Liu, C.-C. et al. (Eds.) (2014). Proceedings of the 22nd International Conference on Computers in Education. Japan: Asia-Pacific Society for Computers in Education

Designing Mobile Application for STEM: Building Individual Interest and Supporting Creative and Innovative Thinking Skills

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Abstract: This paper explains the design of a mobile application that is aimed to support the development of creative and innovative skills using stories as the external factors to create and maintain students' long-term individual interests in STEM area. In this paper, first, we discussed the connection between individual interests and creative – innovative thinking process. Then, we described research proved pedagogical methods, which based on using stories to build and maintain students' individual interests. Following that we illustrated the design of mobile application that applies the pedagogical methods into practice. In the discussion part, we discussed the potential use of the application as well as future follow-up research studies.

Keywords: STEM, creativity, creative thinking, innovative thinking, mobile learning, interest building, individual interest, mobile application design.

1. Introduction

Creative and innovative thinking are couple of the key thinking skills that would be core to science, technology, engineering and mathematics (STEM) education (Atkinson and Mayo, 2010). Developing students' creative thinking skills have significant role in building modern economies.
Investments on creativity and innovation had a dramatic positive impact on the global competitiveness of countries (MacLeod, etl.al., 2007). Similarly, research on highly creative and innovative countries (e.g. Finland, Norway etc.) showed that supporting creative and innovative thinking clearly facilitates the transition from the postindustrial economy, towards an emergent knowledge-based creative economy (Duell, Wright and Roxburgh, 2014). To remain competitive in a challenging global environment, supporting creative and innovative thinking in work and learning plays a crucial role (Ferrari, Cachia and Punie, 2009).

Specially designed work and learning spaces encourage us to think in creative and innovative ways (Oksanen and Ståhle, 2013). According to a meta-analysis of 32 research studies on creativity, enabling social interaction is identified as one of the significant category of the key characteristics of conditions promoting creativity and innovation (Davies et.al, 2013). Similarly, it is possible to provide same characteristics into STEM education to support creativity and innovation (Cooper and Heaverlo, 2013). For instance, using technology to provide social understanding may have different positive influences on creative and innovative thinking skills in STEM (Kärkkäinen and V.Lancrin, 2013). However, solely providing technological tools are not sufficient to develop creative and innovative thinking skills by itself (Selwyn, 2011; Jackson et.al., 2012). It is suggested that technology should often be perceived as a catalyst for change in the application of pedagogical methods in order to have successful results (Watson, 2011).

One of the pedagogical methods that help to have successful results is to helping students to develop an individual interest (Arnone et.al., 2011). For instance, increasing individual interests on a particular subject/object enhance creativity (Shalley, Zhou and Oldham, 2004; Grant and Berry, 2011). Developing students' individual interests towards the STEM related learning activities help them to increase their chance to develop creative and innovative thinking skills (Bairaktarova and Evangelou, 2012).

It has been suggested that students with individual interest for STEM subjects are likely to be motivated to pursue the STEM careers that require creative and innovative thinking (Tyler-Wood, Knezek and Christensen, 2010). Developing interests in STEM requires carefully planned interactive activities in school environment. Informing students on the topic is not a sole component of developing interest (Hidi, Renninger and Krapp, 2004). There should be activities supporting both positive feelings and opportunities for gathering knowledge for social understanding in order to be able to shift students' interests on STEM areas (Renninger and Shumar, 2002). Instead of simply supporting having fun and participation in science, institutions should also provide activities for productive social understanding by addressing individual interests (Stocklmayer and Gilbert, 2002). Research of U.S. National Research Council (2006) clearly indicated that students shows more productive participations in STEM activities when they developed individual interests by finding meaning thorough social understanding in the learning strategies. Social understanding develops through the process of observation, introspection, and imagination (Carpendale and Lewis, 2004).

Student's individual interests in STEM may not be influenced all the time by the school related activities (Hidi, 1990). First of all identifying students' individual interests would need a great effort. Second, these interests may not find a place to be pointed in school subjects. Thus, it is important to understand what types of activity may address interests of different range of the student population. Interest on STEM subject might be an outcome of interactive activity or a content in which the activity and the environment may have an effect on the dynamics of the interests (Krapp, 2005). Other external motivators such as role models (e.g. scientists, teachers) and peers may contribute to an increased emerging individual interest (Krapp and Lewalter, 2001).

After individual interest is developed well, students usually have a tendency to pursue further understanding independently and work on developing deep understanding in STEM fields (Renninger, 2000). It is expected that external factors allowing the well-developed individual interest make it possible for students to maintain positive feelings and interests for STEM related activities in future. Thus it is very important to create a learning environment that provides set of social activities within the inclusion of knowledge from the external individuals in order to create interests in STEM. Also engaging social activities with an established individual interest may extend creative and innovative thinking as suggested in several studies (Stocklmayer and Gilbert; Tyler-Wood, Knezek and Christensen, 2010).

As mentioned above paragraphs, it is expected that individual interest support creative and innovative thinking. Also external motivators could increase it. Thus building individual interests for students becomes a very important factor in success of students in STEM. Addressing the needs, this study discusses the design of a mobile learning application using a pedagogical model that implements core dynamics of individual interest building using the external motivators in order to develop creative and innovative thinking in STEM field.

The pedagogical methods that are using external motivators to increase individual interest in STEM are discussed in the first part of the paper. Second part of the paper illustrates the design of the mobile learning application, which is conceptualized according to the pedagogical methods in the first part. Finally a discussion part explains the possible use case scenarios of designed application in STEM education.

This paper would be useful for the instructional designers, teachers and school administrators who like to learn more about developing creative and innovative thinking skills and individual interests in STEM field as well as an example design of mobile application for this purpose.

2. Pedagogical Methods

2.1 Increasing Individual Interest

Students with high interest in STEM subjects may possibly have gained more knowledge than their peers due to the fact that they may put more effort on the STEM activities (Tobias, 1992). This implies that students with prior knowledge on the STEM area may have increase individual interest. The argument is also supported by the research. Research suggested that as students become more familiar with an area, their interest toward the areas is expected to increase (Tobias, 1994).

The external sources of information could be integrated in STEM education to increase the prior knowledge of the students. Especially, external institutions (e.g. science centers, research companies, universities and museum etc.) and individuals (e.g. scientists, innovators , artists and researchers etc.) may be a great external resources of information. As the research shows, connecting and having a regular relationship with these institutions and individuals in an out of school may develop a personal interests slowly over time with a tendency of having a long term effect on students' knowledge and values on the subject (Ainley and Ainley 2011; Dabney et.al., 2012; Renninger, Hidi and Krapp 2014). Thus, following the research based suggestions; it is assumed that when students start connecting to institutions and individuals in and out of school, they would have greater prior knowledge on the STEM related areas, which would also increase individual long-lasting interests on STEM area.

Based on this, it is possible to have institutions and individuals as external factors to increase the individual interests. As a pedagogical method, we could seek for possibilities to establish connection with external institutions and individuals. In the application design, we implement elements to apply this practice to increase students' individual interests.

2.2 Using Stories

Stories create engaging and pedagogically effective learning experiences (Mcquiggan et.al., 2008; Kuyvenhoven, 2005; Dyer and Wilkins, 1991). Stories are very effective in learning and theory building (Badreddine and Buty, 2011). Using stories increase students' interests on a particular subject (Fulmer and Frijters, 2011). Similarly, stories are used as pedagogic practices in social learning to support science education (Shelby and Ernst, 2011). Stories that are interesting motivate students to continuously to keep their attention on the subject. For instance, students reading stories with elements such as novelty, character identification, life themes, and activity level may have a continuous interest to get more knowledge about the topic (Hidi, 2001; Hidi and Baird, 1986) including science (Sandoval, 1995). Also stories are powerful applications with a potential to creating an emotional connection to the individual interests that results extending with some degree of continuity on interaction (Tan, 2013). Also stories enable students to make connections between ideas in the ongoing STEM issues which help them to have a personal meaning and interests towards the science concepts (Scott, Mortimer and Ametller, 2011). Stories are also allowing teachers and students to have a platform to share the experiences of the individuals in STEM area to help students to grasp the related concepts, accommodate with diverse perspectives and realties of the experts in the field (McDrury and Alterio, 2003).

It is an accepted idea that enabling students to write stories are commonly used to support their development of the creativity (Hennessey and Amabile, 1988). Similar to writing stories, it is suggested that reading stories are also supporting students to have some initial ideas to be able to have some creative associations (Smogorzewska, 2014). Thus, the system design is expected to have an impact on students' creativity with a certain degree. Reading stories approach is expected to grab and maintain the students' attention. Especially some interesting elements such as life themes of scientist and how they react to the challenges in daily life, their solutions and services to the important problems of global scene etc. is expected to arouse the students' curiosity which will also expected to turn into the individual interests with a long term interactions. Thus, carefully selected stories of external individuals in STEM area may help students to understand the tasks involved in the professional STEM related fields such as decision making process in daily tasks, theories, tools and work environments. As the second pedagogical method, we implement the idea and key elements of using stories to create individual interest in STEM related areas

3. System Design

Implementing the pedagogical methods described in Section 2, we designed a learning environment where students have a chance to use a platform to connect to the science and read stories about the problems in science and the scientists' lives. As research studies suggested, by connecting students to science using the stories as a meeting point, it is expected to maintain students long-term individual interests on STEM areas. Also as an effect of continuous long-term individual interest, it is expected that students may develop their creative and innovative thinking skills, which would be essential in STEM education. To enable the pedagogical methods, we designed the system architecture prototype as in Figure 1. Accordingly, story content collector engine collects the STEM related stories form different online resources using RSS then sort and tags into database. Distributor engine sends out the stories to student based on the rules defined by individual interest profiler. Individual interest profiler creates a dynamic profile of individual interest for each student in the system and feeds the distributer engine with rules. Interactive interface displays the content received from the distributor engine with a set of interactive events.

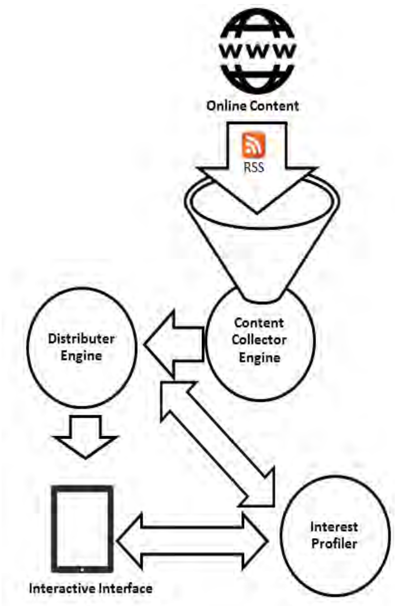

Figure 1. Mobile Application System Architecture

3.1 Story Collection and Distribution

Story contents are fed into the system in forms of newsletters and short articles forms, which are collected from the online resources. The content collections are categorized in a variety of topics. Themes would be challenges in science, new scientific and technical developments as well as professional lives of scientists.

The content collection is centralized and processed by the story content collector engine using "Really Simple Syndication" (RSS). The content collector engine signs up automatically to the various online resources related to STEM subjects and collects the content to centralize them before the distribution. Once the system administrator set up the resources' addresses for the content collection the content collector will continue to function for as long as the system runs. System administrators have no need to check the online resources to find out what is going on and whether there is a new update available. All the updates and stories come automatically to the content collector engine and sorted and tagged according to the topics.

The distributor engine sends out the stories to students according to a rule set defined by the individual interest profiler. When students log in to the system, they also start building their profile in the system. According to their profile, students would regularly receive stories related to STEM fields, which are selected and personalized according to each student's individual interests in the topic. The selection of the stories according to individual interest analysis is described in the next section.

3.2 Individual Interest Profiler

The individual interest profiler identifies students' individual interests. The individual interests and related mechanism is dynamically calculated according to students' previous selections of the topic as well as asking feedback from the students. When students registered into the system they are asked to fill a registration form. In the registration form, students are asked to respond to a questionnaire developed according to the instruments that measure the students' views on nature of science (Osborne, Simon and Collins, 2003; Chen, 2006). Furthermore, students are also asked to indicate which topics and subjects they feel they like to read in STEM areas. Moreover, in addition to the initial data collection, after each time reading a story, students are asked to give feedback on their individual interest in the stories. Students indicate their self-interest using a 5 points rating scale. Our system does not rely on self-rating data, it also have its own tracking and measurement system embedded in individual interest profiler. Accordingly, the system tracks and measures students' interactions by activity analysis, clicks and patterns of behavior in relation to other interface and content.

3.3 Interactive Interface

Interactive interface displays the story content. This interface is where students engage in to the stories. It is designed for mobile devices including tablets, which allow students to benefit from the application in and out of the school and to follow the content according to their own phases.
The interactive interface is designed as a scientist's diary application (e.g. design of look and feel of the application, activities etc.) where students would get their STEM stories regularly.
In the application students have a library where he could select stories that are updated according to his/her individual interests regularly (Figure 2).

Figure 2. Mobile Application Interactive Interface for reading STEM related stories

The interface has basically functions as e-readers application. However, to have a look specific to STEM education, the reading interface provides additional design functions to create experiences for the students to help them feel like they are engaging in scientific diary reading experiences. This special design makes the interface design different than the traditional e-readers. More than just embedding the content from the online source and delivering it on a tablet device without adding any value to the content, the interface have interactive features such as scrolling up and down in a blocks of text and using some artwork to resemble a science related reading activity. In the application, the reading interaction is scrolling based in which students need to scroll up and down to see the contents and swipe it right and left to turn the pages. In that sense, the interface captures the essence of reading science diary rather than reading a book. Adding the interactivity, the interface creates a meaningful science reading experience for the students. Interface also has standard functions such as search, bookmark, sharing, printing annotation and taking notes.

4. Discussion and Future Studies

The mobile application intended to build students' self interest, which has a direct connection in supporting the creative and innovative thinking process. Using the mobile application to deliver science related stories as the external resources for motivational process; it is aimed to increase the individual interest in STEM areas. Relying on the research studies that show the connection between the interest and creative – innovative thinking, we expect that the mobile application will be helpful to support the development of that mentioned skills of creative and innovative thinking. The design of mobile learning application was based on the implementations of pedagogical methods that we picked based on the suggestions of several reach studies as explained with details in the previous chapters.
This mobile application can be used to increase students' long-term interaction in STEM subjects. It could be used as a part of class project where students may read regular science stories in the classroom. As the application is good for tablet devices, students may use it in and out of the classroom.

As a future study, we expect to test the mobile application in terms of design effects on helping students in developing motivation and the creative – innovative skills within experimental studies.

5. Conclusion

In this study, using the stories in STEM areas as the external motivators, we designed a mobile application that helps building and maintaining students' individual interest in STEM area. As previous studies suggested it is expected increasing interest would directly support students' creative and innovative thinking. For addressing this issue, applying the pedagogical models using stories as the external motivators, we provided a design for a mobile application. The mobile application is expected to build and maintain students' individual interests, which also result in development of their creative and innovative skills in STEM area. The pedagogical methods and the design of the mobile learning application are discussed in the course of the paper. Finally in the discussion part, the possible use case scenarios and future studies are mentioned shortly.

This paper would be useful for the instructional designers, teachers and school administrators who like to learn more about developing creative and innovative thinking skills and individual interests as well as an example design of mobile applications for this purpose.

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