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Using Learning Managemant System in Fundamental of Analytical Chemsitry Course*:* Effect on Students' Critical Thinking through The Authentic Assessment

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Abstrak

Berpikir kritis adalah keterampilan utama untuk menghubungkan hubungan antara konsep-konsep ilmu kimia dalam satu lingkungan yang koheren. Oleh karena itu, diperlukan suatu metode pembelajaran dan evaluasi untuk membantu mahasiswa menguasai pemaknaan ilmu kimia terhadap fenomena lingkungan. Mata kuliah Dasar-dasar Kimia Analitik mengajak mahasiswa mempelajari teknik penentuan kadar suatu senyawa. Ini relevan untuk meningkatkan kemampuan berpikir kritis mereka. Penelitian ini bertujuan untuk menganalisis pengaruh implementasi Technology-based Authentic Assessment (TbAA) terhadap kemampuan berpikir kritis mahasiswa pada mata kuliah Kimia Analitik Dasar. Dirancang sebagai penelitian pre-eksperimen, pretest-posttest kelompok diterapkan. Sebanyak 26 mahasiswa S1 Kimia diikutsertakan sebagai sampel melalui random sampling. TbAA dilaksanakan selama 7 kali pertemuan, kemudian kemampuan berpikir kritis yang dinilai melalui instrumen essay meliputi aspek interpretasi, analisis, evaluasi, inferensi. Uji validitas dilakukan secara teoritis oleh 2 ahli kimia ahli pembelajaran terhadap 4 soal yang berpikir kritis yang telah dikembangkan. Setelah data diperoleh, statistik deskriptif dan uji Wilcoxon dilakukan untuk menjawab tujuan penelitian. Berdasarkan hasil analisis, terdapat perbedaan yang signifikan pada kemampuan berpikir kritis siswa setelah penerapan TbAA.

Kata kunci: teknologi, penialaian otentik, dasar-dasar kimia analitik

Abstract

Critical thinking is the main skill for connecting relationships between chemical science concepts in a coherent environment. Therefore, a learning and evaluation method is needed to help students master the meaning of chemistry to environmental phenomena. The Fundamental of Analytical Chemistry course invites students to study the technique of determining the concentration of a compound. This is relevant to improve their critical thinking skills. This study aims to analyze the effect of the implementation of Technology-based Authentic Assessment (TbAA) on students' critical thinking skills in Fundamental of Analytical Chemistry course. Designed as a pre-experimental, one group pretest-posttest study was applied. A total of 26 undergraduate Chemistry students were included as samples through purposive sampling. TbAA was held for 7 meetings, then critical thinking skills were assessed through essay instruments covering aspects of interpretation, analysis, evaluation, inference. The validity test was carried out theoretically by 2 learning chemists on 4 critical thinking questions that had been developed. After the data was obtained, descriptive statistics and the Wilcoxon test were carried out to answer the research objectives. Based on the results of the analysis, there is a significant difference in students' critical thinking skills after the application of TbAA.

Keywords: technology, authentic assessment, fundamental of analytical chemistry

Introduction

Currently, the world is in the industrial revolution (RI) 4.0 and society 5.0. This happens in line with the rapid advancement of technology that helps humans in all sectors of life. Technological progress referred is technology that has a good impact on humans, which facilitates human activities in the form of artificial intelligence (such as computers, robots) and digitalization of information using internet networks (Meylinda, 2018). Various skill competencies need to be owned to become provisions so that human resources can continue to survive, such as critical thinking skills, collaboration and leadership, adaptation, communication, problem solving, creativity and curiosity, as well as the ability to access and analyze information (Wagner, 2010). Critical thinking ability is defined as a person's ability to think rationally about things to learn, what to do, and what to believe (Dwyer, Hogan & Stewart, 2014). Through this definition, critical thinking becomes one of the abilities that chemistry students need to have (Stowe & Cooper, 2017), because through critical thinking skills, chemistry students can analyze existing facts to make ideas and defend them through comparisons of existing concepts, so that a solution can be obtained for a challenge or problem faced (Cottrell, 2017). As an institution that produces experts, students of diploma and tertiary education institutions have critical thinking skills, collaboration and leadership, adaptation, communication, problem solving, creativity and curiosity, as well as the ability to utilize information technology which is still lacking (Bernie, 2009). For this reason, an effort is needed from educators to continue to develop themselves and the learning process, so that these competencies are achieved.

The characteristics of chemistry are cultivating critical, creative, independent scientific thinking as well as the ability to understand, design, solve problems, know how and why to do, analyze, monitor, evaluate, communicate and develop conceptual understanding (Ministry of National Education 2013). Critical thinking is the main skill for linking the relationships between chemical science concepts in a coherent whole, both through concept studies, experiments, and their application in the environment. Based on these characteristics, there are two things that students must mastery completely: chemical concepts and critical thinking skills. Therefore, a learning and evaluation method is needed to help

students master and understand the meaning of chemistry in the environment. Critical thinking skills are needed so that each individual does not only know an answer, but is able to develop various possible answers based on the analysis of information obtained from a problem as a reasoning activity with an open mind (Thompson, 2011). Through an open mind, someone who has the ability to think critically will be able to think rationally and clearly, not assuming the information they receive has the same truth (Facione, 2013). The thinking activity of someone who has the ability to think critically, shows intellectual activity in conceptualizing, implementing, analyzing, drawing conclusions and evaluating information that is believed so that they can receive perspectives and reflections on the problems they face (Lisa & Snyder, 2008; Radulovic, 2017). An individual's critical thinking ability can be identified through indicators of critical thinking ability (Facione, 2013), namely:

1. Interpretation, as a process of understanding and expressing a meaning from judgments, events, experiences, situations, data, conventions, criteria, rules, or procedures, including categorizing, describing and explaining the meaning of an issue.
2. Analysis, is the process of identifying the intent and actual relationship between concepts, statements, descriptions, questions, to state what is believed to be the result of evaluating arguments and information to produce appropriate explanations.
3. Evaluation, as the stage of assessing the credibility of statements or using appropriate strategies to present information descriptions and concluding relationships between statements, descriptions, questions and ideas that have been made using deductive and inductive reasoning.
4. Inference, as a process of identifying and obtaining the necessary elements to describe a logical conclusion in the form of a hypothesis by considering information and data.

It cannot be denied that technological developments have had their own influence on students' thinking abilities. Along with the development and integration of Learning Management System (LMS) as a technology in learning activities, appropriate assessment techniques are needed, one of which is authentic assessment. Authentic assessment is a significant measurement of student learning outcomes in terms of attitudes, skills and knowledge (Svinicki, 2004). Authentic assessment can also be interpreted as a process of gathering information about the development and achievement of learning carried out by students through various techniques that are able to reveal, prove or show precisely that learning objectives have been truly mastered and achieved (Gulikers, Bastiaens & Kirschner, 2004). Authentic assessment is a form of assessment by asking students to perform "real world" assignments that demonstrate the meaningful application of knowledge and skills (Mueller, 2008), as well as attitudes, that they need to use in their professional lives (Rennert-Ariev, 2005; Lombardi, 2008). Authentic assessment involves various forms of performance measurement that reflect student learning, achievement, motivation, and attitudes towards activities relevant to learning (Herrington & Oliver, 2000). Implementation of authentic assessment is not only carried out in offline learning, but can also be implemented in online learning (Mueller, 2005; Herrington & Kervin, 2007). Implementation of authentic assessment is carried out by assessing the work that has been done by students and uploaded to the learning management system (LMS) based on the assessment rubric that has been made and validated previously (Barber, King & Buchanan, 2015). In authentic assessment, students will be involved in activities to practice how to apply their knowledge and skills to new assignments. This assessment model is more of a standard setting than standardization of test instruments. The assessment process will involve various activities such as oral interviews, problem solving both individually and in groups, performance, and creative portfolio writing (Callison, 1998; Rennert-Ariev, 2005).

Several studies have shown that the implementation of authentic assessment has an effect on critical thinking skills (Hairida, 2016; Suastra & Ristiati, 2019), learning motivation (Skaik & Borg, 2018) and science process skills (Duda, Susilo & Newcombe, 2019). The assessment is carried out by actually utilizing technological assistance, it will increase the effectiveness of learning, especially online mode. LMS allows students to get satisfaction from the assessment made on what they have done. This is because they can see immediate feedback through authentic assessments. In addition, students have the opportunity to review lecture topics and discussions so as to enable them to get additional thinking time to learn, reflect and solve problems based on other supporting learning resources. This research attempts to implement authentic assessment using LMS as an online learning mode technology for the Fundamental of Analytical Chemistry course. This course is used in research because it is relevant to real problems of everyday scientific phenomena that can be explained by chemistry. For example, students learn about qualitative analysis which is the identification of sample components with specific reagents. In addition, students practice to perform quantitative analysis such as determining the amount (grams, percent) of a chemical in the sample component. Because lectures emphasize the ability to master lecture material logically and scientifically and the ability to use the scientific method in solving everyday phenomena, this supports the implementation of authentic assessment. However, the use of the LMS for online mode of lectures is not yet optimal, so that the assessment in this course is not optimal because it has not been able to confirm the results of student work, whether they really understand the chemistry concepts studied in this course. Therefore, in this study, researchers tried to apply authentic assessments to confirm their understanding of real phenomena through the analytical chemistry concept. Thus, the research question proposed in this study was how does the using of Learning Management System (LMS) on Fundamental of Analytical Chemistry course affect students' critical thinking skills through an authentic assessment?

Research Method

This research is experimental research in which the researcher controls at least one variable, controls other relevant variables, and observes the effect on one or more dependent variables. The type of pre-experimental design used in this study is a one group pretest-posttest study. The independent variable in this study is a technology-based authentic assessment applied to the Fundamentals of Analytical Chemistry course. Meanwhile, the dependent variable in this study was students' critical thinking. The population of this study were all students of the 2nd semester of the Chemistry Udergraduate Program who took the Fundamentals of Analytical Chemistry course. Because not all members of the population were selected as samples, the sampling technique used was simple random sampling (N=26).

Critical thinking instrument was developed in the form of essays which include 4 indicators of critical thinking skills, namely interpretation, analysis, evaluation, inference (Facione, 2013). Theoretical validity was done by asking for the assessment of experts in the fields of chemistry and education. The expert examines the suitability of the statement with each indicator, sentence structure and content of the instrument. Suggestions from experts are considered and revised to improve the quality of the instrument. The results of expert validation in terms of appearance and content show that the instrument can be used with a value of 4 out of 5 criteria. The instrument repairs were carried out according to expert input to be corrected in the second stage and used in research.

Table 1. Critical thinking instruments' indicator

Critical Thinking Aspect	Indicators	Question Number
Interpretation	Given information about the qualitative analysis of cations experiment results, students are expected to explain the meaning of the solution test result to identify the contents of Ag^{+}, Pb^{2+} and Hg_2^{2+}	1
Analysis	Given information about the analysis of the qualitative experimental results of chloride compounds of Ag^{+}, Pb^{2+} and Hg_2^{2+}, students are expected to explain the actual relationship between concepts about the results of the separation of each ion through the addition of K_2CrO_4 solution and the formation of PbCrO4 precipitate products to show the amount of $PbCrO_4$ untuk menunjukkan banyaknya ion Pb^{2+} in the sample	2
Evaluation	Students are able to use appropriate strategies to infer relationships between statements about determining the % mass of a salt compound based on the experimental procedure of the titration reaction to the precipitate resulting from an anhydrous homogeneous mixture containing salt compounds of barium chloride, magnesium chloride, and barium nitrate using silver nitrate.	3
Inference	Given information about the formation of $BaSO_4$ precipitates, students are able to formulate hypotheses based on the precipitate titration test procedure using silver nitrate.	4

Authentic assessment which is applied in the fundamentals of analytical chemistry lecture activities, is a form of assessment that tries to give the meaning of chemistry as close as possible to reality in the social and natural environment of students. Through this intervention, ideally, can measure what should be done by the tasks (Mueller, 2007). In this assessment, students demonstrate certain skills and competencies, namely applying the skills and knowledge they have mastered (Stiggins, 1987) so that researchers can assess students' chemistry abilities in contexts that are very similar to actual situations. Materials and assessment assignments look as natural as possible so that students are expected to be able to use the knowledge and skills acquired in the real world critically. Authentic assessment has four steps: (1) identifying standards (basic competency), (2) selecting authentic tasks; (3) identify task criteria; (4) creating a rubric. Teaching intervention is shown at Table 2.

Table 2. Teaching intervention

	Activities
Preliminary	At each meeting, the lecturer provides an overview of phenomena that are relevant to the lecture theme at each meeting. This is done as an initiation of students' thinking skills to be able to construct their understanding of real phenomena. Furthermore, discussions and learning activities are carried out in

	groups. In this section the lecturer conveys basic competence as the initial stage of authentic assessment.
Core	In the core part of learning, there are no specific learning steps that are carried out based on a particular strategy. In this section the lecturer focuses more on assessing the student learning process in real terms and determining authentic tasks *for students* in the form of writing written reports on the results of group work. 1. Students discuss to determine the actual problems of the articles they find. With the help of LMS, students can write their reasons more freely to be revealed and written based on their understanding. Researchers assess their process of determining credible sources of articles and the reasons why those articles were selected. At this stage, the authentic assessment carried out by the researcher is to observe student participation in group discussion activities. Participation that is directly observed here is whether students actively provide ideas for the theme of environmental problems to be discussed, proven through experimentation, and belief in ideas based on certain literary sources. 2. Students carry out experiments in laboratories that are relevant to the problem topics they choose. This is done because the Theoretical Analytical Chemistry course is integrated with practicum. At this stage students conduct experiments with certain procedures and analyze them based on the results of the experiment. Ideally, students are able to present arguments about the results of their experiments based on chemical concepts and techniques when conducting experiments. Discussion activities, conducting experiments, analytical skills, argumentation, written communication are some of the variables to determine authentic assessment criteria in this study so that they can be observed through rubrics. So that the authentic assessment carried out at this stage is a process rubric of how students formulate relevant experimental procedures. Inaccuracy in the selection of procedures, tools, and experimental materials will be a reflection of the student learning process. In addition, the process of determining the data to be taken is also part of the observation. This is because students should first understand the concept of chemistry and then implement it in the experiments carried out. 3. Students present experimental results and relate them to the concepts they understand when identifying articles. Changes in the understanding of the concept before and after conducting the experiment becomes an evaluation of the understanding of certain natural phenomena that can be explained by chemistry. Authentic assessment carried out at this stage is the ability of students to convey the results of their experiments using scientific language. at this stage the researcher uses a scientific communication rubric and a results report writing assessment rubric.

Closing	Feedback is directly given by the lecturer to confirm student understanding. Ideally, this can be used as material for reflection on student learning to understand chemistry concepts correctly and improve the learning process in the next meeting.

Result and Discussion

The research results in this report are presented based on the results of descriptive statistical analysis and inferential statistics. The results of descriptive statistics in this research on critical thinking skills, as can be seen in Table 3 below.

Table 3. Descriptive statistical results of critical thinking skills

Critical Thinking Aspects	Pretest			Post-test		
	N	Mean	SD	N	Mean	SD
Interpretation	26	75.46	3.98	26	78.15	3.96
Analysis	26	69.46	4.90	26	70.62	4.68
Evaluation	26	71.19	3.51	26	72.54	3.48
Inference	26	71.19	3.02	26	70.54	3.34
Overall	26	71.83	3.23	26	72.96	2.81
Highest Score	82			85		
Lowest Score	60			60		
n-gain	0.0402					
n-gain Cathegory	increase					

Based on Table 3, it can be seen that after the Technological Authentic Based Assessment was applied to the fundamental of analytical chemistry class, students' critical thinking skills increased (M=72.86) compared to the average pre-test score (M=71.83). Furthermore, the Wilcoxon Test was carried out to analyze differences in students' critical thinking skills before and after the implementation of Technological Authentic based Assessment. The results of the Wilcoxon test on learning critical thinking skills can be seen in Table 4.

Table 4. Results of wilcoxon test analysis for critical thinking

Data	N	Mean Rank	Sum of Rank	P	Conclusion*
Pre-test	26	9.50	9.50	0.000	significant difference
Post-test	26	11.08	221.5		

*Sig 0.05

During lectures, researchers use the help of technology platforms to implement authentic assessments. In this research, it is called as TbAA. This is done by assessing the results of discussions or works that have been done by students and uploaded to the learning management system (LMS). In authentic assessment, students apply their knowledge and skills to assigned tasks, such as solving problems relevant to analytical chemistry concepts, portfolios and reports in groups. This became a treatment during the research, so that at the last meeting a post-test was carried out to see the effect of applying TbAA. The post-test results were compared with the pre-test to answer the research objectives.

In accordance with the aspects of the ability to think critically (Facione, 2013) as outlined in the critical thinking questions and analyzes that have been carried out, the results are that:

a. Interpretation ability of students tends to increase. This ability is a process for students to understand and express a meaning from assessments, events, experiences, situations, data, conventions, criteria, rules, or procedures, including categorizing, describing and explaining the meaning of an issue.
b. Students' analytical abilities tend to increase. This ability is a student process to identify the intent and actual relationship between concepts, statements, descriptions, questions, to state what is believed to be the result of evaluating arguments and information to produce appropriate explanations.
c. Student evaluation abilities tend to increase. This ability is a student process for assessing the credibility of statements or using appropriate strategies to present information descriptions and concluding relationships between statements, descriptions, questions and ideas that have been made using deductive and inductive reasoning.
d. Students' inference ability tends to decrease. This ability is related to the process of identifying and obtaining the elements needed to draw logical conclusions in the form of hypotheses by considering information and data.

Based on these results, the implementation of TbAA in Fundamental of Analytical Chemistry courses is a learning method that can improve students' critical thinking skills. This is because authentic assessment can assess a variety of contexts that are very similar to the actual situations in which these abilities are used. Increasing students' critical thinking can increase because in this intervention they need to construct their own understanding of nature and use the information they have collected from lecture material. Thus, the assessment, which is facilitated through the LMS, provides an opportunity for students to write freely the results of tracing certain natural phenomena that can be explained with chemistry. For example, ozone depletion which can be explained by the phenomenon of increasing motor vehicle pollution. This phenomenon needs to be proven through experiments. Experimenting means that students need to develop their own research procedures and tools, then explain chemical concepts. Through TbAA, students must also be asked to demonstrate that they have been able to reflect on their learning process.

Another factor, TbAA tends to give students more freedom in how they will demonstrate what they have learned by carefully identifying other scientific phenomena. Although student performance may be expressed very differently from one student to another, in this TbAA, the researcher assesses through authentic contexts using examples that are considered meaningful to students. In addition, the information that students collect into the LMS demonstrates their ability to communicate, process, apply, and construct knowledge. For example, how do students find articles in the context of chemistry, explain, and generalize information. Directly, through the LMS, researchers provide feedback to students about how their learning process is, how well they learn, and which parts need improvement. In this way, students are able to reflect on their learning process to be able to develop their critical thinking skills.

The results of this study are supported by previous research that authentic assessment can measure various cognitive skills. This means that authentic assessment measures how well students can apply what they know in real life (Razmawaty, 2017). The use of various indicators and portfolios in authentic assessment can measure identified higher order thinking skills such as critical thinking, which may not always be identified in exam questions, this is because authentic assessment involves complex

tasks in terms of cognitive level (Damayanti, 2017). Therefore, it can be said that authentic assessment has high potential to measure higher order thinking skills. Through the implementation of this research, some of the challenges for implementing authentic assessment are that the level of assessment literacy required is quite high, while it is possible that the lecturer is already racing against time to complete the many learning objectives, so that time and resources need to be considered (Koh, Tan & Ng, 2012). In addition, authentic assessment does make students want to think openly and be literate. It is relevant to the 21st century that knowledge relevant to teaching and competency assessment is a future challenge. From the results of this study, authentic assessment is recommended to be implemented in science learning. the use of LMS during online mode of learning may not be sufficient to measure student understanding, so an authentic assessment is proposed. This is due to the authentic assessment of analytical skills and their integration in the real world, so that students can reflect on their thinking skills creatively and collaboratively. In addition, as long as the authentic assessment is carried out with the help of the LMS, it is recommended to involve more observers and equalize perceptions.

Conclusion

Based on the results of the research and discussion, it can be concluded that there are significant differences in students' critical thinking abilities in the using of Learning Management System in Fundamentals of Analytical Chemistry lectures through the authentic assessment. The need for an authentic assessment activity for science students so they can develop critical thinking skills and practical skills with a combination of technology to improve evaluation performance. Thriugh the authentic assessment of analytical skills and their integration in the real-world initiates students to reflect their thinking skills creatively and collaboratively.

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