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An Innovative Chemistry Learning Material With Project and Multimedia to Developed Students Thinking Skill on the Teaching of Anion Analysis

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ABSTRACT
Students' thinking skills become the target life skills to be achieved at State University of Medan and can be supported through learning innovation. This research aims to develop an innovative project-based learning with multimedia to build critical thinking skills of students in teaching of Anion analysis. This study was carried out by developing mini project sets on the topic of Anion analysis followed by multimedia integration into the chemistry learning resource. The learning package is then implemented to guide students to carry out independent learning. The results showed that an innovative project-based learning resource with multimedia was successfully built for the subject of Anion analysis. An innovative learning resource has successfully been used to guide the students to study chemistry independently without having to be in a laboratory. Analytical Chemistry teaching can be done from home during the lockdown period to avoid the danger of diseases caused by Corona virus diseases (COVID-19). The contents of the chemistry contained in an innovative learning resource has succeeded in building critical thinking skills and ultimately improve students outcomes. Projects examples available in teaching materials presented in the form of video that can guide the students to learn to analyze and synthesize new knowledge. Students who are taught by using an innovative learning resources in experimental group (M = 81.90±4.49) are having higher score compared to those of the control group (M = 78.46±5.55) who study by using students handbook.

Keywords: *Innovative learning resource, Project with multimedia, Thinking skills, Students outcomes, Anion analysis, Covid-19*

1. INTRODUCTION

Students' thinking skills become the target life skills to be achieved when implementing the competency curriculum set by the Indonesian National Qualification Framework (Kerangka Kualifikasi Nasional Indonesia, KKNI) at Universitas Negeri Medan [1,2]. The University policies must be supported through the application of learning strategies to build appropriate knowledge and skills after completing the subjects they are learning. Learning innovation is one of the strategies that can be used to improve the quality of education, because it will be able to produce new knowledge in accordance with the latest technological advances [3]. Learning innovation is the main key in providing innovative learning resources that can be used by students in optimizing their learning in order to fulfill the desired competencies in accordance with the demands of the KKNI-based curriculum [4]. An innovative learning resource that is supported by technological advancements become a good choice because they are believed to be able to guide the students to learn independently, especially during the Pandemic COVID-19 period, which expects the students to learn from home. An ideal innovative learning resource is integrated with the latest technology that can facilitate students to learning optimally according to their needs, and learning activities can be done at any time without being limited by time and place. One of the demands of the KKNI-based curriculum is the fulfillment of competencies for students, namely to have sufficient skills and knowledge in the field of science they are learning. Learning innovation is also directed to build students' critical thinking skills, which in turn can improve their competence [5].

Various strategies have been carried out to improve the competence of students, especially students

majoring in chemistry to become chemists, such as the application of learning methods and strategies, the use of instructional media, and the application of innovative learning [7-9]. Innovative learning is a strategy in engineering a learning, or the efforts to improve academic activities to produce new learning. Innovation can be done in various aspects such as designing instructional materials, directing the learning atmosphere, and changing learning activities inside or outside the classroom to adjust to the curriculum. Innovative learning has been proven effective in improving student learning outcomes in higher education, including chemistry teaching. Various innovation steps have been taken to produce innovative learning so that there are good learning resources and standards to support lectures. One of them is a project-based learning innovation that is directed at fulfilling innovative learning resources that leads students to active learning [10,11]. Innovative project-based learning resources have been proven to be effective to facilitate the students in developing critical thinking skills. The ability to think critically is a skill that must be possessed by students as prospective chemistry teachers. In addition, project-based learning resources have also been proven to play an important role in facilitating students to learn independently in order to achieve the desired competence in the field of chemistry. An innovative project-based learning is able to stimulate critical thinking skills as one of the soft skills that students must master to be able to complete globally.

Analytical Chemistry course is one of the compulsory subjects for students in the Department of Chemistry. Studying Analytical Chemistry can build students knowledge and skills in the field of analytical determination relating to the presence of chemicals compounds qualitatively and quantitatively [12-14]. This course is very interesting, and becomes a very challenging, because it can be a strategy for building critical thinking skills which combines the theory and practice, and also involves knowledge and skills in the use of instrumentation for the purposes of analysis. One of the subject matter that must be mastered by students is Qualitative Analytical Chemistry, namely the knowledge of chemistry that studies the presence of substances or chemical compounds in the sample. The knowledge of qualitative analytical chemistry starts from studying the subject of Anion Analysis. Thus, innovative project-based learning is very relevant for teaching Analytical Chemistry. The purpose of this research is to develop an innovative learning material integrated with project and multimedia in the topic of Anion Analysis to be used as a learning resource to build students' critical thinking skills in Analytical Chemistry.

2. METHOD

2.1. Population and Sample

The study was carried out in the Department of Chemistry Education, Faculty of Mathematics and Natural Sciences (FMIPA), Universitas Negeri Medan at academic year 2019/2020, during the Pandemic COVID-19 time. The study was conducted involving 58 students who were selected purposively, divided into two groups, namely the experimental group and the control group.

2.2. Research Procedures

The research includes the development of an innovative learning resources with projects and multimedia, standardization of learning resources, and implementation of the resource in the teaching of Analytical chemistry. The steps to do this study were carried out following the procedures described in the previous studies [15,16]. The development of learning resources is done through the preparation of complete teaching material for the subject of Anion analysis, compiling the project packages to support the teaching material, and integrating multimedia to facilitate the students to study Anion analysis. Standardization of innovative learning resources is carried out by using of a set of standard questionnaires that are distributed to expert lecturers who are experienced in teaching Analytical chemistry. The developed learning package is assessed by the lecturer, and all input provided by expert lecturers is accepted to improve the quality of learning resources.

The experimental group is a class of students who are taught using innovative learning resources resulting from development, while the control group is students who are taught using the Analytical Chemistry textbook. The implementation of innovative project-based learning resources and multimedia is done by distributing innovative teaching materials to the experimental group students, and as a comparison, textbooks are required to be owned by the control group students. Next to the experimental group and the control group given online teaching aims to explain the project assignments that will be done by all students. Teaching is done using the Google classroom learning application. At the time of the short teaching, all targets for the learning bills (assignments) will be outlined to be fulfilled by students while learning from home during the COVID-19 pandemic. The timetable for the submission of project proposals and project reports, as well as the final exam is specified in detail in the short lectures conducted online. All tasks collected, in the form of project proposals and project final reports, are used to assess the achievement of students' thinking skills on analytical chemistry, as well as to measure

student skills in project implementation. Formative examination is carried out at the last stage of the study aimed to measure the level of mastery of student knowledge on the subject of Anion analysis.

3. RESULT AND DISCUSSION

3.1. Innovation of Project-Based Learning Resources and multimedia

Innovative learning packages with projects and multimedia have successfully been developed for the teaching of Anion Analysis. Learning packages for subject Anion analysis is compiled systematically, consisting of complete chemical materials, incorporating project packages into teaching materials, and multimedia integration to facilitate online learning. Teaching material of Anion analysis consists of 5 sub-chapters, and has 10 mini project titles that are relevant to the teaching material in each sub-topic [17]. A brief description of learning innovations is summarized in Table 1, and a complete arrangement of mini projects can be seen in previous research [18]. Supporting learning facilities available in innovative learning packages include project implementation guidelines, observation sheets, project implementation report formats, and questions that need to be answered by students. Furthermore teaching materials are packaged into a compact learning resource in the form of soft copy (electronic-book) that is ready to be uploaded into a learning resource on the website for teaching the subject of anion analysis. Learning resources for subject matter of Anion analysis is then packaged in an attractive design for later use in online learning. To facilitate the students to study anion analysis, the teaching material is equipped with the objectives and the targets learning outcomes to be completed by students. The contents of the teaching material are supplemented with contextual case examples of anions analysis, that is presented in the form of learning videos to make the students able to repeat the teaching material freely, and have the opportunity to observe the projects and multimedia at any time. The project package contains project implementation procedures, observation techniques, and chemical handling in order the students can design and implement their own projects in accordance with the target anions qualitatively [19,20].

3.2. Standardization of Learning Resources for Anion Analysis

Innovative learning packages with projects and multimedia have been standardized to see the feasibility of teaching material to be used as a learning resource for undergraduate students on teaching of Anion analysis. The results from expert respondents' assessments are summarized in Table 2. The respondents generally agree with the learning material that has been packaged and have given a good assessment to each of the components in teaching materials in accordance with the criteria set by the Indonesia National Education Standards Agency (BSNP). The assessment results for all components were an average of 3.72, which is classified as very good. Expert respondents stated that the innovative teaching material developed for the subject of Anion analysis has met the criteria in all components, such as: the complete contents of the chemical material, the contextual material coverage, the depth of teaching material for college students, the design and appearance of the material, the writing presentation, illustrations and readability, the language, grammar, language that is easy to understand, and writing chemical formulas that are correct [21,22].

Table 1. Description Innovation of learning resources and titles media or multimedia/projects examples for the teaching Anion analysis

No	Sub subjects	Types of innovations that are integrated into teaching materials	Media or multimedia titles / Mini project titles
1	Introduction to Analysis Anion	The development of teaching materials for analysis of anions, integration of power point, website packaging and student learning projects	Project 1: Grouping of anions based on specific reactions
2	Preliminary reactions to anions	Enrichment of material Preliminary reactions to anions, examples of learning videos showing anion reactions and integration of student learning projects	Project 2: Testing and confirmation of the presence of the oxidizing anion and the reducing anion
3	Specific reactions to anions (Part I): Testing of sulfide anions (S^{2-}); sulfite anions (SO_3^{2-}); and sulfate anions (SO_4^{2-})	Enrichment of teaching materials for Specific Reactions to Anions (S^{2-}, SO_3^{2-}, SO_4^{2-}), website packaging for teaching of Anion analysis, integration of student learning projects, and provision of practice questions	Project 3: Testing of sulfide anions (S^{2-}) with hydrochloric acid Project 4: Determination of sulfite anions (SO_3^{2}) by using based solution Project 5: Determination of sulfate anions (SO42-) in water

4	Specific reactions to anions (Part II): Testing of carbonate anions (CO_3^{2-}); nitrite anion (NO_2^-); and Nitrate anion (NO_3^-)	Enrichment of teaching materials for special reactions to anions (CO_3^{2-}, NO_2^-, NO_3^-), power point media integration, website packaging for anion specific reactions, integration of learning projects and practice questions	Project 6: Testing carbonate anion (CO_3^{2-}) in chicken eggshells Project 7: Testing nitrite anion (NO_2^-) with urea Project 8: Testing nitrate anion (NO_3^-) in cabbage
5	Specific reactions to anions (Part III): Testing of anion iodide (I^-), bromide (Br^-), and chloride (Cl^-). Specific testing for phosphate anions (PO_4^{3-}) and Chromate anion (CrO_4^{2-})	Enrichment of teaching materials for special reactions to anions: iodide, bromide, chloride, phosphate, and Chromate, integration power point media, website packaging, learning projects and exercise	Project 9: Testing the presence of halide anions (Iodide, Bromide and Chloride) in river water samples. Project 10: Determination of phosphate anions (PO_4^{3-}) in well water

Table 2. The opinions of expert respondents (L) towards the components of a project-based learning material for Alkenes topic

No	Assessment criteria and the description components of learning resources	Respondents opinion* (*M*±*SD*), L (*n*=4)
1	**The Content:** the depth of the contents of teaching materials and the suitability of the contents of chemical materials to the competency target of Analytical Chemistry	3.72±0.46
2	**The Extension:** Mini project and multimedia integration, the learning resource support facilities, the project implementation guidelines with assessment rubrics, and the hyperlinks on web sites	3,70±0.46
3	**The Depth:** Clarity and depth of contents of the project package, systematic suitability and availability of examples of analytic applications	3.66±0.51
4	**The Design:** Systematic of typing, design and layout, presentation of images, illustrations, tables, and color settings	3.70±0.46
5	**The Language:** The use of language and grammar, the readability of the content, the writing of chemical formulas and terms, and the suitability of the content with students maturity level.	3,70±0.48
	Average	3.72± 0.47

3.3. Implementation of innovative learning with projects and multimedia

The developed standard innovative learning package has been used for teaching Anion analysis. Due to the fact that during the COVID-19 Pandemic period, the students were required to learn from home, then the learning activities are done online. Student learning relies only on innovative learning packages and learning resources available online. Assignments are given to students to plan their respective projects, and their implementation is modified without having to carry out activities in the laboratory [23-26]. The new project plan starts after obtaining approval from the lecturer (instructor / researcher). Projects must be forced to do by imitating the project examples contained in the learning package. All stages of the implementation of this project, from planning, implementation, to reporting become aspects of project appraisal. Assessment of students' critical thinking skills is viewed from the submitted projects (proposals and reports) which is reported by students online. The components of students 'thinking ability are summarized in Table 3. These results indicate that the students' critical thinking skills for the Anion analysis in the experimental group and control groups belong to good category. The value of students' critical thinking skills in the experimental group (M = 83.41±051) was higher than the control group (M = 77.80±0.60). These results indicate that innovative learning packages can improve students' critical thinking skills.

Table 3. Assessment of students' critical thinking skills based on project implementation (Project Proposal and Report) for the Anion analysis Subject

No	Aspect of critical thinking	Description of critical thinking skills	Student's achievement*	
			Experiment	Control
1.	Interpretation	The skills in understanding the problem, which is shown from the ability to identify and choose theories that are relevant to the objectives of the Anion Analysis project	83.62±0.61	76.72±0.65
2.	Analysis	The skills in analyzing the relationship between theory and its application in project implementation, that is shown from the ability to plan, implement, and report project activities	77.59±0.49	72.41±0.67

		correctly		
3.	Inference	The skills in using appropriate strategies for contextual implementation of projects in accordance with the Anion Analysis topic	91.38±0.48	87.93±0.51
4.	Evaluation	The skills in evaluating the results already obtained which are shown from the suitability of the project with the concept of science that already exists in anion analysis	81.03±0.44	74.14±0.57
	Average		83.41±0.51	77.80±0.60

An innovative The ultimate goal of implementing innovative learning with projects and multimedia is an increase in student learning outcomes caused by an increase in critical thinking skills in the teaching of Anion analysis. Student learning outcomes are obtained from both the value of the project report and final test (posttest) as summarized in Table 4. The value of the project report in the experimental group (M = 81.03±4.43) is higher than the control group (M = 78.14±5.34). Learning outcomes based on final exam scores for students in both class are also noted. The average value of student learning outcomes learned using an innovative learning resources (M = 82.76±4.55) is higher than the value of students who are taught by using student handbooks (M = 78.79±5.77). These results confirm that the average learning outcomes in the experimental group (M = 81.90±4.49) are higher than those of the control group (M = 78.46±5.55). It can be stated that innovative learning with projects and multimedia can effectively develop students' critical thinking skills in teaching anion analysis, and subsequently have an impact on improving student learning outcomes [27,28].

Table 4. Students learning outcomes in the experimental group and control group in teaching anion analysis

No	Assessment aspects of Learning outcomes	Student achievement score	
		Experiment (n=29)*	Control (n=29)**
1	Reports (proposal and project report)	81.03±4.43	78.14±5.34
2	Formative Exams (Postest)	82.76±4.55	78.79±5.77
	Average	81,90±4.49	78,46±5.55

4. CONCLUSION

Innovative learning packages with projects and multimedia for teaching Anion analysis has successfully been developed and standardized into become an effective learning resource for undergraduate students to develop students' critical thinking skills. The chemical material contained in the innovative learning package consists of 5 sub-topics and 10 mini projects. Expert respondents gave an excellent assessment of the learning package, and were declared appropriate as a learning resource for undergraduate chemistry students. The results show that innovative learning resources are very effective in increasing skills and knowledge in Analytical chemistry. The innovative learning package implemented in the experimental group provides higher learning outcomes than the control group that uses student handbooks. The value of students' thinking skills in the experimental group and the control group was good. Student learning outcomes, which are seen from the average value of project reports and formative exams, show a very good value. The mean score of the experimental group (M = 81.90±4.49) was higher than the control group (M = 78.46±5.55). It is recommended that innovative learning with projects and multimedia can be implemented for the teaching other subjects because it has been proven to be able to develop students' thinking skills and at the same time improve learning outcomes.Figures and tables should be placed either at the top or bottom of the page and close to the text referring to them if possible.

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