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Development of Student Worksheets Based on the Nature of Science (NoS) on Chemical Bonds Topic

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Abstract

The problem that is often experienced in learning chemical bonds topics is that students do not know the benefits of learning chemical bonds in everyday life, one of the causes is because the teaching materials used have not been able to link the material with contextual examples, real problems in everyday life, and the lack of opportunities for students to conduct investigations, making the learning less meaningful. This research aims to produce valid student worksheets based on the Nature of Science (NoS) on chemical bonds topics and determine user response. The research method used is Research and Development (R&D) using the 4-D development model (define, design, develop, and disseminate). The data collection instruments were validation sheets and user response questionnaires for teachers and students. The data analysis method in this research was carried out quantitative and qualitative data description. The results indicated that the developed student worksheets based on the Nature of Science (NoS) were deemed valid, with an average validation score of 96.12% from 3 validators. One-on-one trials were conducted with 3 students with different abilities to gather feedback for improvements. The user response test was conducted to 2 chemistry teachers and 20 students (10 students from SMAN 4 Pekanbaru and 10 students from SMAN 1 Pekanbaru), yielding response percentages of 90.06% from teachers and 90.84% from students, both categorized as very good. So, it can be said that these student worksheets have good potential to be used in learning chemistry, especially on topics related to chemical bonds.

How to Cite

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INTRODUCTION

The curriculum implemented at this time is called an independent curriculum or the concept of independent learning. Free learning means educators and students can learn and innovate creatively and independently (Fitriyah & Wardani, 2022). Teachers have an important role as facilitators to facilitate students in learning activities, where the teacher does not just provide knowledge to students, but students must build their knowledge (Hakiky et al., 2023). To help students construct their knowledge and train their learning independence, the right teaching materials are needed to support the learning process (Wahyuni et al., 2022). One printed teaching material commonly used in the teaching and learning process is the student worksheets.

Student worksheets can be used for chemistry subject matter. Chemistry is the science of matter, focusing on its structure, composition, properties, transformations, and the energy involved in these processes (Artini & Wijaya, 2020). The material studied in chemistry includes a variety of concepts, ranging from simple to more complex, with varying difficulty levels. Chemistry is one of the branches of natural science that directly relates to everyday life (Salsabiila et al., 2024). However, chemistry is often considered difficult by students, especially on the chemical bonds topics in phase F of class XI senior high school (Elath et al, 2025). Chemical bonds topics includes abstract concepts that must be remembered and understood. Therefore, to understand chemical bonds requires a deeper cognitive process, more than just memorization.

The results of pre-research interviews with two chemistry teachers at SMAN 1 Pekanbaru and SMAN 4 Pekanbaru show that teachers have used printed books recommended by the school, modules, and sometimes use student worksheets as teaching materials. However, the student worksheets used in both schools only contain brief material, practice problems, minimal pictures, and do not have an attractive design, and there are no steps of a particular learning model, so it has not been able to involve students to actively participate in learning, solve problems, and find concepts independently. The presentation of student worksheets rarely connects material with real life examples, so learning becomes less meaningful (Sinaga et al, 2020). Interviews with grade XI students further indicated difficulties in understanding subtopics such as covalent bonds and polarity, as well as connecting the bonds owned by a compound with its physical properties. Students also admitted that they do not know the benefits of learning chemical bonds topics in everyday life, so this topics is less imprinted in students memories. Therefore, the concept of chemical bonds must be taught with real life examples and contexts to make learning more contextual and interesting (Wardani et al, 2024).

Overcoming the problems identified, teaching material innovations are needed, such as the development of student worksheets on the topic of chemical bonds that meet didactic, construction, and technical requirements (Hanifha & Copriyadi, 2021). In addition, the application of a learning model that is connected to the student worksheets is also needed, such as the Nature of Science (NoS) learning model. The NoS learning model connects lessons and activities with natural phenomena and scientific processes, to increase understanding of the nature of science for students, so that it can guide students in understanding the material studied (Nugraheny & Widodo, 2021). The NoS learning model consists of six stages: background readings, case study discussions, inquiry lessons, inquiry labs, historical studies, and multiple assessments (Wulandari et al., 2019).

The Nature of Science (NoS) learning model was chosen because it can increase student activeness, build knowledge independently, and apply it to solve daily life problems, so that students better master and understand the concepts learned (Muttaqin et al., 2022). In the process, there are opportunities for students to read relevant literature, discuss formulating questions or problems, learn independently, conduct experiments, analyze and communicate data, and apply the skills that have been obtained (Wardhana et al., 2022). In addition the use of pictures, illustrations, and animated videos in student worksheets is expected to increase student motivation in learning abstract chemical bonds topics. Student worksheets based on the Nature of Science (NoS) learning model are also expected to improve student understanding and create a more meaningful learning experience.

Relevant research conducted by Wulandari et al. (2019) entitled "Development student worksheets based on the Nature of Science to Improve Science Process Skills" obtained student worksheets feasibility results of 95.35% from material experts and received a positive response from users with an average score of 87.2%. So, the student worksheets based on the Nature of Science (NoS) on environmental pollution material in junior high school that has been developed

are suitable for use to improve science process skills, through a series of activities using the steps in the NoS syntax. Another research by Suryati et al. (2022) entitled "Development of interactive E-Modules based on the Nature of Science on Redox Reactions and Electrochemistry Based on for the Cultivation of Student Science Literacy" showed the feasibility of E-modules with a percentage of 83.05% (feasible) for material aspects, 83% (practical) from teacher responses and 86.08% (efficient) from student responses. These results indicate that E-modules in chemistry learning are feasible to use as teaching materials and can attract students interest and motivation while improving their science literacy. furthermore, the development of e-modules based on Android and Nature of Science (NoS) has also been carried out by Accraf, et al (2018) on the subject of chemical bonds and intermolecular forces to foster scientific literacy. However, there has not been much research on development of student worksheets based on the Nature of Science (NoS) for chemistry learning.

Based on the background described earlier, it is necessary to provide students worksheets for chemistry learning to provide different learning experiences for students so that students can more easily build their understanding by investigation activities and real problems in everyday life, accompanied by the help of animated video explanations in the student worksheets. This research aims to develop of student worksheets based on the Nature of Science (NoS) on chemical bonds topics for class XI senior high school to help students understanding chemical bonds topics.

METHOD

The type of research used is Research and Development (R&D), with the 4-D (Four D) development model consisting of four stages: Define, Design, Development, and Disseminate (Abdias et al., 2019). The selection of the 4-D development model is based on the simplicity of the development stages, ease of understanding, and a detailed explanation of each step in the development procedure, which explains what researchers will do in developing teaching material products (Sugiyono, 2019). However, in this research, only the development stage was carried out because the purpose of the research is to develop a valid student worksheets product and to assess user responses during the learning process. The research steps in the 4-D development model can be seen in Figure 1.

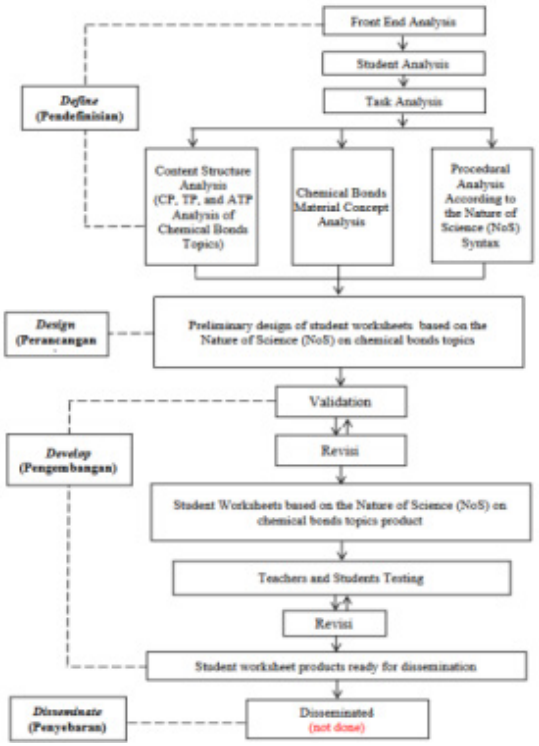

Figure 1. Student worksheets development flow on the chemical bonds topics using the 4-D model (Modified)

The trial subjects involved 3 students with different abilities in the one-to-one trial. According to Rusdi (2018) the one-on-one test is part of the formative evaluation carried out on product development in order to get suggestions or messages from students as an effort to identify and reduce errors in product use. Then, 2 chemistry teachers for the teacher response test, and 20 students in the small group trial. The data collection tools used include a validation sheet to determine the validity category of student worksheets based on the NoS and a user response questionnaire to determine the category of user response to student worksheets based on the Nature of Science (NoS). Explanation of the six stages of Nature of Science (NoS) learning model can be seen in the Table 1.

The type of data collected in this study consists of two data, namely qualitative and quantitative data. Qualitative data was obtained from interviews with teachers and students, as well as suggestions from validators, then quantitative data was obtained from the calculation of validation questionnaires and user response questionnaires for teachers and students.

Table 1. Stages of the NoS learning model

Stage	Student Activities
Background readings	Students read reading material that is the background of learning before continuing with discussion activities.
Case study discussions	Students discuss identifying problems and formulating problems by asking questions from the presented discourse.
Inquiry lessons	Students formulate hypotheses or initial guesses based on the formulation of the problem that has been determined.
Inquiry labs	Students prove the hypothesis that has been made previously through experimental activities either directly or by observing the experiment indirectly.
Historycal studies	Students make conclusions and communicate the results of previous discussions through presentations.
Multiple assesments	Students apply the concepts they have obtained in new or different situations by completing the assigned tasks.

The type of scale used is a likert scale with a score of 1 - 4. The data collected was then subjected to certain analysis techniques. The validity data analysis used the equation from Azimi., et al (2017):

$$\text{Percentage} = \frac{Score\ obtained}{Maximum\ score}\ x\ 100\%$$

The validity analysis and user responses were conducted using a likert scale with four options, based on the scoring guidelines according to Sugiyono (2016) listed in Table 2.

Table 2. Likert Scale

Attitude Statement	Score
Agree	4
Quite Agree	3
Less Agree	2
Disagree	1

The percentage validation score was then converted into a qualitative value based on the validity criteria according to Riduwan and Kuncoro (2017) listed in Table 3.

Table 3. Validity Criteria

No	Percentage (%)	Description
1	80.00-100	Very good/very valid/ very feasible
2	60.00-79.99	Good enough/quite valid/quite feasible
3	50.00-59.99	Less good/less valid/ less feasible
4	0-49.99	Not good/invalid/not feasible

The user response data that has been collected is then analyzed using the equation from Arikunto (2021):

$$P = \frac{f}{n} x100\%$$

P is the percentage of user scores in the form of percent (%), f refers to the frequency/ number of respondents answers, and n is the total number of respondents. The percentage of user response scores obtained was then converted into qualitative values according to the criteria according to Sari, et al (2016) presented in Table 4.

Table 4. User Response Criteria

No	Percentage (%)	Description
1	75.00-100	Very Good
2	50.00-74.99	Good
3	25.00-49.99	Less Good
4	0.00-24.99	Not Good

RESULT AND DISCUSSION

This development research produces products in the form of student worksheets based on the Nature of Science (NoS) on chemical bonds topics for class XI senior high school independent curriculum which has been declared valid. The following are the results and discussion of the 4-D (Define, Design, Development, Disseminate) development model of the student worksheets based on the Nature of Science (NoS) products developed.

Define Stage

The development of this student worksheets from the define stage, which is carried out through pre-research, which began with interviews with chemistry teachers and students. This stage consists of 3 steps which include, front end analysis, student analysis, and task analysis. At

the front end of analysis, information related to teaching materials used by the teachers was obtained in the matter of chemical bonds topics. Teachers have used student worksheets, but not too often. Student worksheets used are less interesting, not based on learning models that encourage students to find concepts independently, and are not associated with everyday life, so that chemistry learning becomes less meaningful. Teaching materials also need to be arranged systematically to make it easier for students to learn. Therefore, a student worksheet is needed that contain an interesting learning model to motivate students in learning chemistry, especially on of chemical bonds topic. One of them is by using the Nature of Science (NoS) learning model which provides understanding to students through the surrounding natural conditions and daily life events in the form of problems that must be solved by students (Nugraheny & Widodo, 2021).

In the analysis of students, it was found that students have difficulty learning chemical bonds topics, especially on covalent bonds and polarity of compounds. This difficulty is caused by the many abstract concepts that must be remembered and the lack of connection with real life, so they do not understand the benefits. Students in grade XI senior high school aged 16-17 years, according to Haryanto (2020), are close to maximum intellectual ability based on Piaget theory, however limited experience makes it difficult for them to utilize their knowledge. Therefore, teaching materials are needed that are interesting and help their understanding of chemical bonds.

Finally, task analysis consists of content structure analysis, concept analysis, and procedural analysis. Content structure analysis is carried out by analyzing chemical bonds topics in phase F of independent curriculum, which is listed in the learning outcomes section: Students can understand chemical bonds in relation to interactions between particles of matter and the physical properties of matter. The learning outcomes or CP are then derived into learning objectives or TP and then arranged into a flow of learning objectives or ATP on chemical bonds topics. The concept analysis then obtained sub topic of chemical bonds which were arranged systematically so as to produce a concept map of chemical bonds including, elemental stability and lewis symbols, ionic bonds, covalent bonds, polar and nonpolar covalent compounds, and metal bonds. The procedural analysis is useful for determining the stages of task completion used in the student worksheets activity, in this case using the six stages of the Nature of Science (NoS) learning model.

Design Stage

The design stage produced an initial draft of student worksheets, validation sheet instruments, and user response questionnaires. The results of the student worksheet product design include the main cover page and cover of each student worksheets meeting, instructions for use, learning outcomes and learning objectives, characteristics of student worksheets with the Nature of Science (NoS) learning model, a bibliography, and an assessment column. Figures 2-6 present an example of the appearance of the developed student worksheets.

Figure 2. Cover page of student worksheets

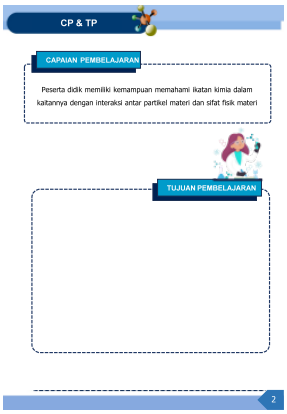

Figure 3. Learning outcome learning objectives

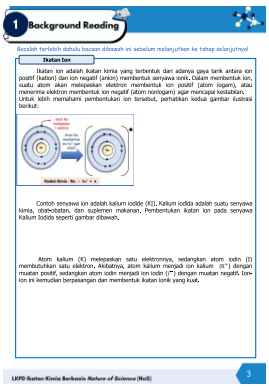

Figure 4. Short material on the background readings stage

Figure 5. Discourse of the case study discussions stage

Figure 6. Experiment activity stages of inquiry labs

Figure 2 is the cover of the student worksheets at meeting 2 which contains the logo, title, subject matter, students identity column, and a cover images that describes the contents of the student worksheets. Figure 3 is the learning outcomes and learning objectives for ionic bonding topics that has been adjusted to the contents of the student worksheets. The learning outcomes for each meeting are the same, while the learning objectives are different for each meeting of the student worksheet. Figure 4 is a student worksheets activity according to the first stage of the NoS learning model, namely backgroud readings, containing brief material readings before proceeding to the discussion stage. Figure 5 contains activities in the second stage to discuss what problems arise from the phenomenon of "the danger of electric shock during flooding" that has been provided. Figure 6 is an experimental activity "test the electrical conductivity of ionic compounds" which includes the fourth stage. Each meeting of the student worksheet has experimental activities according to the material studied in it.

This stage also produced validity sheets and user response questionnaires as tools used to collect data. The material validation sheet has 5 aspects of eligibility, namely content eligibility, NoS characteristics, language eligibility, presentation, and graphics. Meanwhile, the user response questionnaire was prepared based on response statements to the use of student worksheets during learning.

Development Stage

At this stage the product that has been designed will be validated and tested. The completed product design results were then validated to determine the products validity. Three material expert validators carried out validation twice. Overall, the validation results showed valid criteria with an average validity level of 96.12%. This shows that the student worksheets developed have good quality as teaching materials and are suitable for learning. The validation results are shown in Figure 7.

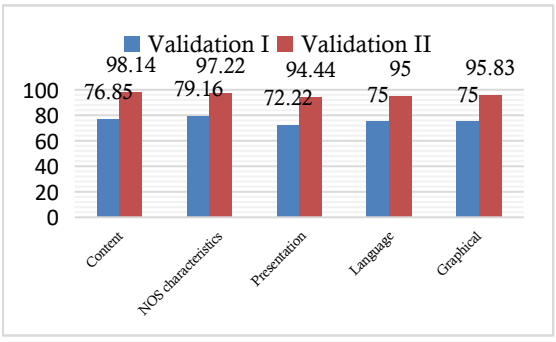

Figure 7. Percentage Chart of Validation

Figure 7 shows an increase in the percentage of validation 1 to validation 2 in each aspect of the assessment. From the results of the first validation, comments and suggestions from the validator will be obtained, which are used to improve the student worksheets. In other words, in the first validation, the student worksheets developed have not met the criteria for use, so further revisions need to be made until finally a valid student worksheets is obtained and is suitable for use in the learning process after the second validation.

The results of the content feasibility validation obtained a percentage of 98.14% with a very valid category in validation 2. This means that the material in the student worksheet is following the applicable independent curriculum and following the demands of the Learning Outcomes (CP) and Learning Objectives (TP). The suitability of the material is based on the explanation of the material and tasks that are following the competencies, learning objectives and material concepts (Asri & Dwiningsih, 2022). However,

there are some improvements made, such as adding learning videos in the form of animated videos at each student worksheet meeting through QR codes that students smartphones can scan to help students complete tasks in the student worksheets, as well as adding chemical figures that originated chemical bonds to enrich students insights. In line with according Khaira (2021), processing the material to be taught by the teacher in the form of animated videos can facilitate the absorption of information effectively and efficiently so that lessons become interesting and not boring. Improvements based on validator input can be seen in Figures 8 and 9.

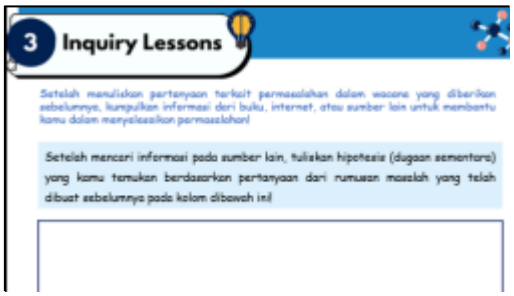

Figure 8. Before adding a learning video QR Code

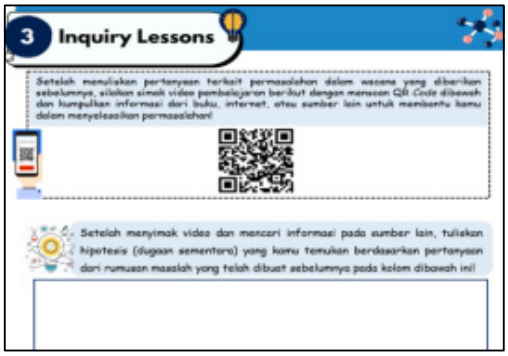

Figure 9. After adding the learning video QR Code

The results of further validation on the feasibility of Nature of Science (NoS) characteristics obtained a percentage of 97.22% with valid criteria, meaning that the completion of student worksheets tasks is by the stages of the Nature of Science (NoS) learning model. However, there are still comments in the form of reading discrepancies at the background readings stage and changing the experimental activities on metal bonds which initially only analyzed from the experimental video to conduct simple experiments on some of the physical properties of metals so that experiments can be carried out directly by students. This is in accordance with what was stated by Khery, et al (2019) that the purpose of the inquiry labs stage is to provide direct experience to students to prove the concepts that have been obtained previously, starting from determining tools and materials, conducting experiments according to the object of learning, collecting data in the form of tables, classifying and analyzing data.

The feasibility of the presentation, the validity was obtained at 94.44%, which shows that the completeness of the student worksheets format is by the student worksheets structure according to the National Education Department (2008), including containing titles, learning instructions, objectives, supporting information, tasks or work steps, and assessments. Teaching materials with good presentation can benefit students, including being easy to use because they are arranged systematically (Magdalena et al., 2020). However, there were some revisions made according to the suggestions from the validators, including expanding the answer column, adding an assessment column, and the latest references in the bibliography. The more credible references, the more value it gives to what is written (Sukendar et al., 2021). Then, according to the validator's suggestion to expand the answer filling column, in accordance with the construction requirements, namely providing sufficient space to allow students to write or draw on student worksheets (Latif et al, 2022).

The validation results on linguistic feasibility obtained a percentage of 95% with a valid category, meaning that this student worksheets has used good and correct Indonesian language. However, some improvements need to be made according to the validators suggestions, such as improving the preparation of sentences and language that could be more precise in discourse, questions, and command sentences. Using sound and correct Indonesian language per the guidelines can make it easier for students to interpret the purpose and objectives of the student worksheets (Rery et al., 2022). Another revision that has been made is to use more communicative and simple words in the command sentence at each stage of completing the task in the student worksheet so that it is easier for students to understand. In line with the opinion of Ramadhani & Emelia (2021) that a command sentence is a sentence that aims to tell you to do something. Thus, making command sentences must be clear.

Finally, the graphic aspect has a validity of 95.83% with valid criteria. This shows that the design of the student worksheets developed is good and attractive, including the type and size of the font used and the layout that attracts students attention to it. Using various colors in student

worksheets increases students attention, motivation, and interest in learning (Lestari & Parmiti, 2020). As for some of the revisions made, namely improving the layout of work instructions on student worksheets to make it more concise and neat, improving the layout of images and fonts on all student worksheets to make it neater and uniform. In line with the opinion of Chalik & Cahyani (2024) that an attractive layout design is a reason for being favored by students and can increase student engagement because a good layout can attract the attention of readers in reading the messages contained in a teaching material. After revision and reassessment in the second validation, a valid product was obtained without any improvement for each aspect of the assessment which was marked by an increase in the percentage of validation results. The valid criteria for content eligibility on student worksheets also indicate the correctness of the substance on the student worksheets which is already good (Aprilia & Suryadarma, 2020).

The student worksheets developed have been valid by integrating the six stages of the NoS model on chemical bonds topic: The first stage, background readings to equip students with basic concepts of chemical bonds before further learning. In this stage, students read articles or brief materials about elemental stability and lewis structure, types of chemical bonds (ionic, covalent, metallic), and physical properties of bonded compounds. The second stage, case study discussion to encourage students to analyze real phenomena related to chemical bonds by formulating questions from case studies presented in the discourse, such as: exploding hydrogen gas balloons at teachers day celebrations (elemental stability), the danger of electric shock during floods (ionic bonds), silica sand (SiO2) in aquariums (covalent bonds), oily hand washing (compound polarity), and knife making (metal bonds).

In the third stage, inquiry lessons, students formulate hypotheses based on relevant case studies for further investigation. At this stage, learning videos are presented in the form of QR codes on each student worksheet to facilitate students in making hypotheses and completing tasks. The fourth stage, inquiry labs where students conduct experiments to test the hypothesis that has been formulated. Some of the experimental activities carried out such as: Investigating the stability of elements (Why is Helium Gas Balloon Safer than Hydrogen Gas Balloon?), test the electrical conductivity of ion compounds, test the solubility of covalent and ion compounds, test the polarity of compounds, and test the physical properties of metal compounds.

The fifth stage, historical studies, encourages students to make inferences from experimental results and understand that scientific concepts evolve over time based on new evidence. In the student worksheet, some brief history or information about chemical figures relevant to the material studied is presented. The last stage, multiple assessments to evaluate students understanding thoroughly in the form of different problems or questions related to the concept of chemical bonds that has been obtained from the previous stages. The questions or problems in the worksheet are in essay form and consist of 2 questions.

After obtaining a valid student worksheet based on the Nature of Science (NoS) product on chemical bonds topics, it is then tested for practicality according to the results of user responses. The user response test begins with a one-on-one test, where students who have studied chemical bonds topic are asked to work directly on the student worksheets that have been developed. The initial one-on-one trial was conducted to identify and eliminate errors or shortcomings in using the product, as well as to obtain information about the users reaction to the material and the message that the product user wants to convey (Rusdi, 2019). This trial was conducted on three students of SMA Negeri 4 Pekanbaru with different cognitive abilities, namely high, medium, and less. Each students worksheet on the results of the one-on-one trial was completed within a time range and obtained different student scores.

One meeting of student worksheets has the same working time limit of 60 minutes. Each student worksheets on the results of the implementation of one-on-one trials was completed within a certain time range, and different scores were obtained from students. In each meeting, students with high abilities can work on student worksheets in a relatively faster time and get higher scores than students with medium and low abilities. Low ability students usually tend to take a long time to understand and answer questions, while high ability students are able to solve problems by planning the application of ideas productively and smoothly without experiencing significant difficulties, thus obtaining good grades (Mohamad et al., 2023).

The results of the one-on-one trial also obtained comments from students in the form of difficulty opening the learning video QR Code due to network constraints, the answer column is not wide enough, and the limited time for working on student worksheet 4 on polar and nonpolar covalent compounds because there are two expe-

riments that must be completed. These comments will be the basis for researchers to correct the errors in the student worksheets, resulting in better student worksheets that are ready to be tested in small groups and tested for teacher response. The results obtained from the response questionnaire data to 20 students in the small group trial obtained an average percentage of 90.84% with a very good category. The average percentage of the attractiveness aspect obtained was 92.81% which indicated that the student worksheet was very interesting. The results of the students response test are shown in Table 5.

Table 5. Recapitulation of Small Group Trial Results

No	Aspect	Percentage (%)	Criteria
1	Attractiveness	92.81	Very Good
2	Effectiveness	89.10	Very Good
3	Practicality	90.62	Very Good
Average Percentage		90.84	Very Good

From the one-on-one trials and small group tests that have been carried out, the results are not much different, where the problems or difficulties experienced by students during the students worksheets include the learning video in the QR Code that cannot be accessed so that the researcher assists the students in opening the learning video. Overall, students think that the presentation of student worksheets can increase their interest and motivation to learn chemistry because it has an attractive appearance, clear images and is equipped with learning videos that are easy to understand and improve students understanding of concepts. Students understanding can be supported by teaching materials that combine images and text that attract attention to the presence of videos and pictures that can convey the meaning of learning materials (Safitri, 2022). The steps of the Nature of Science (NoS) learning model in the student worksheets are also coherent and clear and can guide students to understand the concept of chemical bonds and provide meaningfulness for students through solving problems in everyday life related to the subject matter. Through the Nature of Science (NoS) learning model, students will experience the practicum activities themselves, and through this experience, they can build the knowledge gained so that it is stored in their memory for a long time (Aulia et al., 2024).

The results of the response test to 2 chemistry teachers each from SMAN 1 Pekanbaru and SMAN 4 Pekanbaru obtained an average percentage of teacher response questionnaire of 90.06% with a very good category. In addition, the results of the teacher response test obtained several comments including changing all learning videos on student worksheets using the researchers voice to be more innovative, and adding a video link to the polarity experiment of compounds based on the direction of flow deflection in student worksheets 4 because it cannot be done directly due to the limited laboratory at school. The results of the teacher response test are shown in Table 6.

Table 6. Recapitulation of Teacher Response Test Results

No	Aspect	Percentage (%)	Criteria
1	Content feasibility	84.37	Very Good
2	Learning activities	93.75	Very Good
3	Effectiveness	94.64	Very Good
4	Attractiveness	87.5	Very Good
Average Percentage		90.06	Very Good

The results of the teachers response show almost the same thing as the results of the previous students responses. Where the teacher assesses that the student worksheets based on the Nature of Science (NoS) has an attractive appearance with examples of the application and relationship of chemical bonding material in everyday life. The material presented in the student worksheets is able to support the achievement of learning objectives on topics related to chemical bonds. The success of student learning is influenced by the teaching materials used by the teacher which can increase the enthusiasm and learning outcomes, as well as the motivation of students when carrying out learning activities (Ramdoniati et al., 2018). In addition, teachers considered that these student worksheets were easy to use in learning activities. Using practical teaching materials allows teachers to maximize the time available (Adawiyah et al., 2021).

The average user response to the use of student worksheets based on the Nature of Science (NoS) is very positive, indicating that these student worksheets are practical to use as teaching

materials.

The limitation of this research lies in the abstractness of the concept of chemical bonds so that it is difficult to relate to the characteristics of Nature of Science (NoS) learning model which contains real phenomena that can be observed directly. For this reason, it is hoped that future research can apply on the Nature of Science (NoS) learning model to other chemical materials that contain contextual concepts and have a lot of relevance in everyday life such as acid base topic and others, so that it will be easier to integrate in student worksheets. In addition, this research was only conducted up to the development stage in the small group test due to time constraints. Therefore, it is hoped that the student worksheets that have been developed can be carried out a large group trial at the disseminate stage, to test the effectiveness of student worksheets in the learning process by implementing a wider scope in the learning process through further research.

CONCLUSION

Student worksheets based on the Nature of Science (NoS) on chemical bonds topics for class XI senior high school independent curriculum developed were declared valid by validators based on aspects of content feasibility, Nature of Science (NoS) characteristics, presentation feasibility, linguistic feasibility, and graphic feasibility with an overall percentage of the average validation score of 96.12%. Then, the results of the user response, namely the teachers response and the students response in the small group test, get a percentage of 90.06% and 90.84% respectively with very good criteria so that the Student worksheets based on the Nature of Science (NoS) that has been developed is feasible to use as teaching material in chemistry learning.

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