Chemistry Learning Through Designing Digital Games

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INTRODUCTION

As the labour market of the 21st century become increasingly emphasize on skilled human capital which are highly knowledgeable and innovative, STEM (Science, Technology, Engineering and Mathematics) education has slowly been making its way into classrooms. Efforts have been undertaken to improve the quality of STEM education in order to produce STEM literate students, i.e. students who are capable of identifying, applying, and integrating the STEM concept to understand complex problems and generate innovation to solve the problems (Chew, Noraini, Leong & Mohd Fadzil, 2013).

STEM literate students must have mastered the knowledge of science, particularly chemistry because chemistry is essential as the basic of most of the fields of science, technology and engineering (Balaban & Klein, 2006). Indeed, chemistry is often called the central science (Brown, LeMay, Bursten, Murphy & Woodward, 2011; Chang, 2007). Chemistry is also the foundation for innovation, scientific literacy and most notably problem solving in connection with sustainable development (Risch, 2010). Using chemistry knowledge, for instance, one can make judicious decisions to design new materials that are environmentally safe to solve various problems in everyday life. In the 21st century, chemistry will continue to play a leading role in providing solutions to ensure sustainable development.

Apart from knowledge, innovation and problem solving in the 21st century requires a new range of skills known as 21st century skills. For example, innovation and problem solving in today's world is driven by the formation of networks with multiple parties including experts and researchers with related interests as well as consumers and customers. The 21st century skills enable one to communicate and collaborate effectively with various parties.

Clearly, students in the 21st century need to become proficient in both chemistry knowledge and the 21st century skills. Therefore, the authors have initiated an innovation instructional strategy to support the acquisition of chemical concepts and the 21st century skills. A module known as MyKimDG has been developed as a mechanism for accomplishing the desired goals. The purpose of this article is to present conceptual framework of MyKimDG and demonstrate a brief lesson in MyKimDG to the teaching and learning of a specific chemistry unit.

BACKGROUND

Chemistry is usually perceived as a difficult and unpopular subject due to the abstract nature of chemical concepts. Previous studies on students' conception have revealed that students have many alternatives conception in chemistry. While the literature is replete with studies and papers, which

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investigate students' understanding of chemical concepts and suggest potential remedies, fewer studies focus simultaneously on improving conceptual understanding and developing the 21st century skills. Hence, educators should be encouraged to design innovative and effective learning strategies to enhance both students' conceptual understanding and their 21st century skills. In this case, a change in chemistry teaching and learning approaches is critical. This is especially more crucial when educating today's students who are 'digital natives' (Prensky, 2001). The teaching and learning approaches must befit the needs of these digital natives and subsequently achieve the desired aspiration.

One approach suggested by researchers to educate the digital native generation is the integration of digital games in the teaching and learning processes as digital game is a medium favoured by students. Nowadays, the integration of digital games in learning or digital game-based learning (DGBL) is gaining popularity parallel with their popular reputation among students (Kamisah & Nurul Aini, 2013). Many studies have reported that DGBL can provide positive impact on students' learning. In general, the studies on DGBL were carried out through two approaches, namely (1) student as game consumer or player, and (2) student as game designer.

In the first approach, the students were involved in playing commercial digital games in the market or educational digital games developed by educators. However, there are many obstacles to implementing the student as game consumer approach. For instance, the contents of commercial digital games are inaccurate or incomplete (Van Eck 2006) and the development of professional educational digital games is time-consuming(Hwang et al. 2013). In addition, many gamers do not play educational digital games as they find these games not compelling (Pivec 2009). This happens because educational digital games are designed by academics who do not really understand the art, science and culture of digital game design (Van Eck 2006). As a result, the product has failed dismally as a game. Prensky (2008) also raised this issue and states '...the students had no input into its creation, and the stuff came out cute to the adults, but boring to the kids'. According to Prensky (2008), students even told straight forwardly: 'Don't try to use our technology, you'll only look stupid.'

One alternative of DGBL approach that has been proposed by some scholars (such as Kafai, 1996; Papert, 1998; Jung & Park, 2009; Kamisah & Nurul Aini, 2013) is for students to design their own digital games. Many studies have reported that this approach provide opportunities for students to explore ideas according to their own interests (Kafai & Ching, 1996); acquire knowledge of programming (Kafai, Ching & Marshall, 1997); as well as become active participants and problem solvers, engage in social interaction by sharing their designs and helping each other, and take ownership of their own learning (Baytak & Land 2010).

In addition, Vos, van der Meijden and Denessen (2011) has reported that the student as game designer approach is a better way to increase student motivation and deep learning compared to the student as game consumer approach. Lim (2008) and Prensky (2008) also recognized the potential of this approach in improving student motivation and engagement. According to Lim (2008), when students are given the autonomy to take responsibility for their own learning and co-design learning experiences with teachers and other students, they are more inclined to engage in their own learning process. Hence, one way to do so is by allowing students to become designers of their own digital games based on their own interpretation of the school curriculum. For Prensky (2008), students will be motivated if they are allowed to do something extraordinary in learning at school and gain recognition for producing digital games. Therefore, the authors have initiated an innovation to take advantage of the student as game designer approach to support the acquisition of chemical concepts and the 21st century skills.