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Hands-on and Minds-on Learning of Science using a Microbial Fuel Cell

Lee Yew Jin, Sam Choon Kook and Timothy Tan

KEY IMPLICATIONS

1. Design-based inquiry using microbial fuel cells is an effective pedagogical approach to drive "minds-on" (not just "hands-on") science lessons and hence the development of holistic scientific literacy in terms of scientific knowledge, skills and attitudes.
2. We have developed a curriculum package that features: STEM integration—applied learning across biology, chemistry, physics, engineering design and more; authentic inquiry-based learning; and, an affectively engaging context and mode of learning.
3. Secondary 2 students are capable of successfully engaging in complex design-based inquiry challenges to produce working improvised microbial fuel cells that outperform standard cells.

BACKGROUND

There is a need to find strategies that foster "minds-on" engagement in practical science work, beyond mere "hands-on" activity. Even inquiry-based learning does not guarantee such engagement, the lack of which imperils the fundamental tenets of science education. At the same time, there is also a need for authentic interdisciplinary lessons in science that bridge the traditional divisions between biology, chemistry and physics.

FOCUS OF STUDY

This study examines the implementation of one of the lesser used inquiry-based pedagogies, design-based inquiry (DBI), in science lessons based on the microbial fuel cell (MFC).

KEY FINDINGS

The use of DBI with the MFC is effective for the holistic development of scientific literacy beyond the conventional accumulation of content knowledge. Students gain broader perspectives on science as a field and as a way of knowing about the world. Important process skills are also developed, especially in terms of applying science knowledge in reasoning and decision-making. The implementation of this unfamiliar pedagogy requires support from school leaders and the commitment of teachers.

SIGNIFICANCE OF FINDINGS

Wider use of DBI in science teaching deserves consideration. It has strong potential, especially in stretching higher-ability students, and it clearly aligns with MOE's science curriculum and 21st

Century Competencies Framework that places emphasis on "education for the future".

PARTICIPANTS

An intact class of Secondary Two students (n=37) from a government-aided, co-educational secondary school, underwent a school-based "scientific-thinking" programme conducted during curriculum time. Lessons were conducted by three science teachers (one discipline specialist each from biology, chemistry and physics), supported by various colleagues and the research team.

RESEARCH DESIGN

A curriculum package based on DBI with the MFC was co-developed with teachers from the school. Teachers conducted eight weekly lessons during curriculum time and each session was video recorded for later analysis in a mixed methods approach with a learning sciences focus. Student work in the form of worksheets, logs, online postings and other artefacts such as drawings were collected. Selected students were engaged in focus group discussions.

About the authors

LEE Yew Jin and Timothy TAN are with the National Institute of Education (NIE), Singapore. SAM Choon Kook recently retired from NIE.

Contact Yew Jin at yewjin.lee@nie.edu.sg for more information about the project.

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Request for more details

Please approach the Office of Education Research, National Institute of Education, Singapore to obtain a copy of the final report.