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Development of TRIZ based competency test material and its influence on improving problem solving skills

E A B Cahyono¹, D Artanto², P Arbiyanti³ and G Heliarko⁴

^{1,2,3,4} Politeknik Mekatronika Sanata Dharma, Yogyakarta, 55282, Indonesia

E-mail: eko_aris@pmsd.ac.id

Abstract. Vocational education provides necessary education and skills, which is directed at the mastery of certain expertise. As the learning outcome of this education, the graduates of Politeknik Mekatronika Sanata Dharma have been able to solve engineering problems in terms of maintenance and repair, operation, and assembly of industrial automation machines. For this reason, problem solving skills are important to learn. This paper presents a research on the effect of developing TRIZ-based competency test material on improving problem solving skills. The subjects of this study were 60 students of Politeknik Mekatronika Sanata Dharma. After several TRIZ-based competency tests, the results revealed that the problem solving skills of students on the basis of a systematic approach have increased, while problem solving on the basis of intuition (trial and error) have decreased.

1. Introduction

National standards of higher education in Indonesia aim to ensure the achievement of higher education goals that play a strategic role in the intellectual life of the nation, advancing science and technology. National standards of higher education consist of national standards of education, national standards of research and national standards of community service. One of the standards in national education standards is graduate competency standards. The graduate competency standard is a minimum criterion regarding the qualifications of graduate's abilities which includes attitudes, knowledge, and skills expressed in the formulation of learning outcomes.

One of the main learning outcomes (special skills) for the 5th level of mechatronics engineering is the ability to solve engineering problems in terms of maintenance and repair. To measure whether students meet the competency targets or learning outcomes that have been determined, competency testing is needed. Making competency test material that can measure these abilities effectively is very important. The competency test must be able to demonstrate the ability of students to find problems that occur in the machine and provide a solution to the problem. So that when they have graduated and work in the industry as a technician, if the production machines are in trouble, they can find the problems that occur and provide solutions precisely and quickly.

One method that can be used to obtain effective and optimal competency test material is the TRIZ method (Theory of Inventive Problem Solving). The TRIZ method develops material by registering various possibilities that can occur by taking into account all available resources. It is more structured and based on logic and data, not intuition or brainstorming. The development of the TRIZ-based competency test material in this research focuses on the competency test for the Automation System Maintenance Technician Cluster scheme at Sanata Dharma Polytechnic of Mechatronics (PMSD).



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2. Literature Review

TRIZ is a Russian acronym for "Theory of Resheniya Izobretatelskikh Zadatch," which means "Theory of Inventive Problem Solving." This theory was originally developed by Russian patent engineer named Genrich Altshuller in 1946. After reading technical information revealed in 200,000 patents from around the world, he chose 40,000 patents that were considered innovative and used inductive methods to explore their solutions. Not all patent inventions or creativity come from trial and error methods. Instead, there is a systematic logic in the similarity, repetition, and innovative discoveries in all the patents he examined [1].

Although the ideal approach to problem solving is to do the standard Plan-Do-Check-Action process flow with equal emphasis, the actual situation is that we plan little, Do a lot, Don't Check, and Do lot of work to contain a problem and fix the root cause. A typical problem-solving process (Figure 1) consists of [10]:

1. Problem definition
2. Root cause identification
3. Solution generation
4. Solution implementation
5. Evaluation
6. Refine solution if needed

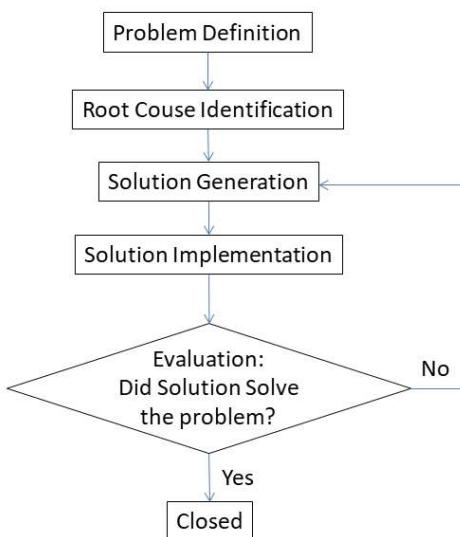


Figure 1. Typical problem solving process flow [10].

Problem solving generally is moving directly from specific problems to find specific solutions. However, there are many examples where this approach might not work because of contradictions that prevent good solutions from being produced. In most cases, solutions using the normal problem-solving process will be in the form of compromise. The TRIZ problem solving process that works to resolve contradictions while providing inventive solutions is as shown in Figure 2 [5].

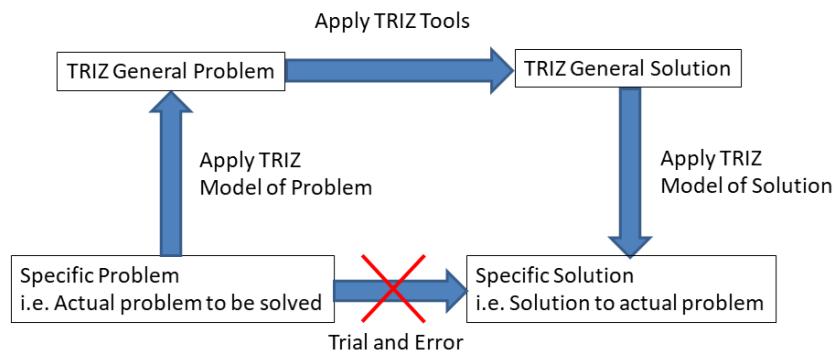


Figure 2. TRIZ way of problem solving [5].

Special problems can be generalized to TRIZ general problems that basically model the problem. Based on this common problem, TRIZ provides tools to solve it. The user still takes the final step to determine the specific type of solution needed based on the recommended general TRIZ solution. Based on the typical problem-solving process as explained earlier in Figure 1, TRIZ is able to complete and improve steps 1 to 3 of the problem-solving process [10].

The TRIZ process flow for solving a specific problem is detailed in Figure 3. This flow starts with the original problem to be solved. The original problem is usually at a high level and does not provide enough details to solve the problem. To filter the problem to the next level, two key steps are performed. The first step is to perform a Function Analysis on the identified system. If the analysis of functions is carried out rigorously and in sufficient detail, the next steps in the process will be much easier. The second step is to do a Chain of Cause and Effect Analysis. Analysis will help identify fundamental root causes. This is then done by a process called Trimming followed by the use of various TRIZ tools [10].

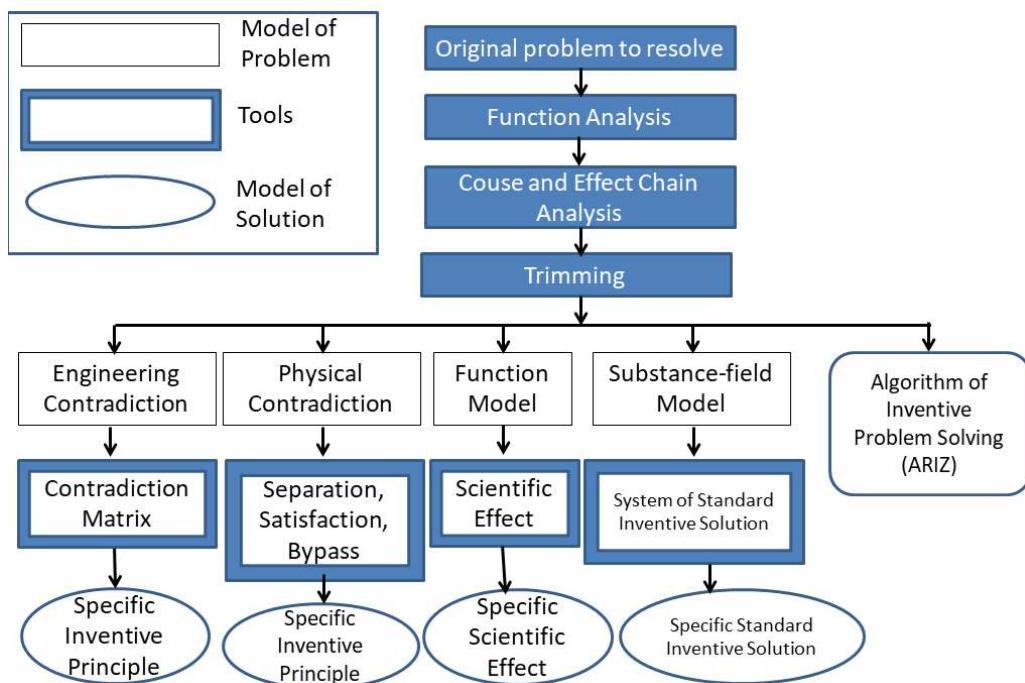


Figure 3. TRIZ problem solving map [6].

3. Method

The use of TRIZ to produce competency test material is carried out by conducting the following data collection:

1. List of abilities to be measured
2. List of equipment owned
3. List of possible test material
4. List the relationships between the three that are most effective

By looking at the list above, the most effective competency test material was considered. One of the contents / material scenarios chosen is as follows:

1. Using Modular Production System (MPS) Festo, including distribution station, handling station, processing station, and testing station (Figure 4).



Figure 4. Modular Production System (MPS), a=Distibution Station, b=Testing Station, c=Processing Station, d=Handling Station.

2. The problem being tested was the improvement of the system at each station. One part of the system was made problematic, so the system work stopped in the middle of the process.
3. The problematic parts were in the form of disconnected cables, wrong line cables, improperly connected terminal contacts, blocked air pipes, wrong line pipes, incorrect sensor positions, improper mechanical construction, or insufficient air pressure.
4. Each system was equipped with a work process flow in the form of a sequential diagram.

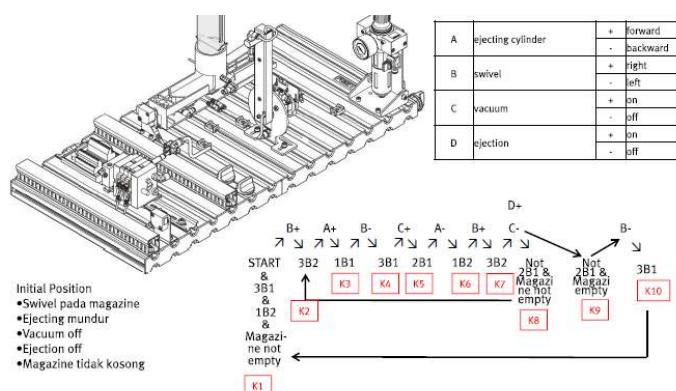


Figure 5. Sequential Diagram.

The sequential diagram is an application of the TRIZ problem solving method that helps students when dealing with problems that occur in production machines so that students will be easier to provide solutions. The source of the problem is easier to find because it was searched using a systematic method rather than trial and error. The influence of the competency test material made based on TRIZ above saw whether it is able to measure the ability of students in problem solving, and also whether it influences students to choose problem solving systematically rather than trial and error. For this reason, after the competency test, a survey was given to the competency test students, with the following questions:

1. In the competency test that you have carried out, can you find the cause of the problem so the system does not work?
2. If the answer is yes, did you find the cause of the problem based on trial and error or by following the sequence of steps in the sequential diagram?
3. If answer no. 1 above is no, do you not understand the workflow of the system in the sequential diagram?
4. If you are given the opportunity to remedy the competency test again, then you will choose to find fault with intuition (trial and error) or by looking at the work sequence in a sequential diagram? Give your reasons.

4. Result

60 participants were tested using competency test material made based on TRIZ (figure 6.). The effect of the competency test material made based on TRIZ proved to be able to measure the ability of problem solving and influence students to choose systematic problem solving rather than trial and error. This can be seen from the results of the survey given to students participating in the competency test.

From the competency test, the following results were obtained:

1. As many as 60 participants were tested, 35 participants passed, while 25 participants failed.
2. Out of 35 participants, 3 participants found errors by trial and error, while 32 participants used a system workflow check on a sequential diagram.
3. From 25 participants who failed, 20 participants could not understand the meaning of the sequential diagram.



Figure 6. Competency test.

5. Conclusion and future works

From the competency test results, it can be seen that the test participants who used systematic error finding were more successful than by trial and error. If competency re-test was given, students who fail would prefer to find fault in a systematic way rather than trial and error. This shows that there was an effect of competency testing on improving problem solving ability.

In the future, the development of competency test material using TRIZ can be also applied to the Industrial Robot and SCADA Technician scheme. The making of competency test material for the two schemes above, which effectively measures the ability to solve engineering problems in terms of repair and maintenance in the Industrial Robot and SCADA, is the next important development target.

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