Developing thinking skill system for modelling creative thinking and critical thinking of vocational high school student

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Abstract. Vocational students must have practical skills in accordance with the purpose of vocational school that creating the skilled graduates according to their field. Graduates of vocational education are required not just as users, but be able to create. Thus requiring critical and creative thinking skills to assist students in generating ideas, analyzing and creating a product of value. Based on this, then this research aims to develop a system to know the level of ability to think critically and creative students, that resulted students can do self-reflection in improving the ability to think critically and creatively as a supporter of practical ability. The system testing using Naïve Bayes Correlation shown an average accuracy of 93.617% in assessing the students’ critical and creative thinking ability. By using modeling with this system will be known level of students' critical and creative thinking ability, then the output of the system is used to determine the type of innovation in the learning process to improve the critical and creative thinking skills to support the practical skills of students as skilled vocational students.

Keywords: vocational student, student modeling, machine learning, NBC, decision support system

1. Introduction
Vocational education is a higher education that prepares graduates to acquire certain skills according to their area of expertise. The field of expertise accordance with the needs of the business and industry. Cognitive skills, in particular creative and critical thinking skills, constitute key competencies for 21st century professionals and citizens [1][2]. The development of critical and creative thinking (higher-order thinking skills) [3] can be developed during the learning process especially for vocational education because the existing technology continues to grow [4][5][6]. One of the general aims of the present day education systems is to educate the students as creative individuals and make them acquire talents to produce creative ideas in order to be able to solve problems which may arise during their life cycle [7]. Good critical skills resulted vocational student can created new ideas, [8][7] have indicated that creativity is important in connection to problem solving and creating new ideas.

Having known the level of critical thinking skills and creative students it can be done improving the learning process. Innovation of suggested learning methods is a learning method that uses a constructivism approach such as Problem-Based Learning (PBL) [9]. The underlying principle in PBL, which is one of the student-centered teaching methods in education, is the development of students’ higher-order thinking skills. For this reason, in the PBL process, it is necessary to investigate creative
thinking, one of the higher-order thinking skills [3][10]. Through the innovations of this learning method is expected to improve students’ critical and creative thinking skills that can support the practical ability of vocational education students to be skilled graduates.

Based on the importance of developing critical and creative thinking skills in support practical ability by using connected problem solving and creating new ideas [7], it is necessary to assess the ability of critical and creative thinking of students. This study aims to develop a system that accommodates these needs, using a K-Means [11] clustering algorithm to create class that validated by an expert, resulted Knowledge Base (KB). KB used as the initial initiation of Thinking Skill System, that using Naïve Bayes Classifier (NBC) algorithm.

2. Related Work
The critical and creative thinking can be developed during the learning process especially for vocational education because the existing technology continues to grow. Research on this development, [4] developing a course for engineering scholars with the aim of developing students’ critical thinking, creativity, and innovation. The study [12] aims to develop student creativity by creating a collaborative brainstorming environment for programming design. The ability approach that an IT student must have is the ability to solve abstract problems and logical thinking [13]. Furthermore, the development of creativity in learning with web-based learning environment shown that architectural design has increased creativity [14]. Similarly [15] showed that e-schoolbags can improve students’ high-order thinking skills, especially analytical skills and analytical skills. Both of these abilities refer to the type of critical thinking ability.

This study based on the importance of developing critical and creative thinking skills in support practical ability by using connected problem solving and creating new ideas [7], aims to developing modeling thinking skill system. This system using digital validate questioner to modeling the creative and critical thinking of student, using NBC algorithm. This algorithm have good accuracy and also fast [15][16][18], based on this result this study using NBC.

3. Methodology
The research methodology is shown in Figure-1, the first stage of research is the literature review that used to determining the state of the state-of-the-art of research topic and composing research instruments. The next step is instrument test, this step using pilot project schema, this test using for proved that instruments can be use, using statistical test using validity and reliability test, the validity shown by equation 2, reliability shown by equation 3 using SPSS. This research continuing with cluster the data, this step create class that validated by an expert, resulted Knowledge Base (KB). KB used as the initial initiation of Thinking Skill System, that using Naïve Bayes Classifier (NBC) algorithm.

Data analysis in this research using K-Means Clustering and validated by experts. NBC accuration test step used to NBC test using data trainer (SMKN 5 Malang), this step resulted the accuracy score of NBC based on research data.mThe next step is to classify data by using the Naïve Bayes Classifier (NBC) shown by Equation 1. NBC implementation conducted by the research begins with the transformation of the questionnaire’s data, by change the range of 0-50 became 1-5. The values then divided into three classes based on the type of class, then the data is stored for later comparison. The last step is discuss and conclusion, resulted evaluation of this research.

4. Discussion
Object of previous studies on student modeling such as understanding the learner behavior [19], learners have different needs and characteristics. This research aims to modeling critical and creative thinking of student, resulted understanding of student condition. Process to understanding student in this research, using tested questioner. This research continuing with cluster the data, this step create class that validated by an expert, resulted Knowledge Base (KB). KB used as the initial initiation of Thinking Skill System, that using Naïve Bayes Classifier (NBC) algorithm. Data analysis in this research using
K-Means Clustering and validated by experts. NBC accuracy test step used to NBC test using data trainer (SMKN 5 Malang), this step resulted the accuracy score of NBC based on research data. The next step is to classifying data by using the Naïve Bayes Classifier (NBC) shown by Equation 1 [17].

$$p(A|B) = \frac{p(B|A)p(A)}{p(B)}$$

(1)

The population used in this research was the Malang Senior High School (SMKN 4 Malang, SMKN 5 Malang, SMKN 6 Malang, SMKN 8 Malang, SMKN 11 Malang, and SMKN 12 Malang), with 44 student for data trainer and 188 student as data test. 44 student using as clustering process, to creating KB of the system (using expert judgment), this data also using to test NBC using Weka [20], Weka is a collection of machine learning algorithms for data mining tasks, resulted judgment accuracy algorithm for the research case/data.

In the implementation of NBC, system produces a value \((prior \times prob)\), the value is used as a determinant of posterior value. In the implementation of the research to make changes in the formula NBC, by eliminating the value of evidence, it is based on the assumption that the value of the same events can be removed. For example, a value that has same denominator, the value of the denominator can be removed, so just compare the value of the numerator. NBC implementation conducted by the research begins with the transformation of the questionnaire’s data, by change the range of 0-50 became 1-5. The values then divided into three classes, then the data is stored for later comparison.

$$r_{xy} = \frac{n \sum XY - (\sum X)(\sum Y)}{\sqrt{[n \sum X^2 - (\sum X)^2][n \sum Y^2 - (\sum Y)^2]}}$$

(2)

$$r_i = \frac{k}{(k-1)} \left[ 1 - \frac{\sum \sigma_i^2}{\sigma_i^2} \right]$$

(3)

In this research, system identification thinking skill student using questioner shown by Table 1. This questioner divided in two part, critical thinking and creative thinking. This system identification each part, resulted level of critical thinking and creative thinking, this research defined 3 level, low, medium, and high. Based on system level result, having known the level of critical thinking skills and creative students, teachers can be improving the learning process. Innovation of suggested learning methods is a learning method that uses a constructivism approach such as Problem-Based Learning (PBL).

In Figure 3, it appears that the data is spread evenly, marked by the distribution of data with the color label green, blue, and red. There are several intersections or intersections of data with different labels,
this intersection is good enough to indicate well-separated data. The result of the use of NBC classification algorithm shown by Figure 4 shows that the error generated from this process is quite enough, so that the result of average accuracy with ten times test using technique 10 fold is 93.617%.

5. Implementation
Implementation in this research shown by Figure 2. There are two actors in this system, students and teachers. The interaction between the two actors requires login. In this study the system developed will only provide predictions of students’ thinking ability level, while the next action is left entirely to the teacher. This aims to provide opportunities for teachers to improvise to improve students’ critical and creative thinking skills [3].

| Variable       | Sub-Variable | Indicator                          | Number of Items |
|----------------|--------------|------------------------------------|-----------------|
| Thinking Skill | Critical     | Gives a simple explanation         | 1, 2, 3         |
|                | Thinking     | Build basic skills                 | 4, 5            |
|                |              | Conclude                           | 6, 7            |
|                |              | Provide further explanation        | 8, 9, 10        |
|                |              | Setting a strategy / tactic        | 11, 12          |
| Creative       | Smoothness   |                                    | 13, 14, 15      |
| Thinking       | Flexibility  |                                    | 16, 17, 18      |
|                | Authenticity |                                    | 19, 20          |
|                | Details      |                                    | 21, 22, 23      |

6. Conclusion
Based on the importance of developing critical and creative thinking skills in support practical ability by using connected problem solving and creating new ideas [7], it is necessary to assess the ability of critical and creative thinking of students. This research develop a system that accommodates these needs, using a K-Means clustering algorithm to create class that validated by an expert, resulted Knowledge Base (KB). KB used as the initial initiation of Thinking Skill System, that using Naïve Bayes Classifier (NBC) algorithm. This research resulted 93.617% average accuracy with ten times test using technique 10 fold.

Based on the results of this test concluded that the research can be used, it is based on the error rate generated in the test of 6.38%. The results of this study are expected to be used by teachers and students in improving the learning process so as to optimize the creative and critical creative ability of the students. However, methods for improving students’ creative and critical thinking skills are left to the teacher. This system does not form a learning path on its output, but only limited to provide a picture of the level of students' thinking ability.
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