International Journal of Advanced Education and Research
ISSN: 2455-5746; Impact Factor: RJIF 5.34
Received: 23-03-2020; Accepted: 21-04-2020; Published: 28-04-2020
www.alleducationjournal.com
Volume 5; Issue 2; 2020; Page No. 45-49

Improving the technical competence for students through the use of technical troubleshooting problem

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Abstract
Technical capacity is one of the important determinants of the quality of training, the competitiveness in the labor market and the career development opportunities of engineering students. Technical capacity is formed by the specific technical activities and is structured by three components: the technical knowledge, technical design and technical application. In order to develop this capacity, the technical problems can be used in technical teaching process, such as: the technical analysis problem, the technical design problem, the technical identification problem, the technical control problem, and the technical troubleshooting problem. However, the current technical training process is still focused on theory, the information receiving and the caculation of designing. We are not interested in using effectively the technical problems in the teaching process to develop the technical thinking and fostering the technical capacity for students. The article discusses the ways to improve the technical capacity for the students through the use of the technical troubleshooting problem.

Keywords: capacity, technical capacity, technical student, teaching method, technical troubleshooting problem

1. Introduction
The Industrial Revolution 4.0, artificial intelligence or rapid changes in labor demand will put great pressure on education of uniersities [1]. Students in general and technical students in particular will face increasing demands on qualifications, professionalism, dynamism, creativity and autonomy; ability to think critically, forecast, discover and solve problems in practice so that they can create jobs in the labor market and advance in your career. In order to do so, the students need to be fostered in terms of technical thinking and technical competence.

2. Content
2.1. Some basic concepts
2.2. Competence
Competence is the ability, subjective or natural condition to perform a certain activity [3]. It is understandable that capacity is a complex personality attribute, it involves skills and techniques which are formed based on the basic knowledge and attached in the diversity with purposes and the corresponding habit, helping people satisfy the requirements of work.

2.3. Technical competence
The technical competence is a combination of psychophysiological attributes of individual that help him/her meet the requirements of a certain technical activity [2].

Technical competence belongs to professional competence, including: (1) the key factors include the technical thinking and the technical imagination, (2) the fulcrum factors include the visual observation and the visual memory, and (3) the support factors include the technical interesting and the dexterity.

The technical competence is expressed as follows:

- Ability to perform well technical activities when assigned the tasks;
- Know how to find the new, concise and creative solutions for familiar technical problems;
- Know how to find problems, analyze and properly solve new technical problems;
- Know how to answer quickly and accurately technical questions;
- Present a problem flexibly, propose many solutions to solve.

The forming mechanism of technical competence is a combination of three factors: Technical awareness, technical design and technical application. The levels of expression of technical competence include: technical knowledge, technical proficiency and technical innovation [2].

2.4 The technical incidents
The technical incident is a whimsy or damage of the machines, equipment, supplies, or the quality of a product that exceeds the permissible technical limit, which occur during a labor process, cause damages or risk for people, property and the environment [2].

2.4 The technical troubleshooting problem
A technical problem is a problem or a situation that has a limit in terms of searching for information. In the field of engineering, it requires being solved by scientific methods, based on the use of aggregate knowledge, skills and techniques [2]. According to the field of the technical activities, the technical problems include the design, technology, identification, troubleshooting, technical control problems [2]. In that, the technical incident occurs frequently in the process of control, operation of machinery and equipment, in technical labor... A basic feature of this

problem is that it often appears unexpectedly and requires the quick, effective resolution. To solve this problem, the implementers have to understand the knowledge of the object, mobilize the knowledge to analyze, synthesize, infer, compare...; perform many flexible solutions; must have a fast orientation, handle immediately the amount of transmitted information to have the most appropriate solution. Therefore, the technical troubleshooting problem is a difficult problem but it brings great efficiency in consolidating, expanding of knowledge, training skills of knowledge application, contributes to the development of technical thinking and fostering technical competence for technical students.

3. The reality of technical training

In fact, the technical students are often provided the detail knowledge of machines, equipment, materials, practical techniques as well as an introduction to the probable incidents, causes and how to avoid them in theory and before practicing. Therefore, most of the current technical students only meet the level of technical knowledge, that is, they are able to identify the structure, principles and operation of tools, machines, functions and methods of using them. However, the technical proficiency (acquiring skills, technical expertise in specific and complex operations) and the technical creativity (creation of new products, discovering new functions, finding new solutions ...), the ability to detect problems and solve technical problems are still limited. The causes of the limitation is explained as follows:

Firstly, the knowledge transfer of teaching method makes the students passive. They are recognized knowledge but have little opportunity to perform the thinking manipulations such as analysis, synthesis, comparison, generalization, systematization, to understand deeply the nature of the problem as well as the nexus between the problems in a technical system Therefore, the students will have difficulty in solving the more complex problems such as the technical problems in real production in the enterprises.

Secondly, the current training programs often focus on theory. The practice credits are about 20%. The content of practice is focused on providing knowledge about the structure, operation of machines and equipment, using of measuring instruments, the types of failures, the causes and the way to overcome errors/fail during the processing, assembling, manufacturing technical products. However, many lecturers are not interested in training and fostering the technical competence for students through the using of technical troubleshooting problem.

We know that a technical problem occurs with many different kinds of phenomena. Even a phenomenon that can be caused by many different potential reasons. When meeting the technical problems, each person with different technical competence will achieve different technical troubleshooting results. The person who has poor technical competence will choose the troubleshooting method by removing every detail and comparing it with the standard. If they are lucky, they will find damage in the first test. If not, they must take a lot of time and cost to check out all involved details. The person who has good technical skills will mobilize a deep understanding of the functions, operations, structures and experiences to judge the elimination of unnecessary work, focus on examining certain areas, and thus it makes the solving technical problems effectively.

In summary, the technical troubleshooting problems are complex problems. Discovering potential causes requires a huge amount of working and it takes us a lot of time to perform. If we don't have a scientific method of thinking and working, we may make the problems more complex, spend a lot of time and effort, lead to deficiency, mistakes, hardness. We are difficult to solve the familiar technical problems and even deadlocked completely with new situations in reality. Therefore, the application of technical troubleshooting problems in technical teaching is really necessary and meaningful. It contributes to improve the competence of solving and preventing the technical incidents; to ensure safety for people and equipment, to ensure productivity and quality of products. It helps the technical students develop the technical competence to adapt quickly and develop in professional practice.

4. Improving technical competence of students through the use of technical troubleshooting problem

To improve the technical competence for the students, the lecturers can build two types of technical troubleshooting problem.

(1) Forward problem: Identify possible technical problems to prevent.

With this problem, the lecturers need to guide the students to judge technical problems, predict the consequences, then identify the causes and set up troubleshooting solutions. However, in fact, there are many technical incidents without our prediction and control, so it is necessary to develop the highest level of technical thinking capacity of the students.

(2) Inverse problem: From the technical incident occurred to determine the cause to troubleshoot it.

In order to solve the technical incidents smoothly and effectively, it is necessary to develop a technical troubleshooting process in detail. The process may include: (1) Confirm certainly the phenomenon; (2) Assess the phenomenon; (3) Determine the location and cause of damage; (4) Check and repair; and (5) Prevent re-damage and complete the inspection.

Now, we will proceed to solve the inverse problem. First of all, to ascertain the failure phenomenon, it is necessary to repeat the operation status to accurately consider the damage phenomenon. First of all, to affirm certainly the failure phenomenon, we need to repeat the operation state to consider accurately the damage phenomenon. With this task, the students can apply the 5W1H method by five questions: Who, When, Where, What and How. For example, to confirm a damage phenomenon of a motorcycle that had a problem, we need to answer the questions: Who (Who is the operator?), When (When did it occur? How often?), Where (Where does it occur?), Which (Which is driving condition, operating condition, weather condition?), What (What is the condition of the road? What is the damaged part?) and How (how does the phenomenon happen?). These complementary questions help us predict the parts that involve the problem and narrow significantly the target.

To identify the area and the cause of the problem, we need to recognize and approach many different aspects of the technical object. An effective way that helps the students trace the causes of technical problems is the Cause-and-

effect diagram (also called Fishbone Diagram) [4].

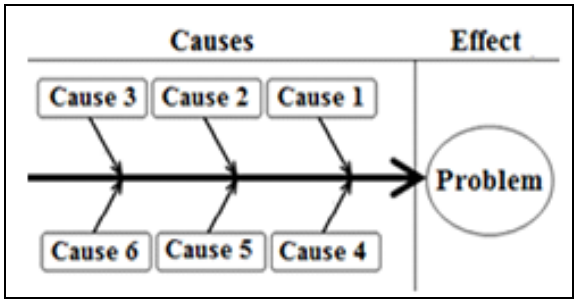

Fig 1: Cause-and-effect diagram

To use the chart, the students need to identify the problem to be solved (fish head), then draw a horizontal line as the backbone; identify the influencing factors called causes (each cause corresponds to a "rib bone").
The complex problems needs to be built a fishbone diagram inclues the backbone with many big bones. Each big bones is a system (layer). Each system consists of many average bones, and many small bones containing name of phenomena, causes or parts of technical objects.

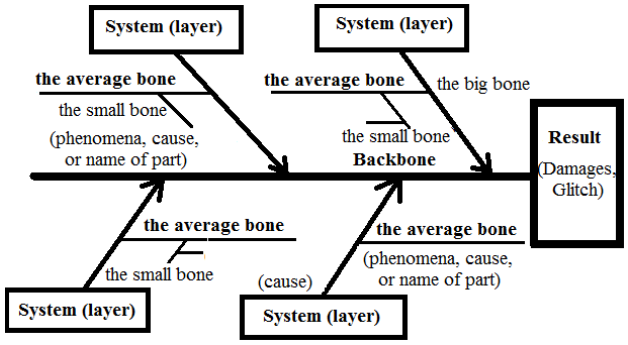

Fig 2: Diagram of identifying the cause of a complex problem

To identify the cause of the technical incident, the students should try to list as many factors as possible and think of groups of causes, such as: man, material, machine, method, milieu, measurement, management, maintenance, From these key factors, the students can find out smaller factors which could be the root cause of the technical incident.
To identify the root causes on each bone branch, the students can perform the 5Why method by asking and answering the following questions: (1) Why did it [problem] happen? => [Answer 1]; (2) Why did it [Answer 1] happen? => [Answer 2]; (3) Why did it [Answer 2] happen? => [Answer 3]; (4) Why did it [Answer 3] happen? => [Answer 4]; and (5) Why did it [Answer 4] happen? => [Answer 5]. [Answer 5] is considered to be the root cause requiring removal, prevention or minimization to an acceptable level.
The following is an example of solving size errors of hole on the parts of motorcycles in manufacture process. If this problem is not resolved, the parts must be destroyed, so it will cause economic losses for the company. The task to be completed is to reduce the positive hole diameter error to 0. We will perform the following steps:
Step 1: Confirm certainly the phenomenon.
Survey errors and affirm the need to fix the error.

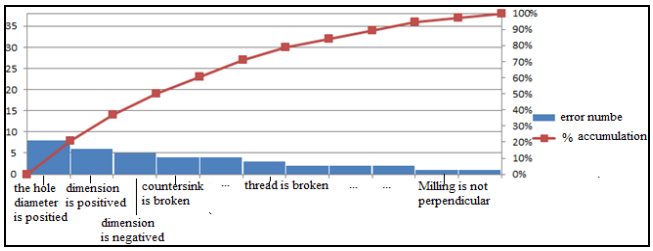

Fig 3: Detection of errors

The result in figure 3 shows that the error of hole diameter was the largest.
Conduct to test the series of hole to confirm the phenomenon.

Fig 4: Measuring and confirming th error

Step 2: Assess the phenomenon.
Assess the error by measuring the size of the hole in depth sizes 5mm, 10mm, 15mm and 20mm.

Fig 5: Error evaluation

The results show that the hole size decreases with the hole depth. The errors cause the hole defects.
Step 3: Determine the location and causes of damage.
Use the Cause-and-effect diagram and 5Why method to identify the location and cause of hole defects (Figure 6).

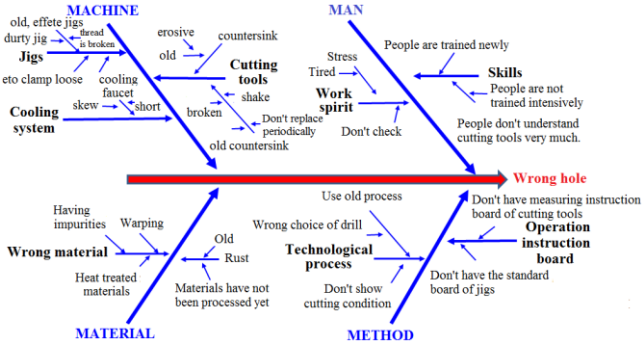

Fig 6: Determine the causes of hole defects

Examine the causes of errors b man, machines, materials and method of manufacture process. An example of determining the causes of error are caused by machining materials.

Fig 7: The errors are caused by machining materials

Rusty material (a), warping due to steam cutting b).
From the cause, the students proceed to build a solution.

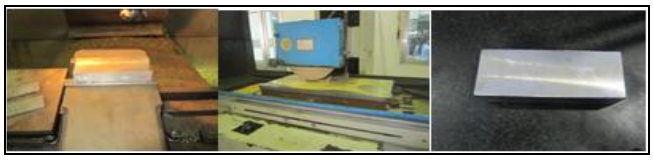

Fig 8: Solution of materials

Milling the workpiece edges (a), grinding the standard plane (b), cleaning the bavia edges (c)
After identifying the causes and implementing the solutions of the materials that have not overcome the defect, we proceed test with the causes of cutting tools, jigs, cooling systems.

Fig 9: Determine the causes

To be caused by jigs (a), cutting tools (b) and cooling systems (c)
Step 4: Check
After implementing the solutions, the students measure the size of the holes and then analyse the deviation average value and variability of the hole diameter.

RESULTS							
Location	X1	X2	X3	X4	Total	Deviation Average value	Variability
1	10.015	10.013	10.016	10.002	40.046	10.0115	0,014
2	10.008	10.009	10.012	10.01	40.039	10.00975	0,004
3	10.013	10.006	10.008	10.012	40.111	10.009	0,007
4	10.006	10.015	10.003	10.014	40.038	10.0095	0,012
5	10.004	10.016	10.002	10.011	40.033	10.00825	0,014
6	10.006	10.005	10.013	10.012	40.036	10.009	0,008
7	10.007	10.013	10.011	10.011	40.042	10.0105	0,006
8	10.01	10.015	10.017	10.016	40.058	10.0145	0,007
9	10.009	10.014	10.008	10.005	40.036	10.009	0,009
10	10.012	10.009	10.012	10.013	40.046	10.0115	0,004
11	10.014	10.011	10.005	10.007	40.037	10.00925	0,009
12	10.015	10.005	10.014	10.009	40.043	10.01075	0,010
13	10.01	10.015	10.015	10.015	40.055	10.01375	0,005
14	10.01	10.012	10.008	10.012	40.042	10.0105	0,004
15	10.003	10.011	10.009	10.002	40.025	10.00625	0,009
16						150.17175	0.122
17						10.01145	0.00813333

Fig 10: The results of the hole size test

As the results, the error of the hole size has been reduced to zero (in July).

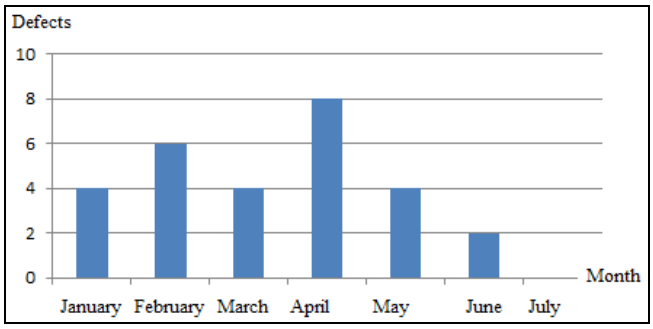

Fig 11: The results of the solution implementation

Step 5: Prevent re-spoilage and completed inspection.
After the implementation of the solution has been effective, the machining process needs to overcome all the causes of the machining defects by the human factors, mechines, methods and materials in Figure 5 to prevent re-damage and so the process of inspection and the troubleshooting of hole defects has been completed.
Thus, in the process of the technical teaching, the lecturers should promote the role of technical troubleshooting problems to train and improve the ability of technical thinking for the students. The implementation of the technical troubleshooting problems following 5 steps helps the students practice a variety of thinking operations such as analysis, synthesis, experiment, comparison, testing, evaluation, ... due to the compentence of innovation and solving the technical problems has been raised. This compentence helps the technical students adapt quickly and develop their careers in abundant and complex manufacturing practices.

Conclusions and Recommendations

1. The solving of the technical troubleshooting problems is an important content that contributes to improve the ability of technical thinking and improve the technical competence for technical students.
2. There are two kinds of the technical troubleshooting problem:

(1) Forward problem: Identify possible technical problems to prevent.
The way to solve this problem is prediction of the technical incidents and its consequences, determination of the causes and seting up for the troubleshooting solutions.
(2) Inverse problem: From the technical incident occurred to determine the cause to troubleshoot it.
The effective process to solve problem: (1) Confirm certainly the phenomenon; (2) Assess the phenomenon; (3) Determine the location and cause of damage; (4) Check and repair; and (5) Prevent re-damage and complete the inspection.
During the implementation process, the students need to use accurate measuring tools to confirm and evaluate the phenomenon; need to investigate the frequency of phenomena occurring over time, working records; and should use 5W1H method. To identify the area and the cause of the problem, the students should apply the Cause-and-effect diagram and 5Why method, attend specilly to man, material, machine, method, measurement, management, maintenance,… Corresponding to the causes, the students formulate specific solutions, implement

solutions and evaluate the effectiveness of the solution. The technical troubleshooting problem is completed when the technical problem is solved and it does not repeat within a sufficiently reliable time.

To implement effectively the technical troubleshooting problems, the lecturers have to design the problem into the technical situations, organize and encourage the students to solve the problem. However, the decisive factor is the students. They must be fully aware of the importance of the problem, have the knowledge of the way to solve a problem, think actively to detect the problems, build the solutions and make decisions to solve the problems. Therefore, the competence of technical thinking of the technical student will be continuously improved and developed.

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