MATHEMATICS TEACHERS' AND TUTORS' IMPRESSION ON THE CONCEPT AND STRUCTURE OF THE *OPTIMISING PROBLEM SOLVING* (OPS) FRAMEWORK

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Abstrak

Beberapa kerangka kerja telah disarankan untuk meningkatkan kemampuan pemecahan masalah matematis siswa seperti *Problem Based Learning* (PBL), *Research Skill Development* (RSD), Taksonomi Blooms, dan *Optimising Problem Solving* (OPS). Kerangka kerja OPS merupakan salah satu framework terbaru yang dikembangkan oleh para ahli dalam pemecahan masalah. Kerangka kerja ini telah diterapkan untuk meningkatkan kemampuan pemecahan masalah siswa di sekolah teknik. Oleh karena itu, kerangka OPS juga dapat menjadi alternatif bagi guru dan tutor matematika. Penelitian ini bertujuan untuk menganalisis kesan guru dan tutor terhadap konsep dan struktur kerangka OPS. Kajian ini dikategorikan ke dalam etnografi dengan menggunakan pendekatan *thematic content analysis*. Hasil dari penelitian ini menyatakan bahwa terdapat masing-masing dua kriteria yang berkesan oleh guru dan tutor terkait dengan konsep dan struktur dari kerangka kerja OPS. Kesan terhadap konsep OPS terkait dengan aspek non-sekuensial dan judul faset. Sedangkan kesan terhadap struktur OPS yang menarik perhatian guru dan tutor adalah terkait dengan bentuk pentagon, serta format kata dan warna pada OPS.

Kata Kunci. Kerangka Kerja, Optimising Problem Solving, Matematika

Abstract

A number of frameworks have been proposed to help students become more adept at solving mathematical problems, including Problem Based Learning (PBL), Research Skill Development (RSD), Blooms' Taxonomy, and Optimising Problem Solving (OPS). One of the most recent frameworks created by professionals in issue solving is the Optimising issue Solving (OPS) framework. It has been demonstrated to enhance students' ability to solve engineering-related problems. Consequently, the OPS framework might potentially be a different framework for mathematics teachers and tutors. This research aims to analyse teachers' and tutors' impression on the concept and structure of the OPS framework. The study are categorised into

an ethnographic by using a thematic content analysis approach. It resulted in two concepts and two structures of the OPS framework that impress the mathematics teachers and tutors. The concepts are related to the non-sequential facets and the facet titles. While, the structure of the framework that impress the teachers and tutors are related to the pentagon shape, and the word and colour format.
Keywords. Framework, Optimising Problem Solving, Mathematics Learning

1. Introduction

Many frameworks, including Problem Based Learning (PBL), Research Skill Development (RSD), Blooms' Taxonomy, and Optimising Problem Solving (OPS), have been recommended to help students become more adept at solving mathematical problems. Each of these frameworks helps students develop their higher order thinking abilities. Six facets can be used to integrate the PBL, RSD, Bloom's, and OPS frameworks in problem solving. Since the facets offered are not considerably different from one another, the frameworks are correlated with one another. (Anderson & Sosniak, 1994; Fogarty, 1997; Missingham et al., 2014; Willison & O'Regan, 2007).

For instance, one of the frameworks that teachers regularly employ to teach problem-solving is PBL. Teaching by solving problems is a kind of problem-based learning (PBL). PBL is a methodology that is built on open-ended, ambiguous, unstructured real-world issues, according to Fogarty (1997). Problem situations are frequently intricate and comprise disparate pieces of information..

The first step in learning mathematics is to gradually present questions that encourage enquiry, moving from a tangible to an abstract setting. Through problem-based learning, students are strongly driven to seek out genuine and pertinent knowledge and to learn from actual events that occur in their daily lives. (Hmelo-Silver, 2004; Schmidt, 1983).

The RSD framework, which is utilised as a medium to diagnose, plan, encourage, understand, and perceive both the potential and realised research skill development of the student, is another comparable framework for problem solving (Willison & O'Regan, 2007, p. 401). The RSD framework is displayed as a table, with the six main student research facets represented by rows and the level of student autonomy represented by columns. The six facets in the RSD framework are: embark and clarify to identify a knowledge or understanding gap; find and generate to hunt for necessary information using a suitable technique; critically review information or data and the process to find and generate the information or data; organise information or data that has been gathered or created, manage research processes, synthesise, analyse, and apply new knowledge, and disseminate new knowledge and the methods used to produce it while keeping ethical, social, and cultural considerations in mind. (Willison & O'Regan, 2007; Willison, 2010)

The OPS framework is additionally one of the most recent frameworks created by problem-solving specialists. This OPS framework, which is a development of RSD and has already been used in a Mechanical Engineering programme, was built to maximise students' problem-solving skills. The improvement of the students' visual, written, and oral communication in the problem-solving processes was highlighted by the successful implementation of OPS in the Design Graphics and Communication courses of a Mechanical Engineering programme, and the students also retained a broader understanding of all the essential components of problem solving. (Willison et al., 2016).

For three reasons, the OPS framework is appropriate for use while addressing mathematical problems. The OPS has some 'street cred' because it was created for students by students. Second, the framework was created to foster students' problem-solving skills in a variety of circumstances and to be reviewed over an extended period of time. Thirdly, the OPS framework is a member of the Research Skill Development framework family. Utilising OPS allows for a direct link between solving mathematics problems and other types of thinking, such as research-based learning and critical thinking. (Willison, 2015).

Teachers and tutors can utilise the Optimising Problem Solving (OPS) framework to help their students with problem-solving. It needed revisions that used vocabulary common in an engineering programme because it was based on the well-researched RSD framework (Missingham et al., 2014). The six facets of the RSD and the facets of the OPS framework are compared in Table 1.

Table 1. Facets of the OPS lined up with the Facets of the RSD

Research Skill Development (RSD) facet descriptions	**Optimising Problem Solving (OPS) pentagon facet descriptions**
Embark & Clarify *What is our purpose?* Students respond to or begin research and define the information needed while taking team, ethical, cultural, and societal issues into account.	**Problem Definition and Specifications** Examine the problems to determine their meaning, purpose, and effects.

Research Skill Development (RSD) facet descriptions	**Optimising Problem Solving (OPS) pentagon facet descriptions**
Find & Generate *What do we need?* Students use the right methodology to identify and produce the information and data they need.	**Find & Reflect** Gather information, data & knowledge.
Evaluate & Reflect *What do we trust?* Students evaluate the reliability of sources, data, and information. They also make their own research methods clear.	**Generate & Evaluate** Examine potential alternatives and decide if they are practical. Be objective in your thinking.
Organise & Manage *How do we arrange?* Students manage teams and processes while organising information and data to show patterns and themes.	**Organise & Manage** Plan the presentation of your work and decide what information and sources to utilise. Put your work in order with graphs, tables, themes, etc.
Analyse & Synthesise *What does it mean?* Students synthesise new knowledge and critically assess information and data to generate coherent individual and team understandings.	**Analyse & Synthesise** Analyse your ideas and evidence critically. Make up your own concepts, readings, and conclusions.
Communicate & Apply *How will we relate?* While performing the procedures, understandings, and applications of the study, students discuss, listen, write, respond to feedback, and take into consideration ethical, cultural, and societal issues.	**Communicate & Apply** Effectively communicate to others your ideas, beliefs, options, deeds, outcomes, recommendations, etc.

Source: (Willison et al., 2016, p. 3)

In addition, the OPS framework is typically displayed as a pentagon, as seen in Figure 1. It was created by student tutors for first-year students in the Engineering programme at the University of Adelaide (Williamson et al., 2016).

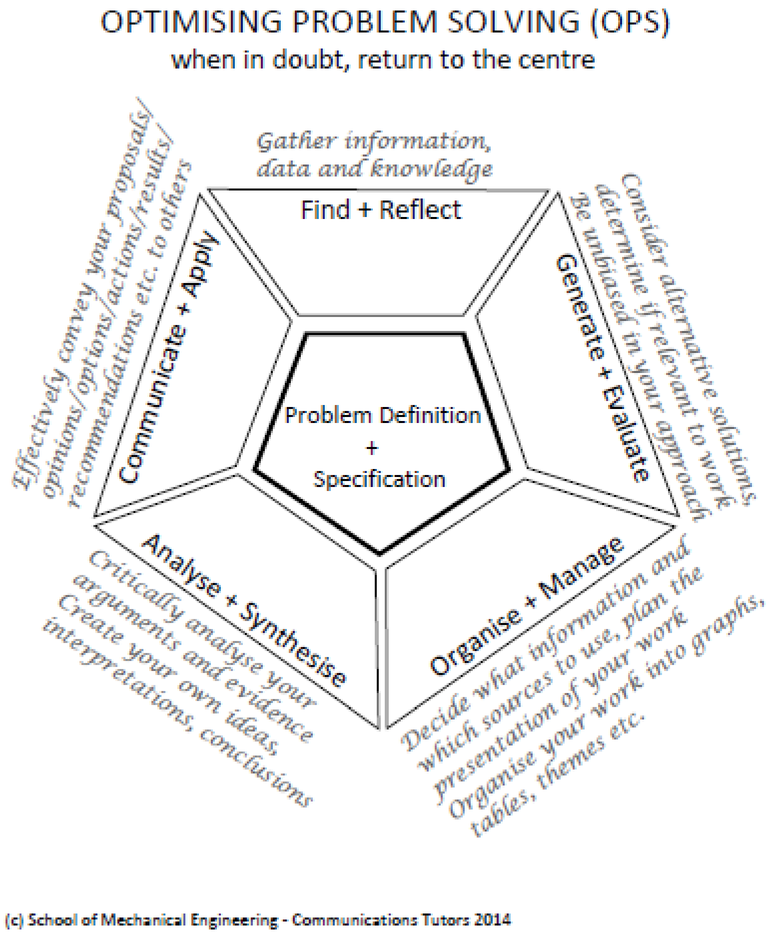

Figure 1. The Optimising Problem Solving Pentagon (Mechanical Engineering Tutors, 2014)

If students have any questions on how to solve a problem, they should go back to the OPS pentagon's special centre. The pentagon's centre places a focus on the process of establishing challenges and requirements. The Optimising Problem Solving (OPS) lacks circularity, order, linearity, and sequentially. The pattern is more like guidance from a more seasoned student than it is a set of rules to follow (Willison et al., 2016). The idea is known as non-sequential facets in this study. Students can and often do communicate while establishing the problems and requirements, for instance.

Since teachers and tutors operate as the "gatekeepers" for teaching and learning activities in the context of mathematics, it is crucial to be aware of their perceptions before applying the OPS framework. A principal or an education department may force instructors to adopt a framework, but this does not guarantee that its use will be effective if the teachers do not comprehend it or misunderstand it. They may also apply it incorrectly or not agree with it. To assist students in achieving their learning objectives, teachers are responsible for creating a productive learning environment. According to various studies, teachers encounter some challenges while developing their lesson plans and selecting an effective pedagogy to use (Schifter & Fosnot, 1993; Walshaw & Anthony, 2008). This study makes the case that the OPS framework might be an alternative for tutors and teachers when it comes to teaching mathematics, particularly when it comes to solving mathematical problems.

However, there is a paucity of study that examines and investigates how mathematics tutors and teachers feel about the OPS framework's concept and structure. Therefore, the purpose of this study is to investigate and critically evaluate the opinions of mathematics tutors and teachers regarding the concept and structure of the OPS framework. This study's research question is:

"What are the impression of mathematics teachers and tutors regarding the concept and structure of the OPS framework?"

2. Methods

This research used qualitative approach and was categorised into an ethnographic study. Teachers of mathematics, whether they work in a high school, university, or Mathematics Support Centre, made up the population of this study. Purposive sampling was used to choose the sample. One of the most common non-probability sampling techniques, intentional sampling seeks to find the right individuals for the study (Welman & Kruger, 2001). Since the researcher is looking for participants with relevant expertise or background to the case to be researched, in this case, individuals with a background or experience in teaching mathematics, this sampling strategy is an effective and appropriate approach to apply for this research (Kruger & Stones, 1981).

Two mathematics tutors as well as seven mathematics teachers make up the sample population. They are tutors from the Mathematics Drop-in-Centre at the University of Adelaide and students who are also teachers in the Master of Education program. There are two males and seven females among them. The following criteria have been developed as the inclusion criteria of the participants for this study:

1) The participants in this research will be teaching Mathematics or training to teach Mathematics.

2) They are Master degree students who have a background as a Mathematics teacher or Mathematics students in their Bachelor degree, and tutors who help students in Mathematics learning.
3) The participants' prior knowledge of the OPS framework is not required in this study.

This research used the interview as a data gathering method, since the limitation of the study is that the researcher cannot directly observe the implementation of the OPS framework. Due to the small number of documents addressing the application of the OPS framework in a mathematical environment, it was also impossible to conduct a document analysis.

A semi-structured interview was used in this research to understand the impressions of teachers' and tutors' on the concept and structure of the OPS framework. The participants were asked to attend an interview process with a maximum duration of 40 minutes. As preparation for a semi-structured interview in this study, the researcher had developed 16 interview questions in an interview protocol, which would provide guidance for the researcher in investigating relevant data about participants' impressions of the OPS framework.

In this research, the researcher used thematic content analysis. Thematic content analysis is considered as a suitable basic concept to be used for qualitative analysis. There are many benefits that a researcher can gather from a thematic content analysis, such as flexibility, the fact that it is easy and quick to learn and use, suitable for a beginner researcher, as well as the fact that it can explore unanticipated information during the data gathering process (Braun & Clarke, 2006). A thematic content analysis consists of steps to discover, interpret, report patterns and clusters of a sense of the data (Ritchie, Lewis, Lewis, Nicholls, & Ormston, 2013).

3. Results and Discussions

The Optimising Problem Solving (OPS) framework was a new framework for all participants. They had never heard about this framework before. A brief standardised 3-minute explanation was given by the researcher to the research participants. After some brief explanation, participants' initial impression of the framework could be divided into two categories. The first category was the concept of the framework, while the second category was the structure of the framework.

3.1. The Concept of OPS Framework

Two factors could be used to categorise how the concept of the framework was received. When in doubt, return to the centre is one of the non-sequential components of the OPS framework's first criterion. Five out of the nine participants believed that this OPS framework concept might be helpful in teaching mathematical problem solving. The participants contended that the non-sequential aspects of the OPS framework were particularly beneficial for developing students' mathematical thinking since they taught them how to find solutions rather than directing them to the outcome. These participants' views were consistent with the idea of thinking routines proposed by Richhart and Perkins (2008), who found that students needed to internalise strategies for structuring their thinking and concentrating on the problem-solving process. One of the main ideas of these thinking routines is that the teacher serves as a facilitator, giving students a variety of concepts so that they become second nature to their thinking. OPS use with non-sequential aspects has been used successfully with mechanical engineering students as a thinking routine to improve students' communication and problem-solving skills as well as make the learning process less result-oriented (Willison, 2016).

On the other hand, some of the participants (three out of nine) indicated that having *non-sequential facets* might create some barriers for students and teachers. The implementation of the OPS framework will consume a lot of time and needs some adjustment for students and teachers to use. Since there was no linear way to follow in the OPS framework, students might spend a lot of time in finding the best way to solve the problems and adapt to the use of this framework in problem solving.

Since the sample is not representative, so the number of participants who agree or disagree with the concept of *non-sequential facets* do not represent the more people. The concept of *non-sequential facets* in the OPS framework might take longer time for students to use and understand, but a study by Willison, et al. (2016) has shown that the students improve more in their learning by using the OPS framework with the concept of *non-sequential facets*. However, by using the search key terms of “non-sequential approach in learning” in several search engines, such as Google scholar and ERIC, there was no appearance article of “the concept of non-sequential facets”. Most models have a sequence, such as Bloom’s Taxonomy and PBL, so the investigation on non-sequential facets of the OPS framework will be very useful to give insight to students and teachers in mathematics learning.

The second criterion of the OPS framework concept was the facet titles. With all the participants, each facet title was mentioned at least once explicitly as an important aspect of teaching mathematics problem solving except for “generate and evaluate”. As presented in the results, participant B argued that the “generate and evaluate” facet overlaps with “organise and manage”. “…people usually do generating and evaluating when they are organising and managing.”

The participants’ negative impressions of “generate and evaluate” facet maybe because of the educators under prioritise the importance of this facet, while without the “generate and evaluate” facet, the educators might miss something in their teaching. If the students are not explicitly encouraged to “generate” ideas (for example, brainstorming and think outside the box), a crucial aspect of solving problems will be minimised and the goals of mathematics learning will not be achieved (National Council of Educational Research and Training, 2006; Schoenfeld, 1994).

The use of “generate and evaluate” facet in the OPS framework has shown a good impact on Mechanical Engineering students’ problem solving abilities (Willison, et al., 2016). In addition, the importance of all facets including “generate and evaluate” to scaffold students’ mathematical problem-solving abilities had also been mentioned in some problem-solving frameworks in previous studies. One of the frameworks is PBL which uses terms: problem scenario, identify facts, generate hypotheses, ID knowledge deficiencies, apply new knowledge, abstraction, formulate and analyse [the] problem, self-directed learning (Hmelo-Silver, 2004, p. 237). Almost all the facet titles are similar between PBL and OPS. Previous research showed that the PBL facet titles used to solve the problems succeed in supporting students’ mathematical problem-solving abilities (Hmelo-Silver, 2004).

There are at least some possible reasons why the participants had diverse impressions of the OPS concept as shown above. First, the participants had different roles in teaching mathematical problem solving. Participant E who mentioned the concept of word “Optimising” in relation to alignment with the learning process, assessment, and learning goals is a Mathematics teacher for senior high school students, so he concentrated on the usefulness of the OPS framework in his in-class teaching activities to achieve his learning goals. On the other hand, two tutors (Participants H and I) in the Mathematics Learning Centre did not really consider class teaching and learning processes. Second, the research participants had some similarities in teaching experience. Two out of five participants who seemed impressed by the concept of non-sequential facets in the OPS framework were the tutors. Based on their teaching experience in teaching problem solving, they argued that non-sequential facets in a framework could be an interesting thing to try.

3.2 The Structure of OPS Framework

This study discovered that the OPS framework structure also fascinates the majority of participants (five out of nine), in addition to the idea of the collection of facets. The framework's pentagonal shape was the first structure that was brought up for discussion by the attendees. They both agreed that the pentagon is an appropriate and suitable shape. Participant G "loved" the framework's structure, comparing it to Bloom's Taxonomy by saying that it resembles a hierarchical network, but that this one is adaptable and encourages cooperation between participants. The claim made by Participant G is consistent with the OPS framework design idea put forth by the mechanical engineering teachers in 2014 (Missingham et al., 2014). The graphic design of the pentagon, according to the tutors for mechanical engineering, provides a clear centre, allowing students to refer back to "define problem & specification" when unsure. The five facets that surround the core allow the students to go back and forth between the facets as they work on an issue (Willison, et al., 2016).

As mentioned by participant G, the OPS pentagon design is totally different from Bloom's Taxonomy. One of the differences is that Blooms' Taxonomy has a triangle shape as a design which describes a sequence and hierarchy among the facets of the Bloom's framework. The first step in problem solving with Blooms' Taxonomy is by remembering, and then the respective processes related to the steps of understanding, applying, analysing, evaluating, and creating as a very highest step in Blooms' Taxonomy. However, the similarities between the OPS framework and Blooms' Taxonomy are the aims of both frameworks to enhance students' higher order thinking skills, some similar facet titles in each framework, as well as Blooms' explicit incorporation into the RSD and continued existence in the OPS (Bloom & others, 1956; Willison, 2012; Willison, 2015).

The second structure, on the other hand, is connected to the word and colour format of the framework, according to the participants. The participants offered several suggestions for how to enhance the OPS framework's word and colour format so that it is more useful for solving mathematical problems. Four out of nine participants recommended making the word format easier to read by aligning each facet horizontally. Line by line writing was deemed to be the word format best suited to the pentagon's structure. Since visual learners learn best from what they see, this finding is linear and shows how the word format affects a visual learner (Felder, Soloman, & others, 2000). According to the participants' perceptions, the line-by-line approach will help students better comprehend and apply the framework.

Three out of nine participants added that adding a certain colour to the pentagon design may make it more aesthetically pleasing. Studies that address the contribution of colour on student accomplishment are related to the use of colour in learning. According to the findings of some earlier research, colour is a significant factor that teachers should take into account when planning their lessons because it can improve students' performance (Benbasat & Dexter, 1985; Gaines & Curry, 2011). For instance, the RSD framework uses a rainbow spectrum to describe a feature that the OPS framework does not make clear.

On the other hand, the implementation of a colourful pentagon might convey some distinct impressions in different countries. In developing nations, such as Indonesia and Myanmar, a colourful pentagon might present some challenges for teachers and schools. A colourful pentagon could be good for students' learning improvement, but this kind of pentagon requires some extra effort as well as funding from teachers or school departments. In some developing nations, the availability of colour printing and internet access might be one of the problems that should be faced by teachers and schools to provide a colourful pentagon.

Furthermore, compared to a Black and White version, some extra money is needed when teachers want to print the colourful pentagon as a worksheet to a whole class. A different situation might take place in a developed country like Australia, where the availability of internet and colour printing is not a problem for teachers and students. So, a colour version for the OPS pentagon might be something good to be implemented in a developed nation. However, another aspect that should be considered is that the use of colours might distract from the main message of the framework and be counterproductive, an area which needs to be researched with children.

4. Conclusions

This study has investigated and critically analysed the impressions of mathematics teachers' and tutors' on the concept and structure of the OPS framework. The findings of this study revealed that the impressions of the teachers and tutors related to the concept can be categorised into two aspects. The first aspect is the non-sequential facet concept, such as the adage "When in doubt, return to the centre". Most of the participants might support a non-sequential facets concept of the framework, but the nature of the non-sequential facets could be a barrier for some teachers in terms of the time-consuming efforts and the need for adjustment to use the framework. The second aspect is regarding the facet titles concept. With all the participants, each facet title was mentioned at least once explicitly as an important aspect of teaching mathematics problem solving except for "generate and evaluate". Additionally, the "define problem & specification" facet is regarded as the most crucial facet to improve students' capacity for solving mathematical problems.

Furthermore, the impression of teachers and tutors on the structure of the OPS framework can also be categorised into two aspects, which are the shape of the pentagon, and the word and colour format. The pentagon shape is predicted to be effective for the implementation, whereas the word format may be more useful if it is displayed line by line. A coloured pentagon might also be beneficial to improve students' achievement, but there are some barriers faced by teachers and schools to use the coloured format. For some teachers, the OPS pentagon may be outside their experience or their mathematical concepts, so making it unlikely to be implemented in its current form.

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