Implementation of Discovery Learning Resources in Teaching Cation Analysis to Improve Higher Order Thinking Skills and Student Learning Outcomes

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Abstract. This study aims to improve higher-order thinking skills and student learning outcomes through the implementation of discovery learning resources in the teaching of cation analysis in groups IV and V. This study was conducted at the State University of Medan in the academic year 2022–2023. The research involved 60 students and was divided into two classes: the experimental class, taught with discovery learning resources and the control class, taught with the student handbook. The implementation of discovery learning resources could improve students' higher-order thinking skills, as seen in the preparation of project plans (M = 75.892.26) and project reports (M = 81.944.16). The learning outcomes in the experimental class (M = 86.20 5.59) are higher than the scores in the control class (M = 78.80 5.24). It is concluded that the discovery of learning media with the acquisition of standardized values (M = 3.570.41) is feasible to be implemented in the teaching of Analytical Chemistry.

Keywords: Discovery, Learning outcomes, Cation Analysis

1 Introduction

In learning activities, students' higher-order thinking skills are fundamental in improving student learning outcomes.[1] Therefore, learning activities must emphasize higher-order thinking skills, especially in chemistry learning, which requires an active role in cognitive and psychomotor.[2] Moreover, the chemistry learning material has never been taught in high school and is only learned when students are in college. One of which is qualitative and quantitative analysis material. Therefore, learning strategies are needed that can explore students' abilities in learning activities.[3] When learning activities are taught using blended learning at the State University of Medan, it is undoubtedly a challenge for educators to realize the importance of implementing active learning methods that can help create more optimal learning activities. [4.5]

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Moreover, there is a restricted time when participating in practical learning due to pandemic conditions, requiring students to know more about experiments that cannot be practiced. Therefore, interactive and communicative media-based electronic resources are needed to include material, learning videos, practicum guides, and videos of practicum experiments from the coverage of material that can be developed by utilizing web technology in e-book format, which can help students to recognize the characteristics of the material before participating in learning both online and offline.[6]

In developing chemistry learning resources, many experts argue that the discovery method is effective in learning during the COVID-19 period or after the end of the pandemic.[7] Some experts have proven that discovery learning can improve students' cognitive science skills. [8] Also, using discovery learning resources makes learning more qualified. [9] and making it easier for educators to guide students in understanding learning concepts. [10] A study shows that using discovery learning resources increases the initial knowledge of students majoring in chemistry and biochemistry departments in learning that requires theoretical and practical skills. So the selection of this method is the right decision to apply to chemical matter. [11] Other research has also proven that students accustomed to being taught using the discovery method will be more accustomed to finding, determining, and inferring the material taught by themselves so that more insights into the science are understood. [12]

Learning syntax through discovery has proven to be better than the PBL method. Discovery learning requires students to think critically and creatively twice when finding and solving problems. At the same time, problem-based learning requires students to think critically and creatively once when faced with problems given by the teacher. [13] So, the discovery method is constructive in chemistry lessons, especially analytical chemistry.[14] This study aims to develop discovery learning resources in group IV and V cation analysis courses to improve higher-order thinking skills and student learning outcomes.

2 Methods

This study focuses on the development and implementation of discovery learning resources to improve higher-order thinking skills and student learning outcomes in understanding learning both in theory and practice with learning achievement competencies that must be achieved by the curriculum applied at the State University of Medan, namely the Indonesian National Qualifications Framework (KKNI). Research activities include the development, standardization, and implementation of learning resources.

Population and Sample

The population of this study consisted of chemistry education majors at the State University of Medan in the Faculty of Mathematics and Natural Sciences who took qualitative and quantitative analytical chemistry courses in the academic year 2022–2023. The research sample was selected purposively and grouped into two classes of experimental and control subjects. The experimental class was taught using discovery learning resources, whereas the control class was taught using textbooks.

Reseach Procedure

The research process was carried out in the following stages: (1) To complete the analysis of learning resources. It was necessary to examine the learning materials the State University of Medan had previously employed as the foundation for product creation. (2) The design step is carried out by deciding on the description of the creation of learning materials and learning references. (3) Creation of discovery learning materials on the topic of cation analysis groups IV and V have access to practicum videos that are combined with mini project videos as assignment references, as well as e-book learning tools (5) A feasibility study of the created learning medium is subsequently performed and verified by a team of experts from chemistry lecturers at the State University of Medan to obtain suggestions and improvements. (7) The implementation stage is carried out online and offline through the help of the Google meet application, SIPDA learning, and the WhatsApp group to deliver material and collect assignments during research. (8) The final stage is evaluating the student's final assignment in designing and compiling a practicum project report to see students' high-order thinking skills and student learning outcomes with pretest and posttest as evaluations to determine the improvement of student learning outcomes. Assessment of students' higher-order thinking skills is assessed by assigning project reports done by students and uploaded to the SIPDA application with an assessment system using a 0-100 rubric scale. Learning outcomes are measured by giving a value assessment with a scale of 0-100 on the student's ability to answer practice questions at the beginning and end of learning. Feasibility assessment of discovery learning resources is carried out by material and media expert lecturers using a Likert scale questionnaire with categories (4) very good, (3) good, (2) bad, and (1) very bad.

3 Results

Development of Discovery Learning Resources on Cation Analysis

Discovery learning resources developed on group IV and V cation analysis materials are arranged in the form of learning packages consisting of teaching materials, project packages,

media and multimedia, practical project implementation guidelines, and supporting instruments by competency achievement targets. Learning resources can be accessed through SIPDA to provide materials and collect project evaluation assignments and reports.

The development of discovery resources is equipped with learning materials starting from the introduction of cation, the introduction of reactions on cations, group IV cation analysis, and group V cation analysis. In discovery learning, resources have also been equipped with a mini practicum experiment guide as a basis for project assignments consisting of group IV cation analysis sub-materials: Identification of Barium cations (Ba^{2+}), Identification of Strontium cations (Sr^{2+}), Identification of Calcium cations (Ca^{2+}). Furthermore, chemical material for the sub-topic of group V cation analysis: Identification of Magnesium Cation (Mg^{2+}), identification of Sodium cation (Na^{+}), identification of Potassium cation (K^{+}), Ammonium cation identification (NH_4^{+}). Discovery learning resources are integrated with project assignments in each material coverage, and this is done to train students to get used to exploring and finding proof of the theoretical concepts learned. The description of innovative learning resources includes materials and assignments, as summarized in Table 1.

Table 1. Material Description of Discovery Learning Resources on Cation Analysis Learning

No.	Sub-topic material	Discovery learning resource media integrated material coverage	Project Assignments
1.	Introduction to Cation Analysis	The introduction of cation elements begins by classifying the characteristics of each element with the explanation of the material delivered with the help of cation analysis schemes and Youtube videos.	Project 1: Introduction to Elements and Classification of Elements Cation Group 1-5
2.	Cation Reaction Introduction	Explanation of preliminary analysis and cation reactions if a sample indicated to contain Group IV or V cation elements with the help of mini practicum video learning media uploaded to SIPDA learning.	Project 2: Initial analysis of the reaction of group IV and V cations by conducting a flame test
3.	Analysis of group IV cations Ba^{2+} Sr^{2+}, and Ca^{2+} .	Analysis of Group IV cations: Barium, strontium, and calcium. The process of cation analysis is explained in the video and project sheet and is accompanied by a flow scheme for identifying samples containing Group IV cations.	Project 3: Identification of Barium ($Ba^{2+)}$ in rat poison samples. Project 4: Identification of Strontium (Sr^{2+}) in milk samples Project 5: Identification of Calcium (Ca^{2+}) in milk samples
4.	Analysis of group V cations Mg^{2+}, Na^{+}, K^{+}, and NH_4^{+}.	Analysis of Group V cations: Magnesium, Sodium, Potassium, and ammonium. The cation analysis process is explained in the video and project sheet and is accompanied by a flowchart of the identification process for samples containing Group V cations.	Project 6: Identification of Magnesium (Mg^{2+}) in avocado samples Project 7: Identification of Sodium (Na^{+}) in table salt samples Project 8 : Identification of Potassium (K^{+}) in Salt samples Project 9 : Identification of Ammonium (NH_4^{+}) in Fertilizer samples

Standardization of Discovery Learning Resources on Cation Analysis Materials Groups IV and V

Standardization of discovery learning resources by expert respondents is carried out to ensure the feasibility of discovery learning resources in group IV and V cation analysis learning. The

assessment process is carried out by filling out a media and material feasibility questionnaire according to BSNP (National Education Standards Agency). Respondents' results on a feasibility score of 3.57, with an excellent category. It shows that the discovery of learning resources in terms of delivery of material content, language, material depth, and graphic design is suitable to use as a learning resource for content analysis groups IV and V. The standardization of feasibility assessment by expert respondents can be seen in Table.

Table 2. Standardization of Material Content on Discovery Learning Resources

No.	Description of Material Assessment in Discovery Learning Resources	Respondent Results (M ± Sdv) (n=4)
1.	Contents: The suitability of the scope of teaching materials with the achievement of analytical chemistry competence	3.59±0.37
2.	Language: The accuracy of sentence structure, terms, and message readability.	3.65±0.41
3.	Extension: Availability of learning links on the website.	3.44±0.46
4.	Depth of material: the accuracy of the content of teaching materials and project packages, systematic writing of chemistry and the suitability of learning objectives on the subject of cation analysis	3.56±0.39
5.	Design and graphics: order of presentation of material, layout, pictures and graphics, tables, arranged systematically	3.61±0.42
	Average	3.57±0.41

Implementation of Discovery Learning Resources for Teaching Cation Analysis Groups IV and V

The teaching of group IV and V cation analysis was taught with SIPDA Learning, an application media at the State University of Medan. Learning activities are carried out by blended learning by combining online learning through SIPDA and offline practicum activities to complete the assignments of cation analysis projects. Where each student must choose a sample that contains group IV and V cations often found in the material, the selection is checked by lecturers and instructors after approval. Completion of projects can be completed in offline practicum activities at the chemistry laboratory at the state university of Medan, with examples of experimental videos and guidelines for preparing project reports that can be accessed through the SIPDA application.

Using project tasks to discover learning resources efficiently stimulated students' psychomotor abilities and high-order thinking skills in selecting target analytes used in preparing project reports during practicum learning. Students are more active in practicum activities and enthusiastic about completing project proposal reports collected online through the SIPDA application by the instructions and collection deadlines. The proposals and project reports with an assessment system include analysis, evaluation, and creation assessments to measure students' high-order thinking skills. The proposal score is an average of 75.89, and the final

project report obtained an average of 81.94, with an excellent category. The overall score is shown in Table 3.

Table 3. High-Order Thinking Skills of Students Using Discovery Learning Resources

No.	Higher Order Thinking Ability	Description	Average	
			Proposal	Project Report
1.	Analysis	The ability of students to search for project titles and create a supporting theoretical basis	75.83±2.31	82.50±4.31
2.	Evaluate	Student's ability to analyze the chemicals used samples to be tested	76.00±2.42	82.17±4.29
3.	Create	Student's ability to determine the appropriate strategy in completing project reports	75.83±2.96	81.17±3.87
		Average	75.89±2.26	81.94±4.16

* Obtained from a subjective assessment using project appraisal rubric criteria

Furthermore, student learning outcomes from the two classes with different treatment characteristics were evaluated using pre-test and post-test to measure the average learning outcomes. Evaluation activities were carried out using the same instrument test. The pre-test value in control and experimental class averaged 30.67 and 30.90. The final test in the experimental class was carried out with an average of 86.20, as shown in Table 4.

Table 4. Differences in Learning Outcomes of Experimental and Control Classes

No	Aspects of Assessment of Learning Outcomes	Student Learning Score	
		Experiment (n=30)	Control (n=30)
1	Pretest	30.90±6.07	30.67±5.21
2	Posttest	86.20±5.59	78.80±5.24

4 Discussion

The implementation of discovery learning resources with project assignments received a positive response from expert respondents, so they obtained an excellent feasibility value to be used as a learning resource in online and offline learning conditions. Project tasks in discovery learning resources are prepared with video, e-module, project video, and project preparation instrument arranged by the competencies to be achieved in groups IV and V cation analysis. Discovery learning is based on the principle that students can more wholly and actively control themselves to understand the concept of learning media that facilitates the learning process.[15]

Discovery learning resources used in learning cation analysis groups IV and V have proven successful in increasing students' ability, as seen from the results of subjective and objective

acquisitions to measure higher-order thinking skills and student learning outcomes in working on initial and final evaluation instruments, as well as students' abilities in analyzing assigned projects. Students' high-order thinking skills can be seen in how they choose the target analyte in the actual sample, prepare their project reports according to the instructions, make conclusions and report the results of project work on time.

The discovery model has provided a more memorable online learning experience.[16]In addition to providing exciting learning, cation analysis learning not only focuses on academic abilities but also emphasizes the psychomotor abilities of students in carrying out project assignments to improve high-order thinking skills. The research results show that using the discovery model improves learning.[17] The discovery learning method in learning activities can increase students' abilities and enthusiasm for participating in learning.[18] Using HOTS (High Order Thinking Skills) based learning tools, the discovery learning model will provide different conditions for passive learning to be active and creative. [19]

5 Conclussion

The development of discovery learning resources in group IV and V Cation Analysis courses received a good response from expert respondents by obtaining a feasibility value ($M = 3.57 \pm 0.41$). The discovery of learning resources taught in the experimental class improves higher-order thinking skills with an average ($M = 81.94 \pm 4.16$). Moreover, discovery learning impact the acquisition of the final learning outcomes of experimental class students with a suitable category ($M = 86.20 \pm 5.59$) and higher than the control class taught using textbooks with an average score ($M = 78.80 \pm 5.24$). Thus, discovery learning resources are feasible and effective for improving students' higher-order thinking skills and learning outcomes in group IV and V cation analysis courses.

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