The 21st century skills with model eliciting activities on linear program

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Abstract. Human resources in the 21st century are required to master various forms of skills, including critical thinking skills and problem solving. The teaching of the 21st century is a teaching that integrates literacy skills, knowledge, skills, attitudes, and mastery of ICT. This study aims to determine whether there are differences in the effect of applying Model Eliciting Activities (MEAs) that integrates 21st century skills, namely 4C and conventional learning to learning outcomes. This research was conducted at Vocational High School in the odd semester of 2017 and uses the experimental method. The experimental class is treated MEAs that integrates 4C skills and the control class is given conventional learning. Methods of data collection in this study using the method of documentation and test methods. The data analysis uses Z-test. Data obtained from experiment class and control class. The result of this study showed there were differences in the effect of applying MEAs that integrates 4C skills and conventional learning to learning outcomes. Classes with MEAs that integrates 4C skills give better learning outcomes than the ones in conventional learning classes. This happens because MEAs that integrates 4C skills can improved creativity skills, communication skills, collaboration skills, and problem-solving skills.

1. Introduction

The 21st century is a century marked by the rapid development of science and technology. This condition should be followed by learning that can meet the demands of the times. The teaching of the 21st century is expected to produce human resources that can master various forms of 21st century skills. The Educational Testing Service (ETS) in its publication, Digital Transformation: A Literacy Framework for ICT Literacy (2007), defines 21st century learning skills as the ability to a) collect and/or retrieve information, b) organize and manage information, c) evaluate the quality, relevance, and usefulness of information, and d) generate accurate information through the use of existing resources [1]. The skills have been grouped into three main areas: 1) Learning and innovation skills: critical thinking and problem solving, communications and collaboration, creativity and innovation, 2) Digital literacy skills: information literacy, media literacy, Information and communication technologies (ICT) literacy, 3) Career and life skills: flexibility and adaptability, initiative and self-direction, social and cross-cultural interaction, productivity and accountability [2].

Linear program (also called linear optimization) is a method to achieve the best outcome (such as maximum profit or lowest cost) which in its completion using mathematical model. Linear program is one of the material that is considered difficult by students in Vocational High School grade XI. Basic competence to be achieved on linear program material is that students can solve contextual problems related to linear program. The ability of students to solve problems related to daily life such as problems of linear program is relatively low. This condition indicates that students have difficulty in using mathematical concepts to solve real problems. White state that one of the students’ major difficulties is to express mathematically inequality terms [3]. The result of Ogan’s study also showed on Linear Program, student experience difficulties in constructing mathematical meanings of symbols [4].

Along with the development of the era, the ability to solve problems is needed in daily life. Problems in linear program are related to daily life, so it is important to implement a learning that can improve students’ ability to solve problems and make students active in learning. According to Chamberlin and...
Moon, Model Eliciting Activities (MEAs) are written specifically for instruction in mathematics. This model was developed after the Problem-Based Learning approach. MEAs is one of the recommended instructional strategies for teacher in mathematics [5]. Lesh states that MEAs would encourage students to creative mathematical models to solve complex problems [6]. MEAs are a model of mathematical learning to understand, explain, and communicate mathematical concepts contained in a problematic presentation through mathematical modeling. There are six principles of learning with MEAs: 1) Model Construction Principle, 2) The Reality Principle, 3) The self-Assessment Principle, 4) The Effective Prototype Principle, 5) The Construct Shareability and Reusability Principle, 6) The Effective Documentation Principle [7]. MEAs have five learning characteristics when viewed in relation to student learning: collaboration, multiple processes, self-directed learning and self-assessment, fostering of ownership, and model development. Student collaboration is fostered when doing MEAs because students work in groups of three or four [7]. A MEAs is implemented in several steps: 1) The teacher reads a simulated newspaper article that develops a context for students, 2) The students respond to readiness questions that are based on the article, 3) The teacher reads the problem statement with the students and makes sure each group understands what is being asked and students subsequently attempt to solve the problem, 4) After creating multiple iterations of the solution and revising when necessary, students present their models to the class [5]. The result of Altay research is that mathematics learning with MEAs is enjoyable and meaningful as these activities require students to make relation between mathematical concept and real life [8].

The Partnership for 21st Century Skills identifies 21st century skills as critical thinking and problem solving, communication, collaboration, and creativity and innovation- more commonly known as the 4C skills [9].

1.1. Critical Thinking and Problem Solving Skills
Critical thinking Skill is the ability to understand a complex problem, connecting information one with other information, so that eventually emerged various perspectives in solving the problem. Critical thinking skills required students in daily life. Students who are able to think critically can solve problems effectively in social, scientific, and practical problems. Merely having knowledge and information is not enough to be able to solve problems and make decisions. To be effective in the workplace (and in their personal lives), students must be able to solve problems and make effective decisions; they must be able to think critically [10]. Characteristics of Critical Thinking Skills: a) reason effectively, b) ask pointed questions and solve problems, c) analyze and evaluate alternative points of view, and d) reflect critically on decisions and processes [1].

1.2 Communication Skills
Learning is a basic social activity - whether in school, workplace, or other environment. Communication refers to an individual’s ability to communicate clearly, using spoken, written, and non-verbal language. Characteristics Communication skills: a) Articulate thoughts and ideas effectively using oral, written and nonverbal communication skills in a variety of forms and contexts, b) Listening effectively to decipher meaning, including knowledge, values, attitudes and intentions, c) Using communication for a variety of purposes, d) Utilize multiple media and technologies, and know how to judge their effectiveness a priori as well as assess their impact, and e) Communicate effectively in diverse environments (including multilingual)[1].

1.3 Collaboration Skills
Collaboration has become a twenty-first-century trend. The need in society to think and work together on issues of critical concern has increased shifting the emphasis from individual efforts to group work, from independence to community [11]. Collaboration is the act of working together to achieve common goals. The Partnership for 21st Century Expertise says that mastering collaborative skills requires the ability to work effectively with diverse teams. Collaboration is not simply a synonym for students.
working in groups but also aims to instill the ability to socialize and control the ego and emotions. Through collaboration will create togetherness, ownership, responsibility, and caring among members.

Characteristics Collaboration Skills: a) Demonstrate the ability to work effectively and respectfully with diverse teams, b) Exercise flexibility and willingness to be helpful in making necessary compromises to accomplish a common goal, c) Assume shared responsibility for collaborative work, and value individual contributions made by each team member [1].

1.4 Creativity and Innovation Skills
Creativity is one’s ability to generate new ideas from existing ideas. Creativity depends on one’s creative thinking, the process of thinking to create new ideas that lead to new discoveries and often called innovation. Characteristics Creativity and Innovation Skills: a) Develop, apply and convey new ideas to others new invention and often called innovation, b) Open and responsive in viewing new and different views, c) Using technology to make decisions, solve problems, and create new ideas [2].

Based on the characteristics of MEAs and the characteristics of each 4C skills, MEAs that integrates 4C skills in classroom learning is very relevant because it has similarities that are collaboration, communication, critical thinking and Problem Solving, and creativity and innovation skills. The results of Wahyu’s research is the mathematical problem solving skills possessed by the students who use MEAs learning are better than those who taught in conventional learning [12]. Smith L S in his research stated that there is a potential for developing 4C skills with problem-based mat learning. The results show that 4C skills are required in problem based learning [13].

2. Methods
Type of research used in this study is the experimental method. This research was conducted at Vocational High School 2 Surakarta and Vocational High School 4 Surakarta. In this study, four classes were selected as experimental classes and control classes. Sample of this research is 60 students of Vocational High School 2 in Surakarta and Vocational High School 4 Surakarta chosen by random sampling as experimental classes and 60 students of Vocational High School 2 Surakarta and Vocational High School 4 Surakarta chosen by random sampling as control classes. Experimental classes were treated with MEAs learning integrated 4C skills and control classes were given conventional learning treatment. Methods of data collection in this study using documentation method and test method. Documentation method used as initial data. The test method is used as the final test. The test method with linear program material is used as the final test. The instrument consisting 20 items is validated by the head of Mathematics Teachers Association Vocational High School Surakarta and the head of Mathematics Teachers Association Senior High School Central Java. This is then tested in Vocational High School 6 in Surakarta and analyzed. Instrument analysis consist of discrimination power (DP), difficulty level (D), and reliability test with Alpha Cronbach formula. An item is said to be good if it has a discrimination power of more than or equal to 0.30 (DP≥0.30), difficulty level 0.30≤D≤0.70 and reliability index greater than or equal to 0.70 (r_{11}≥0.70). The results of the instrument analysis are 15 items were obtained to qualify for discrimination power and difficulty. The reliability value of the 15 items, r_{11} = 0.76. Reliability value used describe the usefulness of an item in measurement. It means that the result of measurement having a reliability index 0.70 or more then instrument can be used to measurement. The data analysis used in this research is Z-test by taking significance level α = 5% which is to compare two models of learning. Alpha (α) level is the probability of rejecting the null hypothesis given that it is true. As a matter of good scientific practice, a significance level is chosen before data collection and is usually set to 0.05 (5%). Other significance levels (e.g., 0.01) may be used, depending on the field of study [14].
3. Results and Discussion

3.1. Preliminary data analysis

This section, we present the initial data analysis. Preliminary data is taken from final exam score of the previous semester. Table 1 shows the result of normality test with Liliefors method on experimental and control classes. Test were tested with Excell.

| Class      | L-value | N | $L_{0.05;60}$ |
|------------|---------|---|--------------|
| Experimental | 0.1049  | 60 | 0.1143       |
| Control    | 0.0997  | 60 | 0.1143       |

Based on table 1, in the experimental class obtained $L_{-}$value = 0.1049 and in the control class $L_{-}$value = 0.0997. $L_{-}$value is obtained from final exam score of the previous semester each class is sorted from the smallest value to the largest value, then tested with Liliefors method. In experimental classes obtained the maximum value of $L_{-}$value = 0.1049 and control classes obtained the maximum value of $L_{-}$value = 0.0997. $L_{0.05;60} = 0.1143; C = \{L \mid L > 0.1143\}$, because the $L_{-}$value in each class is not included in $C$ then data of two classes are said to be normally distributed.

The $Z$ test can be used to test the data whose sample is large. The number of samples of 30 or more is considered a large sample. In addition, the $Z$ test is used to analyze data whose population variance is known. However, if the population variance is unknown, then the variance of the sample can be used instead. Criteria use of $Z$ test 1) Normally distributed data, 2) Variance ($\sigma^2$) known, 3) Large sample size ($n$) $\geq 30$, and 4) Used only to compare 2 pieces of observation. Tabel 2. Describe the $Z$ test result with Excell to find out whether there are differences in the experimental class and control class.

| Class      | N | Mean  | SD   | Z-value | $Z_{0.05}$ |
|------------|---|-------|------|---------|------------|
| Experimental | 60 | 62.58 | 11.06 | 1.515   | 1.65       |
| Control    | 60 | 59.58 | 10.65 |         |            |

The result of $Z$ test, obtained $Z$-value = 1.515, it is smaller than $Z_{0.05} = 1.65$. It can be said there is no differences in both classes. Both classes have the same initial capability. Furthermore, for experimental classes using MEAs learning integrated with 4C skills and for control classes with conventional learning.

3.2 Analysis of final data

Table 3 present normality test of experimental and control classes final test. Data obtained from the final test scores of linear program material in the experimental classes and control classes.

| Class      | L-value | N | $L_{0.05;60}$ |
|------------|---------|---|--------------|
| Experimental | 0.1076  | 60 | 0.1143       |
| Control    | 0.0948  | 60 | 0.1143       |

Result in table 3 shows L-value in experimental classes and control classes less than $L_{0.05;60}$, then it is said the final test data is normally distributed.
Table 4 shows the result of Z test on the final test of experimental and control classes with Excell. Data obtained from the final test scores of linear program material in the experimental classes and control classes.

Table 4. Z test after experimental

| Class       | N  | Mean  | SD   | z-value | $z_{0.05}$ |
|-------------|----|-------|------|---------|------------|
| Experimental| 60 | 78.37 | 13.17| 2.93    | 1.65       |
| Control     | 60 | 71.07 | 14.12|         |            |

It was obtained from the data analysis that Z-value = 2.93 and $z_{0.05} = 1.65$. Z-value is higher than $z_{0.05}$ so it is said there was a difference in the final test of experimental and control classes. On initial ability of experimental classes, mean = 62.58 and modus = 70. After experimental classes were treated with MEAs learning integrated 4C skills, mean = 78.37 and modus = 80. It means a significant change in learning outcomes. Based on the result of the analysis, it can be concluded that there are differences in the effect of applying Model Elliciting Activities (MEAs) that integrates 21st century skills, namely 4C and conventional learning to learning outcomes. Learning using MEAs by integrating 4C skills in learning activities provides better learning outcomes than conventional learning. This condition can occur because there are differences in characteristics in conventional learning and MEAs learning that integrated 4C skills.

Table 5 shows the differences characteristic of the two lessons.

Table 5. Table of conventional learning characteristics and MEAs learning that integrate 4C skills.

| Conventional learning | MEAs by integrated 4C skills |
|-----------------------|-----------------------------|
| Learning Center       |                             |
| teacher centered      | Student centered            |
| students are a source  | students can find learning   |
| of learning.          | resources not only from the teacher. |
|                       | Teacher as a facilitator.    |
| Classroom environment |                             |
| Students work individually | Students work in groups |
| Learning Activities   |                             |
| Teachers perform the learning steps of explaining material, examples, and exercises. | Teachers begin learning by presenting an article or video about daily life related to problems in linear programming. Students are also active to look for problems with the linear program and solve the problem in the group and then present the group results. |

The character difference in both learning influences students' response during classroom learning. In conventional learning, students wait for teacher and passive explanation, students do not want to ask when they do not understand, that it can cause boredom. Students do not motivate each other, students easily give up when experiencing difficulties because there is no discussion friend. Students' creativity is not built and students do not built communication skills. On the contrary, in learning with MEAs integrated with 4c skills students can develop their creativity and ideas so they are not passive. Students are accustomed to collaborate, respect each other, accept the advantages and disadvantages of others
and students can motivate each other. Students' creativity is awakened and students can develop communication skills.

Table 6 describes activities with MEAs that are integrated with 4C skills.

| MEAs | 4C skills | Activities |
|------|-----------|------------|
| The teacher reads a simulated newspaper article that develops a context for students | Critical thinking and Problem solving | Observe an article given by a teacher or observe a video containing daily activities related to linear programming issues. This activity trains students to find out and apply mathematical concepts in daily life. |
| The students respond to readiness questions that are based on the article | Creativity and Innovation skills | Students search for articles that contain daily activities related to linear program then create problems or problems related to the article and students complete the group. This activity can build students' creativity when student search and solving problems |
| The teacher reads the problem statement with the students and makes sure each group understands what is being asked and students subsequently attempt to solve the problem | Collaboration skills | Work together in groups, help each other and motivate when completing tasks. This activity can develop the attitude of cooperation and mutual respect |
| After creating multiple iterations of the solution and revising when necessary, students present their models to the class. | Communication skills | Discussion to process the given problem and solve the problem, write down the results of the discussion and then present the results. This activity encourages students to dare to communicate opinions |

Students' difficulties to solving problems in linear program can be helped by students being invited to see daily events related to the problems in the linear program that determines maximum results or minimum expenditure. Students are invited to critical thinking how to get maximum profit and how to spend the minimum cost. Students learn creatively to construct a mathematical model in the form of inequalities that can be used to solve problems. Students work together in groups so that communication occurs. Students who have difficulty can ask in groups. This condition causes students not bored so that it can successfully solve the problem. When students in groups are looking for problems related to linear programming then completing the group and presenting the results, making students more confident. Vocational high schools are expected to produce a person who is able to think critically in the marketplace, creative in work and able to collaborate and communicate in the marketplace.
4. Conclusion

The 21st century, 4C skills integrated in MEAs learning can provide better learning outcomes than conventional learning. MEAs and 4C skills have the same characteristics, that is Critical thinking and Problem solving, Creativity and Innovation skills, Collaboration skills, and Communication skills. This learning causes students feel not bored because can be actively involved and happen mutual cooperation. Students also become more courageous to express opinions because there is mutual respect. The 21st century, 4C skills are needed in today’s development. The ability of problem solve is also very necessary in daily life. Based on the research findings, the author suggested that learning using 4C skills are integrated in the model of learning MEAs can applied in the learning of linear program. Suggestion for further research is the researcher using technology to integrate 21st century skills in MEAs.

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