Teachers' and Tutors' Perceptions of the Optimising Problem Solving (OPS) Framework for Solving Mathematical Problems

Shinta Sari[1]

[1]School of Education, The University of Adelaide

Corresponding author email address: shintasari013@gmail.com

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Abstract

At the point when this study was conducted, the OPS framework had already been implemented for some time by tutors in the University of Adelaide's Mechanical Engineering program. The framework helps tutors in teaching problem solving and improves students' problem-solving abilities. (Willison et al., 2016, pp. 8-9). This study aims to investigate and critically analyse teachers' and tutors' perceptions regarding the implementation of the Optimising Problem Solving (OPS) framework in mathematical contexts. This research is an ethnography study with a thematic content analysis approach. It found three aspects of the OPS framework to be important in the context of mathematics teaching; concept, structure, and the holistic nature of the framework. Further studies should use actual academic results as outcomes.

Keywords: *Mathematical Problem Solving, Optimising Problem-Solving Framework*

Introduction

The primary goal of mathematics education is to "mathematise" students' thinking processes. It is not only to teach students about numeration and calculation, but also how to use higher-order thinking to solve daily life problems (National Council of Educational Research and Training, 2006). The sorts of problem solving activities engaged in by students sometimes feature daily life problems as subject matter. However, some mathematics tutors revealed that mathematics tutors are accustomed to teaching mathematical exercises, and so are poorly prepared to engage in more abstract problem-solving teaching and learning (Sakshaug & Wohlhuter, 2010). Furthermore, more commonly, students stated they struggled when facing problem-solving tasks in mathematics. They argued that problem-solving is a complex task which requires some crucial skills, such as analysing, communicating, and critical thinking, and that only the geniuses can solve the problems (Schoenfeld, 2014).

Some engineering students and tutors faced the same problem as above, and they developed a framework to overcome the problem, called the Optimising Problem Solving (OPS) framework (Willison et al., 2016). The OPS framework helps tutors in teaching problem solving and improves students' problem-solving abilities (Willison et al., 2016). This framework is one of the Models of Engaged Learning and Teaching (MELT) family (Willison, 2017). Models of Engaged Learning and Teaching (MELT) focus on students' thinking skills, and can be a guideline for educators in teaching.

The OPS framework is suited to the context of mathematical problem solving for three reasons. First, it was established for students by students and so has a type of 'street cred'. Second, it was designed to scaffold students' problem-solving abilities broadly and be revisited over extended periods of time, in diverse contexts (Willison, et al., 2016). Third, OPS is a framework that is part of the family of the Research Skill Development framework. As such, OPS can intimately connect mathematical problem solving to broader thinking such as research-based learning and critical thinking (Willison, 2015). However, there are a lack of studies discussing and exploring the implementation of the OPS framework in a mathematical context. For this reason, this study explores the potential usefulness of the OPS framework in mathematical context by investigating the perceptions of mathematics teachers and tutors.

It is important to be aware of teachers' and tutors' perceptions before implementing the framework, since teachers and tutors are the front-liners in teaching and learning activities. Teachers have responsibilities to design an effective teaching environment to help students achieve learning goals. Some studies show that teachers face barriers in designing their teaching as well as finding an effective pedagogy to implement (Schifter & Fosnot, 1993; Walshaw & Anthony, 2008). Here, I argue that the OPS framework might be an alternative for teachers and tutors in teaching mathematics, especially in mathematical problem solving. So, the research question of this study is:

> "What is the perceived usefulness, by teachers of international students, of the Optimising Problem Solving (OPS) framework for teaching mathematical problem solving?"

Methodology

This research is an ethnographic study which describes multiple participant perspectives and explores rich details within the specific context of the OPS framework and its implementation in mathematical contexts, especially in mathematical problem-solving. A semi-structured interview was used to gather data regarding teachers' and tutors' perceptions of the OPS framework. The sample was chosen based on purposive sampling.

The intended sample size was seven international students and two mathematics tutors who came from three different countries of origin; Australia, Indonesia, and Myanmar. They were international and local students, themselves teachers, in the Master of Education course, as well as tutors from the Mathematics Drop-in-Centre at the University of Adelaide. Seven of them were females and two of them were males. The researcher implemented six phases of thematic analysis from Braun & Clarke (2006) to analyse the data; familiarised with the data, generated initial codes, searched for themes, reviewed themes, defined and named themes, and produced the report.

Results

The participants commented on three areas of the framework which they considered potentially useful in a mathematical context: concept, structure, and the holistic nature of the OPS framework. Regarding the concept, participants revealed several potentially useful aspects of the OPS framework in teaching mathematical problem solving. The first concept was the use of the OPS framework, which related to students' higher order thinking skills. Some participants (n=5) stated that the use of the OPS framework might improve students' higher order thinking skills in mathematics, including problem solving and critical thinking. One participant described her opinion as follows:

> "If you interpret and if you share this thing [OPS], it will be very helpful and it's good for the improvement of the problem-solving skills and critical thinking. This framework will help the students to go to the higher level while solving problems." (Participant C).

The second concept was about non-sequential facets including the motto 'when in doubt, return to the centre'.

Some participants (n=5) revealed that they found the non-sequential facet structure of the OPS to be impressive. One of the participants stated:

> "Having no sequence could be a strength. If there is no sequence, what might happen is some students may get the solution very quickly. Having no sequence might be good because the students might learn which ways give the solution quicker rather than having a sequence." (Participant H).

The third concept was related to the facet titles. The participants mentioned all facets except "generate and evaluate" as important facets for mathematics learning. Participants had their own favourite facets to enhance students' mathematical problem-solving abilities.

Furthermore, the OPS framework could also be potentially useful based on the structure of the framework. Participants (n=5) stated that the pentagon shape was fine for the OPS framework design. However, they suggested that the pentagon needed some improvement in terms of word formatting and the addition of colour. One participant mentioned that: "I think it needs colour because I think it was also separated out a little bit and it's quite good the way to learn. The colour makes it more visual." (Participant F).

Other potentially useful aspects of the OPS framework were related to the holistic nature of the framework. All participants agreed that the holistic nature of the OPS might be perceived to be useful in a mathematical context, yet requires an appropriate pedagogical strategy, a suitable teaching context, and a sufficient share of the framework. One participant stated,

> "I think it can be implemented, but it requires the correct training and we can cross the board as well, so some people are doing it, but some people aren't. I guess just everyone understands the thing and the implementation has to be done correctly and has to be successful." (Participant F)

Discussion

Results revealed that the perceived usefulness of the OPS framework in teaching mathematical problem solving can be seen in three aspects; concept, structure, and the holistic nature of the framework. The OPS framework can be used to scaffold students' mathematical problem-solving abilities through the integration of the OPS framework with students' learning experience in the class, lesson plan, and the assessment processes. The use of the OPS framework in the lesson plan and assessment processes to scaffold students' mathematical problem-solving abilities was in line with previous studies (Callejo & Vila, 2009; Charles & Silver, 1988; Codina, Cañadas, & Castro, 2015; Coleman, King, Ruth, & Stary, 2001; Jones, Swan, & Pollitt, 2015; Nunokawa, 2005; Saragih & Napitupulu, 2015) which demonstrated the importance of using the framework align learning goals, learning process, and assessment.

Results suggested that the non-sequential structure of facets including the motto ‘when in doubt, return to the centre’ in the OPS framework was potentially useful in a mathematical context, since this structure teaches students to find solutions step by step without being directly guided to the result. Through this concept, the framework was expected by the participants to be able to mathematise students’ thinking. This concept aligns with the concept of *thinking routines* by Richhart and Perkins (2008) which revealed that students need to learn by themselves to arrange their thinking and focus on the process of problem solving. In addition, the OPS as a *thinking routine* was successful in Mechanical Engineering students to enhance students’ communication and problem-solving skills (Willison, 2016). The concept of facets titles has also been used in some other problem-solving frameworks, such as Problem Based Learning (PBL). Almost all the terms are similar between these two frameworks. Previous research has shown that the PBL terms can assist students with mathematical problem-solving (Hmelo-Silver, 2004).

Some improvements related to the structure of the OPS framework were suggested by the participants to make the framework more effective in mathematical problem solving. The suggestions were related to word format and colour of the pentagon. The participants suggested that the word format should be more readable and understandable if the explanation of the facets was written in line by line, not in the diagonal position. Furthermore, some participants (n=3) stated that the colour makes the pentagon more visual. In line with the participants’ comment, there were also some studies discussing the benefit of colour to students’ achievement in learning. The result of some previous studies stated that colour is an important aspect that should be considered by teachers to design their teaching since the colour can enhance students’ performance (Benbasat & Dexter, 1985; Gaines & Curry, 2011).

The other potential usefulness of the OPS framework is related to its holistic nature. All participants (n=9) revealed that the holistic nature of OPS framework could be potentially useful for a mathematical context, but that it requires an appropriate pedagogical strategy, a suitable teaching context, and a sufficient share of the OPS framework. The participants stated that subject, age, student level of education, course type, time and situation are the important aspects that should be considered in the OPS implementation. The statement of this participant was supported by Anthony & Walshaw (2010) study which stated that a teacher should adapt the mathematics learning process to students’ needs, for example in using this OPS framework, the students in younger age needs to learn more contextual, and the older learners can learn in more abstract context. Furthermore, all participants made some comments related to their pedagogical strategies. The participants prefer to introduce the framework, explain the OPS step by step, demonstrate, give some examples, make suggestions on which facets to follow, and provide several alternative frameworks to use.

Conclusion

The perceived usefulness of the OPS framework in teaching mathematics can be categorised based on three aspects. The first aspect is based on the concept of the framework which consists of the concept of higher order thinking skills, non-sequential facet with motto 'when in doubt, return to the centre', and facet titles. The second aspect is based on the structure of the framework which consists of word format and colour of the pentagon. The third aspect is based on the holistic nature of the framework which related to an appropriate pedagogical strategy, a suitable teaching context, and a sufficient share of the OPS framework. Further studies should use actual academic results as outcomes

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