. In every mission, there are questions presented to the students that can help them learn about the objects, materials, plants, and minerals which are easily available in and around the school building. The students carry out the missions in groups of four. While performing the missions, they get to understand how to make use of trivial items easily available in and around the school building and come up with creative ideas to design entirely new objects by integrating and utilizing the items. As shown in Figure1 below, the 'SMART Science' program comprises a total of four stages—mission presentation, mission identification and exploration, evidence collection and upload, and result sharing and discussion.

At the <mission presentation stage>, teachers read stories to students about given missions in order for them to be motivated to perform the four missions and the associated activities and to get actively involved in the program. And then, the teachers hand out rubrics explaining the special characteristics of objects, materials, plants, and minerals that are easily available around them.

At the <Question identification and exploration stage>, the students, divided into groups, get an overview of the given missions and discuss what would be possible answers based on the special characteristics provided in the examples for each question. Meanwhile, each group is asked to prepare a learning activity report, a summary of what they have learned. When they reach a dead end while looking for an answer, they are allowed to get a QR code that has a clue to the answer from the teachers. Once they scan the QR code with their tablet PCs, they can directly go to the website where they can find useful information to solve the problem.

At the <evidence collection and result upload stage>, each group looks for answers to the questions and collects evidence in and around the school building based on the group discussion results. The evidence can be anything that demonstrates the special characteristics described in the questions in various forms including photos, videos, sounds, and texts. Once the evidence is collected, each group uploads it on SNS or prepares a result report by using presentation tools such as PowerPoint and Prezi for uploading it to SNS or online bulletin boards.

**Figure 1.** SMART Science lesson process



At the <result sharing and conducting the associated activities stage>, each group presents to the class its mission performance results, posts its feedback on the work of other groups on SNS, and performs various activities associated with the mission. The associated activities include identifying similarities and differences among the mission performance results of all groups, storytelling based on the results and role-playing, and coming up with new materials and products.

**Theoretical Framework of the SMART Science**

Many science education experts agree that discovery learning helps students deeply understand scientific phenomena and principles (Kangas, 2010; Mayer, 2004). Scientific discovery learning is theoretically based on constructivism (Bruner, 1966; Kirschner et al., 2006). According to the social constructivist theories of learning, students can discover the principles of learning for themselves through collaboration with other students and reconstruct them by integrating with their background knowledge rather than passively accepting knowledge transferred to them by teachers (Vygotsky, 1978). While performing the 'SMART Science' project, the students perform discovery learning through collaborative learning with peers, conduct peer assessment on the performance results of other groups, and provide mutual feedback through SNS. Throughout this process of learning, students are able to understand scientific knowledge embedded in the real-world situation and to apply their learning to their life in the same way.

Obviously, students face difficulties in the process of discovery learning in which they have to solve given questions for themselves. In this case, teachers need to help them to solve the questions. The 'SMART Science' program, which applies guided discovery learning, enables teachers to provide students with a clue such as a Quadratic Residue (QR) code associated with the questions after inquiry activities, if necessary.

Lave and Wenger (1991) argue that mobile technology facilitates situated learning. To put it in another way, making good use of mobile technology can expand learning spaces to the outside of typical classrooms and to diverse spaces and provide students with learning experiences in the context best suited for learning the specific knowledge (Benford, Duncan, Hull, Morrison, Facer, & Clayton, 2004). Students can search the internet by using their tablet PCs from where they are solving their mission and take a shot of the possible evidence useful for solving the mission with the camera equipped on their tablet PCs and upload the images to SNS together with the related text messages. This means that teachers are allowed to give classes in various places outside boring classrooms to help students learn new knowledge in interesting ways. In doing so, students can have creative learning experiences, which are not easily available in typical classrooms.

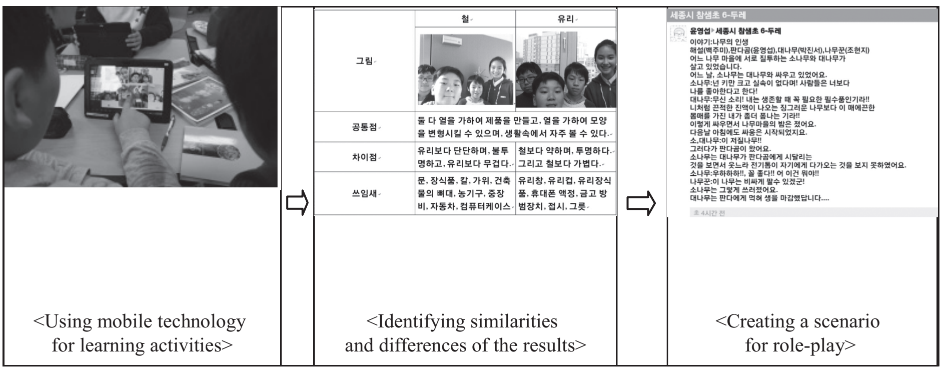
## Research Methodology

### Research Settings

The subjects of the pilot test for the SMART Science project were 60 sixth graders in three classes of a Smart School equipped with wireless internet access. The students were divided into groups and each group was given one tablet PC (Galaxy Tab) for the test. The SNS used in the test was *Classting* (http://classting.com) specifically designed for school education purposes. A 90-minute pilot test comprised two sessions of 40 minutes each. In the pilot test, only one mission was given to each group. After mission performance, the students conducted associated activities including identifying similarities and differences among the mission results of all the groups and recording role-play performed based on the scenario they created.

The teachers gave the students a total of four questions as a mission. The four questions randomly chosen from among seven questions were rearranged in different orders and were given to each group. Each group was asked to prepare a learning activity report while inferring answers to the given questions and verifying the answers. The learning activity report contained classification of what they know and what they do not know among the content described in given examples and the summary of clues to the answers. The students uploaded the grounds for the probable answers to SNS and they actively participated in the learning process

**Figure 2.** SMART Science inquiry activity process



and were encouraged to learn new knowledge. After collecting evidence for finding probable answers, each group was asked to select two answers among them and upload the chosen ones to the group bulletin board on SNS. They were also asked to identify the similarities and differences among the characteristics of the objects, and to suggest their use. Each group created a scenario by applying answers to the questions and recorded each team's role-play based on the scenario they had created. The recorded role-play was uploaded to SNS so that everyone could watch the video by scanning a QR code for each video and each group posted comments on other groups' role-play.

### Data Collection and Analysis

Observations on scientific inquiry activities, one-on-one interviews with the teachers, and e-mail interviews with the students were conducted and analyzed to obtain meaningful results. The scientific inquiry activities were observed after collecting each group's learning activity report and uploading content to SNS by the students. In-depth interviews with three teachers who were in charge of the experiment were conducted to gather their input on the overall process of SMART Science project. A Questionnaire survey was used to gather the students' comments on what they found interesting and difficult about the scientific inquiry activities and other comments related to the activities. The gathered data was analyzed by using constant comparative analysis.

## Research Results

The SMART Science program helped the students to recall what they had learned before and to learn new knowledge. The students found the clues provided in the form of QR code helpful in learning as well. The clues for each question aroused the students' curiosity and interest and facilitated their coming up with several ideas to find the right answers. Also, the use of mobile devices and SNS had a positive effect on enjoyable learning experience and character education through collaboration and information sharing.

> "It was a good opportunity to recall what I had learned before. And the program helped me to get to know new scientific knowledge... When I got the clue to the answer, I couldn't wait to see what it would be and it was interesting that everybody came up with different ideas from the same clue." (a student)

> "We asked the students to upload their mission performance results to SNS so that all the class could share the results and we also asked the groups that had completed their missions to post comments on other groups' mission results. This program is also useful for character education." (a teacher)

Some groups said they felt that certain missions were fairly easy during the discovery learning process, while other groups found them difficult and even some groups came up with wrong answers. They faced difficulties in collecting evidence for certain objects and said that the activities aimed at identifying similarities and differences among the mission results were not easy. Because of that, however, the students found the mission challenging and rewarding.

> "It was difficult to find the right answers. And it felt bad when I couldn't find the objects I was looking for. Finding out what is common and different among the answers presented by each group and story-making were especially difficult."

> "I found it interesting to solve the questions with difficulty. It was hard to look for the object made of materials I had thought by myself, but it was fun to look for it with my group members."

During the pilot test, the students were given an associated activity to compare two objects among the answers presented by each group, create a role-play scenario based on the comparison results, and record their role-play. The scenarios the students created well-incorporated the similarities and differences among the objects they identified. They enjoyed participating in this creative activity.

> "We asked them to create a role-play scenario and to record the role-play they performed in the hallway or elsewhere. This was a good opportunity for them to exert their creativity and we had so much fun." (a teacher)

Besides scientific discovery, the students also found collaborating with other students interesting. Collaboration was one of the most difficult tasks they were given. The students said that it was interesting to solve the questions for the mission partnering with other students. Although some of them had difficulties because of conflicts among the members, they became respectful of each other's opinions in the process of mission performance and, eventually, enhanced their team spirit.

> "It was interesting that I could solve the questions for the science inquiry project with my friends and that no one got angry even though we were so much in a hurry. I think we all got closer to each other. It was good that we could help each other understand what we didn't know and solve the questions with accuracy." (a student)

> "The most difficult moment was when we had different opinions. We quarreled sometimes, but as we solved the questions one by one, we became better listeners to each other." (a student)

The SMART Science program, which requires moving in and around the school facilities rather than sitting in the classroom while performing the mission, could increase the students' physical activities. The students participating in the program enjoyed the learning activities taking place outside their classrooms. Also, while collecting evidence for the right answers, they had an opportunity to go to unfamiliar places in the school and to pay fresh attention to ordinary objects.

> "The most interesting activity was going outside the classroom to perform the mission, because we usually don't have a chance to go out during the class. This was a special and fun experience."

> "Looking at every corner of the school with my friends to solve the questions was most interesting. While doing this project, we got to know more about the objects and my school."

Some groups felt some time pressure. Finding evidence and taking picture of it took more time than coming up with the right answers. This time pressure made the groups compete with each other. Another reason for the lack of time was discord among the group members. But the limited time did not play a negative role in the mission performance.

> "It wasn't that hard but we felt we needed more time. But it was good that the time pressure made us compete with other teams."

## Conclusions

This study aimed at exploring the effect of discovery learning for the science subject by using mobile technology. In conclusion, the SMART Science project helped the students revisit what they had already learned and enhance their ability to explore and think about scientific knowledge. In particular, this program promoted the students' curiosity and interest in science and facilitated their thinking from different angles. When it came to the level of difficulties of the mission provided, the students responded differently but the majority of them answered that the mission was not that difficult to solve. Those who answered that the mission was not easy had had difficulties in inferring the answers to the mission or collecting evidence necessary to solve the mission. Yet, this made them feel a sense of challenge.

The SMART Science program enabled the students to learn scientific knowledge through associated activities, learn in integration with other subjects, and carry out creative activities. Mission-type inquiry activities helped the students set their goals and the competition element among the groups promoted their interest in learning. The use of tablet PCs and SNS for scientific inquiry activities facilitated the students' learning in fun ways, collaborating with other students, and sharing what they have learned with each other. Having them share the results of each group's inquiry activities and post comments on other groups' mission performance results on SNS had a positive influence on the students' deep understanding of the subject they were learning and character education. This study presents the results of the implementation of the SMART Science program. For further development of the SMART Science program using mobile technology for creative discovery learning, many follow-up studies should be conducted to consolidate the effectiveness of the method and create diverse ways of its application to real world situations in schools.

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