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Development of Critical and Creative Thinking Skills to Increase Competence of PLC Programming for Electrical Engineering Education Students

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Abstract. PLC learning emphasizes teaching and learning activities and develops students' concepts and process skills with various teaching methods that are in accordance with the learning material taught. The low ability of students to think due to PLC learning has only tended to hone aspects of remembering and understanding. Critical thinking skills of students in PLC learning must be honed using alternative methods that have been developed, namely through practicum or demonstration. So that students are proficient in solving problems, have their own learning models and have the skills to participate in teams. The role of the teacher as a coach in problem-based learning is to ask questions about thinking, monitoring learning, probing (challenging students to think), keeping students involved, managing group dynamics, keeping the process going. This critical and creative thinking design aims to make students able to think critically and be able to consider everything and be able to act on decisions that have been considered and creative thinking that aims to enable students to create ideas and be able to express ideas to solve problems.
Keywords: critical thinking, creative thinking, PLC programming.

1. Introduction

PLC learning emphasizes teaching and learning activities and develops students' process concepts and skills with various teaching methods that are in accordance with the study material taught. PLC learning requires the active role of students, because PLC learning is a scientific process based on logical thinking. The low ability of students to think is because PLC learning has tended to only hone aspects of remembering and understanding. Critical thinking skills of students in PLC learning must be honed using alternative methods that will be developed. One such method is through practicum or demonstration, because practicum or demonstration activities help students to understand an event, see an event more detailed than before and after that remember the incident.

Wechsler [20] said that to develop problem solving skills required critical or creative thinking. It is said that there are differences and independence in thinking critically and creatively in cognitive performance. Their roles are very small, but they complement each other when solving different creative problems. The flexibility to consider the same information from various sides [17], can improve critical thinking skills. Flexibility and critical thinking can be said to be the main ingredients for solving a problem in many ways [8].

On the other hand, the creativ process supports inductive reasoning, which is the ability to understand relationships in all aspects by making connections through analogies and me phors. This is an important characteristic of creative thinking [19] but has critical intellectual function. With this in mind, crea vity prefers inductive reasoning, especially in identifying sequences and principles or conclusions about relationships, which do not occur in relation to logical reasoning, with emphasis on finding unique and best answers.

Dwyer [7] says that critical thinking (CT) is a metacognitive process, consisting of a number of subclasses and dispositions which, when used appropriately, increase the chances of generating logical conclusions to the argument or solution to a problem. From Okan research [16] stated that students' critical thinking skills vary between types of schools. When students counter situations or problems they are unable to cope with, to get help, they must communicate with their classroom teachers in primary ool and with their counselors in high school. Thus, teachers should be prepared to perform services to help students optimally and approach the problem logically.

From these reviews, then made the problem formulation is how to develop the ability of critical and creative thinking? And how to improve the competence of PLC programming students Electrical Engineering Education?

2. Library Review

2.1. Critical Thinking

Critical thinking and creative thinking is the embodiment of higher-order thinking. This is because the ability to think is the highest cognitive competence that students need to master in the classroom. Critical thinking can be viewed as a student's thinking ability to compare two or more information, eg information received from outside with information held. If there are differences or similarities, then he will ask questions or comments with the aim to get an explanation. Critical thinking is often associated with creative thinking.

Some of the thinking skills associated with critical thinking are comparing, differentiating, estimating, drawing conclusions, influencing, generalizing, specializing, classifying, grouping, sorting, predicting, validating, proving, linking, analyzing, evaluating and pattern-making. A student is said to be able to think critically if it has the ability to: 1) choose important words and phrases in a statement and will carefully defined; 2) requires confidence to support a conclusion when he is forced to accept it; 3) (5) evaluating these assumptions, accepting only a few and rejecting other 6) evaluating opinions, accepting or rejecting conclusions and (7) evaluating the assumptions, accepting or rejecting the conclusions; and 7) continually re-examining assumptions that have been made and believed previously. Critical thinking processes include: 1) recognizing situations, 2) considering opinions according to evidence, data, or assumptions, 3) providing arguments beyond proof, 4) reporting and supporting conclusions/decisions/solutions, and 5) applying conclusions/decisions/solutions. One approach that can be used to increase students' sense of critical thinking is by creating a classroom atmosphere where students feel comfortable questioning something, challenging, suspending judgments, and demanding reason and justification because they are dealing with real-world contents and math. Ask questions that stimulate students to monitor, evaluate, and act on their own thinking. For example, Invite students to work in groups to (a) Discuss the situation below, (b) Brainstorming ideas to solve it. (c) Find solutions that all received, or this minority report, and (d) Discuss their thinking to arrive at a decision.

2.2. Creative Thinking

Creative thinking or creativity is often exchanged for its meaning. Weisberg [21] defines creative thinking as referring to processes to produce a creative product that is a new work (innovative) derived from an activity/activity that is directed to the goal. Another sentence is said to think creatively involves intensive production that meets novelty, so that one can be said to be creative by producing something already known before. If you produce something new to you, but it has been generated by others, then you can still be said to be creative.

In looking at the link between creative thinking and critical thinking there are two views. The first view of creative thinking is intuitive in contrast to critical thinking based on logic, and secondly looking at creative thinking is a combination of analytical and intuitive thinking. Intuitive thinking means thinking of getting something by instinct or feeling suddenly without any general facts. The first view tends to be influenced by views of dichotomies of the right and left brain which have different functions, while the second view sees the two hemispheres working synergistically together that are not separated. Creative thinking is a mental activity that considers authenticity and insight. Thinking critically and creatively allows students to study the problem systematically, bringing together many challenges in an organized way, formulating innovative questions and designing/designing original solutions.

Creative thinking as opposed to destructive thinking involves searching for opportunities to change things for the better. Creative thinking does not explicitly organize processes, such as critical thinking. Creative thinking is a habit of sharp thinking with intuition, moving imagination, revealing new possibilities, unveiling amazing ideas and inspiring unexpected ideas. This understanding distinguishes firmly from creative thinking and critical thinking.

De Bono (in Barak and Doppelt) [4] distinguish between 2 types of thinking, namely lateral thinking and vertical thinking. Lateral thinking refers to the discovery of new clues in the search for ideas or commonly called unusual or unusual thinking, while vertical thinking is dealing with the development of ideas and the emphasis on an objective criterion. Vertical thinking is usually called a common or general thought which is also selective and sequential that moves only if there is a hint in the movement. Lateral thinking does not have to produce something right in every step, but can jump and move so that it can build a new clue. And do not have to use the right or wrong categories, classifications or labels. So that it will produce a creative thought. Vertical thinking chooses a very promising and reasonable solution to a problem as long as lateral thinking makes many alternative approaches. Creative thinking is a synthesis between lateral and vertical thinking that complement each other. This understanding states that in creative thinking involves critical thinking (logical and analytical) as well as intuitive, as in the second view in terms of creative thinking.

2.3. Programmable Logic Controller

PLC is a type of control system that has input device, controller and output device. The equipment connected to the PLC which sends a signal to the PLC is called the input divice. While the controller is to perform the calculation, decision-making, control of the input to be issued in the output. How the PLC works can be explained through the block diagram in Figure 1 below. From Figure 1 shows that the PLC construction consists of CPU, input device, output device, supporting equipment, and power supply.

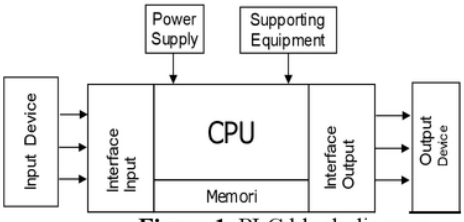

Figure 1. PLC block diagram

To make it easy to write and insert program on PLC then needed some basic stage. Ladder diagram of a program is made first to facilitate the preparation of mnemonic code. The program form mnemonic code can be directly inserted into the CPU via a PC. The ladder diagram consists of a line extending downward from the left side with its branches towards the right. The line extending down on the left side is called the busbar. While the branches are called the instruction line. Along the lines of instruction are placed conditions leading another instruction line on the next right side. The logic combination of these conditions determines when and how the instructions on the right side are executed. The software used is CX-Programmer and Programming Console.

3. Discussion

Science is a system of thinking about the empirical world. Therefore learning needs to develop rational thinking skills about the empirical world. From the taxonomic side of thinking, hence-learning means educating thinking at a certain cognitive level. With Bloom's taxonomy [1], for example, critical and creative thinking lies at the level of analysis-synthesis-evaluation-creation, not at the lower levels of remembering, understanding, and applying. When using the Merrillian taxonomy [10], the thought lies at the level of finding, not at the lower level of remembering and using. In PLC learning where required to be able to do programming with the help of software through personal computer and or with programmable console that requires thinking not only remember it but must use logic through the knowledge of logic circuit. Competencies to be met in PLC learning are hardware, basic instructions, ladder diagrams, mnemonic code, and software.

To improve the PLC programming competence, it is necessary to improve the learning process through the application of variation of learning model and the use of appropriate learning media and cover affective, cognitive and psychomotor spheres. The ability to think critically and creatively to improve the competence of PLC programming is used problem-based learning model. Problem-Based Learning (PBL) Model is a learning model designed on problem solving process that is faced scientifically so that students get important knowledge. Thus expected students are adept at solving problems, have their own learning models and have the skills to participate in the team. Teacher's role as a trainer in problem-based learning is asking about thinking, monitoring learning, probbing (challenging students to think), keeping students engaged, organizing group dynamics, keeping the process going. Student roles as problem solver in problem based learning are active participants, directly involved in learning, build learning.

Generally problem-oriented learning can improve the ability of critical thinking and creative thinking. Such learning is like problem-solving, problem-solving, or problem-based learning. To judge creative thinking actually depends on the criteria or indicator of creative thinking formulated by the researcher or its users. Torrance, Wallach and Kogan, [17,18] use divergent thinking criteria to judge a person's creative thinking. While using varying content and instructions, diverging thinking equals multiple responses and is assessed using fluency criteria, flexibility, authenticity, and elaboration of ideas. According [6] one of the elements of science is the items, namely the science of tangible rational thinking. The realization of rational thinking appears in the use of words, sentences, aleneas, problem solving formulas, or symbols. Prerequisites for realizing these items are the individual's ability to read, write, think and observe. In other words the requirement is the ability to think critically and creatively. The learning process of PLC with PBL model applied to the student of Electrical Engineering Education program class of 2015 cultivates creativity and critical thinking when solving the given problem shown in Figure 2.

Figure 2. Students are solving problems using a PLC training kit at the Unesa Electrical Engineering Control Laboratory.

With PLC media training kits and various problems given, it shows the learning outcomes with an average score of 73.83 with a scale of 100. Learning outcomes are shown in Figure 3 below. The lowest score is 55.5 and the highest score is 85. Students whose value is above average is 21 and below the average is 15 out of a total of 36 students.

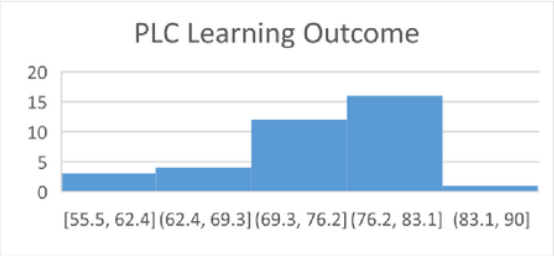

Figure 3. Results of PLC courses in Electrical Engineering.

4. Conclusion

Critical and creative thinking are two inseparable sides and educational goals everywhere. Both are necessary skills in everyday life. To be applied depends on the ability and confidence of the lecturer to apply in the form lab in the laboratory. With the help of training kits, students will be more optimal in understanding the material being taught. Does not depend on difficult or difficult material. Simple problems can lead students to achieve that goal. The learning culture in the classroom that needs to be changed by giving students flexibility to argue and argue can create a critical attitude. By giving the opportunity to give other ideas or other strategies though not the same from the habit can create creative students. Then appreciate every wrong or true task result can make learning fun.

To improve the competence of PLC programming students Electrical Engineering Education, teachers apply problem-based learning model (Problem Based Learning). One of the learning design in order to make the atmosphere of learning activities fun and produce an effective and productive learning process that is critical and creative thinking. This critical and creative thinking design aims to make students able to think critically and able to consider everything and be able to act on the decisions that have been considered and creative thinking that aims to learners are able to create ideas, or ideas and able to express the idea to solve a problem.

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