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Development of Teaching Materials to Support *Merdeka* Curriculum Learning on Solubility and Solubility Product in F Phase

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Abstract: By the Covid-19 pandemic which shows that students' interest in learning is decreasing and cause learning loss, the Ministry of Education and Culture is trying to restore learning given the difficulties that have arisen with launching an *merdeka* curriculum, the teachers and students need using learning tools as learning resources in accordance with the *merdeka* curriculum. This research aims to develop teaching materials to support *merdeka* curriculum learning on the solubility and solubility product in the F phase and reveal the validity and practicality developed. This type of research is development research using the Plomp model. This research is limited to the formation of a valid and practical prototype IV. The instrument used in this study was a questionnaire in the form of a questionnaire of validation and practicality sheets. This study conducted a validity test using the Aiken's V formula and a practicality test using the practicality using the category of practicality level adaption from Purwanto. Validation was carried out by 5 experts, namely 3 lecturers and 2 chemistry teachers. The practicality sheet was filled in by 2 chemistry teachers and 9 Phase F students at SMAN 7 Padang. Also one to one evaluation by 3 students. The validity test data processing results are 0.89 which shows the valid category. For the results of data processing for the practicality test of students, namely 88% and the teacher's practicality test is 94% which shows a very practical category. It can be concluded that teaching materials to support *merdeka* curriculum learning on solubility and solubility product are valid and practical.

Keywords: *Merdeka* curriculum learning; Solubility and solubility product; Teaching materials

Introduction

As a result of the Covid-19 pandemic, various difficulties in implementing learning were identified in educational units (Rahimah, 2022; Fani & Mawardi, 2022). The implementation of learning experiences changes in educational components such as teachers, students, school environment, educational content, educational methods and educational media. However, the limited adjustments to these changes make the implementation of learning less effective and cause learning loss (Jojor & Sihotang, 2022). Learning loss is an event of loss of knowledge and skills in general, specifically, or the occurrence of a setback in the academic process due to certain conditions. Learning loss is a learning process that is not maximally carried out in schools. The learning process that is not optimal will have implications for learning outcomes. Learning loss can have an impact on the quality of human resources (Bahriah et al., 2023).

The Ministry of Education and Culture is trying to restore learning given the difficulties that have arisen with launching an *merdeka* curriculum to address the current problems. In accordance with the Pancasila student profile, project-based learning for the development of soft skills and character is expected to be a program that can make recovery in learning. In addition, the *merdeka* curriculum offers learning about

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essential materials and a more flexible curriculum structure (Fitriyah & Wardani, 2022). The *merdeka* curriculum is a learning curriculum with various intracurriculars covering more optimal content. This is planned so that students have sufficient opportunities to explore concepts and master competencies (Kemendikbud, 2022).

The implementation of the *merdeka* curriculum learning encourages the teacher's role both in curriculum development and in the learning process. Where in line with the opinion of Ainia (2020), the teacher as the main subject who plays a role is expected to be a driving force to take actions that provide positive things to students. Where Yamin & Syahrir (2020), argue that this statement is in the framework of welcoming change and progress of the nation so that it can adapt to changing times. It is hoped that the teacher will be able to carry out a more meaningful learning process, in accordance with the principles that organize learning according to the stages and needs of students, by using learning tools as learning resources in accordance with the *merdeka* curriculum. The learning process activities carried out by the teacher require learning resources that are a source of information for students. In addition, these learning resources are supporting facilities for teachers to make it easier to convey subject matter (Yusliani et al., 2019). Teaching materials are a collection of works made efficiently by experts in their respective fields which contain certain topics and have satisfactory instructions in accordance with predetermined educational programs (Febriana et al., 2022). As a media strategy, teaching materials play an important role in developing students' reasoning, attitudes and interests, as well as their capacity to think, imagine and express merdekaly (Halitopo, 2020).

One of the teaching materials provided by the Ministry of Education and Culture, especially in phase F, is a Cambridge book with the title Chemistry for Class XI Cambridge International AS & A Level High School which consists of student books and teacher books. The *merdeka* curriculum in phase F will only be implemented in the 2022/2023 school year. Along with the demands of technology, there is a need for innovation, ideas and ideas for the development of teaching materials that can support *merdeka* curriculum learning equipped with multiple chemical representations to facilitate the learning process and increase students' learning interest. Teaching materials containing multiple chemical representations are expected to help students generate their own conceptions, deepen their understanding of the subject matter, and develop higher-order thinking skills (Fahmi et al., 2022). Based on Gkitzia et al. (2011), using teaching materials containing multiple chemical representations so that students' can easily connect one concept to another, also effectively used by students with different basic abilities (low, medium, and high) and can increase the success rate of learning by up to 75%. Dudeliany et al., (2021), added that teaching materials containing multiple representations can generate interest in learning, obtain good feedback from students and teachers, and improve the completeness of learning outcomes. As for the one of chemical material studied in F phase listed in the Learning Outcomes (CP), namely solubility and solubility product. The purpose of this study was to development of teaching materials to support *merdeka* curriculum Learning on solubility and solubility product in F phase.

Method

This type of research is Educational Design Research (EDR) or development research design, which was initiated by Plomp. This research aims to produce a product in the form of teaching materials to support *merdeka* curriculum learning on solubility and solubility product in F phase with a valid and practical. The Plomp development model consists of preliminary research, prototyping, and assessment stages (Plomp & Nieveen, 2007; Piawi et al., 2018).

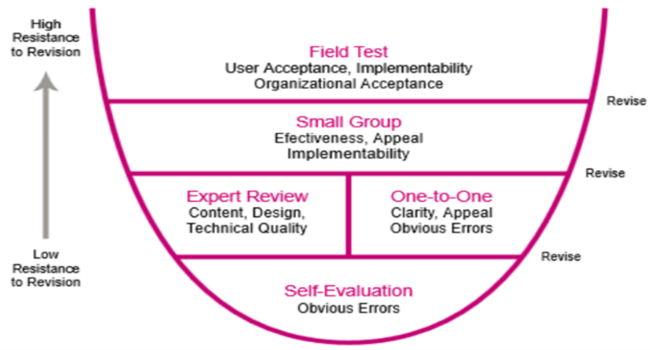

Figure 1. Layers of Formative Evaluation from Tessmer (Nieveen, N., & Folmer, 2013)

The procedure for developing teaching materials with the Plomp model can be seen in Figure 2. Need analyses, context analyses, literature reviews, and the formation of mindsets are all carried out during the preparatory stage of research. In addition, the assessment stage's research was restricted to the small group stage, which includes small group, one-on-one, expert, and self evaluations.

The test subject in this research were validation was carried out by 5 experts, namely 3 lecturers and 2 chemistry teachers. Also one to one evaluation by 3 students. The practicality sheet was filled in by 2 chemistry teachers and 9 students class XI, Phase F in the even semester of the 2022/2023 academic year at SMAN 7 Padang.

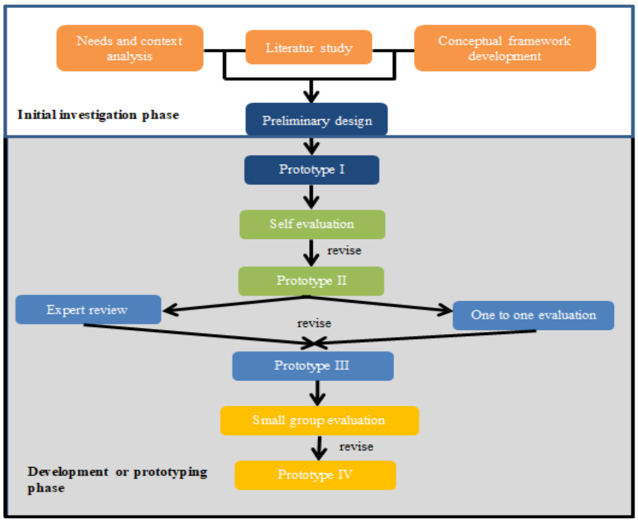

Figure 2. The procedure for developing teaching materials with the Plomp model

Descriptive analysis is the method of data analysis that is employed. The validity and applicability of the teaching materials to promote learning for the *merdeka* curriculum on solubility and solubility product in F phase are described using descriptive data analysis. The Aiken's V formula was used for validity data analysis, and Purwanto's (2010) category of practicality level adaptation was used for practicality. Validator assessments were analyzed using Aiken's validity formula, as follows:

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

Information:
s = r – Io
s: the score assigned by the validator minus the lowest score of the category used
r : Validator's preferred category score
Io: the lowest score in the scoring category
n: number of validators
c : number of categories chosen by the validator

The Aiken's validity index has a range of 0 to 1, and a high value implies that the product is valid (Aiken, 1985; Syafei & Mawardi, 2022). On the answer choice, use the five validators and five category options listed in Table 1. The following table 1 shows the Aiken's validity index-based validity criteria for teaching materials to assist *merdeka* curriculum learning on solubility and solubility product in F phase.

Table 1. Aiken's Validity Index Criteria 5 validator

Scale Aiken's V	Description
V < 0,8	Invalid
V ≥ 0,8	Valid

Source: Aiken, Lewis R (1985)

The assessment of the practicality sheet is obtained from the provision of a learner response questionnaire which is analyzed using a formula modified from (Purwanto, 2010), namely:

$$NP = \frac{R}{SM} \times 100 \quad (2)$$

Information:
NP = Percentage value sought or expected
R = Raw score obtained by students
SM = Ideal maximum score of the test that took place
100 = Fixed number

The level of practicality of teaching materials to support *merdeka* curriculum learning will be seen after being converted to categories such as Table 2.

Table 2. Category of practicality level

Value	Aspects assessed
86% - 100%	Very practical
76% - 85%	Practical
60% - 75%	Practical enough
55% - 59%	Less practical
≤ 54%	Tidak praktis

Source: Purwanto in Radyuli & Khairani (2019); Gaja & Mawardi (2021)

Result and Discussion

This study is a research and development (R and D) using Plomp's development model. Plomp's development model is considered more flexible and flexible than 4-D because each step contains development activities that are tailored to the characteristics of the research. This development model uses a prototype approach, where to obtain a quality product the prototype approach is chosen as an appropriate approach. The research and development involves the participation of teachers and learners and uses interactive procedures to produce learning prototypes (Rochmad, 2012). Plomp's development model with the following stages:

Initial investigation phase

This first research stage requires several steps such as needs and context analysis, review of literature and development of a conceptual framework (Winata & Mawardi, 2021). The goal is to be able to determine and define the requirements in Development of Teaching Materials to Support Learning for the *merdeka* Curriculum on Solubility and Solubility Times Results in F phase.

The needs and context analysis stage aims to identify the fundamental issues that teachers and students encounter when learning chemistry, particularly with respect to solubility and products of solubility, one of the topics covered in the implementation of a *merdeka* curriculum, in order to determine the need for a learning development. A description of the facts, expectations, and potential solutions to fundamental issues will be discovered through this examination. In the needs analysis carried out in this step are: (1) three schools are SMAN 2 Padang, SMAN 7 Padang, and SMAN 9 Padang, where observations were made through conversations with chemistry teachers.

The Government directs the implementation of a new curriculum, namely the *merdeka belajar* (Prototype) curriculum, through the Decree of the Minister of Education, Culture, Research, and Technology of the Republic of Indonesia Number 56/M /2022 concerning Guidelines for Implementing the Curriculum in the Framework of Learning Recovery. The Pancasila Learner Profile Strengthening Project is an important part of the Merdeka curriculum because it gives students the chance to learn new information, improve their current skills, and strengthen the development of the six Pancasila learner profile dimensions (faith, devotion to God Almighty and noble character, global diversity, mutual cooperation, independence, critical reasoning, and creativity) (Nahdiyah et al., 2022).

In implementing the *merdeka* curriculum, it is necessary to update teaching tools in accordance with the *merdeka* curriculum, one of which is teaching materials. It is envisaged that teachers will be able to structure an increasingly relevant learning process in accordance with the principle that prioritizes learning according to the stages and needs of students through the use of teaching materials that are in keeping with the *merdeka* curriculum. The part of chemistry material studied in F phase listed in the CP is solubility and solubility product (Kemendikbud, 2022).

Solubility and solubility product is one of the F phase chemistry materials that involves reactions and requires understanding of concepts to be applied in calculations. So that students are required to find more information from various sources of discussion to solve problems. Learning references in the form of F phase *merdeka* curriculum teaching materials are still limited due to the implementation of the new phase F *merdeka* curriculum in the 2022/2023 learning year. Then the material content available in F phase *merdeka* curriculum teaching materials is relatively concise and there is no multi-representation, especially in solubility and solubility product. So that teaching materials are needed with complete material content, more detailed, accompanied by illustrations / images that are more varied, colorful, and activities that are expected to attract and help students improve their understanding of the material.

The review of literature stage aims to understand the needs of educators and potential solutions to issues by studying previous works, such as Asmaningrum's (2022) Development of Environmental Chemistry Teaching Materials with Ethno-Stem Approach on the Topic of Environmental Pollution; Bahriah (2023), with a study entitled "*Merdeka* Curriculum Application: The subject of learning loss in chemistry learning is addressed in "The Phenomenon of Learning Loss in Chemistry Learning," which offers education that can counteract this issue; Lestari et al. (2019), development of high school chemistry module based on Problem Based Learning (PBL) on solubility and solubility product.

Problems that have been recognized, examined, and connected to preexisting theories and references can typically serve as the foundation for the construction of the conceptual framework stage (Siregar & Mawardi, 2022). By identifying the key ideas that students will acquire and systematically designing in accordance with the sequence, conceptual analysis is carried out. As a result of this study, a product—teaching resources to assist *merdeka* curriculum lessons on solubility and solubility product in F phase was then developed. Figure 3 displays the findings of this investigation.

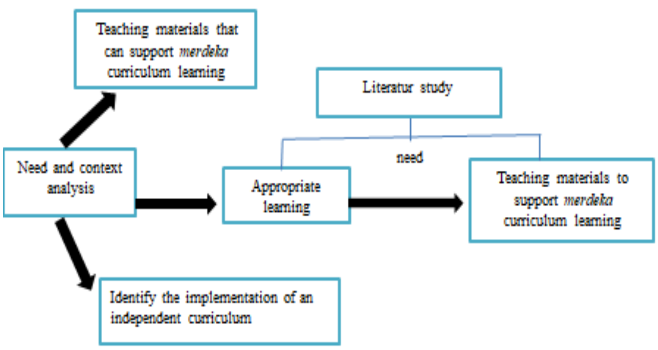

Figure 3. Conceptual framework of developed teaching materials

Development or prototyping phase

The prototype phase is a design stage that is followed by the creation of products in the form of teaching materials to assist the solubility and solubility product learning in the F phase of the *merdeka* curriculum. To improve and perfect the final product, teaching materials that have been designed, made, and assembled in accordance with the design stages will be used by teachers and students. Formative evaluation serves as a crucial research activity during this microcycle of prototyping (Fatmawati & Andromeda, 2021).

Prototyping consists of four steps: self evaluation, expert review, one-on-one evaluation, and small group evaluation. The prototype phase's final products, prototype I, II, III, and IV, represent the results of formative evaluation. Explaining the steps taken throughout the development or prototype formation stage: employing a checklist or a list of design specification characteristics for self-evaluation; expert review, which entails giving evaluations and recommendations for the developed items; individual assessment, or feedback provided on the items created through interviews; Giving students a practicality questionnaire as part of a small group test (Nieveen, N., & Folmer, 2013).

Prototype I

To create prototype 1, instructional materials were created to support students' understanding of solubility and solubility products throughout the F phase of the *merdeka* curriculum. The first prototype starts with the design and component in line with the *merdeka* Curriculum teaching materials from the Ministry of Education and Culture (Kemendikbud), and also material content altered to be able to accomplish the intended learning outcomes (CP). The components of the teaching materials include cover of teaching materials, preface, cover material, CP Chemistry in F phase, concept map, instructions for using teaching materials, table of contents, activities, sample problems and discussions, comprehension test, summary, exercises and final questions, reflection, glossary, index, bibliography. The display of the designed teaching materials can be seen in Figure 4.

Figure 4. View of the teaching materials cover

Figure 5. The list of contents

Figure 6. About this teaching materials

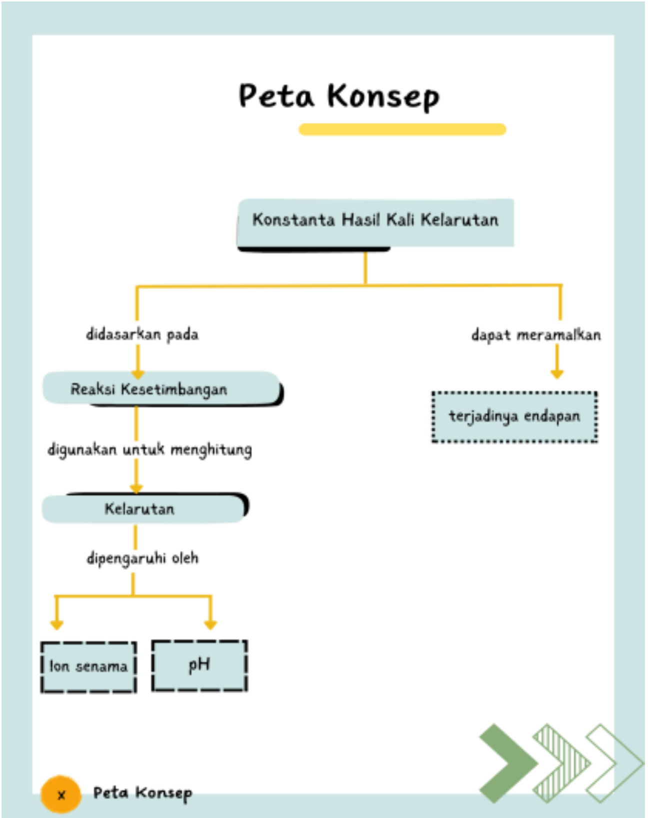

Figure 7. Concept map

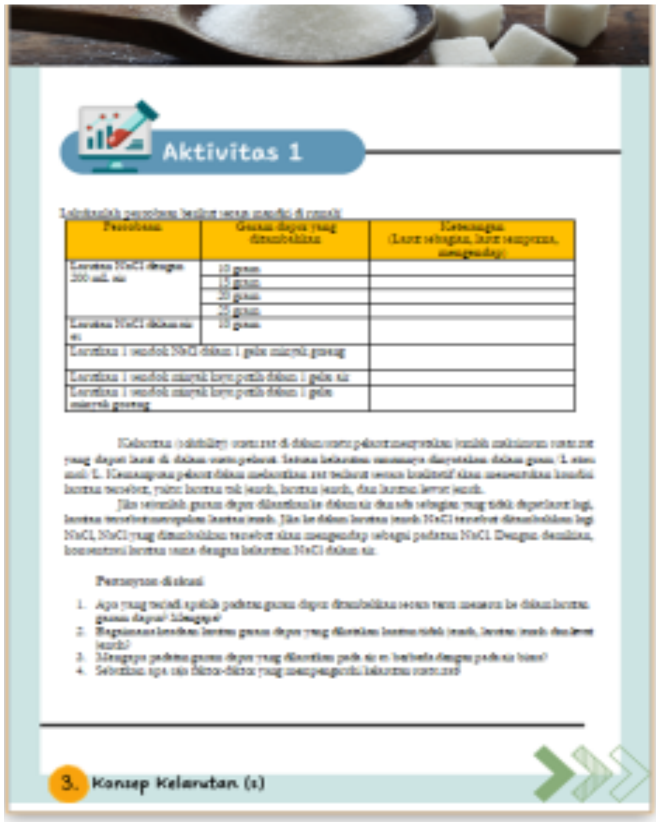

Figure 9. Activity in teaching materials

Figure 8. Initial cover material

Prototype II

The generated teaching materials are self-evaluated using a checklist method as a consequence of prototype 1 to establish their completeness to obtain prototype II. In light of the findings of the self-evaluation, changes will be made to the product's defects and errors that are still present. All items in the checklist table have been deemed complete following the update. Therefore, prototype number two is created (Ismail & Mawardi, 2021).

Prototype III

After the outcomes of prototype 2 have been analyzed by material specialists from three chemical lectures and two chemistry professors, prototype 3 will be made. The goal of the expert evaluation is to evaluate the validity of the instructional materials used to support the solubility and solubility product of the *merdeka* curriculum in F phase learning. After the data has been processed, it is clear that the teaching materials for the *merdeka* curriculum's lessons on solubility and solubility products in the F phase are of a high enough standard of validity. A one-to-one evaluation of three students was also conducted at this point. Additionally, prototype two needs to be revised in order to raise the standard of the prototype. The validity test result of the teaching materials as we can see in figure 10.

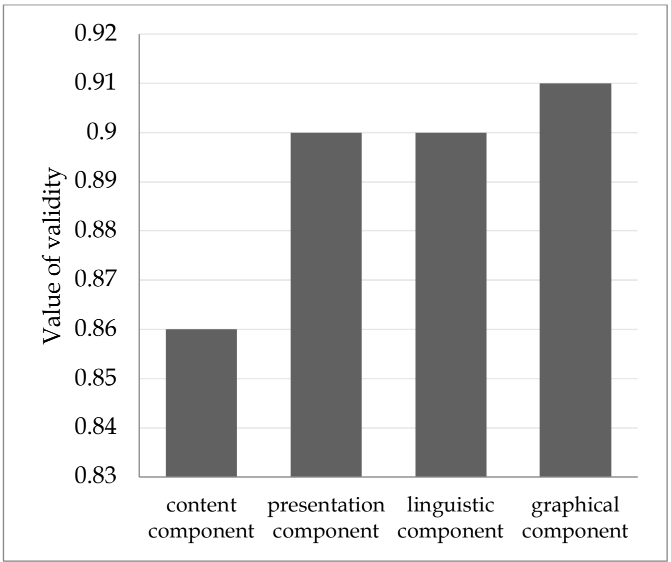

Figure 10. Validation test result

Validation of teaching materials

Assessment of teaching materials is done using the assessment sheet that has been validated by 5 experts. Selection of five experts is based on opinion Sugiyono (2008); Andromeda et al. (2015) which states that to test the validity of the construct instrument, a minimal number of expert opinions (judgment experts) may be used three people. Based on the validation sheet, the five validators provide an assessment on the teaching materials to support learning for the *merdeka* curriculum on solubility and solubility product in F phase produced in terms of content components and construction components. There are four components of validity assessed by validators, including content components, presentation components, language, and graphics (Depdiknas, 2008).

Validation sheet assessment data analyzed using the Aiken's V scale. The validator's assessment was analyzed using the Aiken validity formula and obtained a value of V, which was 0.89 in the valid category. Thus, the results of the assessment of teaching materials to support learning for the *merdeka* curriculum on solubility and solubility product in F phase are developed is valid. Such that delivered Arikunto (2008), that a product is said to be valid if the product can indicate a condition that is in accordance with its content and construct.

Based on the outcomes of data processing, a score of 0.86 indicates that the feasibility of the content component is valid. This information demonstrates that the generated teaching materials follow the *merdeka* curriculum, which is the applicable curriculum. This is in accordance with the opinion of Rochmad (2012), that the teaching materials can be said to be valid if they are in accordance with the existing curriculum. Then, with a result of 0.9, it was determined that the construct feasibility evaluation (presentation component) was valid. The information demonstrates that the instructional materials created have been systematically organized using the components of instructional materials in accordance with (Kemendikbud, 2022). With a value of 0.9, the linguistic component is legitimate. These findings demonstrate the communicative language and lack of ambiguity in the proposed training materials. This is in accordance with Yerimadesi et al. (2017), opinion that an instructional resource must be organized using simple phrases and language to ensure that its consumers can understand it. The last is the assessment of graphics declared valid with a value of 0.91, this information demonstrates that the generated training materials are clearly presented, with good layout, font style, and size choices, as well as an overall pleasing and appealing design.

Although the validity of teaching materials to support learning for the *merdeka* curriculum on solubility and solubility product in F phase produced has been valid, but there is still some components that must be repaired according to the suggestions given by the validator, among others as follows: there are several question that are not quite right appropriate with learning objective (TP), there are several the picture of the solubility must added explanation of the image. In accordance with the suggestions given by the validator, revisions were made to chemistry teaching materials to support learning for the *merdeka* curriculum on solubility and solubility product in F phase.

Figure 11. Content material in teaching materials


Uji Pemahaman

1. Larutan yang mengandung zat terlarut dengan konsentrasi maksimum disebut....
   A. Kelarutan
   B. Hasil kali kelarutan
   C. Larutan tidak jenuh
   D. Larutan lewat jenuh
   E. Larutan tepat jenuh

2. Hasil kali kelarutan adalah....
   A. Hasil kali konsentrasi ion-ion dalam larutan kurang jenuh masing-masing dipangkatkan dengan koefisien reaksi ionisasinya.
   B. Hasil kali konsentrasi ion-ion dalam larutan jenuh masing-masing dipangkatkan dengan koefisien reaksi ionisasinya.
   C. Hasil kali konsentrasi ion-ion dalam larutan lewat jenuh masing-masing dipangkatkan dengan koefisien reaksi ionisasinya.
   D. Hasil kali konsentrasi ion-ion dalam larutan yang mengendap.
   E. Hasil kali konsentrasi ion-ion dalam larutan jenuh.

3. Jika kelarutan suatu garam adalah x mol/L, maka pernyataan di bawah ini yang benar adalah....
   A. x mol garam dilarutkan akan terbentuk endapan
   B. x mol garam dilarutkan akan terbentuk larutan lewat jenuh
   C. x mol garam akan larut dalam 1 gram air
   D. garam dilarutkan kurang dari x mol maka terbentuk endapan
   E. dalam 1 L, jumlah maksimum garam yang dapat larut adalah x mol

4. Besarnya kelarutan dipengaruhi oleh....
   A. pH, udara, kelembaban
   B. Jenis zat terlarut, pH, kelembaban
   C. Jenis zat terlarut, pH, tekanan, udara
   D. Jenis zat terlarut, jenis zat pelarut, udara
   E. Jenis zat terlarut, jenis zat pelarut, suhu, pH, volume

5. Diantara garam sukar larut berikut, yang mempunyai kelarutan terbesar adalah....
   A. $NiCO_3$ (Ksp = 6,6 x 10^{-9})
   B. CrF_3 (Ksp = 6,6 x 10^{-11})
   C. CaF_2 (Ksp = 3,9 x 10^{-11})
   D. Ag_2CrO_4 (Ksp = 1,1 x 10^{-12})
   E. AgCl (Ksp = 1,8 x 10^{-10})

30. Uji Pemahaman

Figure 12. Comprehension test

Additionally, a one-on-one evaluation was conducted by speaking with three students from SMAN 7 Padang's phase F who fell into the high, medium, and low categories. based on the findings of the three students' individual evaluation interview sheet. It was discovered that the teaching materials for solubility and solubility products that were created to enhance the study of the *merdeka* curriculum in F phase were highly interesting and had a design with colors and visuals that made learning more interesting. After that, information is presented in plain terms that can aid pupils in understanding it. The results of the expert review sheet and one-on-one assessment were revised to produce the prototype III, which is reliable.

Prototype IV

Practicality test results to get prototype IV that valid and practice. After the trial was completed, a response questionnaire was given to students as small group trial subjects and a teacher response questionnaire to chemistry teachers. The practicality test results the teaching materials for teachers as we can see in Figure 13.

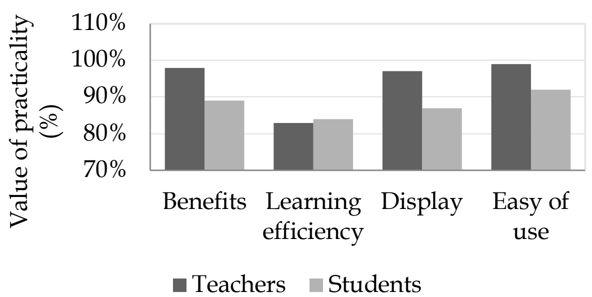

Figure 13. Practicality test result for teachers and students

Practicality Analysis of the Teacher Response Questionnaire

The usability of the product from the outcomes of limited field trials concerning the practicality and applicability of the product being developed can be seen as the practicality of teaching materials in the form of teaching materials to support learning for the *merdeka* curriculum on solubility and solubility product in F phase. Based on the results, a very practical category scored 94% on the instructor response questionnaire. On the basis of this, it is known that the trial school's use of the generated instructional materials is effective. Because the author already produced the teaching materials that match the criteria for the tool assessment (teacher response questionnaire sheet), the instructor assigns a very high practicality value to them. Teaching materials have been developed compiled based on indicators of competency achievement developed. Judging from the aspect of ease of use, the teaching materials developed to make it easier for teachers to achieve learning objectives and facilitate teachers to increase student activity in learning. As Sukardi said, practical considerations can be seen from the aspects of ease of use, time required in implementation, the attractiveness of teaching materials to students' interests.

Practicality Analysis of Student Response Questionnaire

Based on the student response questionnaire's instrument practicality score, which was calculated using the category of practicality level adaptation from Purwanto (2010), the result is 88%. This demonstrates that the practicality category of the teaching materials developed for use in the learning process is very high. Students that are interested in studying are greatly helped by the use of color and design in images.

Researcher-designed teaching materials that have undergone a self-evaluation. Improvements were made in the form of adding covers, changing the font of the material's content, correcting writing errors, aligning the page's index with the index, maintaining orderliness, and double-checking that all of the components were in line with the *merdeka* curriculum teaching materials from Kemendikbud.

Improvements from the self-evaluation process led to the creation of prototype II. The next step is the expert assessment and individual (one-on-one) evaluation of prototype II. The instructional materials have now been approved by a committee of subject-matter experts. This instructional material was created with the intention of assisting both teachers and students in their learning. Because of this, an expert review team or team of specialists conducts the validation stage. According to the findings of the expert review based on figure 10, the teaching resources used to assist the learning of the *merdeka* curriculum's lessons on solubility and solubility products in the F phase fall under the category of valid materials according to the Aiken validity index.

Prototype IV will result from the results of a small group evaluation on prototype III. Small group tests were conducted to determine the practicality of the teaching materials produced by taking into account four aspects, namely ease of use, time efficiency, display, and benefits. The instrument used was a student and teacher response questionnaire. This small group test will be carried out on 9 F phase students and 2 chemistry teachers. Then an analysis is carried out according to the evaluation results obtained so that the practicality value of prototype III is obtained. From the results of the evaluation, revisions were made according to the results of the questionnaire obtained and suggestions.

Based on information from figure 10, we can infer that the teaching materials to support learning for the *merdeka* curriculum on solubility and solubility product of F phase are already very practical, with values for the practicality test of students being 88% and the practicality test of teachers being 94%.

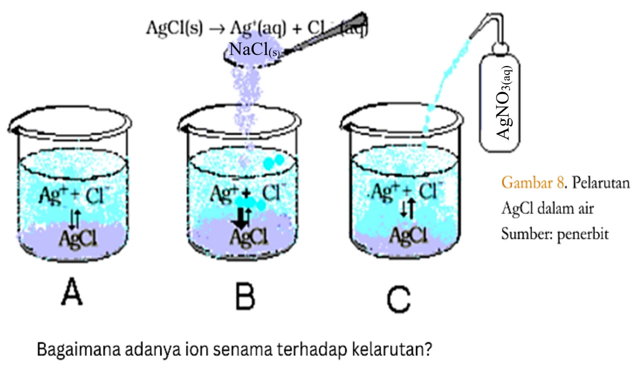

Figure 14. Question in teaching materials

Figure 14 depicts one of the primary question models that students must respond to. Here, it is expected of the students to be aware of how name-brand ions affect solubility. The impact of namesake ions on solubility is known through the findings of interviews with students.

This phase tries to ascertain how the pupils react to the created learning. Based on the outcome of this stage, it is discovered that the teaching materials' image displays are very interesting and clear, making it simple for students to understand the content, and that the language used is simple to understand, making it simple for students to follow instructions and respond to questions.

Conclusion

Based on the research that has been done, it can be concluded that (1) developed for the teaching materials to support learning for the *merdeka* curriculum on solubility and solubility product in F phase based on validity and practicality. (2) The validation score of 0.89 shows that the category is valid. The practicality test results for students show a score of 88%, and the teacher's test results show a value of 94%, both of which indicate a very practical category. (3) This shows that the teaching materials to support *merdeka* curriculum learning on solubility and solubility product in F phase developed has been valid and practical, so it can be used in learning.

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Author Contributions
All author contribute the research article with their respective responsibilities namely Mawardi Mawardi, conceptualization, methodology, validation supervision, review and editing; Mawardi Mawardi; formal analysis, validation; Okta Suryani, formal analysis, validation; Khairani Novia, investigation, data curation, writing-original draft preparation, editing and project administration.

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Conflicts of Interest
The authors declare no conflict of interest.

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