Analysing practical skills of vocational school students in metacognition - a case study of an electronic practical course in Taiwan

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ABSTRACT: The purpose of this study is to explore the metacognition of vocational school students with practical skills learning. Meanwhile, the differences of *problem understanding*, *planning*, *implementation* and *verification* in metacognition were examined by comparing the problem-solving process of experts and novices of the same age. Most of the previous literature has focused on the comparison of adult experts and young novices. The results suggest that it is possible to produce setbacks in learning for the metacognitive development of immature individuals. The subjects of this research were teenage students in a Taiwanese vocational school, belonging to the preliminary stage of metacognitive development. According to skill training in a pre-test score, three experts and three novices were selected as the subjects for this study. The problem-solving processes of the three experts and three novices of the same age, who attended the same skill training course, were compared. The in-depth interview method was used to investigate the six students by exploring the differences of the four stages of metacognitive ability. Also, a practical reference for skills training is provided in technical and vocational education.

INTRODUCTION

The main function of technology education is to cultivate the necessary technical manpower for all levels of industry. The cultivation of implementation skills is the principal feature of vocational and technical education. The educational goals for electrical and electronic students in the …*vocational school curriculum temporary outline* that the Taiwan Ministry of education implemented in 2006 are: 1) cultivate students to posses core abilities in electronic and electrical fields, and to establish the basis of advanced studies for the specialised fields; 2) foster practical and technical talents, who are responsible for operation, maintenance, test and utilisation [1]. Therefore, the vocational education curriculum emphasises the abilities of students' hands-on operation and practical problem-solving. Accordingly, implementation skills are well-known as the most necessary and significant core capacity in industry.

In the future, students who are engaged in the electrical industry after graduation have to acquire professional knowledge and technological capacity through an electronics practice course. As a result, electronics practice plays an essential role in the electrical fields. In order to enhance the implementation skills of vocational schools students in Taiwan, vocational schools have to conduct skills tests and competitions in addition to the implementation practice course. The time is also devoted to participating in international skill competitions [2]. Among the challenges are finding the best way to select potential students as the contestants all over the school and how to provide effective training to the contestant from a novice to an expert, who are able to deal with the high pressure competitions, as well as to solve problems and accomplish tasks within the limited time. All of the above highlight the importance of implementation skills research along with the ability of problem-solving.

Most of the previous literature focused on comparisons between adult experts and young novices. However, considerable disagreements are presented in the development of metacognition in terms of the different age of the two subjects. The results suggest it is possible to produce setbacks in learning for metacognitive development of immature individuals. In addition, the application of the results of the comparison of adult experts and novices would be limited. The subjects of this research were teenage students in a vocational school of Taiwan belonging to preliminary stage of metacognitive development.

METACOGNITIVE KNOWLEDGE

Schoenfeld pointed out that we not only require fundamental knowledge, but also need solving strategy and metacognition in order to solve problems efficiently [3]. The knowledge of metacognition urges the problem solver to coordinate all kinds of solving skills during the process of problems solution. In addition, it allows them to monitor the process of problem-solving. Accordingly, if one is able to set up a complete research project on the process of problem-solving by contestants and novices, and identify which metacognitive skills the novices lack, one will be able to develop teaching strategies to cultivate the metacognition; moreover, to improve the students' problem-solving skills. Elkind pointed out that metacognition starts to develop during adolescence, and it tends to mature until adulthood [4].

The metacognition of Taiwan's vocational school students is in the early stage of development. Accordingly, the problem-solving process of the same age of the experts and novices, who attended the excellent skill training course, was compared in this study, in order to explore the differences of the four stages: *problem understanding*, *planning*, *implementation* and *verification* of metacognitive ability. Furthermore, a practical reference for skills training is provided in technical and vocational education. This research pays attention to the cultivation of vocational school electronic students with metacognition of implementation skill. Metacognition includes the abilities of active command, control and adjustment towards the entire cognitive process when an individual has achieved a specific goal.

In addition to fully understanding metacognition and the problem-solving of implementation skills to the problem solvers, *data collection and re-confirmation* are adopted in this study: 1) First stage: apply videos and sound recording to record the original data from the problem solvers with thinking aloud strategy; 2) Second stage: after the problem-solving, demand immediately that the problem solver explains the application of metacognition. Furthermore, we combine sound recordings to supply or revise the original data with the coordination of the videos. Hence, we might be able to expand the reliability of the analytic results.

PURPOSE OF THE RESEARCH

More specifically, the major purposes of this research were:

1. To explore the different operation of metacognitive abilities within these four stages: *problem understanding*, *planning*, *implementation* and *verification* by comparing the problem-solving process of contestants and novices at the same age.
2. To integrate learning difficulties of students and to enhance the strategies of metacognitive ability according to the results above.
3. Research results - the application of metacognitive abilities in problem-solving and a vital reference for teachers to train contestants, as well as publishing other research results. In addition to the contribution of academic theories in the vocational school implementation skills cultivation, it could be regarded as a reference for the development and implementation of skills courses.

RESEARCH METHODS

Research Framework

In order to accomplish the goal of this research, this study was problem-oriented and used industrial electronic instrumentation test C as the testing material. According to the three stages of problem-solving outlined by Beyer [5], this study proposed a framework as shown in Figure1.

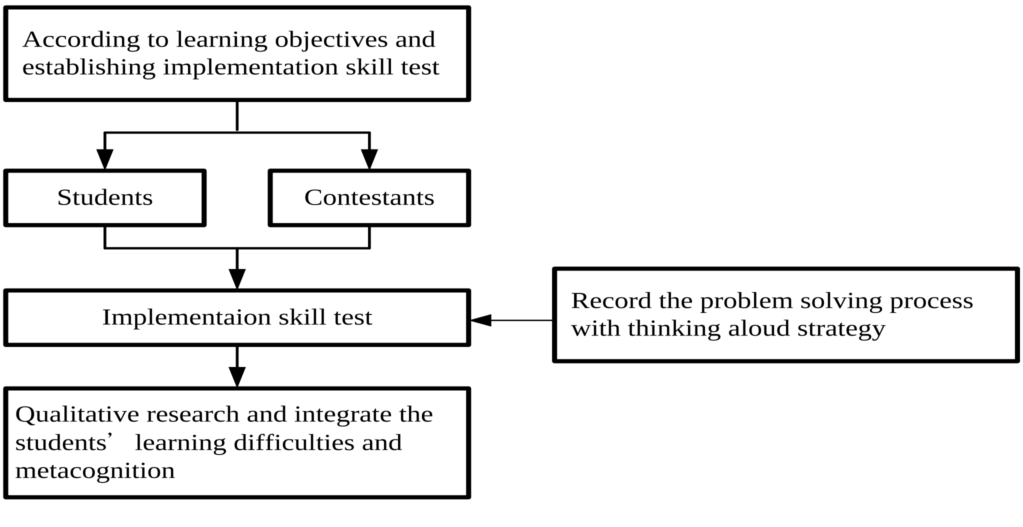

Figure 1: Research framework.

Research Subjects

The purposive sampling method was applied in this study to select three novices and three contestants of the same age in order to examine the metacognition difference in implementation skills.

Research Procedure

The data were collected using the *thinking aloud* procedure in which subjects presented the thinking mode during troubleshooting, and they were asked to indicate the detailed process of problem-solving. Contestants and novices were allowed to solve problems under natural conditions, then, subjects' opinions and emotions were investigated, and the differences in the implementation of skills learning were explored. Based on the recorded video, the problem-solving process, used by the contestants and novices, was observed to draw conclusions about metacognitive applications of problem-solving, and the strategies adopted when difficulties were encountered. After using the *thinking aloud* procedure, in-depth interviews with contestants and novices were carried out that demonstrated the application of metacognition during the process of problem-solving. If the subjects hesitated to answer, the recorded video to help with recall was provided. Ultimately, three teachers were invited to conduct the classification and arrangement of items, in order to enhance the reliability and validity of the collected data by the triangulation method. The research procedure was as follows:

- Procedure 1: Read the instruction of *thinking aloud* to subjects.
- Procedure 2: Illustrate experimental procedures in order to release subjects' emotion and improve the accuracy of research.
- Procedure 3: The researchers demonstrate *thinking aloud* strategy for subjects, and notify them that the procedures are recorded, in order to avoid having the researchers interfere with subjects' problem-solving procedure.
- Procedure 4: Before the formal practical test, let the subjects implement a simple circuit to make them aware of the *thinking aloud* strategy. The formal practice test is shown as Figure 2.

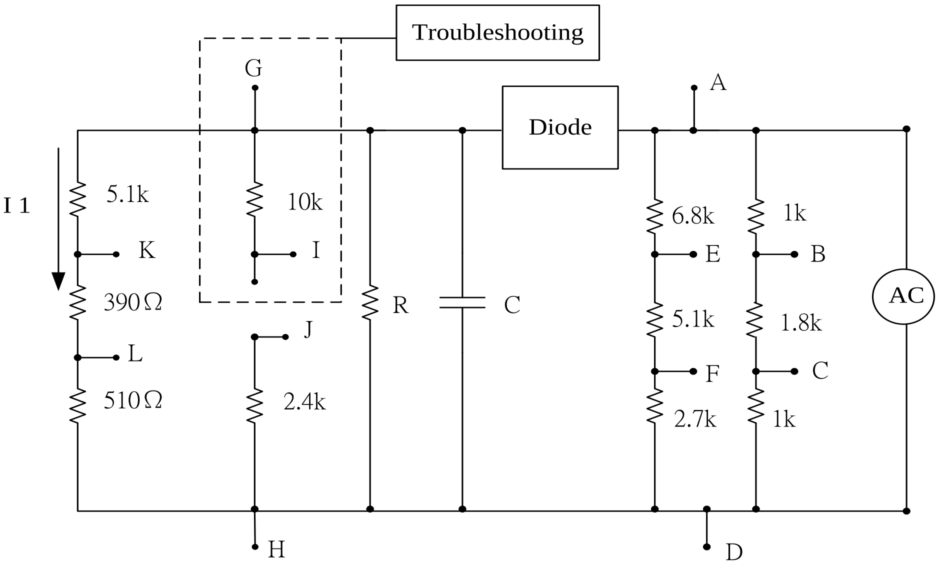

Figure 2: The formal practice test.

- Procedure 5: The subjects perform the function of Figure 2 circuit as follows:

1. Please measure V_{AD} = ______V

AC voltage	Calculated value	Measurement value
	V_{CE} = ______V	V_{CE} = ______V

2. If V_{GH} equals – 20 V, please design the diode in Figure 2.
3. If V_{GH} equals – 20 V, then select one of the capacitors as follows: 220 μF/16V; 220 μF/25V; 220 μF/35V; 470 μF/16V; 470 μF/25V; 470 μF/35V. Please describe your design idea (or calculations).
4. If V_{GH} equals – 20 V, then select one of resistors as follows: 1 kΩ/1/4W; 1 kΩ/1/2W; 1 kΩ/1W; 10 kΩ/1/4W; 10 kΩ/1/2W; 10 kΩ/2W. Please describe your design idea (or calculations).
5. Please shorten I and J, and measure V_{GH} = ______V

DC voltage	Calculated value	Measurement value
V_{IH}	V_{IH} = ________V	V_{IH} = ________V
V_{JK}	V_{JK} = ________V	V_{JK} = ________V
DC current	I_1 = ________A	I_1 = ________A

CONCLUSIONS

This research compared the problem-solving process of contestants and novices of the same age, discussing the different uses of metacognition in these four stages: *problem understanding*, *planning*, *implementation* and *verification*.

Problem Understanding

After reading the test questions, most contestants understood the key points, and planned their subsequent activities according to their abilities. By contrast, novices were often at a loss. After in-depth interviews, it was realised that novices' shortage of professional knowledge led to a decrease in their self-efficacy. Additionally, novices tended to solve problems urgently rather than observe the test questions clearly. Therefore, they could not achieve the task, which was not only time consuming, but also led to learning setbacks.

Planning

Contestants and normal students planned their problem-solving process according to the test questions. But contestants clearly classified their main goals into sub-goals, found the available sources, implemented the problem-solving steps and planned their strategy. Furthermore, contestants possessed a problem-solving method and made further arrangements for different scenarios.

Implementation

Contestants tended to comprehend the questions accurately and planned comprehensively. Hence, they were more likely to succeed during implementation. Even if contestants used troubleshooting, they might make use of their professional knowledge to *smart guess* the solution. Therefore, compared to the novices, contestants were much more capable of finding the solution and demonstrating higher self-efficacy. On the other hand, most of the novices adopted the wrong-trying way to solve problems, when they confronted dilemmas. In terms of inadequate consideration of the questions, they were more likely to be perplexed and, therefore, unable to improve their problem-solving strategy.

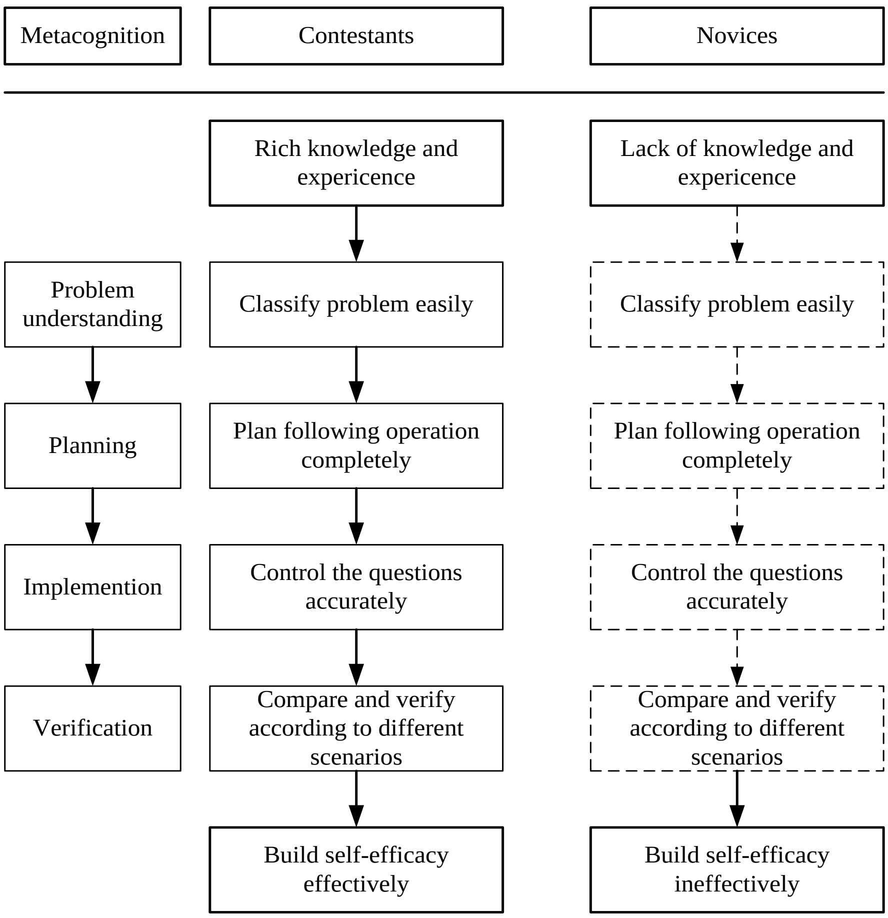

Figure 3: Comparison of contestants and novices in metacognition.

Verification

Contestants and novices were mostly able to evaluate the accuracy of answers from the result. Nonetheless, contestants understood more verification methods and, therefore, gave advanced observations and comparisons according to a range of scenarios. They not only assessed the accuracy of problem-solving, but quickly predicted the problems that might occur in order to choose the most effective strategy for their revision. Due to their lack of knowledge, some novices did not know how to proceed with their verification; therefore, they could not evaluate whether their problem-solving strategy was correct.

The conclusion is shown as Figure 3. Solid lines indicate that the contestants could perform metacognition procedures easily; however, dotted lines indicate that the novices could not perform it smoothly. Because novices lack prior knowledge, this finally makes them fail to build self-efficacy. When novices fail to build self-efficacy, they lose learning motivation. Before the four stages of metacognition, teachers should first build prior knowledge for novices. Furthermore, teachers should introduce novices to applying prior knowledge in problem understanding, problem-solving steps and implementation. Finally, novices should try to verify the learned knowledge and improve practical experiences.

Some suggestions are offered according to the conclusions above:

1. Emphasise the trainable quality of the metacognition ability:

   The influences of metacognition are shown on the learning effect of problem-solving in various fields of professional practice. Focusing on the trainable quality of metacognition is an effective way to enhance learning.

2. Enhance the self-efficacy of students' implementation skills:

   Based on the analysis mentioned above, contestants possessed a higher self-efficacy than novices. Self-efficacy has an obvious impact on implementation skills. Accordingly, teachers may analyse the learners' ability and interests, as well as develop a proper learning program to build a suitable, friendly learning environment. Meanwhile, appropriate learning subjects and contents should be arranged in order to assist students to create a pleasurable learning experience and strengthening their self-efficacy.

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