

## SLR: The Implementations of Problem-Solving Method Using Polya, 5e, 7e Method and its Challenge to Cope with 21<sup>st</sup> Century Learning

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### Abstract

This study presents a systematic literature review on the implementation of Problem Solving Method in HOTS questions. The main objective for this study is to identify the suitable problem solving method to implement in HOTS questions. We consider factors such as publication year, learner type and challenges in the implementation. The full ranges of Dimensions, Scopus, Emerald, Science Direct journals are surveyed and a total 15 research articles were selected for analysis. The analysis reveals that, while different field applies different strategies of problem solving method such as problem based learning, Polya's Model, 5E Model and 7E Model, most of them share similar activities in implementing the problem solving method in higher order questions. These findings act as a new skill in implementing problem solving method in higher order questions.

**Keywords:** Problem Solving Process, Implementation, Educations, Polya, 5E, 7E.

### Introduction

Lately, Malaysia has gone through the transformation in the education sector especially in the area of students' Higher Order Thinking Skill (HOTS) development. Unfortunately, the development of students' capabilities in HOTS is currently in a critical and important matter in the Malaysian schooling system (Ali & Zulkifli, 2016). The teachings of HOTS need to be integrated in the subject syllabus purposefully in a well-planned effort to educate and train the students to think in a higher level manner to solve problems individually or cooperatively. The term HOTS is generally used as a synonym to critical thinking, problem solving, and strategy creation (Sella et al., 2019).

Chien, Lin, & Ma, (2016) defined a problem solving process as a critical part of thinking in information management decision making area. Other than that, Fleischer, Buchwald, Leutner, Wirth and Rumann, (2017) said the important outcomes of all domains of education for future learning achievement is that students are able to solve problems. The problem

solving process are comprised of four steps that are identifying the difficulty, explaining it, proposing solutions, and implementing and monitoring the solutions (Siedman, 2016 ; Kazdin, 2017; Nurdyansyah, Masitoh, & Bachri, 2018)

### **A Systematic Literature Review Methodology**

The aim of this study is to identify the suitable problem solving method to implement in HOTS questions. The identified problem solving method will then be combined, designed and developed to compose new problem solving method. The research questions that guide this study are as follows:

- i. What are the strategies and activities that teachers mostly use in problem solving process for HOTS questions?
- ii. What is the challenge when implementing the problem solving process?

As the aim of this study was to identify the suitable problem solving process in solving a higher order questions, the systematic literature review (SLR) method was used to analyze papers related to problem solving methods in education. There are four stages of SLR method which are identification, screening, eligibility and inclusion (Bhsc et al., 2015). To identify appropriate studies, the searches were logged in by protocol entries stating year, research strings, databases and number items found. The search results were limited to the years 2015-2019 so as to maintain manageability and relevant current cohort of articles.

In the identification phase (Figure 1), four strings were used to search for relevant articles. These are, problem solving process; problem solving process AND implementations; problem solving process AND educations; problem solving process AND implementation AND educations AND secondary. The effort successfully captured a total of 804 papers. In this stage, open access journal was used and the database ranged from Dimensions, Scopus, Emerald, and Science Direct journals. In the screening phase, redundant papers were eliminated leaving 482 relevant papers. Then, the relevant papers were further scrutinized to implementation of problem solving process in education topic of another 318 papers. With the remaining 318 papers, the process was continued by filtering the titles and abstracts. This step revealed 230 papers with the same theme of problem solving process themes. Since the final resort of this SLR method was to include the most relevant papers that contain classroom problem solving method and activities regardless of subjects or fields, a thorough step was further executed on the remaining papers. As a result, 15 papers were found to represent the implementation of problem solving process in the classroom. It was found that these papers were somehow interconnected by the strategies used, activities created and representation of framework. The succeeding sections of this paper summarize the problem solving process used in each paper.

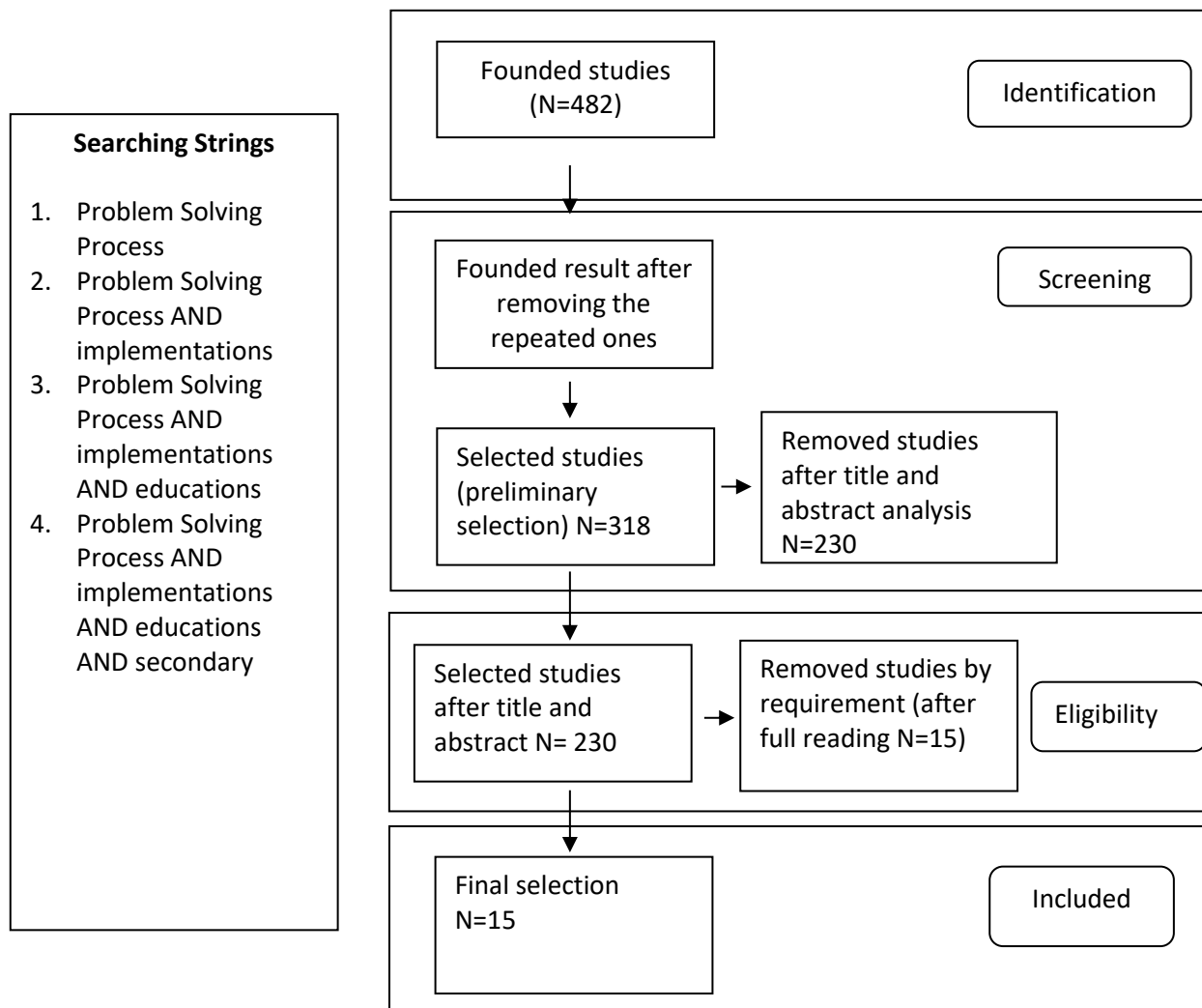


Figure 1: An Overview of the Search Protocol Based on PRISMA Statement

**Results and Discussion**

RQ 1: What are the strategies and activities that teachers mostly use in problem solving process for HOTS questions?

RQ 2: What is the challenge when implementing the problem solving process?

Table 1

*Analysis Strategies and Activities in Problem Solving Strategy*

Author(s)	Study Domain	Strategies	Activities	Result	Remarks
(Unlu, 2018) Examination on Mathematics Teacher Candidates Strategies Used in Solving Non-	Mathematics Education	Solving Non-Routine Problem using Polya Model	<ol style="list-style-type: none"> <li>1. Understanding the problem</li> <li>2. Planning</li> <li>3. Applying the plan</li> <li>4. Evaluate the solution</li> </ol>	Some of the mathematics teachers have adequate problem skills but some of them did not solve correctly.	The activities are suitable in problem solving for HOTS questions. Based on this article, there is an issue in

<p>Routine Problems</p>				<p>The author said the teachers have limited abilities at the stage of “understanding the problem” and “planning”.</p>	<p>the first activity that is understanding the problem and planning the solutions. And it has to revise.</p>
<p>(Kilic, 2017)  A New Problem Posing Approach Based On Problem Solving Strategy : Analysing Pre-Service Primary School Teacher’s Performance</p>	<p>Mathematics Education</p>	<p>Problem Posing Approach Based On Problem Solving Strategy</p>	<p><b>POSE PROBLEMS</b></p> <ol style="list-style-type: none"> <li>1. <u>Editing</u> Tasks that require students to pose a problem without restrictions</li> <li>2. <u>Selecting</u> Tasks that require students to pose problems / questions that are appropriate for specific answer</li> <li>3. <u>Comprehending</u> Refer to tasks in which students pose problems starting from the given mathematical equation / solution</li> <li>4. <u>Translating</u> Require students to pose appropriate problems / questions based on the graphs / diagrams / table</li> </ol> <p><b>PROBLEM SOLVING STRATEGY</b></p> <ol style="list-style-type: none"> <li>1. Understand the problem</li> <li>2. Devising a plan</li> <li>3. Carrying out the plan</li> <li>4. Looking back</li> </ol>	<p>pre-service teachers could produce problems but lacked sufficient knowledge of problem-solving strategies</p>	<p>The second activities (problem solving strategy) for this article are suitable in problem solving to answering HOTS questions.</p>

(Shishigu & Bashu, 2017)	Physics Educations	Problem Based Learning (PBL)	<b>PBL (focus on collaborative group)</b> 1. Form a small group 2. Problem Solving Strategy	PBL is more effective than conventional method in teaching	The activity in forming a small group (PBL) is suitable before doing the problem solving strategy.
(Crowley, 2015)	Mathematics Educations	Problem Based Learning (PBL)	<b>PBL (focus on collaborative group)</b> 1. Form a small group 2. Problem Solving Strategy - Engaged students in problem identification and definition - Engaged students in solution-finding - Encouraged students to evaluate situations / problems	PBL yields more positive results than does traditional classroom instruction	The activity in forming a small group (PBL) is suitable before doing the problem solving strategy. The activities in problem solving strategy also suitable in answering the HOTS questions.
(Mahmud et al., 2018)	English Education	Problem Based Learning (PBL)	Classroom Research Action (CAR) Form a small group 1. Planning 2. Implementation 3. Observation 4. Reflection	There was the statistical improvement of the impact of PBL model applied in teaching English at first-grade students of Muhammadiyah Islamic School Kota Ternate. Index	Forming a small group and the activities are suitable for problem solving in answering HOTS questions.

<p>(Aidoo &amp; Ofori, 2016)</p> <p>Effects Of Problem Based Learning On Students' Achievement in Chemistry</p>	<p>Chemistry Education</p>	<p>Problem Based Learning (PBL)</p>	<ol style="list-style-type: none"> <li>1. Form a small group</li> </ol>	<p>PBL is an effective way than traditional lecture to teach chemistry so as to improve students' critical thinking and problem solving skills</p>	<p>Forming a small group is suitable for problem solving in answering HOTS questions.</p>
<p>(Wickramasinghe &amp; Valles, 2015)</p> <p>Can We Use Polya's Method to Improve Students' Performance in the Statistics Classes?</p>	<p>Mathematics Educations</p>	<p>Polya's Method</p>	<ol style="list-style-type: none"> <li>1. Understanding the problem</li> <li>2. Devising a plan</li> <li>3. Carrying out the plan</li> <li>4. Looking back</li> </ol>	<p>There was a significant improvement of the students' performance in the class in which Polya's method was introduced</p> <p>The authors found that paying particular attention to the first step is vital to the success students have in utilizing the other three steps of the problem-solving method.</p>	<p>The activities are suitable in problem solving for HOTS questions. Based on this article, there is an issued at the first activity that is, understand the problems. And it has to revise.</p>
<p>(Yew et al., 2016)</p> <p>Problem Solving Strategies of Selected Pre-service Secondary School Mathematics Teachers in Malaysia</p>	<p>Mathematics Educations</p>	<p>Poly's Solving Method</p>	<ol style="list-style-type: none"> <li>1. Understanding the problem</li> <li>2. Devising a plan</li> <li>3. Carrying out the plan</li> <li>4. Looking back</li> </ol>	<p>Most of the pre-service teachers used not one specific strategy but a combination of strategies to solve the problem.</p> <p>Pre-service teachers who were unable to solve the problem correctly seemed to use limited and incorrect mathematical terminology,</p>	<p>The strategy activities are suitable in problem solving for HOTS questions. Based on this article, there is an issued at the first activity that is understand the problem. And it has to revise.</p>

				<p><b>lack understanding of the problem,</b> were unable to make representations of the word problems, lack some basic knowledge</p>	
<p>(Siwawetkul &amp; Koraneekij, 2018)</p> <p>Effect of 5E instructional model on mobile technology to enhance reasoning ability of lower primary school students</p>	<p>Mobile learning</p>	<ol style="list-style-type: none"> <li>1) 5E on a mobile application</li> <li>2) a learning management plan</li> </ol>	<ol style="list-style-type: none"> <li>1) Improving student engagement with multimedia</li> <li>2) Exploration through mobile device</li> <li>3) Explanation and discussion of obtained information</li> <li>4) Knowledge elaboration activities and information recording with mobile device</li> <li>5) Evaluation</li> </ol>	<p>The results of this study showed that, the 5E instructional model on mobile technology could foster reasoning ability, reasoning behaviours, and intrinsic motivation in lower primary school students, and not only increased student achievement in learning but also enabled the students to make relationships between the real events and the scientific concepts.</p>	<p>There is no issue on 5E strategy and activities. Its suitable to answer HOTS questions.</p>
<p>(Sen &amp; Oskay, 2016)</p> <p>The Effects of 5E Inquiry Learning Activities on Achievement and Attitude toward Chemistry</p>	<p>Chemistry Education</p>	<p>5E inquiry learning</p>	<ol style="list-style-type: none"> <li>1) Engage</li> <li>2) Explore</li> <li>3) Explain</li> <li>4) Elaborate</li> <li>5) Evaluate</li> </ol>	<p>The results of the study revealed that 5E inquiry learning activities were more effective in improving the achievement in chemical equilibrium compared to lecture-based</p>	<p>There is no issue on 5E strategy and activities. It's suitable to answer HOTS questions.</p>

				traditional activities.	
(Sari et al., 2017)  Effects of the 5E Teaching Model Using Interactive Simulation on Achievement and Attitude in Physics Education	Physics Education	5E teaching model by using interactive simulation	1) Engage 2) Explore 3) Explain 4) Elaborate 5) Evaluate	As a result the 5E teaching model integrated with simulations had potential to help eleventh graders improve their physics academic achievement and attitude. Introduction	There is no issue on 5E strategy and activities. It's suitable to answer HOTS questions.
(Choirunnisa et al., 2018)  Improving Science Process Skills for Primary School Students Through 5E Instructional Model-Based Learning	Science education	5E instructional model-based learning	1) Engage 2) Explore 3) Explain 4) Elaborate 5) Evaluate	The 5E instructional model-based learning successfully enriches the students' knowledge and improves the science process skills. - Observing, interpreting data, communicating	There is no issue on 5E strategy and activities. It's suitable to answer HOTS questions.
(Jati et al., 2017)  Students' Mathematical Communication Ability using Learning Cycle 7E on Junior High School	Mathematics Education	7E Learning cycle	1) Elicit 2) Engage 3) Explore 4) Explain 5) Elaborate 6) Evaluate 7) Extend	Students' mathematical communication ability using 7E learning cycle is better than students' mathematical communication ability using direct learning.	There is no issue on 7E strategy and activities. It's suitable to answer HOTS questions.
(Naqeeb Ul Khalil Shaheen et al., 2015)  Improving Students' Achievement in Biology using	Biology Educations	7E Instructional Model	1) Elicit 2) Engage 3) Explore 4) Explain 5) Elaborate 6) Evaluate 7) Extend	the 7E instructional model was more effective than the traditional instructional in terms of	There is no issue on 7E strategy and activities. It's suitable to answer HOTS questions.



7E Instructional Model: An Experimental Study				students' achievements	
(Gonen et al., 2006)  The Effect Of The Computer Assisted Teaching And 7e Model Of The Constructivist Learning Methods On The Achievements And Attitudes	Physics Education	7E Model And computer assisted teaching	1) Elicit 2) Engage 3) Explore 4) Explain 5) Elaborate 6) Evaluate 7) Extend  AND  Using computer teaching	the computer assisted teaching knowledge and cognition levels are more effective that the 7E model. However, when the final attitudes tests are considered there are no basic differences between these two instruction methods.	There is no issue on 7E strategy and activities. It's suitable to answer HOTS questions.

### Content-Analysis on Problem Solving Method Strategies and Activities and Its Challenge

As illustrated in Table 1, there are four instructional approaches in implementing problem solving method at school level such as Problem Based Learning (form of a small group), Polya's Mothod, 5E Method and 7E Method. The selected research paper represents a difference in strategies, but the activities are nearly the same. Having the similar activities, these strategies and activities are suitable in solving higher order questions/ non routine problems (Mahmud et al., 2018 ; Shishigu & Bashu, 2017; Aidoo & Ofori, 2016; Crowley, 2015; Wickramasinghe & Valles, 2015).

Throughout the content analysis, the main four activities or common ways in solving problem method appeared: understanding the problem, devising a plan, carrying out the plan and looking back the solutions. However, the researchers have reported some challenge arose in the main four activities (see Table 1). The most reported challenge in implementing problem solving method is the first activity that is understanding the problems (Unlu, 2018 ; Kilic, 2017 ; Yew et al., 2016). In other words, the candidate (students / teacher) had limited abilities at the stage of "understanding of a problem" and "planning". It was a due of they could not understand what the problem says and they could not choose an appropriate strategy for problem solving. They make the process difficult and complicated to answer. They have lack of planning, implementation, and revision skills during the problem solving.

Some scholar tell us that 5E and 7E method can be used in many activities such as interactive simulation (Sarı et al., 2017), science process skills (Choirunnisa et al., 2018) and other ways. Other than that, through mobile applications also can effect the students ability through 5E learning (Siwawetkul & Koraneekij, 2018). Through 5E learning also can give positive attitude to the students (Sen & Oskay, 2016). Here, I can conclude that all the

problem solving method either using Polya method or 5E method or 7E method, all of it have potential in answering HOTS questions. Through that result, it also has potential in increasing student's performance.

### A Modified/New Problem Solving Method

Based on the analysis done in the previous section, although the challenges arise, the strategies and the activities discussed can be modified and improved to fit in a new problem solving method. Polya's Model, 5E Model and 7E Model are combined to form a new problem solving method, called as P5E. P5E consists of 5 activities: form a small group, find a keyword, find a strategy, carry out the strategy and check. At the stage finding the keyword from the question, it is modified form the "understanding the problems" activity. The keywords lead the candidates to find a strategy to answer the questions. After that, the candidates will carry out the strategy and finally checking back the answer. Before the candidates answer the HOTS questions, they should be form into a small group to let them have a collaborative work with their team. Throughout the activities, teacher act as a facilitator and needs to interfere if any of the answers is not appropriately presented. Figure below shows the summary of the strategy ad activities involved.

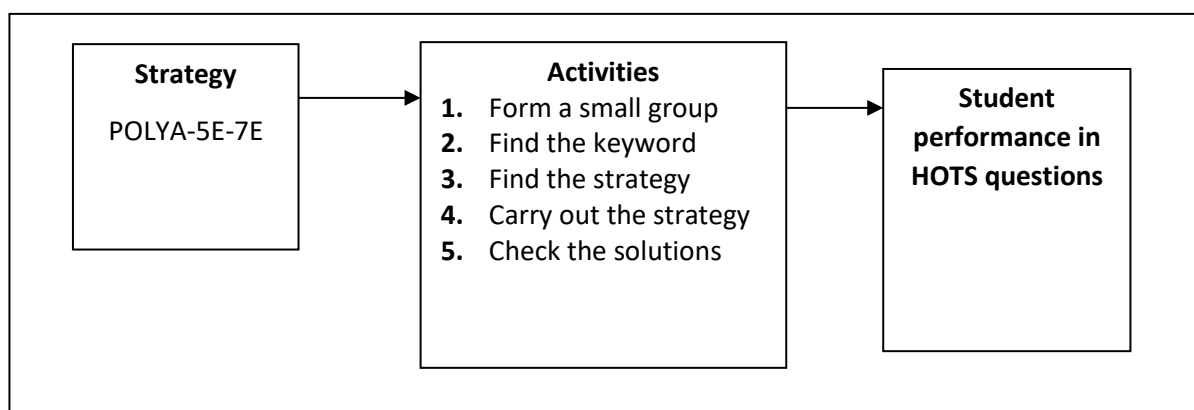


Figure 2: Summary of strategy and activities

### Conclusion

This study was conducted to identify the most strategies and activities that teachers use in problem solving process approach that conducted within the past five years and the challenge faced by the respondents. From this study, all papers were found to have similar activities either using Polya method, 5E or 7E method. They show the same process that understands the problem. Students are engaging with a challenging situation. Then they explore and plan the solutions. After that they explain the answer by applying the plan. They evaluate the solution right after the answer the question. This is the assessment process. However, the first and the second steps of the solving problem process need to revise again. It seems that there are some respondent do not understand the problem. Hence, they cannot engage the problem and fail to plan the solution. Form this finding, future research that is revise the process of the solving problem need to take place and solve the gap to cope with the 21<sup>st</sup> century learning.

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