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Development of Electronics Student Worksheets Based on the Nature of Science in the Organic Chemistry on Polymer Materials Course

Nanda Salwa Aulia[1*], Susilawati[1], Jimmi Copriady[1]

[1] Postgraduate Chemistry Education, Riau University, Pekanbaru, Indonesia.

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Corresponding Author:
Nanda Salwa Aulia
nandasalwa98@gmail.com

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Abstract: This research is motivated by the need to provide teaching materials that can help students understand organic chemistry, especially polymer materials. Based on findings in the field, Organic Chemistry is one of the subjects whose material is difficult to understand. The development of the times and technology has brought developments in teaching materials in learning, namely technology-based. The purpose of this study is to produce E-LKM based on Nature of Science in the Organic Chemistry Course on Polymer Materials that can help students understand polymer materials more easily.The method used is the Research and Development (R&D) method, with the ADDIE model, which consists of 5 phases, namely the analysis phase, design phase, development phase, implementation phase and evaluation phase. The Nature of Science-based Electronics Student Worksheets developed on Polymer material was declared valid based on material and media validation with values of 93% and 97% respectively. The Nature of Science-based Electronics Student Worksheets on polymer material that was developed received a very good response from lecturers and students with scores of 92% and 90% respectively. Electronic Student Worksheet was declared valid and received a positive response from users and can be used in classroom learning.

Keywords: Electronic student worksheets; Nature of science (NoS); Polymers

Introduction

According to Law on the Education System No. 20 of 2003, education is a conscious and planned effort to create a learning and teaching atmosphere so that students actively develop their potential to have spiritual religious strength, self-control, personality, intelligence, noble morals and skills needed by society (Elfian et al., 2018)

Bruton defines learning as a change in behavior in an individual due to the interaction between individuals and individuals and individuals with their environment so that they can interact with their environment. According to Law No. 20 of 2003, learning is a process of interaction between students and educators and learning resources in a learning environment (Faizah & Kamal, 2024).

Organic chemistry is one of the courses studied in the Chemistry Education study program. Organic chemistry is a field of science that studies the structure, properties, changes, composition, reactions and synthesis of compounds containing carbon atoms, not only hydrocarbon compounds, but also compounds containing other elements, such as hydrogen, nitrogen, oxygen, halogens, phosphorus, silicon and sulfur.

However, learning organic chemistry is still considered difficult and less interesting for some students. Based on interviews with lecturers teaching organic chemistry courses, of the total number of new students, 30% of the total number can be said to have high cognitive values. Based on the pre-research questionnaire that the researcher gave to students, it was found that 28.6% of respondents stated that learning organic chemistry was fun, 64.3% of respondents stated that it was so-so and 7.1% of respondents stated that it

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was boring. The instructional materials often used by lecturers when teaching are books and printed modules. Lecturers have also used constructivism-based Student Worksheets in several previous organic chemistry materials.

One of the materials studied in the organic chemistry course is polymer material. Polymer material is interesting to discuss because it is closely related to everyday life, especially the use of plastic. Polymer material is an application of basic organic theory in the form of organic synthesis and has many connections with everyday life. where students should be able to build their knowledge more easily because it is related to everyday life, but this material is still considered difficult by students. Therefore, it is necessary to provide instructional materials that can support the learning process so that students have new experiences in learning and can more easily understand this polymer material.

The use of interesting, practical and interactive instructional materials is important to support the learning process in the classroom. The concepts in Organic Chemistry are not only learned theoretically, but also practically. The use of Organic Chemistry teaching materials in the learning process is an important part that can help achieve effective and efficient learning (Zakaria et al., 2020). Instructional materials are various learning resources that can help educators to provide the desired behavioral changes in individual students. In addition, to improve the quality of learning, various teaching materials can be used. Teaching materials that can train individuals to learn independently and are able to improve high-level thinking skills are modules (Wardhana et al., 2022).

One of the instructional materials that can be used in the learning process is the Student Worksheet. The Student Worksheet is a learning tool designed to help students in participating in the learning process in class (Patresia et al., 2020). Student Worksheet can support students in problem-solving activities. In addition, Student Worksheet also provides materials, summaries and learning instructions (Prastowo, 2015). Student Worksheet can support students to find concepts of the material being studied independently and be more active in thinking and carrying out activities (Aldresti et al., 2021). Through the use of Student Worksheet, it is hoped that students will be motivated to learn independently, so that the learning process is more effective and efficient because students are able to understand the lecture material that will be studied (Utami & Dewi, 2020).

In addition to using Student Worksheets in the learning process, a learning model is also needed. Winaputra in Tayeb (2017) stated that a learning model is a conceptual framework that describes a systematic procedure in organizing learning experiences to achieve certain learning objectives, and functions as a guideline for learning designers and teachers in planning and implementing learning activities.

One learning model that can be integrated into the Student Worksheet in an effort to help students understand polymer material more easily is the Nature of Science (NoS) learning model. The nature of science model provides students with the opportunity to build an understanding of the concept of the material and is accompanied by proof of concept through experimental activities. So that students can know the truth of the concept of the material they have understood.

NoS (Nature of Science) is defined as knowledge of how science works (Lederman & Lederman, 2019). NoS emphasizes the characteristics of science knowledge that comes from the development of that knowledge and is strengthened by scientific inquiry which produces a certain way because of the assumptions that scientists have about how we learn about the world through the process og inquiry (Höttecke & Allchin, 2020). The Nature of Science (NoS) learning model has 6 stages, First, Background reading, students are given reading materials and asked to make a summary of the material to be studied. Second, case study discussion, presenting a short discourse then students are given the opportunity to ask questions about what is unknown based on the summary that has been made and the discourse presented. Third, Inquiry lessons, lecturers guide students to find answers to their questions by guiding several guiding questions. Fourth, Inquiry labs, students collect evidence through experiments either directly or by observing experiments virtually. The goal is to prove the concept of the material understood. Fifth, Historical study, students present the results of the discussion obtained. Sixth, Multiple Assessment, lecturers assess with several techniques, performance, presentation and cognitive tests (Wenning, 2006).

The NOS-based learning model is a constructivist learning model with an inquiry approach that places students as subjects in learning (student centered) (Sudirgayasa et al., 2014). According to constructivist learning theory, learning is not just memorizing, but the process of constructing knowledge through experience. Knowledge is not the result of "giving" from other people such as educators, but knowledge is the result of the construction process carried out by each individual. Knowledge from the results of "giving" will not be meaningful. According to the constructivist approach, knowledge is not a collection of facts about a reality that is being studied, but as a person's cognitive construction of objects, experiences, or their environment. Knowledge is not something that already exists and is available then other people just accept it. Knowledge is

a continuous formation by someone who is reorganized at any time due to new understandings (Abdjul, 2019).

The development of technology and communication in the era of the 4.0 revolution is very rapid. Various supporting technologies for science are increasingly developing in various fields including the field of education. From teaching materials that were previously in printed form, innovations in electronic-based teaching materials are now starting to appear. The need for innovative teaching materials based on technological developments in the 21st century learning process is very important (Taqiyyah et al., 2023). Electronic Student Worksheet has the advantage of being able to simplify and narrow down space and time so that learning becomes more effective and can attract students' interest in learning (Suryaningsih & Nurlita, 2021). The use of technology in learning can provide meaningful learning experiences for students, both as physical (concrete) and non-physical (abstract) tools used as intermediaries between lecturers and students to better understand the contents of the lesson material effectively and efficiently in learning activities (Musdalifah et al., 2024).

The use of Electronic Student Worksheet by integrating the Nature of Science learning model is expected to make students more interested in learning and curious about the material to be studied. Students not only pay attention to the lecturer's explanation in front of the class, but they can also work on learning activities that have been presented in the Electronic Student Worksheet that has been designed. Nature of Science (NOS) challenges students so that they can gain satisfaction by finding new knowledge for themselves. In addition, by implementing this model, students experience the practical activities themselves and with this experience, students can construct the knowledge gained and stored in their memory for a long time (Ulfaturrohm et al., 2014).

Research related to Student Activity Sheets, such as research related to the Development of Constructivism-based Student Worksheets on Free Radical Reaction Material, based on the results of validation and limited testing of the Student Worksheet developed is included in the valid category and can be used in the learning process (Rahmatya et al., 2019). Apart from the Free Radicals material, research has been carried out regarding Student Activity Sheets (LKM) in the Organic Chemistry II course on aldehydes and ketones. Based on the results of validation and trials carried out by researchers, it was stated that the LKM developed was suitable for use in the actual learning process (Hasnah et al., 2019).

The integration of the Nature of Science model into teaching materials has been carried out both in schools and universities. The development of interactive learning modules based on Nature of Science has been carried out by Wardhana et al. (2022) on the material on the development of atomic theory to improve the cognitive level and scientific literacy of students. Savitri et al. (2017) have reconstructed science teaching materials containing Nature of Science on the topic of material particles and material characteristics, which resulted in a teaching material design that has Nature of Science content. The development of digital Student worksheet oriented to nature of science has also been carried out by Mahendra et al. (2022) on simple harmonic motion material. Masruroh et al. (2019) have also conducted research related to the development of inquiry-based science learning integrated with nature of science and seen its effect on students' mastery of concepts.

In addition, at the lecture level, several studies have also been conducted related to the nature of science model. Khery et al. (2019) have conducted research related to the characteristics of Nature of science and the application of car technology in chemistry learning in the Chemistry Education study program at IKIP Mataram. Tursinawati et al. (2019) have also conducted research related to the understanding of Nature of Science in the Digital Era in Elementary School Teacher Education students.

Based on the description above, it is necessary to provide student worksheets in organic chemistry courses on polymer materials, to provide different learning experiences for students so that students can more easily build their understanding, by adjusting the context of the current era which is rapid with the development of technology. This study aims to develop electronics student worksheets based on the nature of science in organic chemistry courses on polymer material.

Method

This research was conducted at the Chemistry Education Study Program, Faculty of Teacher Training and Education, University of Riau. The research period was conducted from February to June 2024. The Nature of Science-based Electronic student worksheets development research was designed using a research and development (R&D) design using the ADDIE model. The ADDIE development model consists of five stages. the first stage is analysis, design, development, implementation and evaluation (Jonnalagadda et al., 2022; Rizkayanti et al., 2023; Stapa & Mohammad, 2019; Yulia et al., 2023). The procedure for developing teaching materials in the form of Electronics Student Worksheet based on Nature of Science with the ADDIE development model can be seen in Figure 1.

The first stage is the analysis stage, which consists of analysis of students, curriculum and materials. The second stage is design, making instrument grids, product design and compiling materials. The third stage is development, namely product realization and product validation. The fourth stage is implementation where products that have been declared valid are tested in learning. The fifth stage is evaluation, each stage of development with the ADDIE model is evaluated, namely comparing the product with the results of the trial and the input given.

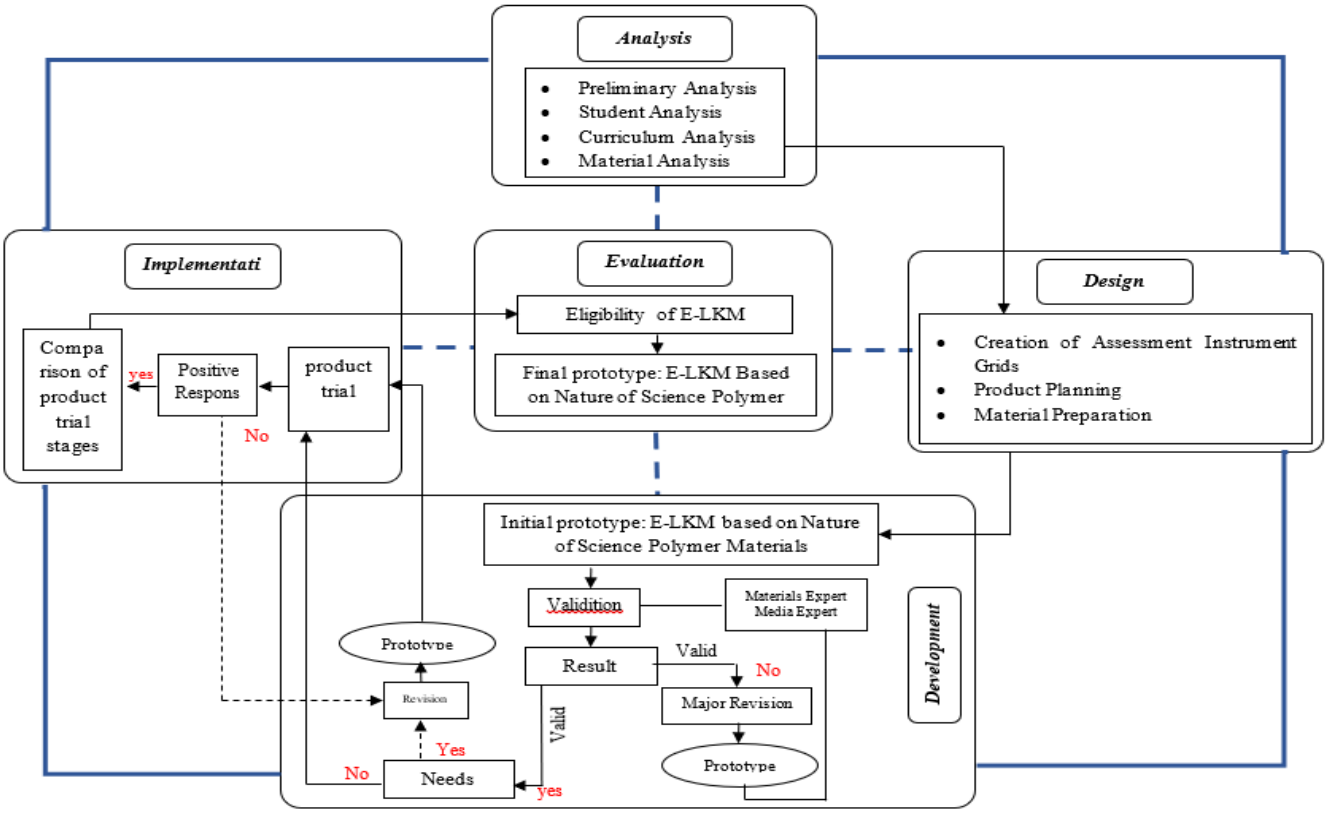


Figure 1. Flowchart of electronic student worksheet development based on nature of science polymer materials developed using the ADDIE model (Husna, 2016), modified

Data was obtained from the validation results of 6 expert validators, consisting of 3 material experts and 3 media experts who were asked to fill out a validation sheet as an assessment of the feasibility of the Nature of Science-based Electronic student worksheets on the polymer material being developed. User response data was obtained from lecturers and students. Involving 3 organic chemistry lecturers and 20 students. User responses use a response questionnaire sheet.

Table 1. Likert Scale Rating Categories (Sugiyono, 2019)

Scoring scale	Criteria
4	Very Good
3	Good
2	Enough
1	Not Good

The data obtained from the validation sheet assessment is in the form of a scale. The type of scale used is a Likert scale with a score of 1-4. The following Likert scale assessment categories by validators are shown in Table 1. Based on the *Likert* scale assessment category table, Table 1, the average percentage for each component is calculated using equation 1 (Suryanti et al., 2023).

$$P = \frac{\sum x}{\sum xi} \times 100\% \quad (1)$$

Information:
P : Score percentage (rounded)
$\sum x$: The number of respondents' answer values in one item
$\sum xi$: The number of ideal scores in one item

Providing meaning and making decisions about the quality of electronic student worksheets products based on Nature of Science on Polymer material uses achievement level conversion with 4 scales as in Table 2.

Table 2. Validity Criteria for Material and Media Validator Questionnaire Data (Arikunto, 2013)

Percentage (%)	Criteria
81 – 100	Very worthy / no need for revision
62 – 80	Worth / no need for revision
44 – 61	Not suitable / needs revision
25 – 43	Not feasible/needs revision

The results of the average score from the questionnaire responses by lecturers that have been obtained are converted into qualitative data to determine the criteria for the practicality of using electronic student worksheets which can be seen in table 2. The product is said to be good for lecturers to use if the minimum percentage achieved is 51% with the criteria Good.

Result and Discussion

The development of electronic student worksheets based on Nature of Science with research and development (R&D) design with the ADDIE development model which consists of five stages is explained as follows:

Analysis

The analysis phase is preliminary research carried out with several analyses, namely initial analysis, students, materials and competencies. Initial analysis was carried out by interviewing two organic chemistry II lecturers at the Chemistry Education Study Program at Riau University. Based on the results of the interview, it is known that the teaching materials that have been used in the learning process for Organic Chemistry II, especially in Polymer material, generally use textbooks, teaching modules and PowerPoint slides. Apart from the learning process for Organic Chemistry II, we have also implemented a constructivism-based learning model, Project Based Learning, with discussion and assignment methods.

Student analysis was carried out with the aim of knowing the condition of the student learning process before conducting research. The results of student analysis based on the questionnaire given showed that students tended to assess organic chemistry learning as mediocre (64.3%). Apart from that, in learning, students prefer group study (57.1%) and if they do not understand the material given by the lecturer, the effort made by students to overcome this is by asking friends who understand better (71.4%).

Curriculum analysis aims to review the curriculum implemented by universities and study programs so that the preparation and development of electronic student worksheets can be in accordance with the curriculum used. Researchers conducted an analysis of the Semester Learning Plan for the Organic Chemistry II course to determine the Learning Outcomes that students must achieve. Based on the analysis carried out by researchers, there are two course learning outcomes that students must achieve regarding polymers. (1) Able to explain organic chemistry knowledge about polymers with independent, quality, measurable and responsible performance. (2) Able to analyze the manufacture of polymers originating from references and national or international journal articles with independent, quality and responsible performance.

Based on the Course Learning Outcomes, the main material included in electronic student worksheets is nature of science based, namely addition polymerization, condensation polymerization and biodegradable plastics.

Design

At this stage, the researcher first creates a product assessment questionnaire instrument. The product instrument of this research is a checklist for material experts, media and learning practitioners, namely organic chemistry lecturers, as well as a questionnaire for students.

Followed by compiling the contents of the prototype taken from sources in the form of Fessenden's Organic Chemistry I and II books, scientific journal articles, and the internet that are relevant to polymer materials. The learning activities organized in electronic student worksheets refer to aspects of the Nature of Science, namely Background reading, Case Study Discussion, Inquiry Learning, Inquiry Labs, Historical Studies, and Multiple assessments.

After that, we continued with the design of the electronic student worksheets display which was done with the help of Microsoft Publisher software. This stage begins with designing the appearance of the electronic student worksheets cover page. The cover page consists the title of Electronic student worksheets, Course Name, Study Material, University logo, Tut Wuri Handayani and Independent Campus, Image depicting the title of the Electronic student worksheets or course and Author's Identity (Said et al., 2023; Wahyuni et al., 2021).

The Electronic student worksheets content display consists of three parts, namely the introduction, core and conclusion. The introductory part consists a foreword, table of contents, instructions for using Electronic student worksheets, Course Learning Outcomes, and study instructions. The core section contains a description of the material, learning stages in accordance with the Nature of Science syntax. In line with (Wahyuni et al., 2021), the content section contains the competencies achieved, lesson materials with learning activities according to the learning model used. The closing section is a bibliography which is a reference for

material in electronic student worksheets. In line with (Lestari et al., 2023), the final section contains evaluation questions, a bibliography and a closing cover.

Development

The first stage carried out was prototyping, namely the process of realizing a previously designed design into a Nature of Science-based electronic student worksheets prototype using Microsoft Publisher software to create each page on the prototype. The prototype that has been developed is saved as a PDF file, then uploaded to the Flip Builder application. The Electronic student worksheets prototype is published in HTML format and published online so it can be accessed anywhere and anytime. In the final stage, a completed electronic student worksheets link is produced, then it enters the assessment stage in the form of validation and small-scale testing. Referring to Wahdatillah et al. (2022), the construction and creation stage of LKM can use Microsoft Publisher and Flip Builder as the main applications.

The developed Electronic Student Worksheet consists of 3 sub-materials according to the material that has been determined at the analysis stage. The following is a display of the Electronic Student Worksheet cover for each sub-material.

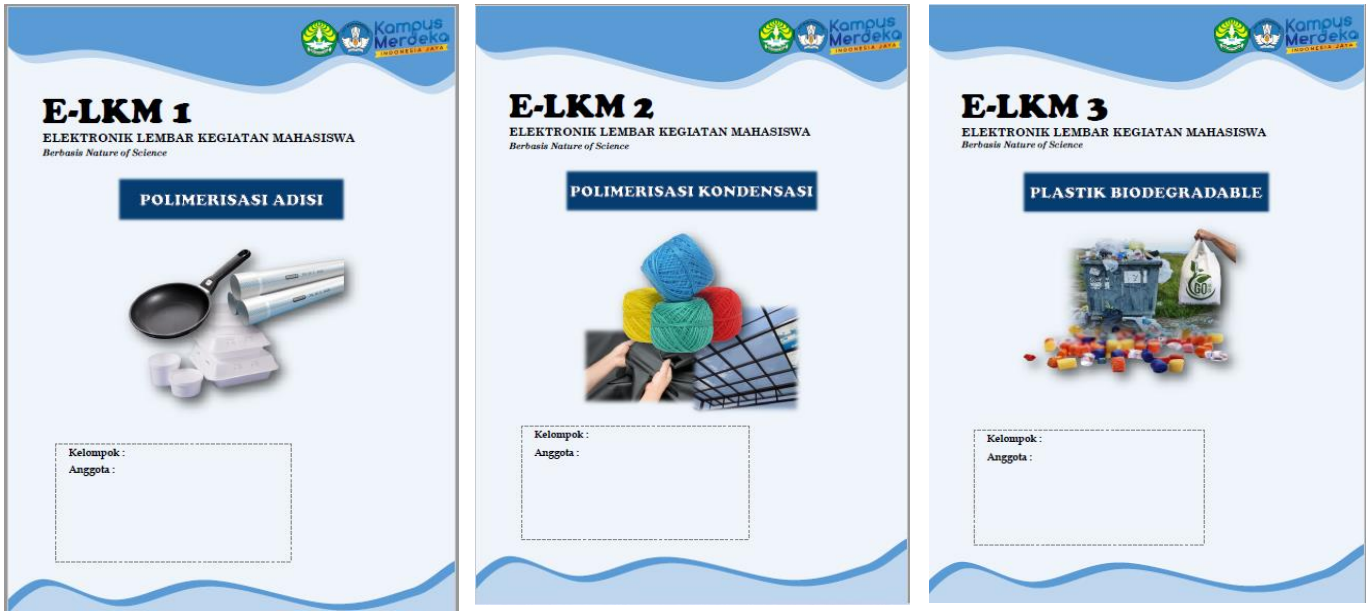


Figure 2. Electronic student worksheet cover display for each polymer sub-material

Validation is carried out by expert validators on prototypes based on aspects of material substance, learning design, appearance and use of software using the validation sheets and rubrics provided. Validation was carried out by 3 material experts and 3 media experts. The results are in the form of suggestions, input and comments which can be used as a basis for analyzing and revising the products being developed and as a basis for conducting product trials on students. The average percentage results for each aspect of the material validation assessment can be seen in Figure 3.

The first validation obtained an average percentage of the 5 aspects of 78% with the appropriate or valid category. Then a second validation was carried out to obtain an even better electronic student worksheets based on Nature of Science on Polymer materials. After revisions were made based on suggestions from the validator, the percentage in the second validation rose to 93%. This is in line with (Ridho et al., 2020) opinion which states that teaching materials can be declared valid if all of its components meet the minimum valid criteria.

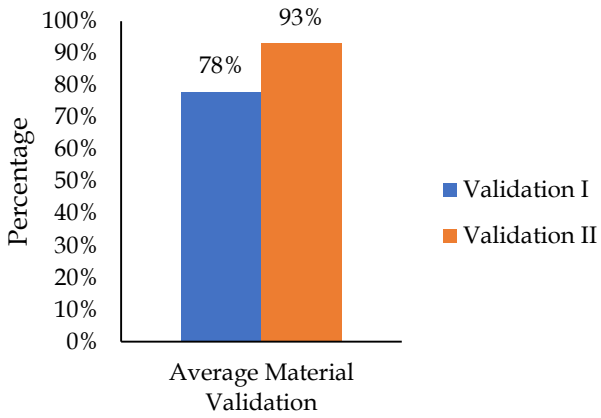


Figure 3. Average results of material expert validation

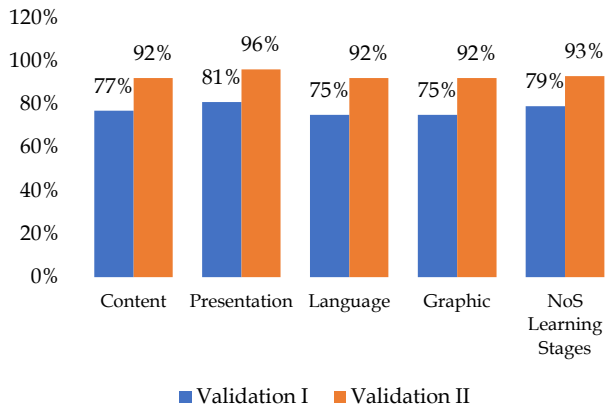
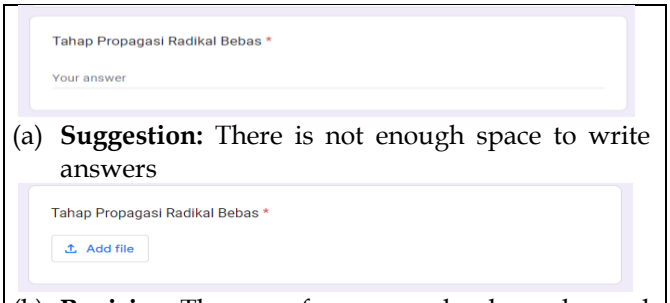


Figure 4. Percentages of material expert validation results

Details of the validation value obtained for each category of material, are content feasibility of 77%, presentation feasibility of 81%, language feasibility of 75%, graphic feasibility of 75% and NoS stage of 79%. After the revision and second validation, an average value of 93% was obtained with details of content feasibility of 92%, presentation feasibility of 96%, language feasibility of 92%, graphic feasibility of 92% and NoS stage of 93%.

Improvements made at the validation stage include the column or place where students write their answers. To write answers, electronic student worksheets is integrated with a Google Form link. The link provided previously is in the form of a paragraph answer. This is less efficient considering that there are answers that need to be written about the reaction mechanism and this is not possible to write in a link in paragraph form. To overcome this, improvements were made by changing the form link to upload a file. So students can first write their answers on paper then take photos and upload them on the link provided. Electronic student worksheets can use Google Slides (Danial et al., 2022) or Google Forms (Ningtyas & Rahayu, 2022) to provide answer space for students. The use of Google Forms can be easily managed and modified (Ai'syah et al., 2022).

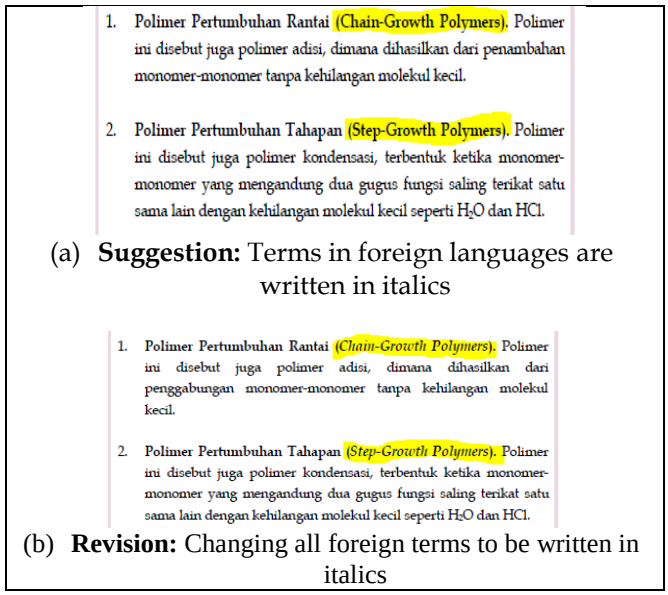


(a) **Suggestion:** There is not enough space to write answers

(b) **Revision:** The space for answers has been changed from paragraph form to file upload form so that there is more freedom to collect answers.

Figure 5. Improving the answer space; (a) before validation, (b) after validation

In line with what was stated by Hendro Darmodjo and Jenny R.E Kaligis in Daif-Allah et al. (2016), the construction requirements for preparing Electronic student worksheets must use appropriate language, use a clear sentence structure, foreign terms must also be written in italics and written consistently. The improvements made can be seen in Figure 6.



(a) **Suggestion:** Terms in foreign languages are written in italics

(b) **Revision:** Changing all foreign terms to be written in italics

Figure 6. Improving the writing of foreign terms; (a) before validation, (b) after validation

Media validation involves 3 validators who are expert lecturers in the media field. The aim of media validation is to assess electronic student worksheets based on Nature of Science Polymer materials based on aspects of the cover design and content design of the Electronic student worksheets. The percentage results for each aspect of the media validation assessment can be seen in Figure 7.

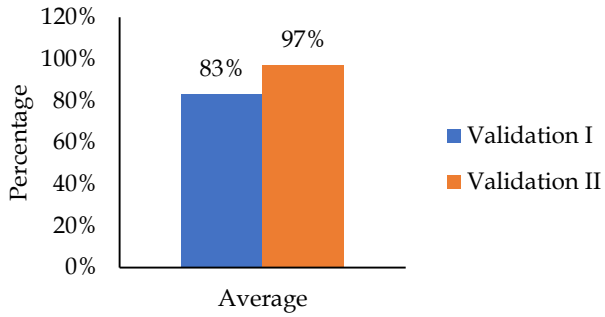


Figure 7. Average results of Media Expert Validation

The media validation stage was carried out twice. In the first validation, a percentage of 83% was obtained with a very valid category. If we look at the percentage value, it can be said that the electronic student worksheets product being developed is in the very valid

category from a media perspective. However, there still needs to be improvements to several electronic student worksheets components to make them even better. In the first validation, suggestions and input were obtained from validators to improve the Nature of Science-based electronic student worksheets, so that researchers carried out revisions and second validation to obtain an even better Nature of Science-based Electronic student worksheets. After improvements have been made according to the validator's suggestions and input, a second validation is carried out. In the second validation, a percentage of 97% was obtained with a very valid category.

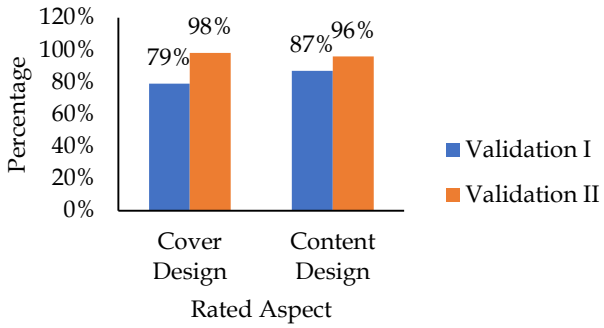
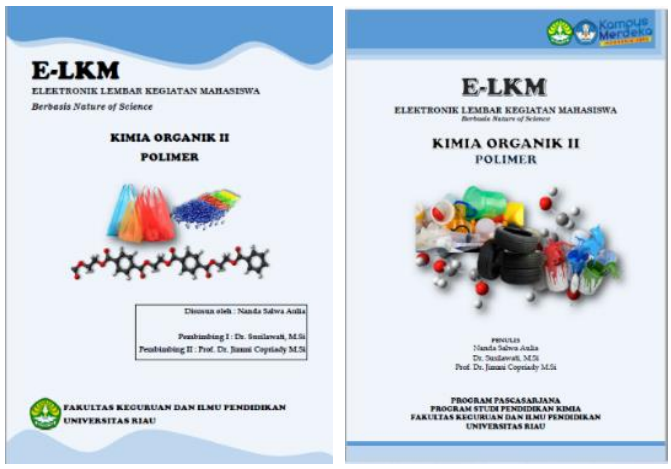


Figure 8. Percentages of media expert validation results

The cover is the first part that students see. The cover design of a student worksheet should describe the contents of the worksheet so that it does not cause a different mindset when students see it for the first time. Therefore, the cover must be made correctly and as attractive as possible (Purwaningsih & Pujaningsih, 2023). The images presented show illustrations of the material on the electronic student worksheet, so that it can attract students' interest in reading, studying and working on activities on this electronic worksheet. So that the images presented are not just images but also have meaning (Nurkhasanah & Rohaeti, 2024).

The validator also provides suggestions for replacing images that are of poor quality or blurry. Apart from that, instructions for using buttons on Electronic student worksheets have also been added, such as play, pause, next, etc. as shown in the Figure 9.

Electronic student worksheets is a type of multimedia, according to Sufyanto in (Khairi et al., 2022) which allows users to interact, navigate, be creative and communicate by using computers to create and combine images, writing using tools and create connections between buttons and pages via link. The characteristic of interactive multimedia is the presence of some kind of control, which is usually referred to as a graphical user interface, which can take the form of icons, buttons, scrolls, and so on (Khairi et al., 2022). So it is necessary to create instructions for the buttons used in Electronic student worksheets to make it easier for users to operate Electronic student worksheets.



(a) (b)

Figure 9. Improving Cover Design; (a) before validation, (b) after validation

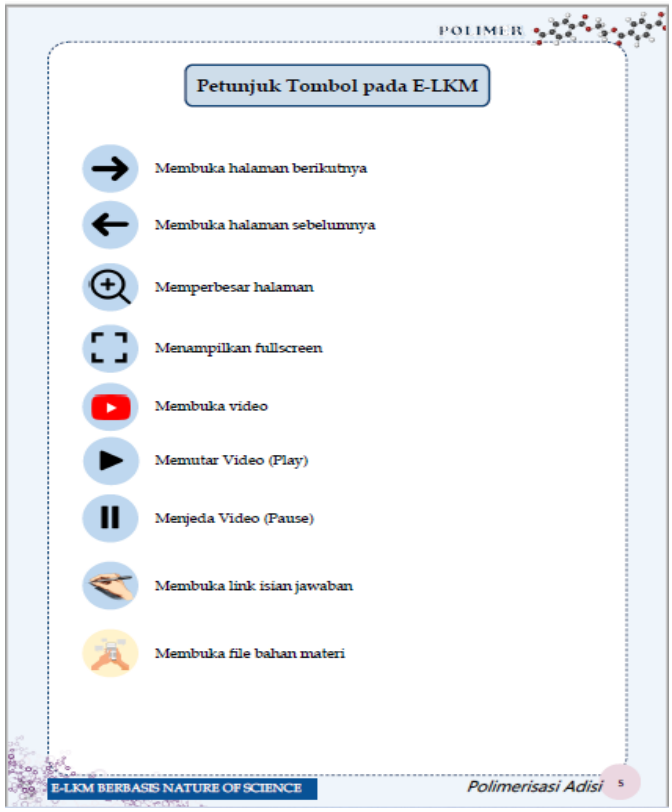


Figure 10. Adding button instructions to electronic student worksheets

Implementation

The implementation phase is the implementation stage of the product being developed, namely electronic student worksheets Polymer Based on Nature of Science. This implementation phase consists of several stages, namely one-on-one trials and small-scale trials involving lecturers and students to determine the response as

users to Nature of Science-based Polymer Electronic student worksheets teaching materials.

The one-on-one test of the Nature of Science-based Polymer Electronic student worksheets involved 3 students who had studied polymer materials, namely students in semester VI from the Chemistry Education Study Program at Riau University. The three of them are students who have different levels of academic ability, namely high, medium and low. The different levels of academic backgrounds enable the research to obtain more comprehensive results from the products developed (Amrina & Budiman, 2024).

During the one-on-one test, students were given a link to the Nature of Science-based Polymer Electronic student worksheets that had been developed. Then, students were guided by researchers to use electronic student worksheets directly. The processing time for electronic student worksheets is the same as the learning process in class. Students take part in learning activities and answer questions on electronic student worksheets. While students were working on electronic student worksheets, researchers recorded the responses given by students to the Nature of Science-based Polymer Electronic student worksheets product that had been developed.

There are several comments and suggestions from students for the Nature of Science-based Polymer Electronic student worksheets. Overall, the electronic student worksheets product developed is interesting and comfortable to read. The presence of experimental videos on making polymer products also makes learning more interesting, because there are new things that have never been known before.

Apart from that, based on the results of interviews and observations of researchers during the electronic student worksheets work process, there are several things that need to be improved. The learning videos attached to electronic student worksheets use English audio. This causes students to need more time to understand the content of the video. Students suggest adding subtitles to the learning video to make it easier to understand the content of the video. By using Electronic Student Worksheet, students feel that learning organic chemistry is more enjoyable, making it easier to understand the material provided. As stated by (Sloane et al., 2023), through the NoS learning steps with an explicit and reflective approach, understanding of a material can be improved. In addition, explicit and reflective approaches can also support the development of further understanding of a material, considering that science is changeable (Utami et al., 2022). so that students can have knowledge of how scientific knowledge develops (Koponen, 2021).

Electronic student worksheets is also practical to use. There are links embedded in certain sections that make it easier to open a file. Such as learning video links, teaching materials, and also links to answer questions on electronic student worksheets. However, there are some answer links that cannot function for uploading question answers. So, this link needs to be reviewed and improved again so that it can be used properly.

The small-scale trial involved 3 Organic Chemistry lecturers and 20 students. Researchers act as observers and do not interact with users. Small-scale trial response data collection was carried out at the Chemistry Education Study Program at Riau University.

At this stage, researchers provide the Nature of Science-based Polymer Electronic student worksheets product that has been developed, then lecturers are given time to view and read the electronic student worksheets before providing an assessment using a response questionnaire. The results of the lecturer response questionnaire are presented in Figure 11.

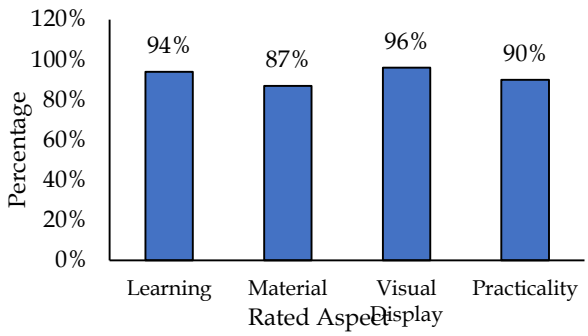


Figure 11. Lecturer response questionnaire data

The results of lecturers' responses to the Nature of Science-based electronic student worksheets Polymer product developed obtained a percentage score of 91% with very good criteria. Based on this value, it can be stated that the product developed has very good criteria.

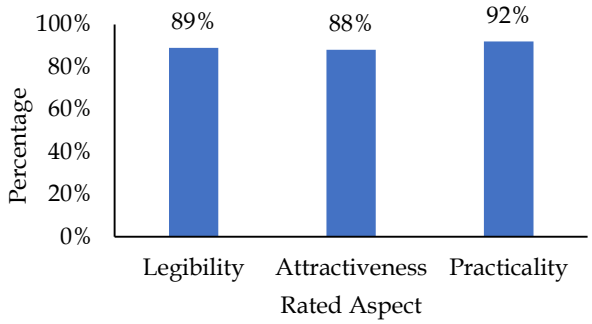


Figure 12. Student response results

In line with Nasution et al. (2023) research, he conducted a trial with respondents by giving them a questionnaire to see the effectiveness of using the Electronic Student Worksheet. Student response questionnaire data was obtained from 20 students from

the VI semester Chemistry Education Study Program as respondents. Researchers gave electronic student worksheets to students, then students were given time to view and assess the electronic student worksheets by filling in a student response questionnaire. The results of student responses to the Nature of Science-based electronic student worksheets Polymer product developed can be seen in Figure 12.

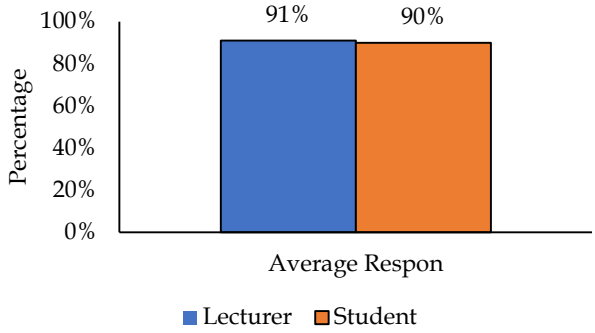


Figure 13. Average user responses

The average result of student responses to the Nature of Science-based Polymer Electronic student worksheets received a percentage of 90%, which is in the very good category. Overall, this shows that the Nature of Science-based electronic student worksheets that was developed received a very good response from students.

Based on the results of small-scale tests that have been carried out, it can be concluded that the Nature of Science-based Polymer Electronic student worksheets developed has received a very good response from lecturers and students.

Evaluation

The evaluation stage in this research was carried out at each stage of ADDIE. The evaluation aims to analyze the data obtained from the research results, initial analysis, students, curriculum and materials; at the preparation of instruments for assessing the quality of teaching materials, product design, preparation of materials, collection of tools and materials; at the stage development, namely at the material and media expert validation stage; and at the implementation stage. The evaluation stage is carried out by analyzing errors and deficiencies during the research. This stage is also carried out at each stage for improvement and follow-up of the results of the improvement of the validation process and the trial of the electronic student worksheets developed (Maulana et al., 2021).

Conclusion

The Electronic student worksheets on polymer material based on Nature of Science were developed using the ADDIE development model, with stages of analysis, design, development, implementation and evaluation. The Nature of Science-based Electronic student worksheets developed on Polymer material was declared valid based on material validation from the aspects of content, presentation, graphic language and Nature of Science aspects with a score of 93%. The Nature of Science-based Electronic student worksheets which was developed on Polymer material was declared valid based on media validation from aspects of the cover design and content design of the Electronic student worksheets with a score of 97%. The Nature of Science-based Electronic student worksheets on polymer material that was developed received a very good response from lecturers and students. User response by lecturers got a score of 92% and user response by students got a score of 90%. Based on the results of a small-scale trial of the Organic Chemistry Electronic Student Worksheet on the polymer material developed, it received a positive response from users and can be used in the learning process in the classroom.

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Author Contributions

Wrote the introduction, methods, results, discussion and conclusions, NSA. Guided and revised, S and JC.

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Conflicts of Interest

There is no conflicts in the funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results”

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