ISSN 2010-3093

RESEARCH BRIEF SERIES

No. 20-003

Model-based and VR-enabled Teaching and Learning for Biomolecules

Yiyu Cai, Zhong Chen, Sandra Tan, Ban Hoe Chew, Zachary Walker, Sui Lin Goei and Wouter van Joolingen

KEY IMPLICATIONS

- Virtual and augmented reality (VAR) technology can enhance students' learning in biology.
- A low-cost solution may be able to produce effective assistance for students' learning.
- Model-based and virtual reality (VR)-enabled solution can be scaled up for STEAM education.

BACKGROUND

Learning worldwide today is still fairly traditional with most of the activities happening in classrooms, laboratories, etc. In addition to textbooks and blackboards, models are playing an important role in teaching and learning. Unfortunately, most of them are usually static due to their physical limitations, causing difficulties for students in their learning.

There is a strong research base providing support for the argument that technology enables the involvement of students in realistic scientific tasks, for example by the use of simulations (de Jong, 2006), VR (Cai, 2013), external data and laboratories (de Jong, Linn, & Zacharia, 2013) as well as modelling tools. These tools allow for the creation of tasks and task environments in which realistic and authentic forms of inquiry are possible and within reach of students in lower-secondary education. The PI and his team have been doing intensive works on 3D modelling, visualisation, and VR for bio-molecular interaction. Efforts were also made on simulation and serious games for science education (Cai, Goei, & Trooster, 2017).

FOCUS OF STUDY

We believe computerised VR models, or more generally VAR models, can help students better understand abstract concepts, complex structures and dynamic processes. With VAR models, students can learn difficult topics through interactive play.

This project aims to develop VAR models which can be used in interactive and immersive learning. The advantages of such VAR models are its detail on demands, dynamic representation and scalable in use. The research question of this project: "Is there a cost effective and customisable approach to designing VAR models that assist students' interactive learning?"

The objective of this project is to come up with a cross-platform solution for VAR technology that enhances learning including smartphone and head-mounted displays (HMD) within a conventional classroom setting.

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KEY FINDINGS

VAR technology for enzymes, digestion, circulation and bio-molecules learning were developed. Efforts were made in design on the affordability, convenience, interactivity and scientific accuracy of the learning apps. This research shows that the model-based and VAR-enabled teaching and learning technology improve students' understanding of the concepts or processes, which are traditionally difficult to them.

As the apps were developed for low-cost devices such as iPAD or Android smartphones, such an approach may be extended for more topics in STEAM, thus assisting students in their learning both in classroom and after school.

The project emphasises on the use of existing teaching environment, built on top of the available textbooks, without introducing high-end VR equipment. The research outcomes show feasibility in developing cost-effective solutions, thus assisting students in tackling difficult or challenging learning topics.

SIGNIFICANCE OF FINDINGS

Implications for practice

Without altering the classroom setting, the solution developed in this project is able to help teaching and learning. Students can have a better understanding of the difficult concepts, complex structures, and dynamic process in biology by leveraging on the VAR technology-enhanced learning.

Implications for policy and research

For next-generation textbooks the Ministry of Education, Singapore is designing, it is possible to incorporate a low-cost VAR solution in textbooks, allowing students to have an interactive and immersive experience in the classroom and at home.

Learning gains

With the aid of low-cost VAR solution, students will be able to have a much better understanding about abstract concepts, complex structure and dynamic process typically involved in biology and other science learning.

Proposed follow-up activities

We plan to roll out this technology in more mainstream schools, and scale up the research by involving more students and teachers.

PARTICIPANTS

Please refer to Table 1.

RESEARCH DESIGN

In this development project, we have invested substantial efforts to design learning applications with a focus on the fidelity modelling and simulation, immersive visualisation, real-time interaction and natural user-interface. The design and development of the content are associated with conceptualisation, storyboarding, scripting and fine-tuning, etc.

Table 1

#	Collaborating Parties / School(s)	Education Level/Grade	Subject	Participant Type	Participant No.
1.	Christ Church Sec	Secondary 2	Biology	School Students	36
2.	Riverside Sec	Secondary 2	Biology	School Students	21
3.	Hwa Chong Institute	Secondary 2	Biology	School Students	12
4.	Raffles Institute	Secondary 2	Science	School Students	62
5.	Nanyang Girls High	Secondary 2	Science	School Students	18
6.	Unity Sec	Secondary 2	Science	School Students	30
7.	Gymnasium Novum	Secondary	Science	School Students	28

Students from partner schools in the project participated in the trial runs and/or control/experiment study of the apps developed in the project. Data of learning outcomes were collected by the partner schools and results were shared during a symposium held in 1 August 2019.

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About the authors

Yiyu CAI is with the Nanyang Technological University, Singapore.

Zhong CHEN is with the National Institute of Education, Singapore.

Sandra TAN is with Hwa Chong Institution, Singapore.

Ban Hoe CHEW is with River Valley High School, Singapore.

Zachary WALKER is with the University College London, United Kingdom.

Sui Lin GOEI is with the Windesheim University of Applied Sciences, The Netherlands.

Wouter van JOOLINGEN is with the Utrecht University, The Netherlands.

Contact Cai Yiyu at myycai@ntu.edu.sg for more information about the project.

This brief was based on the project AFD 06/16 CY: Model-based and VR-enabled Teaching and Learning for Biomolecules.

How to cite this publication

Cai, Y., Chen, Z., Tan, S., Chew, B. H., Walker, Z., Goei, S. L., and van Joolingen, W. (2020). *Model-based and VR-enabled Teaching and Learning for Biomolecules* (NIE Research Brief Series No. 20-003). Singapore: National Institute of Education.

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