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Using Demonstrations to Explain Abstract Science Concepts

Hands-on and Online Demonstration-Based Pedagogy for Enhancing Student Engagement in Physics

Hariom Jani, Aarushi Khandelwal, Leong Tze Kwang, Yarong Yang and Thirumalai Venkatesan

KEY IMPLICATIONS

- To inspire more Singapore A-Level students to take up STEM higher education, efforts should be directed to make science classes more *engaging*, *fun* and *discovery-driven*.
- Demonstrations provide in- and out-of-class immersive learning, helping students to build *connections with real-world applications*. When coupled with predict-explain-observe-explain (PEOE) technique, they help *conceptual development* through peer-learning.
- We have built hands-on and online demonstrations (for Modern Physics A-Level curriculum) which are simple and cost-effective, allowing us to scale-up significantly.
- We have passed them on to educators from *all junior colleges* through a *national-level workshop*, co-hosted by National University of Singapore Nanoscience and Nanotechnology Initiative (NUSNNI) and Ministry of Education Curriculum Planning and Development Division (MOE CPDD). Online demonstrations are to be hosted freely on the Singapore Learning Space.

BACKGROUND

Studies show that demonstrations can stimulate emotions of curiosity, wonderment and positivity in the students (Gurel, 2016; King, Ritchie, Sandhu, & Henderson, 2015). They assist teachers in providing a "connecting experience" through which students can associate concepts to phenomena from their day-to-day life. Hence, instead of being intimidated by equations and abstract ideas, students associate positively to their experience of STEM-learning. Moreover, demonstrations helped to increase the participation (Hilario, 2015) of not only the general student population but also those from under-represented communities in science (women, minorities) who otherwise don't participate actively. This builds a positive reinforcing cycle which can increase students' interest in studying and pursuing STEM.

FOCUS OF STUDY

We embarked on this development project, as we noticed that nearly *85%* of A-level students with science major subjects do not take-up sciences in tertiary education, and *35%* of them leave STEM altogether (MOE). This significantly *constrains the number of Singaporean scientists*

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and engineers that are available to address the country's burgeoning demand in the research and development infrastructure. We believe that while administrative top-down approaches could help in the short-term period, bottom-up approaches involving *grassroot educational transformation* will address this issue in the longer run.

KEY FINDINGS

Demonstrations-based PEOE-scaffolded teaching:

- increased students' interest and excitement for physics, while enhancing their conceptual development, and
- allowed educators to effectively communicate learning objectives while fostering peer-learning.

SIGNIFICANCE OF FINDINGS

For practice

Demonstration-based student-centric pedagogies will help educators create an active-learning atmosphere, inspiring greater interest for STEM in their students.

For policy

Educators have tight class-time restrictions to cover curriculum for examinations. It should be investigated how this pressure can be reduced to nurture innovative pedagogies in Singapore classes.

PARTICIPANTS

Demonstrations in this project were developed and piloted by NUSNNI in collaboration with MOE CPDD at 3 junior colleges (National, Jurong Pioneer and Yishun-Innova JCs) over the span of 2.5 years. The finalised demos were then distributed to A-level educators and lab-technicians from *all* JCs during the NUSNNI-CPDD workshop.

RESEARCH DESIGN

PEOE-based Hands-on and online demonstrations were developed. The former included Radioactivity, Cloud Chamber, Quantum Eraser and Phone Spectrometer. The latter included Quantization, Absorption/Emission and Fission/Fusion.

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About the authors

Hariom JANI, Aarushi KHANDELWAL and Thirumalai VENKATESAN are with the National University of Singapore Nanoscience and Nanotechnology Initiative, Singapore.

LEONG Tze Kwang and Yarong YANG are with the Ministry of Education Curriculum Planning and Development Division, Singapore.

Contact Hariom Jani or Thirumalai Venkatesan at hariom.k.jani@u.nus.edu or venky@nus.edu.sg for more information.

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