Journal of Educational Sciences
Journal homepage: https://ejournal.unri.ac.id/index.php/JES

P-ISSN 2581-1657
E-ISSN 2581-2203

Development of Constructivism-Based Student Worksheets on Free Radical Reaction Material

Okma Rahmatya*, Susilawati, Maria Erna
Faculty of Teacher Training and Education, Universitas Riau, Pekanbaru, 28293, Indonesia

ARTICLE INFO

Article history:

Received: 13 Feb 2019
Revised: 22 April 2019
Accepted: 29 April 2019
Published online: 24 May 2019

Keywords:

Constructivism
Free Radicals
Organic Chemistry

A B S T R A C T

Organic Chemistry is one of the difficult subjects, especially in reaction and strechochemical mechanisms. One effort to reduce it is to utilize teaching materials. This study aims to develop organic chemistry teaching materials on free radical reaction material in the form of constructivism-based student worksheets (LKM). The research method used research and development research design with a 4D development model which consists of the stages of define, design, development, and disseminate. Development of LKM was assessed based on validity criteria and limited trials. The validity of LKM was achieved and assessed by three validators. Limited trials were conducted for the 6th semester students of the chemical education study program totaling 15 people and also three organic chemistry lecturers to see the appropriateness of developed LKM from the lecturers' perspective. The overall LKM results of its validity showed that the LKM has 95.05% valid. The results of limited trials based on the responses of students and lecturers each obtained a percentage of 84.02% and 87.22%, respectively. Based on the results of validation and limited testing of constructivism-based LKM on the material of free radical reaction developed it is included in the category of valid and can be used in the learning process.

1. Introduction

The education process is part of national policy that should not be ignored. Therefore, the implementation of education in both the macro and micro domains needs to be renewed and improved so that the quality of education can be improved gradually and continuously. Some efforts made by the government to

* Corresponding author. Tel./Fax.: +628571923590
E-mail: rahmatyaokma@yahoo.com

Doi: https://doi.org/10.31258/jes.3.2.p.162-173

improve the quality of education, one of which is by implementing curriculum improvements and changes. The government has made improvements and renewal of the curriculum that requires changes in the field of education, which is based on Presidential Regulation No. 8 of 2012 concerning the IQF (Indonesian National Qualification Framework). In addition, the rapid development of current science demands that schools begin to instill high-level thinking skills (HOTS) in students to meet the demands of the 21st century (Yennita et al., 2018)

Chemistry is one branch of IPA that studies the composition, composition, structure, properties, and changes in matter, as well as changes in energy that accompany changes in matter. In chemistry there are two understandings that must be mastered, namely conceptual understanding and algorithmic understanding. Conceptual understanding is an understanding related to concepts, namely abstract concepts and basic theories of science and algorithmic understanding is an understanding of procedures or a series of rules involving mathematical calculations to solve a problem (Robby et al., 2013). Organic chemistry is one of the fields of chemistry that studies the structure, properties, composition of a compound, reaction, and synthesis of organic compounds. Organic chemistry courses are compulsory subjects for students in chemistry education study programs, with integrated 4 credits where 1 credits are practicum and 3 credits theory. In the last three years, the team of organic chemistry subjects have tried to carry out the lecture process by involving students directly to obtain various information about the scope of lecture material. In the lecture process the lecturer has applied the method of presentation, question and answer and discussion of questions. The strategies that have been implemented are effective enough to activate students, but student learning outcomes are still not as expected. This is supported by learning outcomes for organic chemistry courses which are still far from expectations.

The results of interviews with students stated that organic chemistry courses are difficult subjects. The concepts of organic chemistry is abstract and the many sets of reaction mechanisms that must be understood make students less motivated in learning. Generally, the organic course become a subject that some students are fear. In addition, organic chemical material is abstract, especially in the mechanism of reaction and stereochemistry in free radical material, requiring students to be able to think critically and creatively in order to understand it. This is in line with the results of research by Robby, et al., (2013) that reported in general students have difficulty in solving problems involving chemical reactions and chemical calculations. O 'Dwyer (2017) also reports that organic chemistry has been identified as difficult material by students in previous research mainly on the topic of reaction mechanisms.

Based on existing problems, one of the efforts that can be done is by utilizing teaching materials. The use of teaching materials must be improved in line with the development of the curriculum. Quality teaching materials must be able to present teaching material in accordance with the demands of the curriculum, follow the development of science and technology, and be able to bridge learning so that the established competencies can be achieved (Situmorang, 2013). In

addition, learning innovations as outlined in teaching materials are very important so that they can provide better learning outcomes and improve the quality of graduates in filling jobs.

Student Worksheets are one of the teaching materials designed to facilitate students when understanding learning material (Kolomuc et al., 2012). LKMs are made with designs in accordance with the material and needs of students, besides that the LKM is a tool used by lecturers in assisting the acquisition of knowledge during the learning process. The effort that can be done is to develop constructivism-based LKM. According to Von Glasersfeld, constructivism is a philosophy of knowledge that emphasizes that our knowledge is our own construction (Michael et al., 2018; Nilgün et al., 2011). Knowledge is not an imitation of reality. Knowledge is always the result of a cognitive construction of reality through one's activities.

A LKM must fulfill certain conditions in order to become good quality LKMs. Student Worksheet requirements that must be met at least the following requirements (Widjajanti, 2008):

a. Didactic conditions, governing the use of LKMs that are universal and can be used well for students who are slow or smart. LKMs emphasize the process of finding concepts and most importantly in LKMs there are variations in stimulus through various media and student activities
b. Terms of construction, are the conditions relating to the use of language, sentence structure, vocabulary, level of difficulty, and clarity, which in essence must be effective in the sense that it can be understood by the user
c. Technical requirements, emphasizing writing, drawing, and appearance in LKM

Learning with the constructivism approach includes four stages. According to Horsley, they are the stage of apperception (expressing the initial conception and generating motivation to learn), the exploration stage (investigating and discovering concepts through collecting, organizing, and interpreting data), discussion stages and conceptual explanations (discussing and finding solutions based on observations done), the development stage and the application of the concept (applying conceptual understanding obtained by solving fairly complex problems and questions) (Yunus, 2010).

The principles of constructivism in learning are knowledge built by students with the activity process in constructing knowledge so that the concepts that are owned are more complete. One of the abilities that must be possessed by students is the ability to construct knowledge information, if students do not have the ability to construct knowledge information properly, students cannot connect the information so that they cannot provide conclusions and take advantage of the information. In applying the constructivism approach, learning is a process of forming knowledge. Students must actively carry out activities, actively think, develop concepts, and give meaning to things that are being studied.

At present, there are many studies on the use of constructivism approaches to learning. Research conducted by Natasa (2016) on photosynthetic learning with a constructivism model shows better learning outcomes after applied it. Constructivism helps to improve the quality of knowledge acquired by students. Furthermore, research on the influence of social constructivist approaches to problem solving and cognitive levels of students shows that social constructivist approaches have a positive effect on problem solving and cognitive levels (Bay et al., 2012). Subsequently, the research by Supiati, et al. (2013) shows that using constructivist based LKM, it has helped students build their own knowledge and practice science process skills.

The purpose of this study was to develop Constructivism-based Student Worksheets on free radical correction material for organic chemistry courses. Constructivism-based LKM developed are expected to be able to motivate students to study independently so that lectures will be more effective and efficient and are expected to guide students to build their own knowledge.

2. Methodology

The type of this research was a research and development (R&D) study. It used a 4-D development model consisting of four stages, namely Define, Design, Develop, and Disseminate or adapted to 4-P, namely defining, designing, developing, and distributing. The research was only carried out until the development stage because the research objectives are limited to developing and producing teaching materials in the form of valid LKM based on validator assessments.

This research was conducted at Chemical Education Study Program, University of Riau from October 2017 to March 2018. The validation data was obtained from the limited trials. The instrument of data collection consisted of a validation sheet and questionnaire in the form of a questionnaire. The validation sheet was aimed to assess the developed product for the criteria content: eligibility, presentation, graphics, language and aspects of constructivism. The data analysis technique used descriptive analysis techniques using formulas (Abdul, 2013):

$$\text{Persentase} = \frac{\text{n}}{\text{N}} \text{x } 100\%$$

P: percentage (%), n: number of obtained score, N: total score

To find out the feasibility of LKMs that have been developed, the validation results were adjusted to the scoring analysis criteria as in table 1.

Table 1. Eligibility Criteria Percentage Analysis (Sukmadinata, 2002)

Percentage	Remark
80,00 – 100	Good/Valid/ Worthy
60,00 –79,99	Fairly Good / Fairly Valid / Fairly Worthy
50,00 – 59,99	Less Good / Less Valid / Less Worthy
0 - 49,99	Not good (Rejected)

The revised LKM according to the validator's recommendations were tested in a limited manner. Limited testing was conducted on students and lecturers. In this case the student gave an assessment by filling out the given questionnaire. The sample in the limited trial consisted of 15 students in semester 6 of 2017/2018 academic year chemistry education. The developed LKM were also analyzed based on the response questionnaire given to three organic chemistry lecturers with scoring analysis criteria as in table 2.

Table 2. Practical Percentage Criteria

Level of Achievement (%)	Remark
90 – 100	Very practice
80 – 89	Practice
65 – 79	Fairly practice
55 – 64	Less practice
0 – 54	Not practice

3. Results and Discussion

The results of this study include: (1) results of validation of constructivism-based LKM, (2) Limited trial results. The results of the development research are presented for the products in the form of constructivism-based Student Worksheets on free radical reaction material. The stages of LKM development are as follows.

Define phase

The results of defining of the Organic Chemistry II course at the FKIP University of Riau was obtained form the Organic Chemistry curriculum and syllabus which will be used as guidelines for developing Student Worksheets. The results of the front end analysis are the limited number of Student Worksheets that can facilitate students in understanding the concepts of free radical reactions and supporting problem solving abilities. In addition, the results of student analysis show that students are still passive in learning, still unable to reason well and are not accustomed to high-level thinking, especially in understanding abstract concepts.

Task analysis is a collection of procedures for the development of free radical matter. The development of free radical reaction material is based on competency achievements that refer to the syllabus. The results of task analysis produce several results of analysis including: Content structure analysis, procedural analysis and information processing analysis.

The results of the content structure analysis are the content analysis of the curriculum based on the material developed, namely free radical reaction material. The development of free radical reaction material is based on the achievement of basic competencies. The results of procedural analysis are the stages of completing the tasks used in the LKM. The stages used are exploration, discussion

and explanation of concepts and the development and application of concepts. Information Processing Analysis Results are Learning Plans.

Design Stage

The results of the design phase produce the initial design of the LKM and the LKM validation sheet.

The initial design of constructivism-based LKM on free radical reaction material is as follows: Formulation of learning objectives in free radical reaction material, and the design of the developed LKM includes a structure that is in accordance with the guidelines for developing teaching materials, namely:
1. Title
The title of the LKM can be seen in table 3

Table 3. Title of LKM 1, LKM 2, and LKM 3

Type of LKM	Title
Title LKM 1	Free Radical Reactions "The reaction of free radical substitution in Alkana Formation of Free Radicals Mechanisms of Free Radical Reaction, Hydrogen Abstraction"
Title LKM 2	Free Radical Reactions "Stereochemistry Halogenation of Free Radicals, Relative Halogen Reactivity, Chlorination and Brominating"
Title LKM 3	Free Radical Reactions "Other Free Radical Reactions, Initiators, Inhibitors"

2. Learning Instructions
Learning instructions are on the first page of the LKM. The learning instruction are based on the topics that will be learned in the LKM. The learning Instruction is important in order to make student easy searching and doing all the LKM topics.

3. Preparation of LKM material
LKM material is based on the Learning Plan and is prepared using several sources and literature.

4. Student activities in the LKM
Student activities in LKM use a constructivism approach with stages of exploration, discussion and explanation of concepts, as well as the development and application of concepts.

Development Stage

The development phase aims to produce a revised competency-based Student Worksheet based on input from experts.

The validation of LKM covers assessing of five aspects, namely aspects of the feasibility of content, language, presentation, graphics, and constructivism. Validation was carried out by three expert of lecturers to assess the five aspects of feasibility of the LKM. Validation results from experts were used to revise the student worksheets that had been developed. The results of the validation of the five aspects of the feasibility of can be seen in Table 4.

Table 4 shows the results of the validation regarding the feasibility of LKM that have been developed based on aspects of feasibility of content, language, presentation, graphics, and constructivism. Aspects of content Feasibility have 7 components of assessment that aim to assess the accuracy of the concept of free radical material in LKM. The average score of the content feasibility aspect is 95.24%, meaning that the concept in the LKM is in accordance with the learning objectives.

Table 4 Results of MFI validation

No	Indikator	Score validator 1	Score Validator 2	Score validator 3
Content Aspect				
1	LKM is in accordance with Learning Objectives and Indicators	4	4	4
2	LKM is in accordance with student abilities	4	4	4
3	LKM contain concepts related to everyday life	4	3	4
4	LKM is in accordance with the substance of the Free Radical Reaction material	4	4	4
5	LKM is directing students to develop concepts	3	4	4
6	LKM can lead students to discuss and communicate their opinions and work results	3	4	4
7	LKM can lead students to solve questions according to the understanding and analysis they have learned	3	4	4
	Percentage	89,29%	96,43%	100%
	Average percentage		95,24%	
Feasibility of Presentation				
8	Completeness of the format of the LKM (Title, Instructions for learning, Learning Objectives to be achieved, Material, constructivism stages, Questions, Conclusions, assessments)	4	4	4
9	LKM provides sufficient space to give students the breadth to write and describe the things students want to convey	4	4	4
10	LKM already have coherent systematics	4	4	4
11	LKM can motivate students to learn	4	4	3

	Percentage	100%	100%	93,75%
	Average Percentage		97,92%	
Feasibility of Language				
12	LKMs have easy-to-understand information	4	4	4
13	LKM are in accordance with the standard Indonesian language rules	4	4	3
14	LKM use clear sentence structures	4	4	3
15	LKM use language according to the level of ability of students	4	4	4
16	LKM consistent in the use of terms and abbreviations	4	4	4
	Percentage	100%	100%	90%
	Average Percentage		96,67%	
Feasibility of Graphical				
17	LKM use good and interesting types and font sizes	4	4	4
18	LKM has good in layout	4	4	3
19	LKM has good illustrations / pictures / photos and are related to concepts	4	4	3
20	LKMs have attractive display designs	4	4	3
	Persentase	100%	100%	81,25%
	Persentase rata-rata		93,75%	
***Feasibility of* Constructivism**				
21	The material in an LKM is construction of knowledge and not a process of receiving knowledge	3	4	4
22	LKM utilize the students initial knowledge to build knowledge about free radicals	4	3	4
23	LKM can facilitate students to carry out learning activities to gain knowledge about free radicals.	4	4	4
24	The LKM requires students to be active in conducting various learning activities. Aim to build students' own knowledge of free radicals	4	4	3
25	The LKM invites students to build their own new knowledge about free radicals by making connections between experience or knowledge that has been acquired	3	3	4
	Percentage	90%	90%	95%
	Average Percentage		91,67%	
	Average Percentage for all		95,05%	

The presentation feasibility aspect has 4 components of assessment that aim to assess the quality of presentation in the LKM both the LKM format and the systematic stages of the LKM with a percentage of feasibility value of 97.92%. From the assessment, it can be concluded that LKM that are designed in accordance with the general format of LKM have a systematic process that both the writing and translation of the material and LKM. It can motivate students because the LKM contains constructivism stages that help find concepts and solve problems systematically.

Language feasibility aspects have 5 components of assessment that is to assess the level of readability of LKM. The average score of the language aspect assessment is 96.67% so it can be concluded that the language used in the LKM is in accordance with the standard Indonesian language rules, the level of student ability, and easy to understand.

The graphic aspect consists of 4 assessment components to assess the LKM layout, writing, image and design. From the assessment, the results show that the design of the LKM has been good in terms of fonts, layouts and image illustrations with a percentage of feasibility value of 93.75%. Constructivism aspects have 5 components of assessment to determine the suitability of LKM with constructivism characteristics in learning with the percentage value obtained 91.67%, so it can be concluded that the LKM designed are in accordance with the characteristics of constructivism.

The average percentage of the results of the validation of 5 aspects of the LKM component as a whole is 95.05% and is included in the criteria of valid to use. The average score for the five aspects of the LKM feasibility can be seen in table 5.

The validated constructivism-based LKMs are revised according to the suggestions and input provided by the validator so that a final LKM is produced. Cover of the LKM developed can be seen in Figure 1.

Table 5 Recap of MFI validation scores

No	Assessment Aspect	Average score Validator 1	Average score Validator 2	Average score Validator 3	Average score	Remark
1	Content	89,29%	96,43%	100%	95,24%	Valid
2	Presentation	100%	100%	93,75%	97,92%	Valid
3	Langguage	100%	100%	90%	96,67%	Valid
4	Graphic	100%	100%	81,25%	93,75%	Valid
5	Constructivisme	90%	90%	95%	91,67%	Valid
		Average			95,05%	Valid

A limited trial was conducted on 15 random students of 6th semester of Chemistry Education at the University of Riau. The data obtained in the form of student responses to constructivism-based LKM developed in the form of questionnaires filling student responses to the practicality of LKM include aspects of the display, presentation of material and benefits. The results of the assessment are used as input to revise teaching materials. There are 17 assessment points tested on LKM that were developed with the percentage of average ratings obtained at 84.02% which fall into the good category.

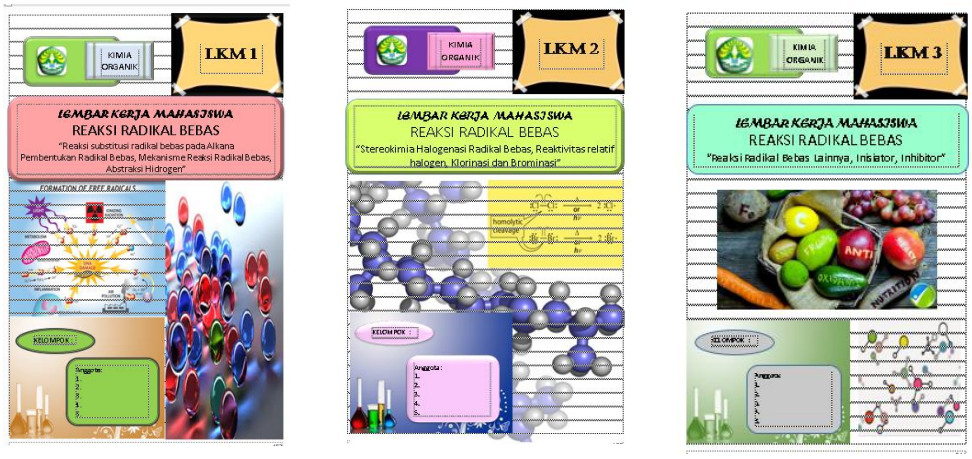

Figure 1. Cover of the developed LKM

Lecturer response questionnaires are used to find out the benefits of LKM usage. Information on usage data from constructivism-based LKM on the material of free radical reaction developed was obtained through lecturer response questionnaires. In this case, three Organic Chemistry lecturers were asked to provide responses to LKM based on the lecturer point of view by filling out a questionnaire consisting of 15 statement points.

The results of the analysis of lecturer response questionnaire data obtained an average percentage rating of 87.22%. Based on the results of the lecturer response questionnaire analysis, it can be explained that constructivism-based LKM in the material of free radical reaction developed are good and can be applied to the learning process.

4. Conclusion

The results of the study can be concluded as the following: The limited number of Student Worksheets can facilitate students in understanding the concept of free radical reactions so that LKM need to be developed that can facilitate students in learning. Based on the results of validation from experts on constructivism-based LKM on the material of free radical reaction developed, it is included in the category of good feasible to be used in learning activities. The results of a limited trial of constructivism-based LKM in the material of free radical reaction is included in the good category and can be used in learning activities.

Acknowledgement

Thank you to the parties who have helped this research, to the postgraduate research team, validators and lecturers of organic clams who were willing to spend their time. To the coordinator of S1 study program and S1 study program who have given research permission, as well as all students who have been willing to take part in the research to complete, and thank the Research and Technology

Research and Technology Department of the Postgraduate Grant Team for research funding assistance.

References

Abdul, R., Purwandi, S., & Sriyanto. (2013). Pengembangan Lembar Kerja Peserta didik (LKS) Berbasis Eksplorasi, Elaborasi, dan Konfirmasi (EEK) Serta Kebencanaan Sebagai Bahan Ajar Mata Pelajaran Geografi SMA/MA di Kabupaten Rembang. *Jurnal Edu Geography, 1(2),* 1-5.

Bay, E., Birsen, B., & Bayram ,C. (2012). The Effects of Social Constructivist Approach on the Learners' Problem Solving and Metacognitive Levels. *Journal of Social Sciences, 8 (3),* 343-349.

Kolomuc, A., Haluk, O., Mustafa, M., & Sibel, A. (2012). The Effect of Animation Enhanced Worksheets Prepared Based on 5E Model for the Grade 9 Students on Alternative Conceptions of Physical and Chemical Changes. *Procedia - Social and Behavioral Sciences, Volume 46,* 1761-1765.

Michael, M. B., Tony, P., Dorian, A. C., & Lisa, L. G. (2018). Constructivism and personal epistemology development in undergraduate chemistry students. *Learning and Individual Differences, 63,* 89-101.

Natasa, D. O. (2016). The Effectiveness of A Constructivist Teaching Model on Students' Understanding Of Photosynthesis. *Journal of Baltic Science Education, 15(5),* 575-587.

O'Dwyer, A. (2017). Who says Organic Chemistry is Difficult? Exploring Perspectives and Perceptions. *EURASIA Journal of Mathematics Science and Technology Education, 13(7),* 3599-3620.

Robby, Z., Wahyu, S., & Ali, K. (2013). Analisis Pemahaman Konsep Siswa SMA Kelas X Pada Materi Persamaan Kimia dan Stoikiometri Melalui Penggunaan Diagram Submikroskopik Serta Hubungannya dengan Kemampuan Pemecahan Masalah. *Jurnal Riset dan Praktik Pendidikan Kimia, 1(1),* 27-36.

Situmorang, M. (2013). Pengembangan Buku Ajar Kimia SMA Melalui Inovasi Pembelajaran dan Integrasi Pendidikan Karakter untuk Meningkatkan Hasil Belajar Siswa. *Prosiding Semirata FMIPA Universitas Lampung,* 237-246.

Sukmadinata, N. S. (2002). *Pendekatan Penelitian dan Pengembangan Pendidikan*. Bandung: Universitas Pendidikan Indonesia.

Supiati, A., Wisanti., & Widowati, B. (2013). Pengembangan Lembar Kegiatan Siswa (LKS) Berbasis Konstruktivis Untuk Melatihkan Keterampilan Proses Sains. *Jurnal Bio Edu, 2(2),* 145-148.

Widjajanti, Endang. (2008). Kualitas Lembar Kerja Peserta didik. *Seminar Pelatihan Penyusunan LKPD untuk Pendidik SMK/MAK pada Kegiatan Pengabdian kepada Masyarakat Jurusan Pendidikan FMIPA* UNY, 1-7.

Yennita, Isra, K., Gibran., & Mitri, I. (2018). Development of worksheet based on high-order thinking skills to improve high-order thinking skills of the students. *Journal of Educational Science, 2(1),* 37-45.

Yunus, Abidin. (2010). *Strategi Membaca Teori dan Pembelajaranya.* Bandung: Rizki Press.

Nilgün, S., & Evrim, U. A. (2011). The effect of constructivist approach on students' understanding of the concepts related to hydrolysis. *Procedia - Social and Behavioral Sciences, 15*, 235-240.

How to cite this article:

Rahmatya, O., Susilawati, & Erna, M. (2019). Development of Constructivism-Based Student Worksheets on Free Radical Reaction Material. *Journal of Educational Sciences, 3(2),* 162-173.