

# The Development and Implementation of Innovative Learning Resource with Guided Projects for the Teaching of Carboxylic Acid Topic

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## ABSTRACT

**Background:** The development of good learning resources in line with current technology to facilitate active learning has become a trend in education. An innovative learning material is believed to be able to motivate the students to learn and to improving students' skills for chemistry and pharmacy students to handle chemical reaction. **Objectives:** The study aimed to enact an innovative learning material with guided project to be implemented as learning resources to improve student's performance in organic chemistry. **Materials and Methods:** This study was carried out at Universitas Negeri Medan with the involvement of 180 chemistry students in the Department of Chemistry. It consisted of the development and standardization of an innovative learning package with guided project and implementing it for the teaching of carboxylic acid topic. **Results and Conclusion:** An innovative learning package with project contextual example related to carboxylic acid topic has been developed in a systematic order and the projects were provided to guide the students to become independent learners. The learning package was easy to follow and guided the students to do scientific investigations. The guide projects integrated in the learning package facilitated the students to gain deeper understanding of organic chemistry concept, be able to set their own project to keep the students engage in curiosity and problem solving and develop students' skills on planning, actions and reporting the project results. The developed learning material is very effective to improve students' competence, where students' performance in experimental class ( $M=83.23 \pm 4.41$ ) was higher than that in control class ( $M=77.22 \pm 4.79$ ). Students' learning style has been changed to become independent learner.

**Key words:** Innovative learning resource, Guided project, Independent learner, Chemistry teaching, Students' performance.

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## INTRODUCTION

The massive change in the information technology has become a challenge in education system where teaching and learning instructional have to be adjusted with current technology to maximize students' participation in learning activities. The adaptation of technology in the teaching and learning process has brought a new learning environment that can enhance students' interest in the subject they learn. The lecture notes provided by lectures may not be sufficient to

improve student's competence.<sup>1</sup> The need for learning resources that are in line with current technology is very crucial since the students nowadays often choose their learning material that suits to their need. The students need to be facilitated with innovative learning material to provide contextual investigations that can promote critical thinking to improve academic performance. Innovative learning resources with guided project become an alternative to facilitate



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the students to engage in curiosity and problem solving to obtain a deep understanding on the subjects they learn. Furthermore, conducting a project is good strategy to to achieve the competencies for chemistry and pharmacy students.

The development of an innovative learning resource with guided project is a strategy to design a learning instruction that can connect the theory with real world to get the students engaged in their learning activities.<sup>2-5</sup> The contents in innovative learning materials are the combination of contents of topics with practical examples and the strategy on contents delivery.<sup>6</sup> An innovative learning resource with guided project is a strategy to do investigation via small research that can transform learning activity into learning opportunities to solve the given problems. The project is designed systematically to develop the knowledge and skills on specific affective target.<sup>7</sup> The project based learning can be carried out through the project in the laboratory, field study, problem solving and assignments completion.<sup>8-10</sup> The project required the students to master skills to manage learning activities starting from planning, actions and reporting the results.<sup>11</sup> Through the project, the students are free to carry out independent learning activities to explore the finding in related to the current theory.<sup>12</sup> The study would be very effective and efficient when the project has been prepared based on the goal target.<sup>13</sup>

Innovations in teaching and learning activities adjusted with current technology development have become the trend nowadays that can be implemented through teaching model, methods and strategy.<sup>14</sup> An innovation is designed to attract students' interest to achieve learning goal. Learning innovation have been implemented via inquiry-based learning, project-based learning,<sup>15,16</sup> and media and multimedia based.<sup>17,18</sup> Innovation was done to provide the students with alternative learning resources to optimize the teaching and learning process, to provide more enjoyable learning environments and to improve learning motivation.<sup>19</sup> One of the learning innovations that attract the attention is by enacting the guided project in the teaching Organic chemistry. A guided project is a semi-independent project that can facilitate learners to work systematically that is adjusted suited to their own learning style. The projects are integrated in the learning resources with the aim to strengthen the students with adequate knowledge and skills through implementation of the theory in to practice with contextual example. The guided project is believed to be able to motivate the students in the learning process as well as to maximize students' involvement in learning activity. Learning via projects, in addition to the regular lecture in the class,

makes the students independent learners. Guided project is believed be able to bring the students to enjoy self-learning.

Organic chemistry is a compulsory course at the university curriculum aimed to develop the knowledge and skills in chemistry.<sup>20,21</sup> Basic organic chemistry topics at university level have to be taught clearly in the principles of the theory and methods. Therefore, the subject has to be taught in a manner that attracts students' motivation to learn to accomplish their scientific competence. Carboxylic acid and its derivatives are a very important topic for undergraduate students that can be taught via project. The topic consisted of introduction to carboxylic acid and its derivatives, preparation of carboxylic acids, reactions of carboxylic acids, reduction of carboxylic acids and acid derivatives, quantitative relationships involving carboxylic acids.<sup>22</sup> The project is designed to develop the skills in handling chemistry reaction, synthesis with calculation of starting material and the yield quantitatively. Therefore, it is important for educator to develop an innovative learning resource that reflect on the current technology development to provide a better understanding on the subject they learn. The aim of this study is to develop a chemistry learning resource with guided project to be used as a learning media on the teaching of Carboxylic acid. The strategy is made to enrich chemistry topics with contextual examples by integrating relevant projects to provide a standard learning material for science major for university students. The learning material is arranged systematically containing rich chemistry contents, learning activities and the assessments aligned to the learning outcome. Implementation of the developed material to improve students' performances has become a main target in this study. The contribution of the learning material to motivate the students to actively engage in learning and constructing the knowledge and skills are also investigated.

## MATERIALS AND METHODS

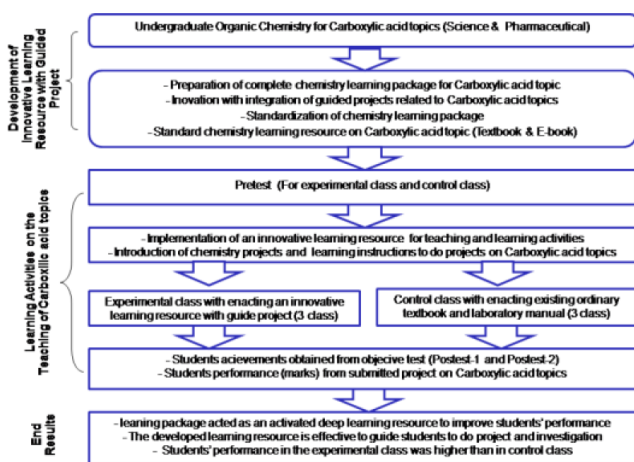
### Population and Sample

The study was carried out in the Department of Chemistry, Faculty of Mathematic and Natural Science, Universitas Negeri Medan, in academic year 2017/2018 with involvement of 180 chemistry students and 9 lecturers experienced in teaching Organic chemistry. The sample are divided into two groups, namely experimental class and control class. The distributions of population and samples involved in the study are presented in Table 1. All samples are homogenized from their performance in preliminary test, where the samples with

**Table 1: The distribution of population and samples included in the study at Universitas Negeri Medan.**

No	Study Program	Number of students	Number of parallel class	Selected sample*		Total sample	Short description of the Study Program
				Exp.	Ctrl.		
1	Chemistry Education	200	4	60	60	120	- Major in Chemistry education
2	Chemistry	76	2	30	30	60	- Major in Chemistry
Total		276	6	90	90	180	

\*Exp. is the students in experimental class that were treated with given an innovative learning material with guided project and Ctrl. are the students in control class that were treated with existing Organic chemistry textbook



**Figure 1: The overview of research procedures in the development of innovative learning resource with guided project and its implementation for the teaching of Carboxylic acid topics.**

relatively having similar achievement are included in the data analysis while the outlier samples are excluded.

### Research Procedures

The research procedure consisted of the development and standardization of an innovative learning package with projects on Carboxylic acid topic that met the requirement as stated in the university curriculum. A developed standard innovative chemistry learning material with guided project is then implemented in teaching and learning activities for experimental class and the existing textbooks are used in control class.<sup>23</sup> The research procedures are summarized in Figure 1.

#### Development of Innovative Learning Resources with Guided Project

The development of learning resource with project is conducted starting from the analysis of Organic chemistry textbooks on Carboxylic acid topics to obtain relevant chemistry subjects to be included in learning materials for undergraduate science students suited to the university curriculum<sup>24</sup> following the procedures explained previously.<sup>25</sup> A package of learning material containing project on Carboxylic acid topics was

prepared with adjustment to local contents and the availability of chemicals and equipments in the laboratory.<sup>26,27</sup> The learning package was then evaluated for its contents by experienced lecturers. The feasibility of developed material was also assessed by senior students that have studied the subject of Organic chemistry in previous year. It is then standardized for its performance based on the criteria given by Indonesian National Education Standards Board (BSNP). A set of innovative learning material was then provided both in printed and electronic versions.

#### Preparation of Research Instruments

The instruments used in this study are similar to those explained in the previous study.<sup>25,28</sup> They consisted of a package of developed innovative learning resource with guided project for Carboxylic acid, sets of standard questionnaires and evaluation tests (pre-test, post-test 1 and post-test 2). The standard evaluation tests (20 Problems) are provided in multiple choice tests to measure students' achievement covering Carboxylic acid topics.

#### Teaching and Learning Activities and Data Collection

Implementation of innovative learning resource with project is carried out for teaching of Carboxylic acid topics. Before teaching and learning activities are carried out, the lecturers are trained to explain their involvement in the study to select the sample, to teach students as listed in a lesson plan, to use the developed learning package, to instruct the students to do project, to motivate the students to use university facilities for self learning, to perform evaluations (pre-test and post-test) and to collect data (marking the submitted projects reports). Preliminary evaluation was performed to investigate how far the students knew the subject of Carboxylic acid topics to be taught. The teaching and learning activities are carried out to experimental classes by using the developed learning resources, while the students in control class are taught by using existing organic chemistry textbook. The allocated time in lecture was similar and the other factors were maintained the same in both classes. The evaluation test (post-test 1)

was carried out after the completion of all materials and the projects on Carboxylic acid topics, where post-test 2 was given a month after finishing post-test 1. The score for evaluation test was obtained from the right answers of multiple-choice test with penalty applied for any wrong answers, followed by converting the score to a 0 to 100 scale.

There are five sets of compulsory projects to be completed during the allocated timetable which are chosen from available ten projects in the learning package. The marks for the submitted projects are from three parts, the contents of the project, the precision value to the target products and the reports. The contents are evaluated from how deep the students is able to construct the projects starting from planning, laboratory activities, record keeping and washing up apparatus. The yield target value is marked from how close recovery of product yield is obtained in the project compared to the true value of target compounds in the given samples. The reports are assessed from report format, which includes font, margin, layout, presentation of figure and table, style, coherency and submission deadline. The score for projects is the average from five submitted projects with marking scale of 0 – 100.

## RESULTS AND DISCUSSION

### Innovative Learning Resource with Guided Project

The development of innovative learning resource with guided project for Carboxylic acid topic is made following the success in previous study.<sup>14,22,25</sup> Various Organic chemistry textbooks are used as sources to construct the learning material on Carboxylic acid topics that are suited to university curriculum.<sup>29-31</sup> A draft of chemistry material is prepared rich in scientific content accompanied with local contents for project based learning and hyperlinked to trusted websites for future reading. The chemistry topic and the type of innovation that have been integrated into the learning resource is summarized in Table 2.

### Standardization of Learning Material

To ensure the requirements for learning material by BSNP criteria has been met, the developed learning material is standardized followed the procedures explained in previous study,<sup>25</sup> and the results are listed in Table 3. The respondents considered that high quality teaching and learning resource has been provided ( $M=3.79\pm 0.40$ ). The chemistry material and the components that are integrated in the learning package have meet the requirement for learning resource criteria. The

lecturer gave positive comments to express the content of Carboxylic acids topic in the learning material suited to the need for undergraduate students.

### Implementation of Learning Material on Teaching and Learning Activities

The students in experimental and control class were then treated differently in the teaching of Carboxylic acid topic. The students in experimental class are given a set of standard innovative learning material on Carboxylic acid topic. The learning resource was facilitated with examples of projects along with the instruction to do similar projects related to subtopic of Carboxylic acid that are being taught. The students in experimental class are required to submit the complete reports of five sets of projects, those are to be chosen from available nine projects that are provided in the developed learning package on Carboxylic acid topic. The other group of control class was also given the same topic with laboratory experiments along with separate instruction of laboratory manual on Carboxylic acid topic, those are the Organic chemistry laboratory manual that has been used in the previous year. Soft copy of Organic chemistry textbooks is also given to students in both class as supplements, however, the students are also suggested to search and chose relevant learning materials of Organic textbooks containing Carboxylic acid topic in the university library.

The students' basic knowledge on Carboxylic acids topic is assessed through pre-test as summarized in Table 4. Screening for outlier samples has been made from students' scores in pre-test and only homogenic sample are included in the data analysis. Students' achievements from pre-test are tend to be similar in experimental class ( $M=20.17\pm 4.61$ ) and control class ( $M=20.28\pm 4.15$ ), where both groups are statistically not different. It can be said the starting knowledge of the students on the Carboxylic acid topics in both groups before commencing the learning activities are assigned to be very low (see students score on pretest in Table 4).

### Students' Performances after Completing the Projects

The students have completed the required compulsory five projects on Carboxylic acid topic and the submitted reports have been marked based on their investigations. The marking system have been adjusted to the chosen projects with the intention to see students' skills and competence that have been achieved from projects activities in the laboratory. Innovative learning resources has influenced the students' learning style in experimental class. They tend to focus on doing the project

**Table 2: Description of chemistry contents of Organic chemistry for Carboxylic acid topics and the innovations have been made into the chemistry learning resource.**

No	Chemistry Topics	The descriptions of innovation that has been made into chemistry learning materials for Carboxylic acid topics	Guided Project
1.	Introduction to Carboxylic Acid and its Derivatives	Introduction to Carboxylic acid and its derivatives consisted of the subtopics of Nomenclature of carboxylic acids, Structure and bonding of carboxylic acid, Naming carboxylic acid salts and Acidity of carboxylic acids. The learning materials are equipped with model structures and a hyperlink to trusted and relevant websites for future reading. The drills and project to construct the structure of carboxylic acids compounds, including carboxylic acid salts and acidity of carboxylic acids. Evaluation test related to carboxylic acid and its derivatives was also prepared.	Project 1 was using media of molimod to illustrate carboxylic acid and its derivatives.
2.	Preparation of Carboxylic Acids	The sub topic of preparation of carboxylic are the oxidation of alkenes, Ozonolysis of alkenes, the oxidation of primary alcohols and aldehydes, the oxidation of alkyl benzenes, Hydrolysis of nitriles, the carbonation of Grignard reagents, Synthesis of substituted acetic acids via acetoacetic ester, Synthesis of substituted acetic acid via malonic ester, $\alpha$ -halo acids, $\alpha$ -hydroxy acids and $\alpha,\beta$ -unsaturated acids. The techniques to prepare carboxylic acids from different starting material were demonstrated by using video and multimedia. A hyperlink to trusted and relevant websites for future reading has been given. The instructions to do project similar to the given examples were integrated. The example of problems and the evaluation test related to preparation of carboxylic acids was also included.	Project 2 and 3 are the preparations of carboxylic acid through oxidation and reduction reactions.
3.	Reactions of Carboxylic Acids	Specific topics on reactions of carboxylic acids were provided with contextual examples. The reaction of Carboxylic acids was provided through Ester formation, Nonreversible ester formation, Methyl ester formation, Amide formation, Acid halide formation, Acid anhydride formation, Decarboxylation reaction, Hunsdiecker reaction and Kolbe electrolysis. Sets of mini projects have been provided on reactions of carboxylic acids. The material was also equipped with a short video on how the reactions of carboxylic acids be proceeded. The problem examples and the evaluation tests on reactions of carboxylic acids were also given.	Project 4-5 are the reaction of carboxylic acids through ester formation or methyl ester formation.
4.	Reduction of Carboxylic Acids and Acid Derivatives	Subtopic on the reduction of carboxylic acids and acid derivatives are arranged with reductions of carboxylic acid derivatives, reduction of esters, reduction of acid halides, reduction of amides, reactions of carboxylic acid derivatives and the reactivity of carboxylic acid derivatives. The technique was focused to equip the students with the skills on handling reduction reaction. The project examples on the reduction reaction are provided. It was also equipped with example problem and solution, the evaluation test and hyperlinks to relevant websites as comparison and future reading.	Project 6-7 are reduction of carboxylic acids and acid derivatives.
5	Quantitative Relationships Involving Carboxylic Acids	The quantitative relationships involving carboxylic acids are provided, mainly on the synthesis with calculation of starting material and the yield quantitatively. Those are including the synthesis of carboxylic acids by the carboxylation of Grignard reagents, the synthesis of carboxylic acids by the preparation and hydrolysis of nitriles, halogenation of carboxylic acids (Hell-Volhard-Zelinsky Reaction) and spectroscopic analysis of carboxylic acids. The calculation composition of the product and the problem examples were also included. The use of spread sheet to determine the composition percentage of the compounds was also introduced.	Project 8-10 are synthesis of carboxylic acids, purification technique and calculation of yield.

by looking and imitating the project examples available in the developed learning material. The students in experimental class are enthusiastic to use the developed material when learning about the Carboxylic acid topic. The complete and systematic structure of the learning material along with the availability of hyperlink of trusted websites that are provided in the learning package are found very helpful to guide the students to learn Carboxylic acid topic. The students are able to do observation and collect the data for their report on the assigned

project. Students' marks that are obtained from portfolio of submitted projects are summarized in Table 5. The results showed that learning material containing guided projects influence students' knowledge on organic chemistry. The student's ability to complete and to report the projects are found different in experimental class compared to the of laboratory reports in control class (see data in Table 5).

The students in experimental class are able to complete the projects in their learning timetable. The students'

**Table 3: Respondents opinions on the feasibility of innovated chemistry learning resource. The number is the average value from Lecturers (L) and Senior chemistry students (S).**

Book components	Short description of innovative learning resource with guided project	Respondents opinion ( $M \pm SD$ )		
		L (n=9)	S (n=58)	Average
Content	- The completeness of Chemistry contents on Carboxylic acid suited to Organic chemistry curriculum for undergraduate chemistry and pharmacy	3.67±0.50	3.83±0.38	3.75±0.44
	- The accuracy of the contents of the learning material with project on Carboxylic acid topic	3.67±0.50	3.86±0.35	3.77±0.42
Extension	- Presented the learning material with project by the integration of local contents, laboratory experiment, contextual application, learning media and the learning strategy in the learning package	3.67±0.50	3.81±0.39	3.74±0.45
	- The Organic chemistry contents and the projects are clearly derived on Carboxylic acid topic	3.89±0.33	3.92±0.28	3.90±0.31
Depth	- The contents of Carboxylic acid topic are presented in good order: introduction, main concepts, problem example, guided projects, drills, quiz and the hyperlinks to trustworthy websites	3.67±0.50	3.86±0.35	3.77±0.42
	- Application of Carboxylic acid topic in real life	3.89±0.33	3.85±0.36	3.87±0.35
Design	- The design of learning material is suitable between the layout with the target material of Carboxylic acid	3.67±0.50	3.85±0.36	3.760.43±
	- Presentation of the illustrations, figures, table and images are adequate to Organic chemistry contents	3.67±0.50	3.90±0.30	3.78±0.40
	- Involving learners for interactive study	3.89±0.33	3.83±0.38	3.86±0.36
Language	- In accordance with the development of learner	3.67±0.50	3.85±0.36	3.76±0.43
	- The chemistry material and the projects are easy to read, the language is simple and provides communicative message to readers	3.78±0.44	3.81±0.39	3.80±0.42
	- The presentation and scientific messages are straightforward, having accurate on the typist of chemical structure, reaction and symbol	3.67±0.50	3.86±0.35	3.77±0.42
Average		3.73±0.45	3.85±0.35	3.79±0.40

**Table 4: Students' starting knowledge on Carboxylic acid topic based on their achievements on pre-test.**

Evaluation Test	Students' achievements counted as the average score ( $M \pm SD$ ) on Chemistry evaluation test							
	Experimental Class				Control Class			
	A (n=30)	C (n=30)	E (n=30)	Average	B (n=30)	D (n=30)	F (n=30)	Average
Pre-test	20.33±6.01	20.67±3.41	19.50±4.42	20.17±4.61	20.33±4.14	20.83±4.17	19.67±4.14	20.28±4.15

\*The learning effectiveness is calculated by comparing post-test 2 with post-test 1. A = Chemistry Education students in regular A class; B = Chemistry Education students in regular B class; and C = Chemistry Education students in regular C class; D = Chemistry Education students in non-regular class; E = Chemistry students in regular A class; and F = Chemistry students in regular B class.

**Table 5: Students performances obtained from five submitted projects portfolio on Carboxylic acid.**

Submitted Projects	Students' marks counted as the average score ( $M \pm SD$ ) on reports portfolio							
	Project reports of Experimental Class				Laboratory reports of Control Class			
	A (n=30)	C (n=30)	E (n=30)	Average	B (n=30)	D (n=30)	F (n=30)	Average
Project 1	80.27±5.53	83.43±3.98	78.40±6.61	80.70±5.37	75.97±6.96	70.17±6.75	73.90±7.19	73.34±6.97
Project 2	84.43±5.46	85.90±4.52	81.70±7.28	84.01±5.75	77.00±6.02	78.47±4.44	77.07±5.67	77.51±5.38
Project 3	83.00±5.08	85.73±5.15	83.00±5.88	83.91±5.37	80.90±7.46	80.27±5.42	81.23±5.69	80.80±6.19
Project 4	83.00±5.08	85.73±5.15	83.00±5.88	83.91±5.37	80.90±7.46	80.27±5.42	81.23±5.69	80.80±6.19
Project 5	83.00±5.08	85.73±5.15	83.00±5.88	83.91±5.37	80.90±7.46	80.27±5.42	81.23±5.69	80.80±6.19
Average	83.64±4.44	85.02±3.16	81.03±5.62	83.23±4.41	77.96±4.41	76.30±4.38	77.40±5.58	77.22±4.79

A = Chemistry Education students in regular A class; B = Chemistry Education students in regular B class; and C = Chemistry Education students in regular C class; D = Chemistry Education students in non-regular class; E = Chemistry students in regular A class; and F = Chemistry students in regular B class

performance obtained from submitted projects in experimental class ( $M=83.23\pm4.41$ ) is higher than in control class ( $M=77.22\pm4.79$ ). The results confirmed that the use of learning material with guided projects is able to help the students to set the target projects. The examples that are provided in the learning material serve to direct students to do organic activities correctly. In accordance to the students' mark on their submitted project reports, the students in experimental class have also showed high motivation to complete the projects and have confidence to complete the challenge that have been targeted in the laboratory works. The presence of project examples that are integrated in an innovative learning material improve curiosity, engagement, attention and results in high satisfaction on the chemistry skills dealing with project management. The facilities that are integrated in the learning material help the students to continue to study chemistry until the required competencies have been achieved.

After completing the teaching and learning activities on Carboxylic acid topic, the post-test 1 is conducted to both groups. The students' achievement results from post-test 1 are summarized in Table 6. The results showed that students' achievement in experimental class ( $M=77.17\pm5.03$ ) is found higher than that in the control class ( $M=69.94\pm5.43$ ). The effectivity of learning resources to extend students retention knowledge on Carboxylic acid topic has been examined in post-test 2 (Table 6). The results showed that students' achievement in experimental class ( $M=82.11\pm5.66$ ) is higher than that in control class ( $M=65.39\pm5.16$ ). For experimental class, the students' achievements in post-test 2 improved compared to their achievement in post-test 1, where the decline trend is observed in control class (see results in Table 6). The results have showed that the effectiveness of the developed learning resource to extend knowledge retention in experimental class

(105%) is higher than the ordinary teaching with laboratory manual (93%) and innovative learning resource has significantly proven to be able to improve student's achievement in Organic chemistry. The developed learning material with guided projects was adequate to be used as a learning resource in the teaching and learning activities. The students in experimental class was observed to participate actively in their learning process starting from planning, action to complete their projects and to write and submitted project reports.

## DISCUSSION

A package of good quality and standard learning resource with complete information on the topic of Carboxylic acid has been properly developed and intensively used in the teaching and learning activities on experimental class. Sets of projects on Carboxylic acids topic have been integrated in the learning material to facilitate the students with simple procedures and complex practical works and all of them are designed with full consideration on laboratory safety. The learning package, both printed and electronic materials have been prepared as a learning media in the class.<sup>27</sup> An innovative learning resource developed in this study can be used as a model of practical guide for scientists of chemists, pharmacologists, biochemists or practitioners on the use of guide projects to study undergraduate Organic chemistry.<sup>32</sup> Implementation of the learning resource with guided projects has been proven to be very helpful to guide the students to learn Organic chemistry through projects. The chemistry contents in the developed learning resource has been proven to be very useful for the students to obtain complete information and knowledge on Carboxylic acid topic. The designed projects that are integrated in the learning material are found very effective to guide unskilled students to perform chemistry project as a strategy to achieve their competencies and to

**Table 6: Students' achievements (post-test 1 and post-test 2) based on students' ability to solve chemistry problems on Carboxylic acid topic.**

Evaluation Test	Students' achievements counted as the average score ( $M\pm SD$ ) on Chemistry evaluation test							
	Experimental Class				Control Class			
	A ( $n=30$ )	C ( $n=30$ )	E ( $n=30$ )	Average	B ( $n=30$ )	D ( $n=30$ )	F ( $n=30$ )	Average
Post-test 1	78.50 $\pm$ 6.45	78.00 $\pm$ 4.66	77.17 $\pm$ 5.03	77.89 $\pm$ 5.38	70.17 $\pm$ 5.33	68.33 $\pm$ 4.79	71.33 $\pm$ 6.15	69.94 $\pm$ 5.43
Post-test 2	82.17 $\pm$ 6.39	82.50 $\pm$ 4.10	81.67 $\pm$ 6.48	82.11 $\pm$ 5.66	65.67 $\pm$ 5.37	62.50 $\pm$ 4.31	68.00 $\pm$ 5.81	65.39 $\pm$ 5.16
Learning Effectivity (%) <sup>*</sup>	105	106	106	105	94	91	95	93

<sup>\*</sup>The learning effectiveness is calculated by comparing post-test 2 with post-test 1. A = Chemistry Education students in regular A class; B = Chemistry Education students in regular B class; and C = Chemistry Education students in regular C class; D = Chemistry Education students in non-regular class; E = Chemistry students in regular A class; and F = Chemistry students in regular B class

improve students scientific research skills.<sup>33,34</sup> The availability of contextual project examples in the learning resource enables the students to deal with complicated chemistry reaction of Carboxylic acids through ester formation, amide formation, acid halide formation and another electrolysis strategy.<sup>35</sup> The project examples are prepared to guide the students to have deeper thinking in the planning and implementing projects so that they engage and sustain in curiosity across the project to make the students learn more deeply, particularly to achieve advance skill on the synthesis and the calculation of starting material and the yield quantitatively.<sup>36,37</sup>

It has been observed in the laboratory that the students in experimental class were conducting the projects very well, including in the chemical handling, collecting data and writing reports. Five projects reports have been submitted by the students and good marks are achieved (Table 6). The students have high score in the project reports because they knew the technique and the product target after reading the project examples in the learning material. However, most of students chose the project topic similar to the examples provided in the learning material. By completing the projects, they have mastered various skills as a way to prepare themselves for careers and future life challenges.<sup>38</sup> The students improve the ability in the academic communication skills, collaboration, creativity and critical thinking.<sup>39,40</sup> The developed learning resource has become an efficient tool to assist the students to learn and to facilitate learning activities to be more enjoyable. The skills on observing the chemical process, recording and collecting the data, analyzing and interpreting the results are also developed.<sup>41</sup> The study on project based learning are proven to develop students' critical thinking and improve the knowledge and understanding on the topic that was being learned.<sup>42</sup> Furthermore, collaborative learning style with independent process to engage with the problem-solving process have also been achieved.<sup>43,44</sup> Students' achievement in post-test 1 is higher in experimental class compare to results in control class, both groups are significantly different. It is proved that the developed learning resource with guided project has a significant contribution to improve students' achievement in chemistry.

## CONCLUSION

An innovative learning resource with guided project on the teaching of Organic chemistry for Carboxylic acid topic has been provided in a standard mode. It consisted of five sub chapters that are equipped with relevant contextual project examples, illustration with integration of learning media, the hyperlink to a trust website, problem solving and evaluation test. The design and

contents of chemistry material has met the requirements for undergraduate chemistry and pharmacy resources. The students were enthusiastic to do the projects, completed and submitted the report correctly. The students' skills on dealing with specific chemical reaction for Carboxylic acid topic has been achieved. Implementation of innovative learning resource with guided project has proven to improve students' performance on Organic Chemistry. Students learning outcomes in experimental class is found higher than that obtained in control class. The developed learning resource is effective to facilitate active learning for students to do investigation that be able to improve students' performance in Organic chemistry.

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## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## ABBREVIATIONS

**UNIMED:** Universitas Negeri Medan; **BSNP:** Badan Standar Nasional Pendidikan (Indonesian National Education Standards Board); **KKNI:** Kerangka Kualifikasi Nasional Indonesia (Indonesian National Qualifications Framework).

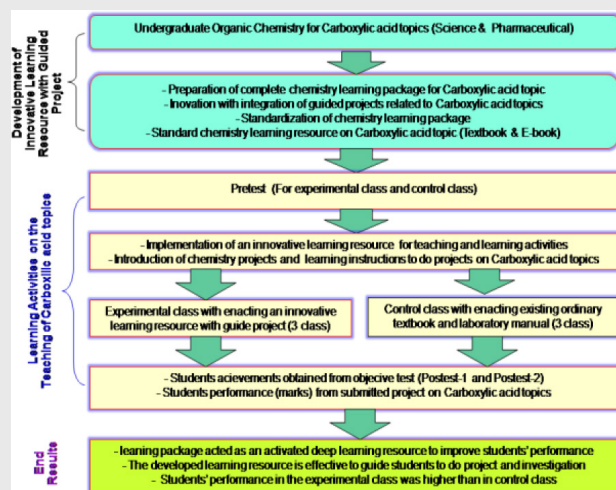
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## PICTORIAL ABSTRACT



## SUMMARY

An innovative learning resources with guided project in line with current technology has been developed for undergraduate chemistry and pharmacy students. This development was carried out by enhancing the learning material with relevant contextual project examples on carboxylic acid topic, integration of learning media, the hyperlink to a trust website, problem solving and evaluation test. The learning resource has been used to guide the students to do project with target target goal to improve students' skills to do investigation and to handle chemical reaction. The results revealed that the developed learning package acted as an activated deep learning resource to improve students' performance on Organic Chemistry. The guided projects integrated in the learning material has transformed student activity to become an enjoyable learning and the target goals are achieved. Students learning outcomes in experimental class is found higher than that obtained in control class.

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