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Implementation of Innovative Learning Material With Project to Improve Students' Outcomes on the Teaching of Hydrocarbon Alkenes

Jamalum Purba[1], Manihar Situmorang[2*], Ramlan Silaban[1] and Ratu Evina Dibiyantini[1]

[1]*Department of Chemistry Education, Graduate Study Program (Program Pascasarjana), Universitas Negeri Medan, Medan, North Sumatera, Indonesia*
[2]*Department of Chemistry, Faculty of Mathematics and Natural Sciences (FMIPA), Universitas Negeri Medan, Medan, Indonesia*
[*]*Corresponding author. Email: msitumorang@unimed.ac.id*

ABSTRACT
Competence is the target to be achieved when implementing an Indonesian National Qualification Framework curriculum. The implementation of an innovative learning material is believed to be able to facilitate students to achieve their competence in the field of organic chemistry. This research aims to provide an innovative project-based learning material Alkenes topic to improve students' outcomes on organic chemistry as required by the national curriculum. This research was carried out by developing sets of mini projects followed by the integration of the projects into the learning materials become a project-based learning package. The learning package is then used to guide students to learn independently in designing their projects on Alkenes topic. The result showed that an innovative learning package with projects has successfully been developed. The feasibility of teaching material has been validated by experts. The developed learning package is suited to the needs of first-year students, and is categorized as very good (M=3.75±0.42). The implementation of a project-based learning material in the classroom proved to be very effective in helping students to learn organic chemistry independently. Students enjoy learning chemistry by using the developed learning package. The facilities in the learning material help students to improve their knowledge and skills to meet the targets competencies assigned in chemistry curriculum. Student learning outcomes obtained from portfolio of project assignments (M=87.28±2.57) and final evaluations (M=78.92±6.26) are all classified as very good. The learning model developed in research is ideally used to facilitate active learning in building knowledge and skills in the field of organic chemistry.

Keywords: *Innovative learning, Project-based learning, Students outcomes, Active learning, Organic chemistry*

1. INTRODUCTION

Improving learning outcomes in accordance with competencies is one of the desired targets by adopting an Indonesian National Qualification Framework (*Kerangka Kualifikasi Nasional Indonesia*, KKNI) curriculum. The KKNI approach has brought changes in the learning system to achieve the require competency for graduates who are ready to fill the workforce in accordance with their field of study [1,2]. The main principle of the implementation of the curriculum is to integrate, juxtapose, and equate the field of science with the competencies needed by the world of work. Thus the learning of chemistry must be adjusted and harmonized with the competencies needed by students as chemists [3,4]. Students in the Department of Chemistry are expected to master the knowledge and skills needed by the world of work in chemistry sectors after completing their studies [5,6]. To achieve this goal it is necessary to choose a good learning strategy that can improve knowledge and skills in chemistry. Several learning approaches have been applied in chemistry teaching such as the application of new learning methods, the determination of appropriate teaching and learning strategies, the choice of media and multimedia, the application of contextual learning models, the provision of guided assignments, the application of active learning, and the implementation of problem-based learning [7-10]. The learning approaches above have been proven to improve learning outcomes [11]. One of learning innovation that needs attention is project-based learning [12-15]. This type of learning is very appropriate to be implemented in teaching chemistry, especially in providing learning condition that can facilitate the learner to learn optimally, improve memory of learning, and make learning more effective and efficient [16]

Basic organic chemistry courses become compulsory subject for chemistry students [17-19]. The students must master organic chemistry that is needed as part of the competencies required by chemists. Arrangement of chemical materials has been carried out in the curriculum structure to make chemical materials are presented systematically starting from the simplest concept up to the complex ones in an effort to build the competence in the field of organic chemistry [20-22]. Learning innovation with project-based learning is very appropriate to be implemented in Organic chemistry teaching to bring the students involve in learning activities as a strategy in improving the learning outcomes [23,24]. Jobs in chemistry require special skills not possessed by other fields of study, and these skills are most widely obtained through teaching and learning activities in classrooms, laboratories and field studies [25,26]. Studying chemistry must combine the concept theory with practice, which is to become specific skills to master by chemists. These skills include the preparation and handling of chemicals, to conduct chemical reactions, to use equipment and measuring devices, to conduct experiments, to do observation and recording, and the knowledge on handling problems that often occur in chemical laboratories. All of these knowledge and skills can be obtained while working on projects related to the subject matter of chemistry being studied. Thus the project-based learning innovation is very appropriate to be developed to improve student learning outcomes in the field of organic chemistry. The purpose of this study is to provide an innovative project-based learning resource to be used as a learning media on the teaching of Alkenes topic with intention to improve students' outcomes on organic chemistry.

2. METHOD

2.1. Population and Sample

The study was conducted at the Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Negeri Medan at academic year 2019/2020. The population and samples involved in the study are summarized in Table 1. There are 88 students to participate in the study that are selected from Chemistry Education Study Program with consideration of having relatively similar knowledge on Basic Organic chemistry. The samples are grouped in to two parallel classes.

Table 1. The distribution of selected samples from the population in the Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Negeri Medan at academic year 2019/2020

No	Study Program	Number of students	Number of parallel class	Selected sample (Class)	Short description of the Study Program
1	Chemistry Education	151	4	94 (3)	- Major in chemistry education
2	Chemistry	31	1	0	- Major in chemistry
Total		182	5	94 (3)	

2.2. Research procedures

The research procedures were carried out starting from the needs analysis phase of Organic chemistry materials, preparation of innovative learning materials with project packages, and implementation of project-based learning followed the procedures explained in the references [27-29]. The needs analysis are done for Alkenes topic based on the learning competency standards to be achieved on Organic Chemistry course. The next stage is the provision of innovative learning materials for the Alkenes topic [30-33]. The learning material is compiled and equipped with relevant project packages, media or multimedia, and hyperlinks to relevant websites to make it become a complete teaching resource for Alkenes topic. The next stage is to evaluate and standardize the developed teaching material to ensure the quality of content in accordance with the needs of students in higher education. The standardization process is carried out trough expert judgments by asking the opinions of experience teachers on the components of teaching materials according to the criteria set by National Education Standards Agency (*Badan Standar Nasional Pendidikan*, BSNP). The assessment was carried out by using a Likert scale survey with the following criteria: (4) is very good, (3) is good, (2) is poor, and (1) is very poor. The final stage of the research is implementing of an innovative project-based learning for teaching of Organic chemistry in the classroom. A standard innovative learning package is distributed to students followed by giving short explanation on the learning scheme along with the project assignments to be completed by students. Assessment of students' skills is done subjectively by observing the students activities during the project assignments. Project reports are marked by by referring to the assessment rubric that has been given in the learning package. Evaluation of learning outcomes are carried out in the final stage of learning, those are obtained from the assessment scores of portfolio project reports and the formative tests. Scores for project reports and final evaluations are 0-100.

3. RESULTS AND DISCUSSION

3.1. Description of Learning Material With Projects and Type of Innovation

Collaboration The development of innovative project-based learning materials for the teaching of organic chemistry has been carried out through material enrichments and integration of mini projects and multimedia into Alkenes topic. It consisted of five Sub-topics, they are: (1) Introduction to Alkenes, (2) The structure and the preparation of Alkenes, (3) Nomenclature of Alkenes and Cis-Trans Isomerism, (4) Properties and reaction of Alkenes, and (5) Application of Alkenes. The descriptions of sub-topics, type of innovations, and project examples integrated to sub-topics are summarized in Table 2..

Table 2. The description of learning material, type of innovation and projects examples integrated into Alkenes sub-topics

No	Alkenes sub-topics	Description of innovation into chemistry learning material	Project integration
1	Introduction to Alkenes	Introduction and the enriching the Alkenes topics, the integration of learning media and multimedia into the relevant chemistry sub-topic. The use of learning media of Molymod molecular model set and computer simulation to help the students to understand double bond and its reactivity.	Project 1.
2	The structure and the preparation of Alkenes	Enrichment of learning materials for the structure and the preparation of alkenes, including the orbital description of the alkenes double bond, the sigma bond framework, the Pi bond, elements of unsaturation in hydrocarbons, elements of unsaturation with heteroatoms), the preparation of alkenes are conducted through elimination reaction, dehydration of alcohols, the dehydrohalogenation of alkyl halides, and polimerization. In this projects, the student's activities in the laboratory are also included.	Projects 2
3	Nomenclature of Alkenes and Cis-Trans Isomerism	Enrichment of chemistry materials for the topic of IUPAC Nomenclature and Isomers have been carried out. Structure of alkenes, Carbon-Carbon double bond orbitals, *Cis, Trans* isomerism in alkenes, nomenclature of alkenes, IUPAC names and common names, the *E,Z* system. The learning projects on explaining the IUPAC nomenclature are designed to make the students understand the chemistry of alkenes. The learning media to demonstrate the IUPAC rules to assign compound names to un-branched alkenes nomenclature, the isomers and naming system. The examples for IUPAC nomenclature are provided.	Projects 3
4	Properties and reaction of Alkenes	The topic on chemical properties of alkenes are enriched, and the project packages, including the video are integrated in the learning material. The projects are designed to study physical properties of alkenes. Stability of alkenes, the reaction of alkenes are including hydrogenation of alkenes, heats of hydrogenation, electrophilic addition of hydrogen halides to alkenes, regioselectivity of hydrogen halide addition: Markovnikov's rule, carbocation rearrangements in hydrogen halide addition to alkenes, free-radical addition of hydrogen bromide to alkenes, addition of sulfuric acid to alkenes, acid-catalyzed hydration of alkenes, hydroboration-oxidation of alkenes, hydroboration-oxidation, addition of halogens to alkenes, epoxidation of alkenes, ozonolysis of alkenes. The students are shown how to do the right procedures on handling chemical reaction and precaution safety.	Projects 4-6
5	Application of Alkenes	The application of alkenes compounds are provided in the learning package, including the naturally occurring alkenes terpene hydrocarbons and synthesis product. The preparation of alkenes are mostly dealing on the commercial importance of alkenes, alkenes synthesis by elimination of alkyl halides, dehydrohalogenation, alkenes synthesis by dehydration of alcohols, and catalytic cracking of alkenes, and the polymer. The students are given the project example on the application of alkenes compounds in industry.	Projects 7

The developed learning material has been adjusted for the needs of first year university students as required by the demands in the KKNI curriculum. Material enrichments and innovations are designed to have adequate learning resources to facilitate the students for independent learning to study organic chemistry. The type of innovation in learning material is adjusted based on the characteristics of sub-topics and adapted to the latest technological advancements. Various mini project packages have been integrated into chemistry materials to make the students easy to learn organic chemistry. By seeing examples of project implementation presented in the form of video and multimedia, students succeed in planning and implementing their respective projects correctly

3.2. Standardization of Innovative Project-Based Learning

To ensure the quality of innovative project-based learning material, expert standardization have been carried out through a survey by comparing components of the standard criteria set by BSNP. The results showed that an innovative learning material package is classified as very good (on average 3.75±0.42). All of the learning components have met the eligibility requirements of a chemistry material. The lecturers have voluntarily provided the opinions to the quality of the learning package as summarized in Table 3. The inputs and suggestions given by lecturers have been considered in revising the contents of chemistry materials and project packages to obtain a standard chemistry project-based learning material.

Table 3. The opinions of expert respondents (L) towards the components of a project-based learning material for Alkenes topic

No	The criteria and a brief description of the components on innovative teaching materials	Respondents opinion* (*M*±*SD*), L (*n*=12)
1	- **The Content:** the depth, accuracy and appropriateness of the contents of chemical materials with the needs of undergraduate chemistry students	3.72±0.46
2	- **The Extension:** Integration of mini projects, laboratory experimental procedures, multimedia, and contextual applications into teaching materials	3.78±0.39
3	- **The Depth:** The contents of the mini project are complete and clear, topics are presented systematically, consisted of the introduction, main contents, applications for real life, project examples, list of observations, questions to be answered, hyperlinks to reliable web sites	3.71±0.43
4	- **The Design:** The design, layout, presentation of illustrations, pictures, tables and figure are available and able to guide the students to learn independently.	3.76±0.43
5	- **The Language:** The teaching materials and projects are easy to learn, simple language and easy to understand, have scientific messages, write symbols, structure and correct chemical formulas	3.77±0.41
	Average	3.75±0.42

*Assessment criteria: (4) is very good, (3) is good, (2) is poor, and (1) is very poor

3.3. Implementation of Innovative Project-Based Learning in Class

Implementation of an innovative project-based learning for Alkenes topic has been performed by first distributing the learning package with mini projects to students in the format of soft file (e-book). Students are given a brief explanation on how to use teaching materials, the stages of project task completion, and the schedule of all stages of the learning process. The results revealed that the innovative learning package functions effectively to help students to understand chemistry concept. Students can follow the stages of learning by following the instructions available in the learning materials because every Alkenes sub-topic are equipped with multimedia and projects examples. there are three projects have successfully been completed by the students, those are selected from at least from two Alkenes sub-topics that are available in the learning material. To avoid mistakes, all phases of project implementations always get lecturer approval. Students have reported their projects on time. Based on an evaluation of the contents of the project report, it appears that the students have expressed their ideas in relation to their findings in project activities. The students are also able to answer questions given in learning material related to the project assignments. The developed innovative learning materials has proven to be effective in guiding the students to master the skills in the field of organic chemistry, and ultimately improving learning outcomes. The outcomes results from the implementation of learning innovation with project based learning are summarized in Table 4. Students' marks from portfolio of submitted proposal (M=89.17±3.13) and submitted report projects (M=87.28±2.57) are all classified to be very good. The learning outcomes from pretest (M=19.91±3.18) is low, while the evaluation score at the end of the learning (M=78.92±6.26) is categorized to be good. It can be stated that the students have mastered the concept of organic chemistry.

Table 4. Student's learning outcomes obtained from the average value of the project portfolio score and based on formative evaluations for the teaching of Alkenes topic

No	Study Program	Number of students	Students' Performance				Competence summary
			Evaluation score*		Reports marks**		
			Pretest	Posttest	Proposal	Report	
1	Chemistry Education A	30	18.65±4.34	78.76±7.78	86.93±3.63	83.74±3.51	Competence achieved
2	Chemistry Education B	30	20.23±2.92	78.88±4.70	92.03±3.09	88.54±1.72	Competence achieved
3	Chemistry Education E	28	20.86±2.27	79.13±6.30	88.53±2.66	89.55±2.49	Competence achieved
Average			19.91±3.18	78.92±6.26	89.17±3.13	87.28±2.57	Competence achieved

***** Obtained from formative test
** Obtained from the average portfolio of submitted project reports

3. DISCUSSION

An innovative project-based teaching material that has been developed suit to the needs of first-year university students. Respondents tend to strongly agree with all components of teaching materials (M=3.75±0.42) covering the content, the extension, the depth, the design, and the language where all of the components already meet the requirements of standard teaching materials appropriate to be used for teaching organic chemistry [34-36]. Learning using innovative project-based teaching materials has been designed to make students have the freedom to learn according to the competency requirements needed [37,38]. Innovative teaching materials have provided supporting facilities such as media and multimedia that enable students to study independently [39-41]. Some skills have been achieved by students from project-based learning. Students already have the skills to use Molymod molecular model as a learning media in setting and preparing of the chemical structure of Alkenes compounds correctly following the IUPAC rules. Observation of the implementation of independent learning when working on their projects showed that the students already have the skills to design their own projects, including choosing and designing appropriate instruments. Students' skills in carrying out, observing and recording the results of experiments have also been carried out correctly [42-44]. Students can complete projects on time and send project reports following the format provided in the learning material.

The implementation of chemistry teaching for the subject of Alkenes topic showed that the students have been able to do independent learning through the use of innovative teaching materials. The developed innovative learning with project-based has proven to be very effective in improving students outcomes as desired in KKNI curriculum [45,46]. The effect of innovative learning on students' academic abilities can be seen from their chemistry skills and the learning outcomes achieved based on project reports and final examinations. Student skills in chemistry can be seen from the ability of students to carry out the stages of learning, especially those related to laboratory activities in project implementation [47,48]. Student knowledge in basic organic chemistry in theory and practice through the application of project-based learning has been proven to be achieved. The student's knowledge on the Alkenes was developed, this is marked by the ability of students to write project proposals and completed the their projects on time. All sub-topics of Alkenes have been known by the students which are indicated by their high learning outcomes in the project reports and final evaluation test. The project-based learning has succeeded in bringing students quickly to understand the chemical properties of organic compounds, especially those related to the reactivity of organic compounds that have double bonds. The chemical reactions including additions, substitution, oxidation and polymerization reactions of Alkenes compounds give the impression to students because they are related to the formation of new compounds that can be directly identified that they are longer be remembered. The project assignments, which are provided from simple to complex, succeed in bringing the students to contextual situations. The project-based learning model has led the students to learn independently by taking advantage of the availability of digital learning resources suited to the latest technology advancements [49-51]. The implementation of innovative learning material with project has succeeded in bringing the students closer to real situations through contextual application, and successfully bring the learned theory directly into real life application. An innovative project-based learning strategies has significantly increased students' knowledge and skills in the field of chemistry, and can greatly improve learning outcomes in the field of Basic Organic Chemistry.

4. CONCLUSION

The project-based innovative learning resource has been successfully been developed through the provision of complete and standards teaching materials integrated with projects for teaching of Alkenes topic. The developed learning resource is very effective in facilitating students to learn organic chemistry independently and guide the students to propose and to complete their own projects. The facilities contained in the innovative learning resources help students to do laboratory activities correctly, and the mistakes in handling chemicals are avoided. Students are very eager to work on the project assigned by the lecturer and report it well. An innovative learning resource succeed in improving students' skills and knowledge in the field of organic chemistry. Students' skills have been developed through the project assignments. Students learning outcomes obtained from assessing project reports (M=87.28±2.57) is categorized to be very good, and the formative test scores (M=78.92±6.26) is assigned good. Based on the results of this study it is known that a developed innovative project-based learning model is very effective in improving students' skills and knowledge, those are competencies that are needed by chemists. Therefore, it is recommended to implement this innovative learning model in chemistry teaching and other courses to build competency in chemistry skills.

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