Educational Affordances of Smart Learning Applications in Science Education

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Abstract: Science educators have made efforts to design and use educational applications of smart devices for meaningful learning. For the design of *smart learning* environments, it is crucial to understand the affordances of educational applications as well as their limitations. This study analyzed 40 applications according to their educational affordances: information acquisition, inquiry, modeling, and collaboration. Characteristics of smart learning applications were described along with specific examples. More efforts are needed to design smart learning applications for collaboration and to overcome the limitations of existing applications.

Keywords: Educational affordance, smart device, application, science education

1. Introduction

A growing number of educators have paid attention to the use of smart devices that promote ubiquitous learning in formal and informal settings. In South Korea, the government has encouraged Self-directed, Motivated, Adaptive, Resource-enriched, and Technology-embedded learning (i.e., SMART learning). In addition, global enterprises like Apple, Google, and Samsung have invested a lot in the development of educational applications for smartphones and tablet PCs. For the design of meaningful learning with smart devices, it is necessary to understand educational affordances of smart learning applications. Educational affordances indicate the properties of an artifact that enable a particular action for learning and teaching (Gibson, 1977; Tan et al., 2012). Some educational applications are more likely to facilitate constructive or collaborative learning activities than others that focus on delivering new information and knowledge. It is crucial for educators to select and use smart learning applications that have educational affordances closely related to learning objectives. Thus, this study intends to explore educational affordances of smart learning applications in science education.

2. Meaningful Learning in Science Education

Science educators recently emphasized inquiry, modeling, and collaborative learning for meaningful learning rather than knowing scientific information and facts. In inquiry-based learning, students are engaged in creating hypotheses, conducting experiments, and explaining collected evidence. These activities help students to develop an in-depth understanding of scientific principles and scientific literacy in authentic contexts. Students who participate in scientific inquiry are likely to be motivated through authentic activities and develop positive attitudes toward science (Ahmed & Parsons, 2013). In addition, modeling is an essential practice in science education because a lot of scientific knowledge consists of models of scientific phenomena. Student-constructed models explicitly show what students understand and what misconceptions they have. Through iterative modeling activities, students can explain causal relationships behind observed scientific phenomena qualitatively as well as quantitatively (Louca et al., 2011). The inquiry and modeling activities are often conducted in a small group because collaborative discourse helps students to perceive multiple aspects of a scientific phenomenon and develop argumentation skills to support their hypothesis with evidence and scientific knowledge. Students can develop more valid explanations by integrating diverse ideas and challenging each other. Thus, in science education, smart learning applications should have affordances to enable inquiry, modeling, and collaboration activities for meaningful learning.

3. Methods

Science education applications, which work in smartphones and tablet PCs using Android as an operation system, were searched in “Google Play Store” in October 2013. Initially 163 applications were identified with keywords of chemistry, biology, physics, earth science, and science education. Two graduate students in science education and one secondary school teacher collaborated to exclude redundant applications and select applications that were closely related to K-12 science education on the basis of Korea National Science Curriculum. As a result, 40 applications were selected for analysis. Through constant comparison and discussion, the three researchers grouped the smart learning applications into *information acquisition*, *inquiry*, *modeling*, and *collaboration* according to their educational affordances. They analyzed which learning activity was closely related to the properties of a smart learning application. The data analysis process was constantly monitored and coached by two professors in the college of education.

4. Findings

According to educational affordances, the 40 applications of science education were categorized into information acquisition, inquiry, modeling and collaboration as shown in Figure 1. Smart learning applications for inquiry and modeling were as many as those for information acquisition. However, the number of applications to promote collaboration was much smaller than others. More attention should be paid to develop smart learning applications to enable students to share their different viewpoints and collaboratively build knowledge

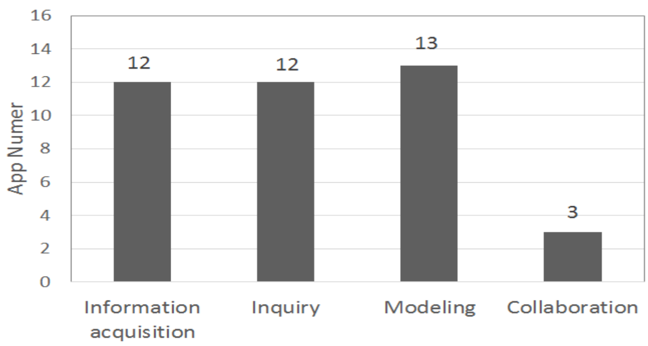

Figure 1. Number of smart learning applications according to educational affordances

Applications of information acquisition enabled students to memorize facts and concepts included in the science education curriculum and to have access to educational resources in the Internet. The applications included the content of a textbook, which allowed students to prepare and review lessons anywhere and at anytime. For instance, the application of “Periodic Table Quiz” helped students to memorize the location of atoms through simple quizzes. However, this kind of applications had limitations in supporting higher-order thinking skills and social competencies.

Inquiry applications enabled students to collect and analyze data with smart devices in and out of school. Students were able to record audio and visual information and to measure the angle, length, height, or temperature of an object. The applications were helpful in observing scientific phenomena and collecting data for scientific inquiry in real world contexts. For instance, the application of “Smart Measure” enabled students to easily measure the distance and height of a target in a smartphone screen by trigonometry. However, we could not find an application that supported a whole process of scientific inquiry (e.g., prediction, observation, and explanation).

Modeling applications visualized scientific concepts and objects (e.g., molecular structure) that could not be observed in everyday lives. The applications allowed students to explore a 3D model from multiple directions and to interact with the model through the touch screen of a smart device. The application of "3D Brain," for example, enabled students to explore the function of each brain region by rotating and zooming around a 3D brain model. Despite the benefits of the applications, they had limitations in encouraging students to iteratively create and modify their own models of scientific phenomena.

Information Acquisition: Periodic Table Quiz	Inquiry: Smart Measure	Modeling: 3D Brain	Collaboration: ISS Detector

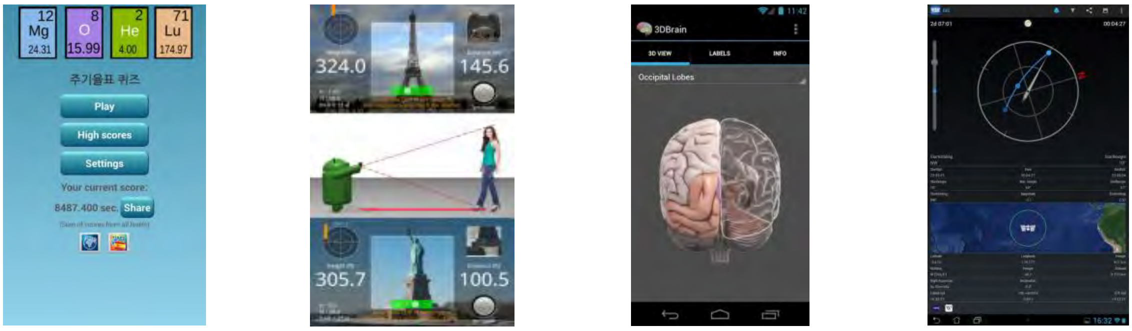

Figure 2. Examples of smart learning applications

Lastly, collaboration applications encouraged students to collaboratively collect data and share their opinions on findings. The applications can support not only discussion in a classroom but also online discussion among students in different schools and regions. For instance, the application of "ISS detector" allowed students not only to get information of the international space station and iridium flares but also to share their insights through social network service (SNS). Despite the potential of smart devices for collaborative learning, there were few science education applications that focus on collaboration. More efforts are needed to apply smart devices for collaborative argumentation and knowledge building in science education.

5. Conclusion

Smart learning applications have diverse affordances to facilitate meaningful learning in science education. This study explored educational affordances of the applications in terms of information acquisition, inquiry, modeling, and collaboration. More attention should be paid to the development of smart learning applications that support meaningful learning in science education. Particularly, more smart learning applications are needed to enable students to share their viewpoints of a scientific phenomenon and collaboratively carry out a scientific task. In addition, future research is suggested to investigate educational affordances of smart learning applications in other sources (e.g., Apple Store) and domains. It is also necessary to carry out developmental studies to overcome the limitations of smart learning applications and to optimize educational affordances of smart devices. The study of educational affordances will contribute to the design of meaningful learning environments that help students to develop key competencies necessary in the 21st century.

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