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Students' Critical Thinking Skills in Innovating Problem Solving in the Physics Entrepreneurship Course

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Abstract

The 21st century physics educators are expected to have 21st century skills, one of which is having life and career skills. One of the life skills assets is professional entrepreneurship. This study aimed to 1) determine the profile of students' critical thinking skills in innovating problem-solving during physics entrepreneurship course and 2) determine students' responses about critical thinking skills in innovating problem solving. This research conducted using preliminary research methods with data collection techniques in the form of description test instrument that filled out by students, and student questionnaires instrument. The data obtained were analyzed descriptively qualitatively. The study was conducted on 30 students of department of physics education at a university in the city of Palangkaraya. The results showed that all aspects of critical thinking skills (Facione's version) that were measured, namely the ability to interpret, analyze, evaluate, inference, explain, and self-regulation were on average in the low category (56.9%). Students gave agreed (A) to very agreed (VA) responses to the implementation of learning that applied critical thinking skills in innovating to solve problems. These results can be concluded that the students have very limited critical thinking skills in solving entrepreneurial problems, so that efforts are needed to improve students' critical thinking skills in solving entrepreneurial problems, one of which is by developing a learning model that can be applied to physics entrepreneurship course which hopefully can improve critical thinking skills of physics education students.

Keywords: Critical thinking skills; Innovation; Physics entrepreneurship; Problem solving

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INTRODUCTION

The challenge of education in Indonesia today is to build the quality of Human Resources (HR) who have 21st century skills as well as character and high entrepreneurial spirit. The 21st century skills that must be possessed include problem solving skills, critical thinking skills, effective communication skills, information, and communication technology literacy skills, and collaborate skills. The first three parts of the framework, which are (a) life and career skills, (b) learning and innovation skills, and (c) information, media, and technology skills, describe proficiencies

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or literacies of students that should be developed and integrated in any academic lesson. The fourth piece, key subjects, suggests 21st Century inter-diciplinary themes or content to engage students in authentic study (Partnership for 21th Century Skills, 2016).

Minister of Research, Technology and Higher Education, Mohamad Nasir, encouraged universities to facilitate student entrepreneurship since they were in college. Currently, many jobs have started to be replaced by technology, therefore students must prepare themselves not only to become employees or workforce but also to be able to create jobs. Students who are entrepreneurial can create jobs for themselves and are not dependent on others, they even can open jobs for others.

The manifestation of the participation of a university in the city of Palangkaraya to build the quality of Human Resources (HR), especially the Physics Education Study Program, is currently equipping students with the Physics Entrepreneurship course. The next manifestation is that graduates will no longer be job seekers only but also job creators. Physics Entrepreneurship is an elective course (2 credits). Through this course, students gain entrepreneurial knowledge and skills, discuss about solving various problems related to the business of the surrounding community and society at large, and carry out entrepreneurial activities independently, so that students gain entrepreneurial experience.

The Physics Entrepreneurship course is expected to provide a broad range of scientific insights and train students to think critically, objectively, and rationally in solving problems in life. Today's physics entrepreneurial learning should train the ability to solve a problem. The problem is essentially a question that invites answers (Hamalik, 2010). It takes a mental and intellectual process to find a problem and solve it based on accurate data and information, so that an accurate conclusion can be drawn. Problem solving is the process of thinking and finding solutions to these problems. Problem solving is concerned with thinking process. Problem solving uses the scientific method by thinking more systematically, logically, more regularly, and thoroughly (Nasution, 2010). The three imaginative skills vary across individuals and predict new venture idea quantity and quality differently over and above the effects of motivation, knowledge, and experience (Kier & McMullen, 2018) which are concluded with implications for theory development in entrepreneurship and creative problem-solving.

Students must be trained in problem solving to be able to develop critical thinking skills both at the beginning and at the end of learning (Shadiq, 2014). Problem based learning is an effective learning model in training higher order thinking skills including critical thinking skills (Trianto, 2015). The results of relevant research found that the problem-based learning model has a positive influence in improving students' critical thinking skills (Herayanti, 2015). The rapidly changing world, increasing complexity, and increasing interdependence make critical thinking a prerequisite for social and economic sustainability (Paul, 2010). Critical thinking is a term that is popular in the fields of education, psychology, philosophy, and has been defined as a "set of intellectual standards" that can be used by an individual in thinking. Critical thinking is a process that has a purpose and an assessment of self-regulatory abilities, this process is done through thinking by considering evidence, context, conceptualization, methods and criteria (Facione, 2015). Furthermore, the consensus states that there are six skills in critical thinking which are considered as the center or

core of critical thinking, namely interpretation, analysis, evaluation, drawing conclusions, explanation, and self-regulation / self-regulation.

Critical thinking is the potential owned by everyone which can be measured, trained, and developed. Referring to the background study that has been described, an analysis of students' critical thinking skills in innovation was carried out for solving physics entrepreneurial problems. This is important to do so that educators can make an appropriate learning design to train and improve students' critical thinking skills and problem-solving skills which are one of the demands of 21st century education. The research result of relevant research found that problem-solving skills and critical thinking skills were essentially the main things in learning (Fakhriyah, 2014; Suarsana & Mahyukti, 2013; Yuli & Dwi, 2015). The result of relevant research found that a high level, positive, and significant correlation was found between critical thinking and metacognitive self-regulation (Gurcay & Ferah, 2018). This indicates that as the students' critical thinking levels increased, they set more learning objectives for themselves, monitor their learning processes and make use of the strategies aimed at raising their learning quality by judging themselves. Through the application of problem-solving based models, it is hoped that students can develop into community members who are able to be part of solutions to environmental problems in Indonesia (Zubaidah, 2016).

Based on the description above, the main purpose of the research was to find out the profile of students' critical thinking skills in innovating problem-solving during physics entrepreneurship course. By using the Facione critical thinking indicator criteria, it can identify the level of students' critical thinking skills.

METHOD

The Physics Entrepreneurship course provides students with an understanding of the concept of technology-based entrepreneurship related to the notion of entrepreneurship in the field of physics. Research has the potential to build business independence, develop creativity and innovation in business, patent filing mechanisms, business idea discovery processes, business planning preparation, understanding business ethics, understanding BEP (Break-Even Point) and technology-based business feasibility assessment.

This course aims to enable students to apply the principles of technology-based entrepreneurship by assuming that the condition of technology products is ready for the market, and combine ideas, innovations, product patents, business planning and marketing strategies through business planning proposals.

The research used descriptive research design and did not test a hypothesis. The results of the study were used to find out the level of students' critical thinking skills in innovating problem-solving during physics entrepreneurship course.

The research was conducted at 2019/2020 academic year with the subjects of 30 physics education students that took the Physics Entrepreneurship course. Data collection in this study was carried out by the test and questionnaire method given to students.

To get the data, instruments used were (1) test questions sheet that contains problems in daily life, (2) answer sheet that contains five steps of critical thinking skills, namely interpretation, analysis, evaluation, inference, explanation, and self-regulation for students to innovate to solve the problems, (3) student questionnaire sheets.

The rubric for assessing student answers referred to the scoring rubric with a set score range in this study was 0

to 4 for each indicator on each question with a maximum score of 4. Students got a score of 0 if they did not write down a solution, a score of 1 if the solution made was wrong, a score of 2 if part of the solution was errors and partly correct, score 3 if the solution made was correct but there were still a few errors, and a score of 4 if the solutions made were precise and complete. The profiles of critical thinking skills in innovation were analyzed on 6 (six) critical thinking indicators of interpretation, analysis, evaluation, inference, explanation, and self-regulation.

The reliability and validity of the instrument test question were tested to test the reliability of the test instruments. Reliability testing in this study was conducted to test the level of confidence of the variable indicators to be able to measure the critical thinking variables. From the results of the reliability test, it was found that the Cronbach alpha value was 0.827 (from a minimum of 0.6) (Sugiyono, 2019). It can be concluded that the research instrument used to measure critical thinking variables was reliable. The results of the validity test for critical thinking variables showed that all R count was greater than 0.3, so the instrument was valid for measuring the critical thinking variables.

RESULT AND DISCUSSION

Critical Thinking Skills in Innovating Problem Solving

The results of this study aimed to determine critical thinking skills in innovating problem-solving during physics entrepreneurship course. The critical thinking skills test (CTTS) was given to students as an evaluation of all critical thinking skills.

The critical thinking skills test was in the form of a description test that has definite answers so that objective scoring could be carried out. The indicator of critical thinking skills used in this study was an indicator of Facione's critical thinking skills.

Each item was adjusted to the item indicators that refer to the critical thinking skills that have been assigned to the TKBK indicators to evaluate students' critical thinking skills which consist of 6 (six) indicators of critical thinking skills, namely 1) interpretation, 2) analysis, 3) evaluation, 4) inference, 5) explanation, and 6) self-regulation.

TKBK was given to students as research subjects. The critical thinking skills score was converted into 5 (five) criteria, namely: 89% <x ≤ 100% (Very High); 78% <x ≤ 89% (High); 64% <x ≤ 78% (moderate); 55% <x ≤ 64% (Low); 0% <x ≤ 55% (Very Low).

The average student's ability in each type of critical thinking skill was included in the low category with an average of 56.9%. Figure 1 shows that the indicators of critical thinking skills possessed by students are 54.7% interpretation; analysis 57.1%; evaluation 59.4%; inference 57.7%; explanation 59.9%; and self-regulation 52.7%. CTTS results are presented in Figure 1.

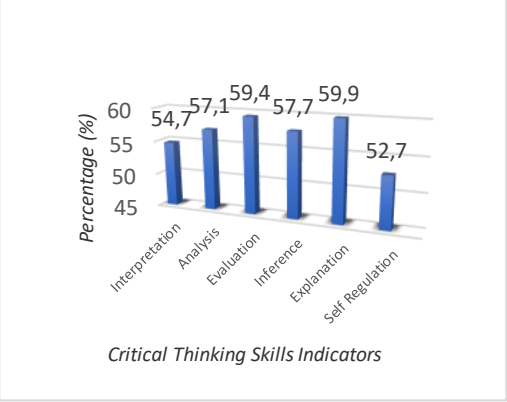

Figure 1 Graph of the Percentage of Students' Critical Thinking Skills

Based on the Figure 1, it obtains an illustration that students have not been able to interpret, analyze, and evaluate the problems faced so that it was assumed that the students' creativity experienced obstacles. This can be seen

in the inference, explanation and self-regulation skills which are also in the low category. Students have not been able to design a solution in solving problems and have not been able to produce products or ideas that can be used to solve problems and opportunities faced. Students might be able to identify problems but have not been able to write down the results of the interpretation, analysis, and evaluation they think about correctly.

Students have not been able to explore solutions by writing problem-solving plans and the formulas used. Students have not been able to formulate strategies to communicate conclusions. Students have not been able to check the results of problem solving and have not been able to arrange solutions with different steps, which is what is expected in self-regulation skills.

Agung argued that the level of individual performance was one of the main things to determine the success of the business that was being run (Agung, 2019). Entrepreneurial knowledge, achievement motives, personal independence have a significant carrying capacity for business independence (Qamariyah, 2012). In accordance with the results of relevant research, entrepreneurship education can shape the mindset, attitudes and behavior of students to become true entrepreneurs, thus directing them to choose entrepreneurship as a career choice (Retno, 2012). However, this influence needs to be studied further whether the existence of entrepreneurship courses can generate interest in entrepreneurship for students.

Recent studies have concluded that a learning model and media are needed to improve students' critical thinking skills. The application of these various models and media can improve the quality of students' critical thinking skills in solving various problems. Relevant research found that the problem-solving skills of students who learn using the PhET-aided inquiry-discovery technique with the theoretical review are higher than those of students who learn using the conventional technique (Wartono, Suyudi, & Batlolona, 2018).

Critical thinking skills are needed by students to be able to solve real problems, not just to memorize concepts but students must have self-regulation skills to be able to solve various problems in the entrepreneurial world. The result of relevant research showed that most students do not apply physics concept to get the answer, but they only refer to the involved variable, random methods, and memorize the same problem they have ever faced before (Riantoni, Yuliati, & Nehru, 2017).

Recent studies indicate that newly hired college graduates do not excel in the higher-level knowledge and information-based skills at the level that employers demand. Entrepreneurs have also indicated that the shortage of highly skilled workers inhibits the growth and development of new entrepreneurial firms. In response to this, there have been multiple calls for educators at all levels to recognize the challenges and opportunities in today's economy and to ensure that students develop the "21st century" knowledge, skills, and abilities (KSAs) they need. A closer look at these 21st century KSAs alongside research and data on entrepreneurial competencies reveals a meaningful overlap between the two (Boyles, 2012). These findings are supported by opinion of Baggen (2015) who argues that entrepreneurial challenges start at an individual level with the identification of entrepreneurial opportunities, which is acknowledged as one of the key competencies for lifelong learning.

Students Responses about Critical Thinking Skills in Innovating Problem Solving

The questionnaire data were analyzed by determining the total score of student responses for each statement. Then the student responses were categorized based on the Likert scale range as follows; it was obtained from the ideal score that the answers of all students were VA, in which Very Disagree (VD) = 30; Disagree (D) = 60; Agree (A) = 90; and Very Agree (VA) = 120. Point for VA = 4; A = 3, D = 2; and VD = 1.

If the total score were in the area between two categories, it was determined that the total score would fall into one of the categories, provided that the total score in the area ≤ half interval (distance of the two categories) was included in the category on the left. Otherwise, if the total score that was in the area > half the interval (distance of two categories) then it was included in the category on the right. To find out the level of approval of respondents, it was done with the formula Sugiyono (2019).

The number of ideal scores (criteria) in this study were 10 x 4 x 30 = 1200. Recapitulation of students' responses data can be seen in Table 1.

Table 1 Recapitulation of Student Responses

Statement	Number of Answer*)				Total Score	Information
	VD	D	A	VA		
I feel comfortable with the atmosphere of learning problem solving with critical thinking.	0	0	27	3	93	A
Learning becomes livelier and more interesting.	0	0	4	26	116	VA
I feel challenged to solve problems.	0	2	22	6	94	A
I feel challenged to think critically.	0	1	24	5	94	A
I agree that the physics entrepreneurial course uses learning that trains critical thinking skills to innovate in solving problems.	0	1	3	26	115	A

*) VD = Very Disagree; D = Disagree; A = Agree; and VA = Very Agree.

The data obtained from filling in the student response instruments showed that students gave an agreeable response to the learning atmosphere of the physics entrepreneurial course by using activities that challenged students to use critical thinking skills in innovation to solve problems. This fact illustrates the results of relevant research on university students in China which showed that the provision of entrepreneurship education could provide a stimulant for entrepreneurial intentions (Zhang, Duysters, & Cloodt, 2014). Students felt challenged to solve problems, but they were still lack of ideas in critical thinking. Students understood the material and found it easy to understand it. The evaluation given could be understood but it was still not used to find ideas in solving problems.

This shows that activities that stimulate critical thinking skills to innovate in solving a problem are in great demand by students, but lecturers must think about ways of implementing the model of learning that are fun and attractive for students. Students' critical thinking skills increased when they were asked challenging questions (Shim & Walczak, 2012). However, they found facts that contradicted the findings of previous studies. Realizing critical thinking can be supported through providing non-routine problems (Santia, Purwanto, Sutawidjadja, Sudirman, & Subanji, 2019). The results of these studies indicated that it took great effort from lecturers to train students' critical

thinking skills to solve entrepreneurial problems. The results of this study also supported the conclusion of relevant research about entrepreneurship education that needs to be packaged with a curriculum that is able to provide significant effectiveness to encourage students to have entrepreneurial intentions (Agni & Rochmi, 2020). The packaging of this curriculum needs special attention for education providers.

CONCLUSION

The critical thinking skills as measured by tests of critical thinking skills showed different results on each indicator of critical thinking which was ranged from low to very low category, but the average overall skills were in the low category. The results of this study provided an overview for lecturers and education observers regarding the condition of students' critical thinking skills in department of physics education at a university in the city of Palangkaraya in the Physics Entrepreneurship course. The average achievement of critical thinking skills of students of the department of physics education at a university in the city of Palangkaraya in the Physics Entrepreneurship course was in the low category, namely 56.9%. This shows that the critical thinking skills of students' interpretation, analysis, evaluation, inference, explanation, and self-regulation are at very low criteria. The results of this study can be used as a reference for designing and developing a learning process that can improve students' critical thinking skills.

The weakness of this research was that the researcher has not conducted a specific analysis of the aspects that affect the low critical thinking skills of students in solving entrepreneurial problems. Suggestions for further research are related to improving students' quality critical thinking skills. It is necessary to have a model, device, and learning media that support the learning process which should be developed as a whole so that it can assist students in achieving the objectives of the Physics Entrepreneurship course.

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