DEVELOPMENT OF PROBLEM BASED LEARNING TEACHING MODULES ON GREEN CHEMISTRY MATERIALS

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DOI: 10.20414/spin.v6i2.10548

ABSTRACT

The change from the 2013 curriculum to the Merdeka curriculum requires adjustments for teachers and students. The lack of availability of teaching tools that are in accordance with the Merdeka curriculum and a learning approach that is still teacher-centered makes students less motivated to participate in learning. The purpose of this study is to develop a PBL-based teaching module on green chemistry material by determining the validity, practicality, and effectiveness of student responses to the content measured in the teaching module. This research is R&D (Research and Development) research with the ADDIE (Analyze, Design, Develop, Implement, Evaluate) model. The data collection technique used a material and media validation questionnaire involving seven material and media expert validators and was analyzed using the Aiken's V test. Furthermore, the validated teaching module was tested limited to 26 class X phase E students. The development of this PBL-based teaching module obtained results in the validity of the material and media of 0.91 and 0.92 in the "Valid" category. Then it was implemented with students in class X-5 and received a response of 83.27% in the "Very Practical" category. Furthermore, the results of the LKPD assignment in the module obtained an average of 83.15% which indicates "Very Effective". Thus, this PBL-based teaching module is suitable for use as a learning tool.

ABSTRAK

Pergantian kurikulum 2013 menjadi kurikulum merdeka membutuhkan penyesuaian bagi guru dan peserta didik. Kurangnya ketersediaan perangkat ajar yang sesuai dengan kurikulum merdeka dan pendekatan pembelajaran yang masih berpusat pada guru membuat peserta didik kurang termotivasi untuk mengikuti pembelajaran. Tujuan dari penelitian ini adalah mengembangkan modul ajar berbasis PBL pada materi kimia hijau dengan mengetahui kevalidan, kepraktisan, dan keefektifan dari respon peserta didik terhadap konten-konten yang diukur dalam modul ajar. Penelitian ini adalah penelitian R&D (*Research and Development*), dengan model ADDIE (*Analyze, Design, Develop, Implement, Evaluate*). Adapun teknik pengumpulan data menggunakan angket validasi materi dan media dengan melibatkan 7 validator ahli materi dan media dan dianalisis dengan uji Aiken's V. Selanjutnya modul ajar yang telah divalidasi diuji coba terbatas pada 26 peserta didik kelas X fase E. Pengembangan modul ajar berbasis PBL ini memperoleh hasil kevalidan materi dan media sebesar 0,91 dengan dan 0,92 dengan kategori "Valid". Kemudian diimplementasikan kepada peserta didik kelas X-5 dan mendapatkan hasil respon sebanyak 83,27% dengan kategori "Sangat Praktis". Selanjutnya pada hasil penugasan LKPD dalam modul diperolehan rata-rata 83,15% yang menunjukan "Sangat Efektif". Dengan demikian, modul ajar berbasis PBL ini layak digunakan sebagai perangkat pembelajaran.

How to Cite

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INTRODUCTION

Education is defined as an effort to build quality human resources. In the aspect of education, of course, we see that policies in education change according to circumstances and developments in the times. One aspect of education that often changes is the curriculum. Thus, teachers and students need to adjust to changes in the curriculum (Safitri & Fajar, 2023).

The Merdeka curriculum is a new curriculum that improves on the previous curriculum. This curriculum change was motivated by the conditions of the Covid-19 pandemic some time ago. The previous curriculum, namely the 2013 Revised Curriculum, was considered complex if applied to online learning. Therefore, the Ministry of Education, Culture, Research and Technology made a new policy related to the curriculum, namely the Merdeka curriculum which was considered to be able to explore the competencies of teachers and students so that they could mutate into Merdeka learning (Prasetyowati et al., 2023).

Learning in the Merdeka curriculum emphasizes student character and adjusts to the level of student understanding. According to (Mahatika et al., 2022) in the Merdeka curriculum there are new terms such as Learning Outcomes are competencies that students must achieve at each phase, Learning Objectives are a description of the acquisition of knowledge, skills, and attitude competencies in learning activities, and Learning Objective Achievement Criteria are a series of indicators derived from learning objectives to show student competency achievement.

Learning tools that are in accordance with the Merdeka curriculum are teaching modules. Teaching modules are guidelines for monitoring the learning process that are made in a structured manner. The following criteria must be met by teaching modules: 1) Essential, which means that students must understand the concept of each topic through learning experiences. 2) Interesting, Meaningful, and Challenging, which means that students must be actively involved in the learning process. Building on previous knowledge and experience so that the learning content that is undertaken will be in accordance with the level of student understanding. 3) Relevant and contextual because it remembers by connecting previous knowledge and experience and in accordance with the context in which students will recognize their interests. In addition, 4) Continuous, because the learning flow will continue to be studied by students.

According to (Priliyanti et al., 2021) green chemistry material is new material included in the Merdeka curriculum. Green chemistry is a science that studies how to design a product to be environmentally friendly so that it can reduce the use of hazardous chemicals. Green chemistry material emphasizes mastery of concepts, facts, and ideas that can increase students' interest in learning.

One learning model that can meet learning objectives that support conceptual material is to use the problem solving or problem based learning (PBL) model. According to (Rahman et al., 2023) the application of a problem-based learning model can have a significant impact on student learning activities. The problem-based learning model makes students more active in the learning process and more courageous in expressing their ideas. In addition, it can encourage students' critical

thinking skills. Problem-based learning builds students' thinking so that they can apply it effectively in solving problems. Students who are accustomed to learning through problems can develop quality attitudes and actions.

Learning with the problem-based learning (PBL) model includes several syntaxes, including orienting students to problems, organizing students to learn, directing Merdeka or group investigations, developing and presenting work results, and analyzing and evaluating problem-solving results. The steps for problem-based learning include 1) Students are given a problem; 2) Students discuss the problem in small groups. They define a problem based on facts. They combine their ideas and concepts. Then they find out what they know and what they need to solve the problem. They research the problem and make an action plan to solve it; 3) Students search for literacy from various sources from books and the internet to solve the problem without teacher assistance; 4) Students share information again with their group; 5) Students convey solutions to the problem topic 6) Students review what has been learned, from this review the teacher also provides learning reinforcement (Suradika et al., 2023).

METHOD

This research is a type of Research and Development (R&D) development research which is a method used to produce certain products, and see the practicality of the product. Research and development (R&D) method The development model used in this study is ADDIE (Analyze, Design, Develop, Implement, and Evaluate). The subjects in this study were students of SMAN 1 Pabuaran Serang class X-5 in the 2023/2024 academic year with a total of 26 students. This study was conducted to determine the feasibility and effectiveness of the developed teaching module. The research instruments used were 1) Teacher and student needs analysis form which was used to find existing problems. So that an accurate analysis can be known in designing the developed product 2) Validation sheet, used to determine the validity score on the developed teaching module (Musthofa et al., 2016), 3) Student response questionnaire, used to determine student responses to the developed teaching module so that its practicality can also be known (Rinawati & Darisman, 2020). The needs analysis is processed qualitatively using short statements (Yes/No) which then the results of the questionnaire analysis will be concluded according to the respondents' answers. Validity is obtained based on the results of the assessment of the teaching module by the raters. Then suggestions and input from the raters are collected as considerations for making revisions, while the assessment data is determined using a Likert scale and processed using the Aiken's V test and descriptive statistics.

Data from the recapitulation of validation results is processed using the Aiken's V formula in formula (1) dan (2) as follows to determine the validity results:

$$V = \frac{\sum s}{[n(c-1)]}$$ ...(1)

$$S = r - Io$$ ...(2)

Description:
V = Validity
c = Maximum score
r = Score from validator
n = Number of validators

According to (Restu et al., 2022), the validation results obtained were then interpreted into the validity level criteria of the Aiken's index which are presented in the following Table 1.

Table 1. Aiken's validity index criteria

Validity index	Interpretation
≤0,4	Low
0,4≤×≤0,8	Middle
≥0,8	High

Furthermore, to determine the percentage of product validity, the data is also processed using formula (3) as following descriptive statistical methods:

$$Vah = \frac{Tse}{Tsh} \times 100\% \qquad \ldots(3)$$

Description:
Vah   : Validation (material and media experts)
Tse   : Total empirical score
Tah   : Total expected score

Then, the results of the validation percentage can be interpreted according to the table from (Kurniawan & Rohmani, 2019) as the scores on each scale given are in Table 2:

Table 2. Interpretation of product validation scores

Percentage Score	Interpretation
0 % - 20 %	Very Unworthy
21 % - 40 %	Unworthy
41 % - 60 %	Quite Worthy
61 % - 80 %	Worthy
81 % - 100 %	Very Worthy

The analysis of product practicality is obtained from the results of student responses during implementation. The average answer to the student response questionnaire is found using the formula (4):

$$P = \frac{Tse}{Tsh} \times 100\% \qquad \ldots(4)$$

Description:
P   : Percentage of Product Practicality
Tse   : Total empirical score
Tsh   : Total expected score

After knowing the practicality of the teaching module, the scores obtained can be interpreted according to Table 3 presented below:

Table 3. Criteria for interpreting product practicality

Percentage Score	Interpretation
0 % - 20 %	Very Bad
21 % - 40 %	Not Good
41 % - 60 %	Quite Good
61 % - 80 %	Good
81 % - 100 %	Very Good

(Rohman & Mutmainah, 2015)

RESULT AND DISCUSSION

This research produces a teaching module product based on problem based learning that is adjusted to students' needs. In this teaching module, what is tested on students includes the steps of problem-solving learning listed in the lesson plan, materials or reading materials in the teaching module, and assignments in the student worksheets. Then students fill out a response questionnaire to find out whether this teaching module is worthy of being tested in class X phase E. The first stage is the analysis stage. At this stage, a needs analysis is carried out on teachers and students through a questionnaire distributed in the form of a form. The results of the needs analysis on teachers can be seen in the Figure 1:

Figure 1. Results of teacher needs analysis

Based on the results of the teacher needs analysis, problem-based learning-based teaching modules are very much needed, because teachers need guidelines that are in accordance with the Merdeka curriculum, where the teaching module itself contains new components that differentiate it from the previous curriculum. In addition, there are still teachers who need adjustments in making Merdeka curriculum teaching tools, so the development of this teaching module will make it easier as an additional reference. The results of the student needs analysis can be seen in the Figure 2:
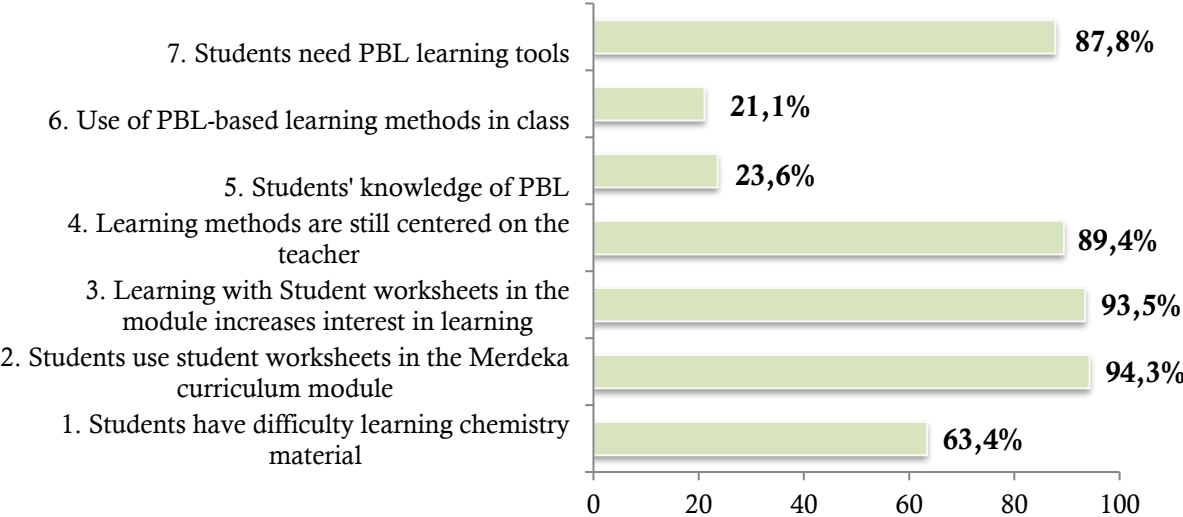
Figure 2. Results of student needs analysis

Based on the analysis of student needs, it was found that students had difficulty in learning chemistry material, especially in the Merdeka curriculum there are some new materials that sound foreign, and learning is still centered on the teacher. So teaching tools are needed with learning methods that can spur student independence to learn. Therefore, a problem-based learning teaching module on green chemistry material is needed to support the learning process for students.

At the analysis stage, a curriculum analysis is also carried out. The analysis of the Merdeka curriculum aims to match the material with learning objectives and the criteria for achieving learning objectives. The curriculum analysis is presented in Table 4.

Table 4. Results of curriculum analysis

Phase	Learning Outcomes
E	At the end of phase E, students have the ability to respond to global issues and play an active role in providing solutions to problems. These abilities include identifying, proposing ideas, designing solutions, making decisions, and communicating in the form of simple projects or visual simulations using available technology applications related to alternative energy, global warming, environmental pollution, nanotechnology, biotechnology, chemistry in everyday life, utilization of waste and natural materials, pandemics due to viral infections. All of these efforts are directed at achieving sustainable development goals (Sustainable Development Goals/SDGs). Through the development of a number of these knowledge, noble morals and scientific attitudes are also built such as honesty, objectivity, critical thinking, creativity, independence, innovation, mutual cooperation, and global diversity.

Learning objectives
Applying chemical concepts in environmental management including explaining the phenomenon of global warming.

Learning Objective Achievement Criteria
1. Students are able to describe the concept of green chemistry.
2. Students are able to explain the concept of green chemistry in environmental management.
3. Students are able to identify the concept of green chemistry in the phenomenon of global warming.
4. Students are able to present solutions to solving problems in environmental pollution.
5. Students are able to determine activities that support environmental conservation efforts.

The second stage is the design stage. Several steps taken at this stage are collecting references in the form of materials, selecting learning content, compiling components of teaching materials, and designing teaching materials. The materials are compiled based on literature from scientific journals and e-books. The selection of learning content is included in the form of a barcode scan containing a video related to green chemistry material. The compilation of teaching material components begins with compiling general information, core components, to attachments containing materials and student worksheets. Then a storyboard and teaching material design are made which include cover design, component design in the teaching module, material design, and student worksheet design. The following are some representative design displays in the entire teaching module presented in Figure 3:

| (a) | (b) | (c) | (d) |

Figure 3. Product design results (a) Cover of Teaching Module, (b) Green Chemistry Material, (c) Student Worksheets Display, (d) Assessment

The teaching module presents assessment components that include initial assessment, formative assessment, and summative assessment. Initial assessment is applied when learning is about to begin, which aims to determine the willingness of students to learn. Formative assessment is carried out during learning with the aim of providing information for teachers and students to improve the learning process. Summative assessment is applied at the end of learning to determine student learning achievement.

The third stage is the development stage. At this point, validity is tested. Seven validators were given a questionnaire to conduct a validity test. The teaching module was developed through the material and media validation stage. The feasibility of the material consists of four components, content feasibility, language feasibility, presentation feasibility, and suitability with the problem-based learning model. Meanwhile, media validation includes three aspects including graphic feasibility, language aspects, and practicality aspects. Based on the scores obtained, the average result of the validation of the teaching module material was 0.91 with the category "Valid". While the average result of the validity of the teaching module media was 0.92 with the category "Valid". The validation results are presented in Table 5 and Table 6:

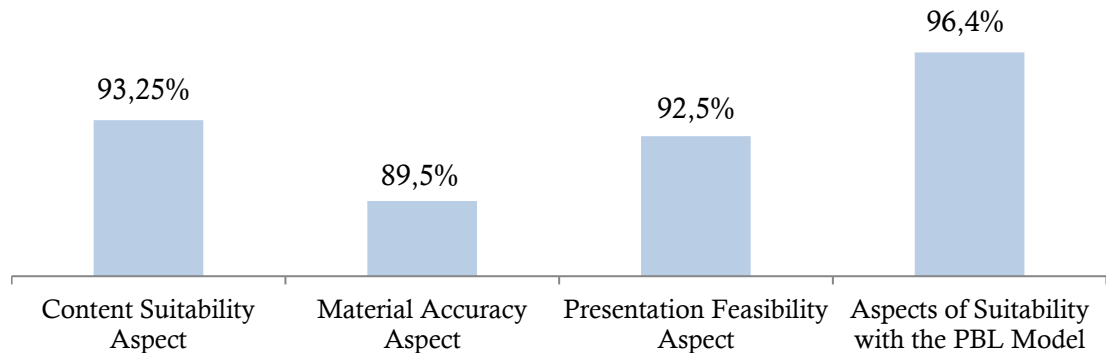**Table 5. Material validation results**

No	Assessment Aspects	Validity	Validity Index
1.	Aspect of content suitability	0,92	High
2.	Aspect of material accuracy	0,87	High
3.	Aspect of presentation suitability	0,91	High
4.	Aspect of suitability with PBL model	0,95	High
	Total average	**0,91**	**High**

Table 6. Media validation results

No	Assessment Aspects	Validity	Validity Index
1.	Graphic feasibility aspects	0,96	High
2.	Language aspects	0,87	High
3.	Practical aspects	0,93	High
	Total Average	**0,92**	**High**

Researchers process validation data using the Aiken test. Researchers use a scale of 5 and include 7 expert validators. Thus, the calculation of validation data is declared valid if it reaches a value of 0.75. Furthermore, after going through the expert v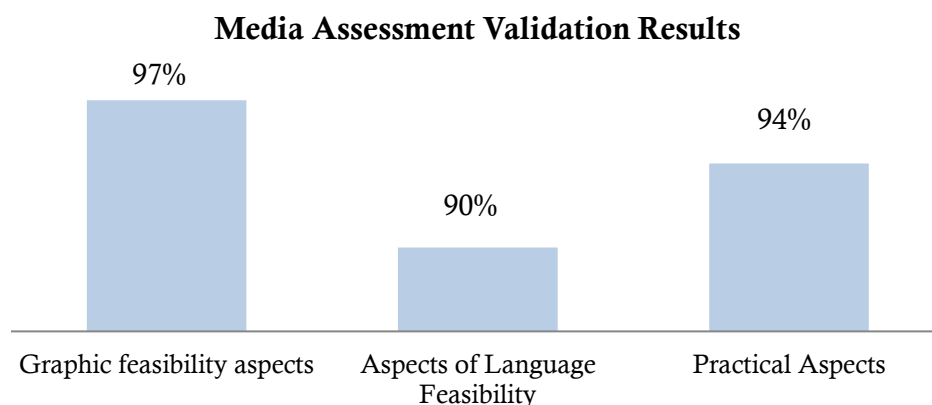alidation stage, researchers make revisions based on suggestions and input from the validators. The results of the validation of the material and media of the teaching module are interpreted in the form of a percentage calculated using the descriptive statistical method. The data is presented in the Figure 4.

Material Validation Assessment Results

Figure 4. Results of the material validation percentage

From the percentage above, it is known that the average material validation score is 92.91% and is categorized as "Very Eligible". According to (Salsabilla & Jannah, 2023) the Merdeka curriculum teaching module is said to be systematic if it contains an essential material structure. Furthermore, in media validation, the scores obtained are as presented in the Figure 5:
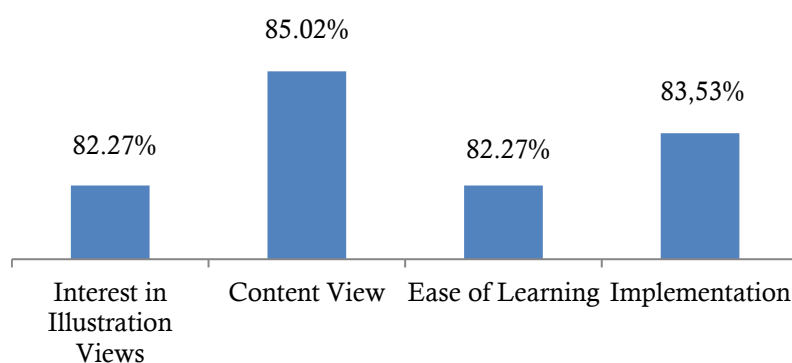
Media Assessment Validation Results

Figure 5. Media validation percentage results

Based on the media validation score seen in Figure 4, the average percentage obtained was 93.67% which was categorized as "very feasible". In the media validation results, the graphic aspect had the highest percentage which included background design, color, and use of fonts. As according to (Andayani et al., 2023) that the use of learning media graphics which include letter color, letter clarity, and illustration suitability will bring out the interesting side for those who see it.
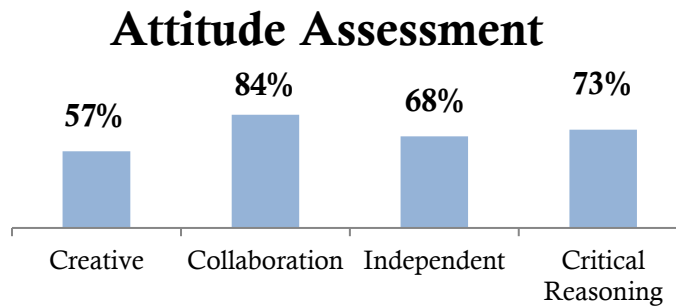
The fourth stage is the implementation stage. At this stage, a field test was carried out in class X-5 SMAN 1 Pabuaran with 26 students. After carrying out a series of learning, the researcher distributed questionnaires to students to find out the response to the learning carried out using this teaching module. The results of the analysis of student responses are presented in Figure 6.

Figure 6. Results of student responses to the teaching module

Based on the image, then from the calculation of the 4 aspects of the student response results obtained an average of 83.27% so that it is suitable for use in chemistry learning on green chemistry material with a problem-based model. At t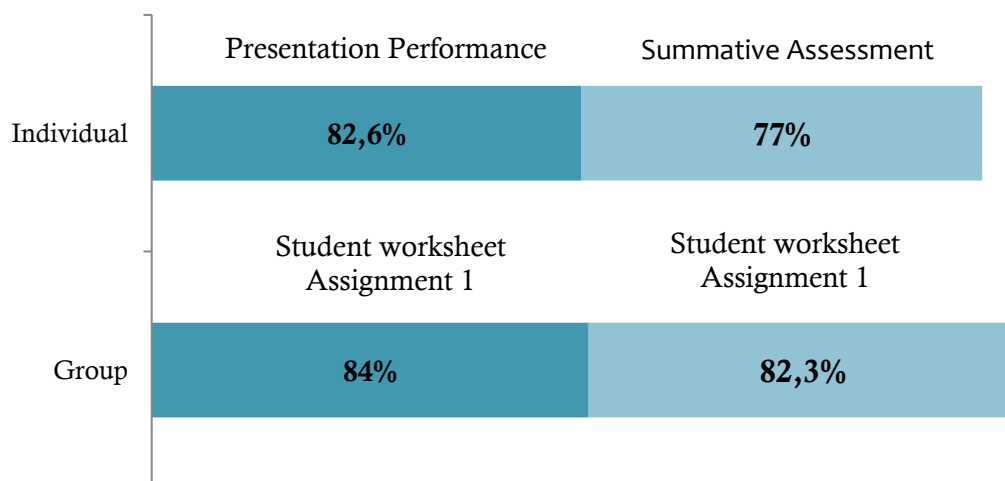he implementation stage, a series of learning is carried out in accordance with the RPP stated in the teaching module. So that student character assessments are also carried out according to the Pancasila student profile. The student character assessment is presented in the Figure 7:

Attitude Assessment

Figure 7. Results of student attitude character assessment

Based on the results of the student character assessment, what is considered in this assessment are the values of creativity, cooperation, independence, and critical reasoning of students. This is in accordance with the motto of the Pancasila student profile where these values are also observed from the contribution of students during learning both Merdekaly and in groups (Oktavia Rahayu et al., 2023). The indicator of the achievement of the problem-based learning model can also be seen from the assessment of critical reasoning character which gets a score of 73% with the category "good". At the implementation stage, student assessments are also carried out in terms of assignment results both individually and in groups. From the individual assessment, what is assessed is the performance during the presentation and the results of the summative assessment. While from the group assessment, what is assessed is the results of student worksheet 1 and 2. The results of student assignments are presented in Figure 8.

Figure 8. Results of student assignment assessment

Based on the results of student assignment assessments, as according to (Ulandari, 2021) that student worksheets can make it easier for students to learn, so that student learning outcomes can foster student interest in learning. In student worksheets assignments 1 and 2, an average calculation of 83.15% was obtained, indicating the category "Very Effective" The last stage is evaluation, according to (Waruwu, 2024) researchers need to review things to find out the weaknesses found during the research process. At the analysis stage, the needs analysis process is carried

out by giving questionnaires to teachers and students, and a literature study is also carried out. Suggestions for further researchers are that interviews can be conducted with teachers and students to find out more information. At the design stage, the use of the Canva website must use a premium account to get more and varied templates and designs. Therefore, it is necessary to know the advantages and disadvantages of the software assistance. At the development stage, the validation process for teaching modules takes quite a long time. So that validation can be done by adjusting the validator schedule first. At the implementation stage, it was carried out on students of class X-5 SMAN 1 Pabuaran Serang. In the field trial, there were obstacles in the time of the trial, because it coincided with the time after the ceremony, so the time for implementation was cut short.

CONCLUSION

Based on the findings of this study, it can be concluded that the PBL-based teaching module that focuses on green chemistry material is valid and effective. Based on the aspect of material validity, it obtained a score of 0.91 and media validity obtained 0.92 which refers to the very valid category. Practicality was obtained from the student response questionnaire, the percentage was 83.53% with a very practical category. Furthermore, the effectiveness aspect was also obtained from the results of student assignments with an average percentage of 83.15% which is included in the very effective category. The development of this teaching module is very essential to be developed because it can support teachers and students in providing learning content that is in accordance with the Merdeka curriculum teaching tools, especially considering that the

implementation of the Merdeka curriculum has been echoed in all schools, both private and public. It is hoped that further research will allow the development of Merdeka curriculum teaching modules on other materials.

REFERENCES

Andayani, Y., Kastari, D., Junaidi, E., Studi, P., & Kimia, P. (2023). *PERSEPSI GURU KIMIA DAN SISWA KELAS XI MIPA SMA / MA KABUPATEN LOMBOK TENGAH TERHADAP LEMBAR KERJA PESERTA. 1999.* https://doi.org/10.29303/cep.v6i1.3424

Kurniawan, M. F. T., & Rohmani, L. (2019). Pengembangan Media Pembelajaran Interaktif Berbasis Aplikasi Android Untuk Meningkatkan Hasil Belajar Kewirausahaan. *Jurnal Pendidikan Ekonomi, 12*(1), 72–77. http://journal2.um.ac.id/index.php/jpe/index

Mahatika, A., Demina, Zulmuqim, & May, C. C. (2022). *Evaluation of Learning Programs in the Independent Curriculum in Elementary Schools. X*(December), 169–178.

Musthofa, N. A., Mutrofin, S., & Murtadho, M. A. (2016). Implementasi Quick Response (Qr) Code Pada Aplikasi Validasi Dokumen Menggunakan Perancangan Unified Modelling Language (Uml). *Antivirus : Jurnal Ilmiah Teknik Informatika, 10*(1), 42–50. https://doi.org/10.35457/antivirus.v10i1.87

Oktavia Rahayu, D. N., Sundawa, D., & Wiyanarti, E. (2023). Profil Pelajar Pancasila Sebagai Upaya Dalam Membentuk Karakter Masyarakat

Global. *Visipena*, *14*(1), 14–28. https://doi.org/10.46244/visipena.v14i1.2035

Prasetyowati, D., Kartinah, K., Sugiyanti, & Harun, L. (2023). Implementasi Kurikulum Merdeka Di Smk Negeri 1 Purbalingga. *PATIKALA: Jurnal Pengabdian Kepada Masyarakat*, *3*(1), 808–813. https://doi.org/10.51574/patikala.v3i1.868

Priliyanti, A., Muderawan, I. W., & Maryam, S. (2021). Analisis Kesulitan Belajar Siswa Dalam Mempelajari Kimia Kelas Xi. *Jurnal Pendidikan Kimia Undiksha*, *5*(1), 11. https://doi.org/10.23887/jjpk.v5i1.32402

Rahman, A., Ilwandri, I., Santosa, T. A., & … (2023). Effectiveness of Problem-Based Learning Model in Science Learning: A Meta-Analysis Study. *JUARA: Jurnal …*, *36*. http://jurnal.upmk.ac.id/index.php/juara/article/view/3128

Restu, N., Nabil, N. R. A., Wulandari, I., Yamtinah, S., Retno, S., Ariani, D., & Ulfa, M. (2022). Isi Instrumen Asesmen Kompetensi Minimum. *Jurnal Penelitian Pendidikan*, *25*(2), 184–191.

Rinawati, D., & Darisman, E. K. (2020). Survei tingkat kejenuhan siswa SMK belajar di rumah pada mata pelajaran produk kreatif dan kewirausahaan selama masa pandemi covid-19. *Journal of Science and Education (JSE)*, *1*(1), 32–40. https://doi.org/10.56003/jse.v1i1.11

Rohman, M. A., & Mutmainah, S. (2015). Pengembangan Media Permainan Monopoli Dalam Pelajaran Seni Budaya dan Keterampilan Kelas VI SDN Tanamera I. *Jurnal Pendidikan Seni Rupa*, *3*(1), 47–56.

Safitri, S. A., & Fajar, F. (2023). Hambatan-Hambatan Dalam Proses Adaptasi Pelaksanaan Kurikulum Merdeka (Studi Pada Guru Sma Negeri 1 Semarang). *Solidarity: Journal of Education, Society and Culture*, *12*(2), 335–347. https://doi.org/10.15294/solidarity.v12i2.76723

Salsabilla, I. I., & Jannah, E. (2023). *Analisis Modul Ajar Berbasis Kurikulum Merdeka*. *3*(1), 33–41.

Suradika, A., Dewi, H. I., & Nasution, M. I. (2023). Project-Based Learning and Problem-Based Learning Models in Critical and Creative Students. *Jurnal Pendidikan IPA Indonesia*, *12*(1), 153–167. https://doi.org/10.15294/jpii.v12i1.39713

Ulandari, A. (2021). *PENGEMBANGAN LEMBAR KERJA PESERTA DIDIK (LKPD) BERWAWASAN GREEN CHEMISTRY UNTUK MENINGKATKAN KEMAMPUAN LITERASI SAINS PADA MATERI ASAM BASA*. *15*(1), 2764–2777.

Waruwu, M. (2024). Metode Penelitian dan Pengembangan (R&D): Konsep, Jenis, Tahapan dan Kelebihan. *Jurnal Ilmiah Profesi Pendidikan*, *9*(2), 1220–1230. https://doi.org/10.29303/jipp.v9i2.2141