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Mathematical Problem Solving for Everyone: Infusion and Diffusion (MinD)

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KEY IMPLICATIONS

1. Students are able to acquire the problem solving processes through being explicitly exposed to mathematical problem solving
2. In order for problem solving to be carried out in school, building teacher capacity through professional development in the form of close collaboration between researchers and schools is crucial
3. Infusion of problem solving into the regular mathematics curriculum must be explored in order for sustainable problem solving

BACKGROUND

This research project, which is based from an earlier research project M-ProSE (OER 32/08 TTL), aims to scale up an innovative approach of teaching problem solving using the science practical paradigm from one specialized school to the entire spectrum of Singapore schools. In the process, the original project design was tweaked to meet the demand of the individual schools. The modes of collaboration between the researchers and the participating schools evolve, ranging from the professional development programme for teachers to the joint design of the problem solving curriculum for the individualized schools.

FOCUS OF STUDY

The researchers developed a mathematical practical module (Toh et al., 2011) and tweaked the original M-ProSE design to meet the demands of the individual participating schools. While structures were modified, the parameters were kept constant: (1) problem solving is meant for every student, rather than for the elite few; and (2) problem solving must be assessed (not only the product but the process). The problem solving module became a distinctive feature within these schools' mathematics curriculum, and was infused within their regular mathematics classrooms in various ways. The M-ProSE design was also used to re-design one undergraduate mathematics module at the National Institute of Education (NIE), which was incorporated into the teaching of pre-service teachers during the research period. This had resulted positively towards their acquisition of mathematics content knowledge.

KEY FINDINGS

- With appropriate design modifications to meet the needs of the individual schools, the original problem solving package that was designed in MInD is sustainable in these schools as it had become a permanent

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feature, implying that the concept of MInD is acceptable for schools.

- For its implementation and sustainability, the schools have infused problem solving into their curriculum in various ways: one school tapped on MInD to introduce the language of problem solving to all levels; another school used e-learning for certain portions of the problem solving lesson so that more time can be reserved for the actual problem solving process; another school continued to develop their own materials to support the problem solving module by generating more related problems.
- Student teachers generally respond positively to this new mathematics learning approach. At the undergraduate level of mathematics teaching especially for student teachers, problem solving could be potentially infused to create more opportunities for "success stories" in learning mathematics.

SIGNIFICANCE OF FINDINGS

Implications for Practice

Problem solving can be introduced into the school mathematics classrooms and with the appropriate design structure, is sustainable.

Implications for Policy and Research

The corresponding assessment strategies developed by MInD is an important message: If we think that "processes" are as important as "product", appropriate assessment strategies must be designed to assess the processes in addition to assessing the product. Existing assessment in our local high-stake national examinations only focuses on the product of that process.

Learning Gains (for studies involving intervention)

Problem solving works! More importantly, students' belief about problem solving and their performance in mathematics achievement test are positively correlated to their performance in mathematical problem solving.

Proposed Follow-up Activities

More teachers need to participate in problem solving professional development, in addition to content and pedagogy professional development workshops.

POPULATION

Five secondary schools participated in this research: (1) Specialized school in Mathematics and Science; (2) Integrated Programmes school; (3) autonomous school; (4) two typical mainstream secondary schools. All the students in the Express stream participated in this study.

All Year 3 NIE mathematics pre-service teachers in 2012 participated in this study as part of the course (AAM331 Differential Equations) they read; and all Year 1 NIE mathematics pre-service teachers in 2014 participated in this study as part of the course (AAM 104 Number Theory) they read.

RESEARCH DESIGN

We tap on three main timely developments to advance its research:

1. The recent advances in methodological thinking which support the use of multiple methods in seeking insights into the complexities of teaching and learning.
2. A new development in the educational landscape of Singapore, namely, the establishment of IP schools which targets educational "peaks" for academically-inclined students and are given relatively greater freedom to explore curriculum innovations.
3. Recent research focus on diffusion of innovations.

We use "design experiment" as the methodological backbone. Design experiment arose from the attempts of the education research community to address the demands of research in real-life school settings in all its

complexity. Design experiment argues for the application of multiple techniques to study a complex phenomenon in education. It permits the use of a slew of methods such as participant observation, interview, video-taping, and paper-and-pencil testing to provide corroborative evidence for findings.

REFERENCE

Toh, T.L., Quek, K.S., Leong, Y.H., Dindyal, J., & Tay, E.G. (2011). *Making Mathematics Practical: An Approach to Problem Solving.* Singapore: World Scientific.

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