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Technology-Immune/Technology-Enabled (TITE) Mathematical Problem Posing Process Model on Inservice Mathematical Teacher

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Abstract

Technology will always develop, starting from Pressey learning machines using computer devices to the idea of using applications as intermediaries for problem-solving. Baumanns & Rott's problem-posing descriptive model which consists of situation analysis, variation, generation, problem-solving, and evaluation phases needs to be linked to technology-immune/technology-enabled (TITE) problem types so that a technology-integrated problem-posing process model can be described. This research is a qualitative descriptive study. The subjects studied consisted of 2 high school mathematics teachers and data collection was carried out in the form of assignments and interviews. The task given is in the form of a TITE assignment. Data analysis consists of data reduction, data presentation, and conclusion/verification. It was found that the technology-integrated problem-posing model starts from the Analysis concept and technology phase, Simplifies, Solving with technology, evaluation, and generation. The main contribution of this study lies in proposing a refined problem-posing process model that explicitly integrates technological considerations at each stage, thereby extending Baumanns and Rott's model through the incorporation of TITE problem types.

Keywords: Inservice Mathematic Teacher, Problem Posing, TITE

The development of globalization impacts all sectors of life, especially in education (Geo-JaJa & Majhanovich, 2016; Bakhtiari & Shajar, 2011; Sharma, 2012; Quainoo et al., 2022; Farahat, 2012). Technology plays an essential role in how we learn (Mentis, 2008; Huda et al., 2018). The initial use of technology in learning was the creation of a Pressey learning machine. This allows students to participate actively in the learning process (Abramovich, 2016). The next era of development was the emergence idea of automatic instructions which developed in line with the rise of programming languages such as PASCAL. There are also several research in the field of education to teach mathematics with exploration and discovery utilizing this programming language (Lvov et al., 2022; Murni & Anggraini, 2019; Pehlivan, 2019).

The next development is the shift to practical and ready-to-use applications such as Geogebra, Maple, Matlab applications, and so on. The biggest challenge arises when using various applications to be able to answer math problems just by taking a photo of the problem, such as Auto Math. This certainly affects procedural skills. The use of such applications must still pay attention to specific procedural skills. The combination of conceptual understanding and procedural skills is the main pillar in posing mathematical problems (Felia & Defitriani, 2021; Surif et al., 2012; Afrillia et al., 2022; Mutawah et al., 2019), especially when using technology as an intermediary. This aligns with the idea of the duality of mathematical objects, where mathematics is seen operationally as a process and structurally as an object

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(English & Sharry, 1996). Various studies have been conducted to make computer applications an intermediary-related problem posing (Greiff et al., 2013; Rus, 2022; Yurniwati & Soleh, 2020).

Silver (Baumanns & Rott, 2022) described problem posing as the process of forming new problems and reformulating given problems, where both activities can occur before, during, or after the problem-solving process. Silver and Cai (in Siswono, 2004) provided 3 types of problem posing based on mathematical cognitive activity, such as a. pre-solution posing where a student makes a problem from the situation held, b. within-solution posing where a student reformulates the problem as it has been solved, c. after post-solution posing, the student modifies the objectives or conditions of the questions that have been solved to create new questions. In this case, the research uses type c, namely post-solution posing in which it is adapted to the topic of discussion

Chapman (2012) found that the word “problem-posing” was challenging for teachers who lacked formal instruction or theoretical exposure to problem-solving or problem-posing. Although many of them can create interesting problem situations, their understanding of posing problems often overrides conscious consideration of mathematical structures regarding the context of the problem or its relationship to the problem situation. Some of the problems they pose are sometimes incorrectly formulated, not mathematical, provide insufficient information, or are closed questions with possible yes/no/don't know answers when asked to pose open-ended problems.

Another view comes from Kadir et al., (2020), which revealed some of the challenges faced by Indonesian teachers when posing problems based on the given situation. Difficulties in posing problems are indicated by posing problems with insufficient information, not by the given situation, or contexts that are not suitable for their students. Tichá & Hošpesová, (2013) suggested that problem-posing is often used to raise teachers' awareness of the need to improve their initial ideas about mathematics and mathematics education. The problem posed shows the monotonous nature of the situational context. Teachers may not realize that small changes in wording can play an important role.

Problem posing can be seen as a learning model, strategy, part of problem-solving, or a stand-alone activity. For this research, problem posing is limited to a model that has steps. The model used refers to the problem-posing descriptive model (Baumanns & Rott, 2022). The proposed descriptive model consists of situation analysis, variation, generation, problem-solving, and evaluation phases which are described below. Situation analysis describes the condition captured by the problem poser regarding single or multiple conditions from the initial task. Variation is changing or eliminating aspects of single or multiple conditions from the initial assignment or assignment that was previously submitted. Generation is seen as generating tasks by establishing new conditions for the originally given or previously proposed tasks. Problem-solving describes the activity in which the person who poses a problem solves a task they have previously proposed. Finally, Evaluation is when the problem poser assesses the proposed assignment based on criteria determined individually.

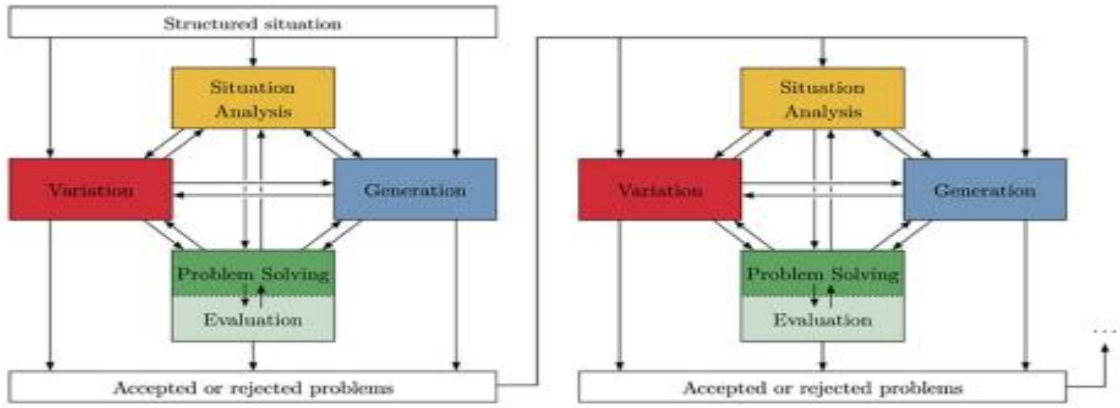


Figure 1. Baumanns & Benjamin Rott Descriptive Model

There are various types of problems, one of which is the technology-immune/technology-enabled (TITE) problem that integrates problems with technology. The TITE problem was introduced as an extension of the framework for the use of Type 1 vs. Type 2 technology, where there are two dichotomies related to the use of technology. Type 1 views technology as a need to distance itself from drill and practice, while type 2 sees the use of technology as a conceptual tool (Abramovich, 2014). It can be said that the TITE problem is an issue that cannot be automatically solved using the application. However, the function of the technology related to this problem remains significant. The TITE problem can serve as an alternative assessment tool for problem-solving skills included in the problem-posing process (Abramovich, 2016). Of course, the problem used is a non-routine problem. Therefore, this study aims to describe a technology-integrated problem-posing model for in-service mathematics teachers based on the TITE framework.

METHODS

This was qualitative descriptive research. The subjects studied consisted of two high-school mathematics teachers; subject 1 is a male teacher, and subject 2 is a female teacher. Both subjects were classified as novice mathematics teachers who were teaching at senior high school. There were two types of instruments used in this research, namely tasks and interview guidelines. The data collection carried out in this study was in the form of assignment and semi structured interviews. The assignment was a TITE task instrument. The TITE task instrument was used to find out the procedure for posing a TITE problem. The question of the TITE task was:

"*Find the prime numbers between 11 and 531*
that have the form of 10n+1 and create a similar problem"

The instrument used was adapted from (Abramovich, 2016) regarding the TITE problem posing. Data analysis consisted of data reduction, data presentation, and conclusion. The first step was data reduction. In this case, the researcher summarized and selected the main things that suited the research theme, which was the TITE model. Data that was irrelevant or had no connection to the research theme would be discarded. The next was data presentation. In this step, the researcher collected information to enable conclusions and actions to be drawn. The results obtained were a structured collection of information. The final step was the conclusion. In this stage, the researcher drew descriptive conclusions from the findings. To validate the data, the triangulation method was used.

RESULTS AND DISCUSSION

Result

Regarding the TITE problem posing, an overview of the problem posing's process was obtained according to the descriptive model, as portrayed in the following description.

Male Teacher TITE Problem Posing Model

1. Situation analysis

The subject's description of the conditions related to the given TITE-based problem was about related concepts and the technology used. Regarding the concept according to the problem such as prime numbers, multiples, and the Eratosthenes filter, although the filter name was not explicitly mentioned, the steps were clearly stated. The technology used was Microsoft Excel which can be seen in the following figure.

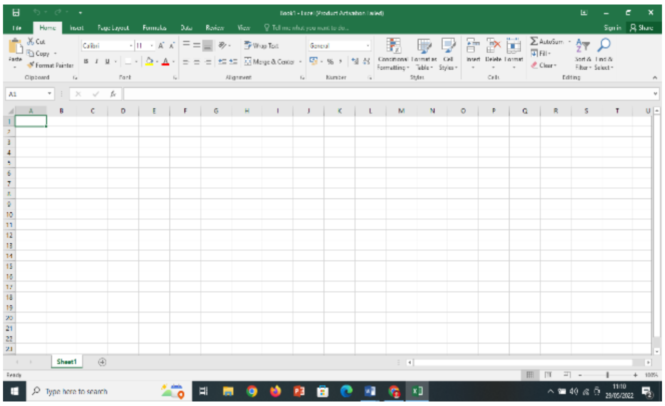


Figure 2. Microsoft Excel

2. Variation

The variation stage of the subject was seen when the subject changed the problem to a simpler one, where the basis used was to check prime numbers that were not divisible by prime numbers. The prime number chosen if squared was less than the initial number. The subject only mentioned the filter without any names following it. The example proposed by the subject was the form of searching for prime numbers less than 101. From the number 101, the next action done was looking for square numbers that were more than 101; in this case, 121 was chosen. Subsequently, this stage included the action of looking for prime numbers that when squared were less than 121. The results were 3, 5, and 7. To find out whether 101 was a prime number or not, it was checked whether 101 was divisible by 3, 5, or 7.

3. Generation

The generation stage of the subject was seen when the subject submitted a new assignment and performed two generations. The first generation carried out by the subject was related to conditions of the task given, namely palindrome numbers that were prime and divisible by 7. Then, the second generation carried out by the subject was to pose a problem of palindrome numbers that were prime or divisible by 7. This second generation was both an advanced stage of the first generation and the result of the revision.

4. Problem-solving

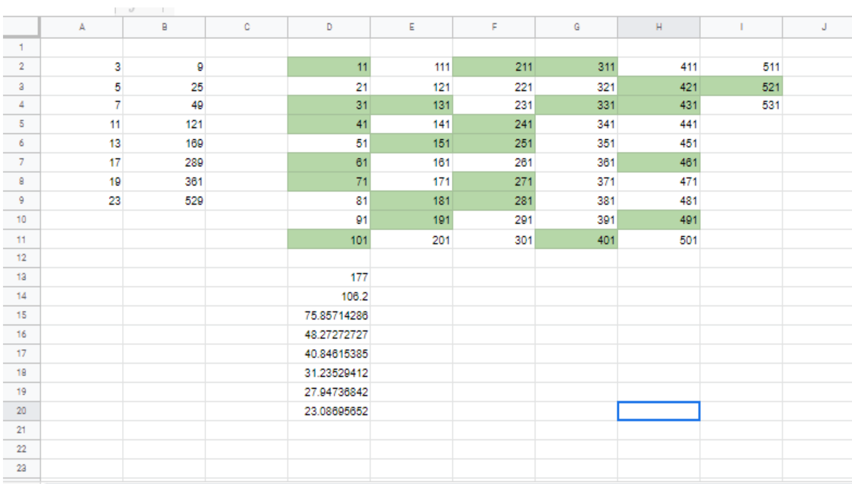
There were two problem-solving activities carried out by the subject. The first problem-solving was related to solving the problem posed by the researcher, while the second was solving a problem related to the problem posed. The problem-solving steps related to tasks carried out by the subject applied the

Eratosthenes filter concept to Microsoft Excel. The first step was to determine the prime numbers that squared were close to 531. By using the Excel formula, the prime numbers were 3, 5, 7, 11, 13, 17, 19, and 23. Then, in the side column and using the subject Excel formula, the next action done was to write down numbers that had the general form of 10n+1, where n was an integer starting from 11 to 531 according to the assignment. Then the numbers that had the form of 10n+1 were checked to see whether they were prime numbers or not. Checking prosecco was done by dividing and using an Excel formula. Numbers that produced commas when divided by 3, 5, 7, 11, 13, 17, 19, and 23 were then marked in green to be identified as prime numbers. The obtained numbers were 11, 31, 41, 61, 71, 101, 131, 151, 181, 191, 211, 241, 251, 271, 281, 311, 331, 401, 421, 431, 461, 491, and 521.

The second problem-solving was related to the completion of palindrome numbers, which were prime and divisible by 7, as the problem posed by the subject. It was found that the work process was carried out through mental activity, and the problem had no solution.

5. Evaluation

At the evaluation stage, there was a check of the answers related to the assignments given. It was found that after the evaluation stage, the subject was convinced that the answers listed in the problem-solving step related to the task given were correct. Meanwhile, the second evaluation was seen in the assessment of the assigned task. It was found that the problem posed by the subject, namely the palindrome numbers, which were prime and divisible by 7, was a problem that was impossible to do because it used the conjecture 'and'. Therefore, the subject of the question was replaced by changing it to prime palindrome numbers or palindrome numbers that were divisible by 7 without giving any restrictions.



	A	B	C	D	E	F	G	H	I	J
1										
2	3	9		11	111	211	311	411	511	
3	5	25		21	121	221	321	421	521	
4	7	49		31	131	231	331	431	531	
5	11	121		41	141	241	341	441		
6	13	169		51	151	251	351	451		
7	17	289		61	161	261	361	461		
8	19	361		71	171	271	371	471		
9	23	529		81	181	281	381	481		
10				91	191	291	391	491		
11				101	201	301	401	501		
12										
13				177						
14				106.2						
15				75.85714286						
16				48.27272727						
17				40.84615385						
18				31.23529412						
19				27.94736842						
20				23.08695652						
21										
22										
23										

Figure 3. Problem Solving Subject 1

An overview of the TITE subject 1 problem posing process can be described as in the Figure 4.

Female Teacher TITE Problem Posing Model

1. Situation analysis

The description of the conditions carried out by the subject was related to the TITE-based problem given regarding the linked concepts and the technology used. The concept was based on the problem, namely prime numbers and multiples, while the technology used was the handphone application. The application was "Determining Prime Numbers," created by Mawan Agus Nugroho. The way it worked was that we had to input the desired number, and it would immediately show the identification related to the prime number.

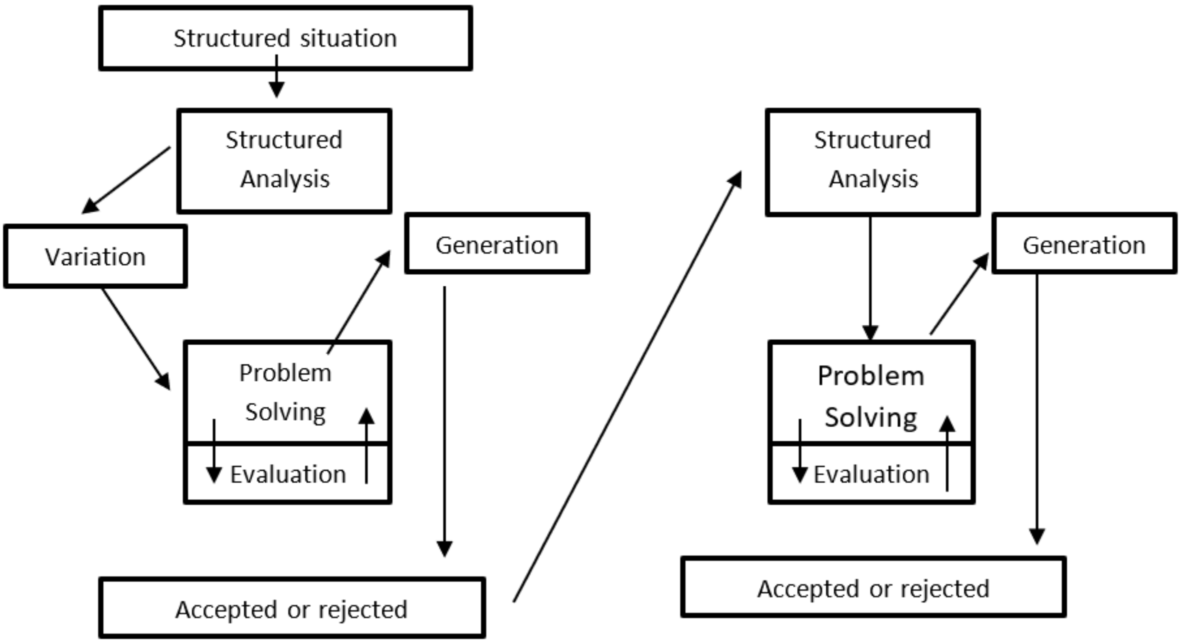


Figure 4. Possing TITE Subjek 1 Process

2. Variation

The variation stage of the subject was seen when the subject changed the problem to a simpler one. The problem used was the search for prime numbers that were less than 150. It was found that the subject considered the problem easy to solve using the manual method, even though it was not done directly, only through mental processes. The subject considered that problems related to finding prime numbers above 151 were very difficult to find, so they needed technological assistance.

Figure 5. Handphone Application

3. Generation

The generation stage of the subject was seen when the subject posed a new assignment related to the problem given by the researcher. The subject posed questions in the form of prime numbers between 10-500 in the form of 4k+1. Thus, the subject only did one generation.

4. Problem-solving

Problem-solving carried out by the subject was related to solving the problems given by the researcher. First, the subject manually created numbers that formed a pattern of 10n+1, where n was an integer. The numbers formed were numbers that lied between 11 and 531. The numbers were 11, 21, 31, 41, 51, … 531. From the list of numbers, one by one, they were checked into the handphone application. The subject checked prime numbers starting from numbers greater than 150. The checking process carried out by the subject was portrayed in the following description.

This process was continuously carried out until all the numbers had been identified regarding the determination of prime numbers. The subject's answer was then written down on a piece of paper. The display of the subject's answers can be seen in the following figure.

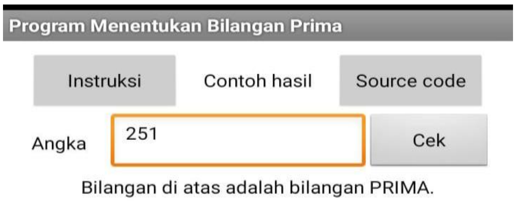


Figure 6. Use of Handphone Application

5. Evaluation

At the evaluation stage, the answers related to the given assignments are assessed. The subject revised the answer because a number in the form of 10n+1 was missed when checked using a phone application.

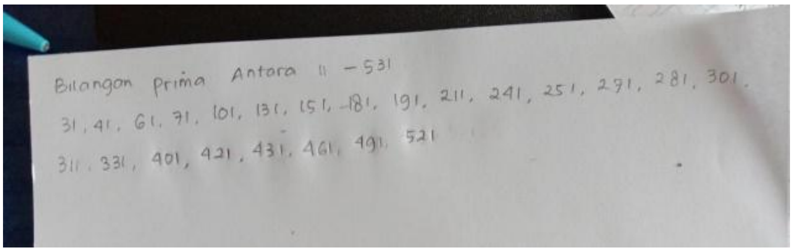


Figure 7. Subject 2 Answer

An overview of the process of TITE subject 2 problems posing is described as follows.

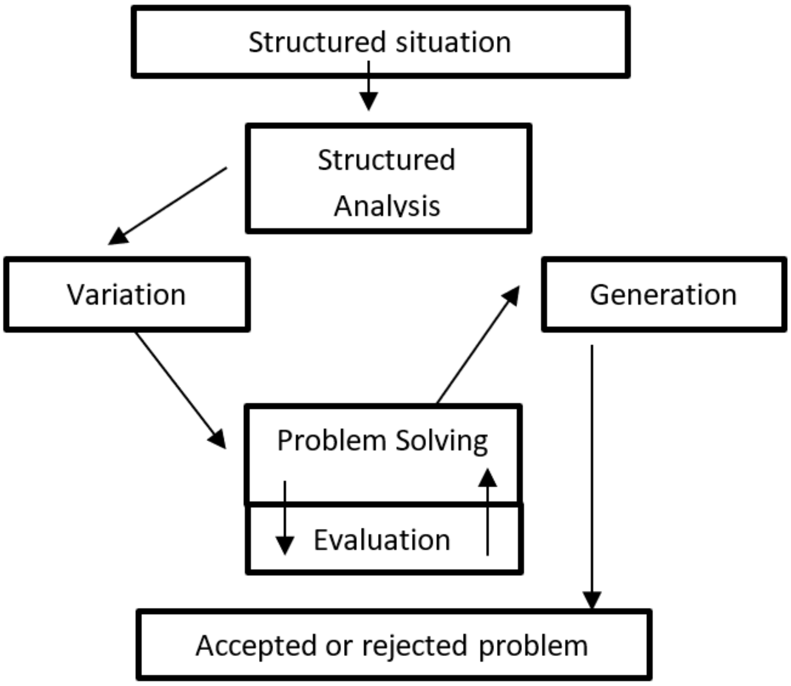


Figure 8. Possing TITE Subjek 2 Process

In general, there are similarities in the problem-posing models of subject 1 and subject 2. The process of posing a problem when given a task starts with structured analysis, then followed by the variation step, only after this comes problem solving and evaluation, and it ends with the generation step. The difference for subject 1 lies in the iterations that are formed.

Discussion

In posing the TITE problem, several systematic steps were carried out by both subjects, namely structured analysis, variation, problem-solving, evaluation, and generation. In the structured analysis stage, both subjects used technology to solve the problems provided by researchers. The first subject used Microsoft Excel, while the second subject used a phone application called "Determining Prime Numbers". Both subjects were able to operate these technologies properly and correctly without any operational errors. The use of this technology is inseparable from the teachers' belief in utilizing technology, given that all aspects of life today are deeply intertwined with its use (Usaini et al., 2021; Giek, 2021). Almost all teachers are familiar with the use of ICT for tasks such as the preparation of lesson plans, worksheets, and homework (Taneri & Seferoglu, 2013). Additionally, at this stage, an overview of the concepts observed in the problem is obtained. From this, it can be concluded that the process of proposing integrated problems for the structured analysis stage was changed to focus on concept analysis and technology.

The second stage is the variation aspect, where the two subjects model the problem in a simplified form. Problems with a limit of five hundred were changed to hundreds without altering the context of the question. This aligns with the opinion of Isoda and Katagiri (2012) where sometimes problems are difficult to solve from the outset. Therefore, the idea emerged to disregard some conditions and reconsider the problem in a simpler form, known as “Thinking that Simplifies”. It can be seen that both subjects were able to solve these simplified problems, but were incomplete in explaining the technical procedures. From this, it can be concluded that the variation stage was simplified.

Meanwhile, the next stage, problem-solving, was carried out by both subjects through technological intermediaries. However, there are significant differences regarding the problem-solving approach. Subject 1 tends to complete the assigned task in a way that is directly integrated with the application used, namely Microsoft Excel. Every step of the process, including the using of the Eratosthenes filter was perfectly implemented through the Excel application. In terms of procedural skills and conceptual abilities, subject 1 was able to understand the mathematical context both procedurally and conceptually. Subject 1 understood the duality of mathematics, viewing it both as an operation and as a structure (English & Sharry, 1996). On the other hand, subject 2 tends to prefer instant solutions, seeing technology primarily as a calculation tool for solving problems. When associated with the duality of mathematical objects, subject 2 tends to overlook the operational aspect of this duality. Based on the two subjects’ approaches, it can be concluded that the problem-solving process was shifted to solving through technology.

Regarding the evaluation stage, the main difference between subject 1 and subject 2 was that subject 1 went through the two stages twice, once to answer the given task and once for the questions that had been asked. Meanwhile, subject 2 completed the evaluation only once, focusing on answering the given task. During the evaluation, both subjects tended not to rely on technology but on logic and accuracy of the answers. The evaluation process was proven to be effective and efficient. It is because, fundamentally, when someone is faced with solving a problem, an evaluation naturally follows, especially when the problem faced is complex (Ersoy & Bal-Incebacak, 2017). In the evaluation process, there was no change.

Next is the generation stage, where there is a significant difference between the two subjects. The first subject went through the generation process twice, while the second subject did it only once. It can be seen that the first subject generated TITE questions with different concepts but similar solutions. In contrast, the second subject created questions that were similar both in terms of concept and solution. This indicates that subject 1 understands the concept of TITE questions better than subject 2. Furthermore, based on the problem-solving process, subject 1 demonstrates a deeper understanding of the meaning of integration better than subject 2. Abramovich (2016) believes that the understanding of technology integration is often misinterpreted as merely using technology as a calculation tool. There was no change in the generation process either. From these various stages, the process of posing technology-enabled problems can be described as follows.

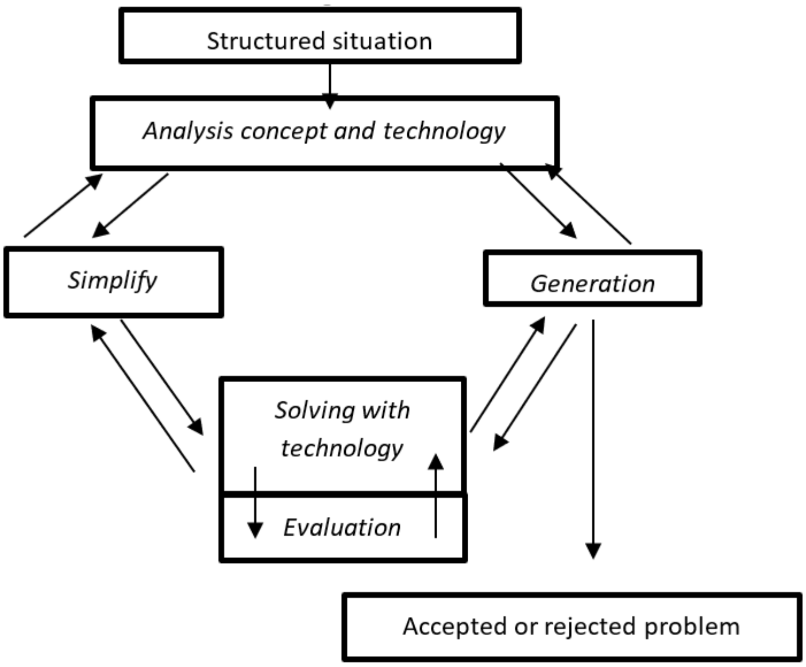


Figure 9. The Process of Technology-Enabled Mathematical Problem Posing Model

CONCLUSION

The process model for posing math problems integrated with technology consists of several stages, starting from the concept and technology analysis, simplification, solving with technology, evaluation, and generation. The analysis of concept and technology involves examining the concepts and technology present in the given problem. Simplification refers to simplifying the problems present in the given task without involving technology. Solving with technology relates to solving problems using technological tools. The evaluation stage consists of assessing both the problems that have been solved and those that have been posed. Lastly, the generation stage involves posing problems that are integrated with technology. This process model implies a structured and systematic approach to technology-integrated mathematical problem posing, where learners are guided to develop conceptual understanding, critical thinking, and technological proficiency in a sequential manner. The model also highlights the role of technology not merely as a computational aid but as a cognitive tool that supports exploration, reflection, and the creation of new mathematical problems, thereby fostering higher-order thinking skills and meaningful learning experiences

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Declarations

Author Contribution	:	Author 1: Conceptualization, Writing - Original Draft, Editing and Visualization; Author 2: Writing - Review & Editing, Formal analysis, and Methodology; Author 3: Validation and Supervision (https://www.elsevier.com/authors/policies-and-guidelines/credit-author-statement)
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