Immersive Learning of Biomolecules

Yiyu Cai*[1], Wouter van Joolingen[2], Sui Lin Goei[3], Sandra Tan[4], Zhong Chen[5], Zachary Walker[5], Ban Hoe Chow[6], and Teresa Dias Pedro Gomes[3]

[1]Nanyang Technological University, Singapore

[2]Utrecht University, The Netherlands

[3]Windesheim University of Applied Science, The Netherlands

[4]Hwa Chong Institution, Singapore

[5]National Institute of Education, Singapore

[6]River Valley High School, Singapore

*Corresponding author: Yiyu Cai, contact: myycai@ntu.edu.sg

Abstract

This paper reports a new international initiative on the use of virtual and augmented reality (VAR) technology to assist student learning of biomolecules. Researchers, developers and educators from Nanyang Technological University, National Institute of Education, Hwa Chong Institution and River Valley High School in Singapore, Utrecht University and Windesheim University of Applied Science in The Netherlands, will work together for two years on this project. The objective of this research is to investigate the benefits of applying the latest VAR technology to enhance students' learning of molecular biology. In particular, the project is keen to design new immersive and interactive contents for selected topics such as enzymes, proteins, DNAs etc., in molecular biology. This interdisciplinary collaboration has a potential to grow globally.

Key words: Virtual & Augmented Reality • Technology Enhanced Learning

1. Introduction

Science education aims to build students' skills and attitudes towards Science, Technology, Engineering, and Mathematics (STEM). In STEM, the learning issue can be defined at two levels. At a generic level, students need to learn about the nature of scientific knowledge and the role of models as representation of that knowledge in particular. Within the specific domain, e.g. molecular and cell biology that will be studied in this project, the relation between models and reality is particularly apparent. It is important that students gain insight in both the explanatory powers of models and their limitations in understanding in this domain, and learn to see the added value of using multiple representations and multiple models. The construction and evaluation of scientific models (Lohner, van Joolingen, Savelsbergh, & van Hout-Wolters, 2005; Minner, Levy, & Century, 2010) provide a means to offer students experience with scientific research. Several modelling tools (Blikstein, Abrahamson, & Wilensky, 2005; Louca & Zacharia, 2011) have been developed to enhance and stimulate deeper learning. Virtual Reality (VR) is widely considered as one of the most viable applications for use in education (Freina & Ott, 2015; Merchant et al, 2014). These tools allow for the creation of task environments in which realistic and authentic forms

of inquiry are possible and within the reach of students in secondary education. The benefit of such a realistic context can be linked to the potential of technology to make students' learning experiences more authentic and vivid, and to increase exposure and interaction. Authenticity is considered important, because more authentic learning experiences may lead to higher cognitive fidelity, which in turn could contribute to better learning outcomes.

Over the years, we have developed innovative technologies including Virtual & Augmented Reality (VAR), Simulation and Serious Games to enhance learning (Cai, Tay & Ngo, 2013; Tan & Waugh, 2013; Chow & So, 2012; Cai & Goei, 2013; Cai, Goei, & Trooster, 2016; Rutten et al., 2012; van Joolingen & de Jong, 2003; Cai, 2011 & 2013; Cai et al, 2006; van Joolingen, de Jong, Lazonder, Savelsbergh, & Manlove, 2005).

This paper presents an international effort to develop and evaluate the efficacy of VAR technology to enhance secondary school students' learning of molecular biology. Researchers, developers, and educators from Singapore and The Netherlands tie up through this international collaboration. The research outlined is an attempt to bring together educators, researchers, teachers, and students using a cross-cultural partnership not only to develop effective and validated pedagogies for inquiry-based learning, but also to model and stimulate skills and attitudes in our students and student teachers that are relevant for functioning in highly complex and fast-changing 21st century working environments, in which professional teams need to collaborate, cross boundaries in activity systems, and develop and speak a common professional language. The VAR technology to be developed aims to create immersive learning environments for students to better understand bio-molecules through VAR interaction.

2. The Focus

This research focuses on Molecular Biology. Presently, textbooks typically depict molecular and cellular processes such as enzyme operation and protein synthesis with iconic representations of specific molecules, illustrated to highlight a simplistic generic mechanism that students must learn. Despite this representation useful to obtain a view of the processes, there are aspects that are not covered, but important for understanding the essence of the processes involved. For example, apart from the 'lock and key' idea of an enzyme for molecules to 'snap' into each other, the molecules themselves are dynamic structures and their movement within the cells adds to the dynamic. Whereas the textbook representation may give rise to the misconception that molecules display purposeful behavior, a representation that incorporates dynamics can give rise to a more accurate 'mechanistic way' of reasoning that is capable of explaining the effects of external factors such as temperature and pH value in the cell. The project aims to develop models and modeling environments in which students can create and play with such multiple representations, as well as lesson plans to support learning in these environments. In this way students can learn concepts, processes, and functions within the domain of molecular biology and

develop 21st century competencies related to the understanding of science and scientific knowledge.

3. Lesson Study

Lesson study is a collaboration-based teacher professional development approach that originated in Japan (Fernandez & Yoshida, 2004). In this approach, teachers collaboratively engage in research inside their classrooms using a design cycle: prepare and design lessons, perform the designed lesson as a research lesson and evaluate them in order to feed into the next cycle (Cerbin, 2011). Teachers collaboratively design one or more research lessons in which they attempt to adjust to the varying educational and instructional needs of their students (Goei, 2013). Great thought is devoted to predicting how students may react. Importance in the Lesson Study cycle is that teachers as Lesson Study team members observe the students when the research lesson is enacted in the classroom, and have special attention to the learning activities and behaviors undertaken by the students. Immediately after the lesson, it is evaluated with the focus on the learning activity, rather than on the performance by the teacher who executed the lesson (Becker, Ghenciu, Horak, & Schroeder, 2008; Oshimaa, Horinoa, Oshimab, Yamamotoc, Inagakid, Takenakae, Yamaguchif, Murayamaa, & Nakayamaf, 2006). Observations are shared, ways of refining and improving are discussed and the subsequent review of the lesson is planned. In the design, implementation, and evaluation of the modelling activities, teachers will be actively involved using Lesson Study (Lewis, Perry, & Murata, 2006).

4. VAR Technology Enhanced Learning

Over the past 10 years, the Singapore team has been developing VAR technology for educational use. Figure 1 shows students from River Valley High School engaged in interactive learning of Biology in their daVinci VR Lab.

Fig. 1: Students from River Valley High School doing interactive learning of biology in their daVinci VR Lab

The VAR enabled solutions will be designed by the Singapore team specializing in immersive and interactive education technology (Cai, 2013) in collaboration with the Dutch team emphasizing on sketching and drawing (Bollen & Van Joolingen, 2013). The pedagogy will be jointly developed by the Singapore and Dutch teams based on Inquiry-based Learning and Modelling. The novelty of the development is in the intersection of general concepts of models in multiple levels with multiple variables for teaching and learning. These variables will be limited to temperature and pH in a simplified setting, and become generalized possible later. The models include simulation and 2D/3D visualizations. Researchers, developers, teachers, and teacher educators from both Singapore and the Netherlands will work together to create the content. The validation of the designed pedagogies and lesson plans will be done via the Lesson Study method.

Figure 2 shows the initial design of interactive and immersive learning of macromolecules using the daVinci VR Lab available at Hwa Chong Institution.

Fig. 2: VAR Technology Enhanced Learning of biomolecules in the daVinci VR Lab at Hwa Chong Institution

4. Conclusion

This project has the timeliness to explore the application of VAR technology in education, especially STEM education, aiming to help students better understand scientific concepts through model-based simulation for interactive learning. With the VAR tool, it may be possible to allow students to try self-engineering a *de vova* enzyme and validate the effectiveness of the virtually engineered enzyme using the models and VAR tools developed. Last but not least, one of the existing challenges for higher education is to internationalize its programs and to make students more globally competent. Although teaching is often tailored to local contexts, international collaboration can be important for educators as they grow professionally through exposure to innovative ideas and best practices in other settings. It may be expected that in the two countries, teaching traditions, learner and teacher dispositions are different, providing teachers on both sides of the collaboration with fresh insights. These insights and viewpoints will add to the depth of which VR lessons are created for student learning.

Acknowledgment

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