TEACHING & LEARNING RESEARCH INITIATIVE
NĀU I WHATU TE KĀKAHU, HE TĀNIKO TAKU

Investigating the Impact of Non-Routine Problem Solving on Creativity, Engagement and Intuition of STEM Tertiary Students

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Project Description

In recent years, some universities in Australia, Europe and the USA, have introduced formal academic courses or seminars for their first-year Science, Technology, Engineering and Mathematics (STEM) students based on a Puzzle-Based Learning (PzBL) pedagogical strategy, with some making them compulsory. The primary aim of our project was the evaluation of a strategic and innovative pedagogical intervention based on PzBL in undergraduate STEM courses. In particular, it investigated the effects of this pedagogy on student engagement and its influence on their intuition and creativity.

Research Questions

To fulfil this aim, the project sought to answer three important research questions:

- Does the integration of non-routine problem solving in lectures affect participants' engagement in lectures, and/or their ability to inhibit intuitive thinking and exhibit creative thinking?
- Are any observed effects moderated by individual differences such as demographic characteristics or prior ability?
- How do students react to the integration of non-routine problem solving in their lectures?

Why is this Research Important?

In 2012, the New Zealand government identified as a priority the need to address the undersupply of students studying STEM subjects for delivering its Business Growth Agenda (www.mbie.govt.nz). Low engagement and retention rates in STEM subjects contribute to the shortage of STEM graduates, producing a negative impact on the New Zealand economy. The PzBL pedagogical strategy has the potential to increase the students retention rate in STEM subjects by improving their engagement. Another aspect is the role of creativity in students future careers. Whilst creativity has an intrinsic value and is generally considered to be important, its greatest effect arguably is on students employability as it is a workplace requirement nowadays.

Key Findings

Engagement

- Students' behavioural engagement was significantly greater during the intervention. The evidence showed that students found the non-routine problem solving more engaging than the lecture itself, with fewer instances of off-task behaviour observed.
- The group with C grades in prerequisite courses reported the highest engagement in non-routine problem solving.

Self-efficacy

- Students mostly indicated higher levels of self-efficacy in solving non-routine problems. They saw themselves as capable of solving non-routine problems, and enjoyed doing so, indicating a positive emotional disposition.

Intuition

- Even though students saw the importance of inhibiting intuitive thinking, it did not change significantly over time. This may have been due to the short timescale of the intervention and a strong resistance of the (primary) intuition to change.

Group Differences

- Grades in prerequisite courses did not significantly influence over time student self-efficacy in, emotional disposition toward, or perceived value of, non-routine problem solving. However, students with prior B and C band grades reported an increase in self-efficacy and intrinsic interest.
- The results suggest that the intervention may have been more effective for males than females.

Student Perceptions about Learning

- The vast majority of the students agreed that solving non-routine problems was useful for their learning and could enhance their creative and innovative thinking abilities. They talked about the need to "think outside the box" and think holistically rather than be focused on a single approach.
- Perceptions of the utility value of non-routine problem solving improved at the end of the semester for all students.
- The students strongly agreed solving non-routine problems in their courses would be beneficial to their future learning, as well as their careers and other areas of life.

Creativity

- There were no significant changes in students' creativity (originality, fluency and elaboration traits of the divergent thinking) over the intervention. This may have been due to the short intervention.

Implications for Practice

- We would recommend that tertiary institutions seriously consider initiating the PzBL pedagogical strategy in their STEM subjects.
- Such an intervention is highly amenable to scaling up with a relatively small development investment and easily transferable to other tertiary STEM courses, since it requires minimal time.
- That the greatest effect on both self-efficacy and intrinsic interest appeared to be for students with lower prior achievement, should add to the appeal of the approach for many institutions because it has the potential to increase the student retention rate.

Our Partners

The partners in this project represent a rich array of disciplines and institutions as well as expertise and experience. Our partnership also includes: Professor Glenda Anthony, Professor of Mathematics Education, Co-Director of the Centre for Research in Mathematics Education, Massey University; Professor Merrilyn Goos, Professor of STEM Education and Director of the National Centre for STEM Education, University of Limerick, Ireland; Professor Barbara Jaworski, Professor of Mathematics Education, Loughborough University, UK; and Fields Medalist Sir Vaughan Jones KNZM FRS FRSNZ FAA, Stevenson Distinguished Professor of mathematics, Vanderbilt University, USA and Distinguished Alumni Professor, University of Auckland.

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