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Android-Based Project-Based Learning Integrated Gravimetric Analysis for Chemical Expertise Analysis of Vocational School: Development of Teaching Materials

Hayuni Retno Widarti [1,*], Deni Ainur Rokhim [1,2], Muchammad Musleh Kadafi [1]

[1] Chemistry Education, Faculty of Mathematics and Science, Universitas Negeri Malang, Semarang Street No. 5 Malang, East Java, Indonesia
[2] Chemistry, SMAN 3 Sidoarjo, Dr. Wahdin Street No. 130 Sekardangan, Sidoarjo, East Java

[1] Corresponding author: hayuni.retno.fmipa@um.ac.id*

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ABSTRACT: This study aimed to produce gravimetric analysis teaching materials and determine the validity test of gravimetric analysis teaching materials. The development of teaching materials is carried out using the ADDIE development model (Analysis-Design-Development-Implementation-Evaluation). The results of the development of teaching materials are in the form of applications with the APK extension that can be run on Android smartphones. The teaching material validation test obtained the percentage of assessment which included aspects of the content of teaching materials by 84.3% (very feasible), media aspects by 83.9% (very feasible), construct aspects of teaching materials by 81.7% (very feasible), aspects the language used is 79.2% (decent), and the aspect of conformity with the PjBL is 80.9% (very decent). Of the five aspects of the gravimetric analysis validation test assessment, the teaching materials developed were very feasible, with a total percentage of 82.87%. While the readability test got a percentage of 87.3%, so it was categorized as very feasible to use.

Keywords: ADDIE, Android, Gravimetric, Project Based Learning

INTRODUCTION

The curriculum is a set of rules used to meet educational needs. The current curriculum applied in Indonesia uses the 2013 curriculum revised edition of the curriculum in 2018 based on Permendikbud No. 34, 35, 36, and 37 of 2018 are related to the improvement of the 2013 curriculum. The 2013 curriculum does not only emphasize the cognitive aspects but also the aspects of the attitudes and skills of students [1], [2]. The existence of this policy change requires adjusting the implementation of learning for all subjects to maximize the process of teaching and learning activities in all schools in Indonesia, both primary and secondary schools.

Gravimetric analysis is a subject of competency in analytical chemistry skills at SMK/MAK which has abstract material characteristics so it requires teaching aids/media that can make it easier for students to learn. The results of the interview found that learning activities were still teacher-centered, which appeared in the explanation that still used the lecture method, as well as learning resources that were still based on print media and the use of learning resources from the internet which was less effective and less attractive. Teacher-centered learning activities are not in accordance with the 2013 curriculum where learning is directed at student centers which can trigger active students in learning activities. The 2013 curriculum suggests the use of innovative and creative technology-assisted teaching materials and the use of suggested learning methods or models to create active students in learning activities. The use of teaching materials is one of the most appropriate innovations to use, considering that teaching materials are external factors for students that can strengthen internal motivation to learn [3] The development of teaching materials on gravimetric analysis material has been carried out by Nurhalimah [4]. The teaching materials developed are still based on print media and still use the 2006 KTSP, so the teaching materials are less relevant to use. So it is necessary to develop teaching

materials that are in accordance with the demands of the 2013 curriculum which includes adjusting teaching materials and using creative and innovative teaching materials by utilizing technology [5].

In addition to the use of teaching materials to help students to be actively involved in learning activities, the 2013 curriculum also requires the use of a scientific approach (scientific approach) using the recommended learning model in learning activities. To apply a scientific approach to each learning process, a learning model is needed that is in accordance with the characteristics of the scientific approach [4]. Some of the suggested learning models using a scientific approach are discovery learning, project-based learning, problem-based learning, and inquiry learning [6]. The project-based learning model (PjBL) involves students in learning activities, collaborating knowledge and skills [7], [8].

Based on the description above, it is necessary to research the development of gravimetric analysis teaching materials with the Project Based Learning (PjBL) model and utilize technology (based on Android) to produce creative and innovative teaching materials [9]–[11]. The development of gravimetric analysis teaching materials is expected to be an alternative teaching material for learning activities at SMK/MAK. This research can be used to develop Android-based teaching materials on other subjects.

RESEARCH METHODS

Research and development of Android teaching materials is carried out using the Research and Development (R&D) method, using the ADDIE (Analysis-Design-Development-Implementation-Evaluation) development model, developed by Kemdikbud [12] The ADDIE model consists of 5 development stages, namely 1). Analysis stage, 2). Design stage, 3). Development stage, 4). Implementation stage, 5). Evaluation/feedback stage. The ADDIE stage is explained in Figure 1.

Analyze: analyze the need for the development of teaching materials that include needs analysis, curriculum analysis, namely the identification and review of core competencies and basic competencies in the 2013 curriculum for chemical expertise analysis in gravimetric and titrimetric analysis subjects on basic competencies 3.15, 3.16, 4.15, and 4.16 material for depositional gravimetric analysis, task analysis, and analysis of learning activities.

Design: teaching material product design that will be developed based on the results of the previous analysis. The design includes:

- Selection of instructional media using Microsoft Power Point software with iSpring Suite 8.7 and Website 2 APK Builder 3.4 [15], [16].
- Preparation of reference tests in the form of a question grid to test students' understanding,
- Format selection using Project Based Learning steps according to Abidin [7].
- Display design which includes icon, video, audio, font (color, size and font type), background color, etc. that will fill teaching materials.

Development: realization of product design (the process of developing teaching materials based on the design that has been made). At this stage, a validation test is carried out to determine the feasibility level of the teaching materials being developed. The validators consisted of 2 Universitas Negeri Malang, chemistry lecturers and 2 SMK Negeri 7 Malang teachers. The validation test results get a percentage of 82.87%.

Implementation: implementation of the design of methods or teaching materials developed in real situations, namely class [17] was carried out to 29 students of class XI analytical chemistry expertise program at SMK Negeri 7 Malang. The legibility test results obtained a percentage of 87.3%.

Evaluation: improve teaching materials developed based on the constraints found. Evaluation is carried out based on the suggestion/comment/opinions of the validator and some relevant suggestions/comments from the test respondents.

Implementation: implementation of the design of methods or teaching materials developed in real situations, namely class [6]. Implementation was carried out to 29 students of class XI analytical chemistry expertise program at SMK Negeri 7 Malang. The legibility test results obtained a percentage of 87.3%.

FIGURE 1. The ADDIE stage

Method of Product Test

The product test was conducted to determine the feasibility level of the developed android-integrated gravimetric analysis teaching materials. The results of product trials are expected to obtain data on the feasibility level and comments/opinions/suggestions from respondents regarding the product being developed. Product testing includes validation tests and legibility tests. The validation test was carried out by expert validators and the legibility test was carried out by 29 students of class XI SMK Chemical Analysis. The validator criteria are: (1) experience in the field of teaching materials, both printed and non-printed, (2) understanding visual communication of teaching materials to users, (3) having experience in analytical chemistry lab activities, (4) mastering and understanding gravimetric analysis material. The criteria for students are to have studied gravimetric analysis material.

The data obtained in this development research are in the form of quantitative data and qualitative data. Quantitative data were obtained by filling out a questionnaire using a Linkert scale. The Linkert scale can be used to measure the attitudes, opinions, and perceptions of a person or group of people about social phenomena or about a research variable [13]. The answer to each instrument item using the Linkert scale has a gradation from very positive to very negative by using certain words and scores/numbers ranging from 1 to 5. The Linkert scale can be made in the form of a checklist or multiple choice [13] Qualitative data were obtained from suggestions/comments/opinions from respondents regarding the teaching materials developed by filling in the fields provided on the validation/legibility sheet.

The data analysis technique used is the percentage calculation technique adopted from Riduwan [14] with the following formula.

$$\text{Percentage } (\%) = \frac{\text{X}}{\text{Xi}} \text{x } 100\% \quad \text{.....(1)}$$

Information:
Percentage (%) = percentage of assessment results by each validator and respondent
X = The total score of each parameter of the validation result items
Xi = Total ideal/maximum score

The results obtained from the data analysis above are then interpreted as related to the validation results of gravimetric analysis teaching materials developed using various validation criteria. Data validation results and readability tests are described using the validation results criteria listed in Table 1.

TABLE 1. Validation Level Criteria

Percentage (%)	Criteria
0 – 20	Very weak/Inappropriate/Invalid (total revision)
21 – 40	Weak/Inappropriate/Invalid (revision)
41 – 60	Sufficient/Sufficiently worthy/Sufficiently valid
61 – 80	Strong/Eligible/Valid
81 – 100	Very strong/Very feasible/Very valid

RESULT AND DISCUSSION

Description of Android Integrated Gravimetric Analysis Teaching Materials

This development research resulted in a product in the form of Android-integrated teaching materials on the subject of gravimetric analysis assisted by a project-based learning model. This teaching material is a soft file that can be installed on an Android smartphone. This teaching material can be used by students and teachers, by using the same appearance but different access to certain menus.

Android-integrated gravimetric analysis teaching materials consist of concept maps, basic competencies, learning, materials, instruments, glossaries, and guides. The learning activity used in this teaching material is a project-based learning model adopted from [7]

The teaching material component includes the first part which contains the initial view which contains the application icon and the application cover display. The application icon display is shown in Figure 2 (a), click the application icon to open the teaching material. The design of the application icon is based on a drawing of laboratory equipment, there is gravimetric writing and there is a color silhouette showing the letter "G" which means Gravimetry. The cover view is a display interface when you first enter the application. Then, the cover display is made as attractive as possible by inserting several navigation buttons for easy use, including buttons for entering applications and buttons for adjusting audio. The cover display contains the logo of the Universitas Negeri Malang, the subject matter of the teaching materials (Gravimetric analysis, deposition method), and the intended users for the SMK Chemical Analysis.

(a) (b)

FIGURE 2. Initial Display of Teaching Materials; (a) Icons and (b) Covers

The second part is the content of teaching materials which contains the main menus of the application. The menus consist of the competency menu, concept map menu, learning menu, instrument menu, work safety menu, manual menu, and glossary menu.

The Competency Menu contains basic competencies as determined by the government in Perdirjen Dikdasmen No.464/D.D5/KR/2018 [9]. In this competency menu, Indicators of Competence Achievement (IPK) are also presented. The Competency menu display is shown in Figure 3.

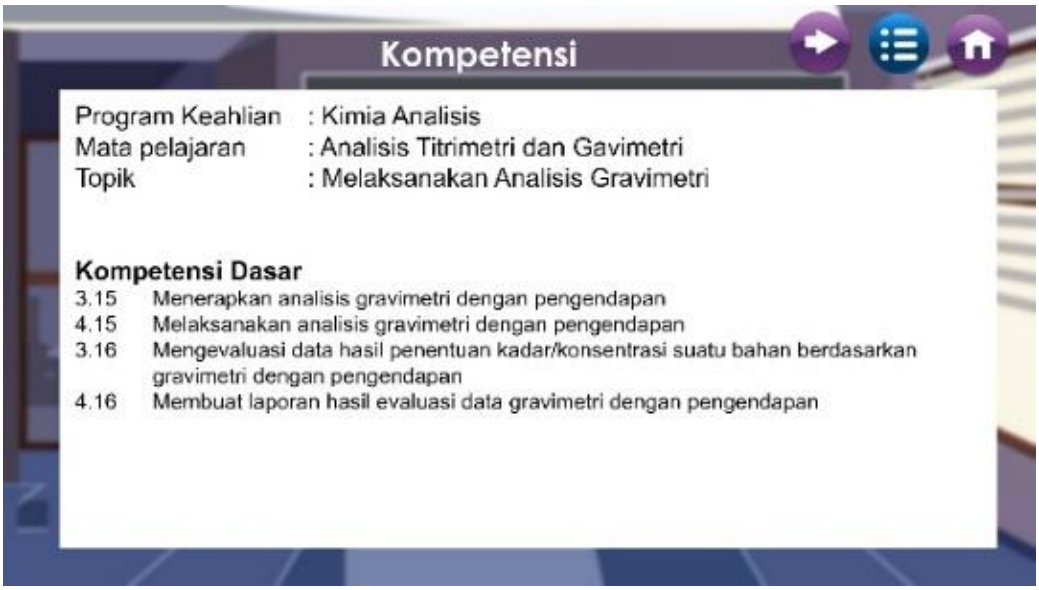

FIGURE 3. Competence Menu

A concept map contains an image chart that shows or explains a thing that contains a concept represented by keywords connected by connecting lines. In this concept map menu the important concepts that are part of the subject matter of gravimetric analysis with deposition are arranged in accordance with the demands of the Basic Competency of precipitation gravimetric analysis. The Concept Map menu display is shown in Figure 4.

FIGURE 4. Concept Map Menu

The Learning Menu contains structured activities that will be carried out by students in learning activities. On the learning menu, students are directed to take part in learning activities by clicking on the navigation on teaching materials, in this menu there are several instructions for learning gravimetric analysis, namely the determination of Ag^+ content as AgCl, Determination of Ba^{2+} content as $BaSO_4$, Determination of Ni^{2+} content as NiDMG, Determination of Fe^{3+} content as Fe_2O_3, Determination of Al^{3+} content as Al_2O_3, and Determination of Chloride (Cl^-) content in table salt as AgCl. The display of the Learning menu is shown in Figure 5.

FIGURE 5. Learning Menu

The Material Menu contains the main material of gravimetric analysis. This material menu can be used by students to deepen their knowledge of gravimetric analysis material as a theoretical basis in gravimetric analysis practicum. On the material menu contains several sub materials including apa itu analisis gravimetri? prinsip analisis gravimetri pengendapan, tahapan analisis gravimetri pengendapan, penerapan analisis gravimetri, dan daftar pustaka. The material menu display is shown in Figure 6.

FIGURE 6. Material Menu

The Instrument Menu contains questions related to gravimetric analysis. Questions are made based on the material contained in this teaching material. Several types of questions that can be done by students, including: latihan soal prinsip analisis gravimetri, latihan soal tahapan analisis gravimetri, tugas mandiri, soal evaluasi, dan soal uji kompetensi. The material menu display is shown in Figure 7.

FIGURE 7. The Instrument Menu

The Work Safety Menu contains tips while working in a laboratory which include chemical hazards, personal protection, general protection, disposal of chemicals, and initial actions to take when an accident occurs. The work safety menu display is shown in Figure 8.

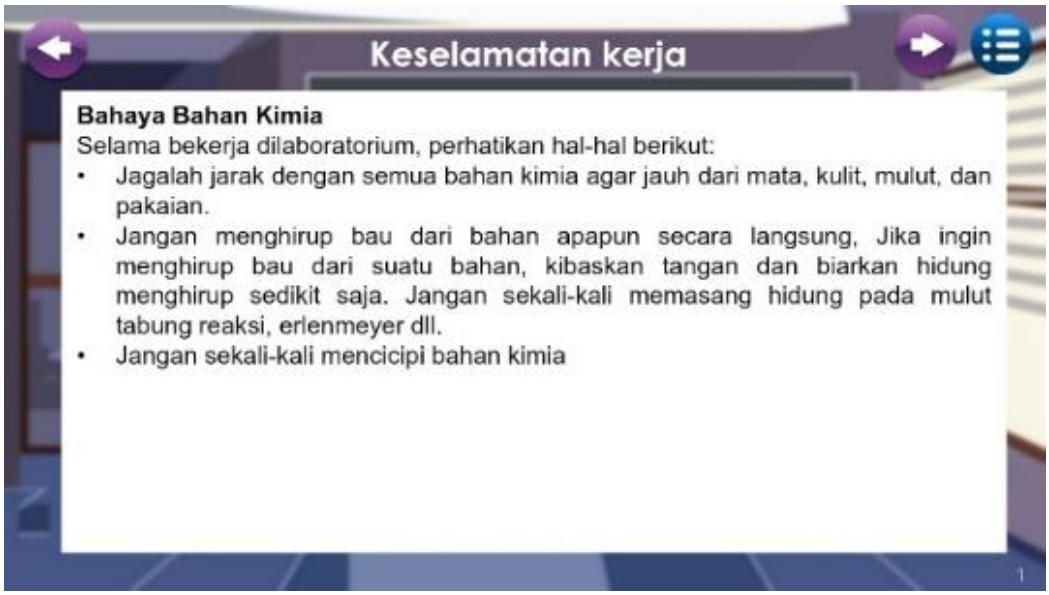

FIGURE 8. Work Safety Menu

The Glossary Menu contains important words found in this gravimetric analysis teaching material. These important words are accompanied by their true meaning so as to help the reader understand the concept and reduce the risk of unwanted misconceptions. The glossary menu display is shown in Figure 9.

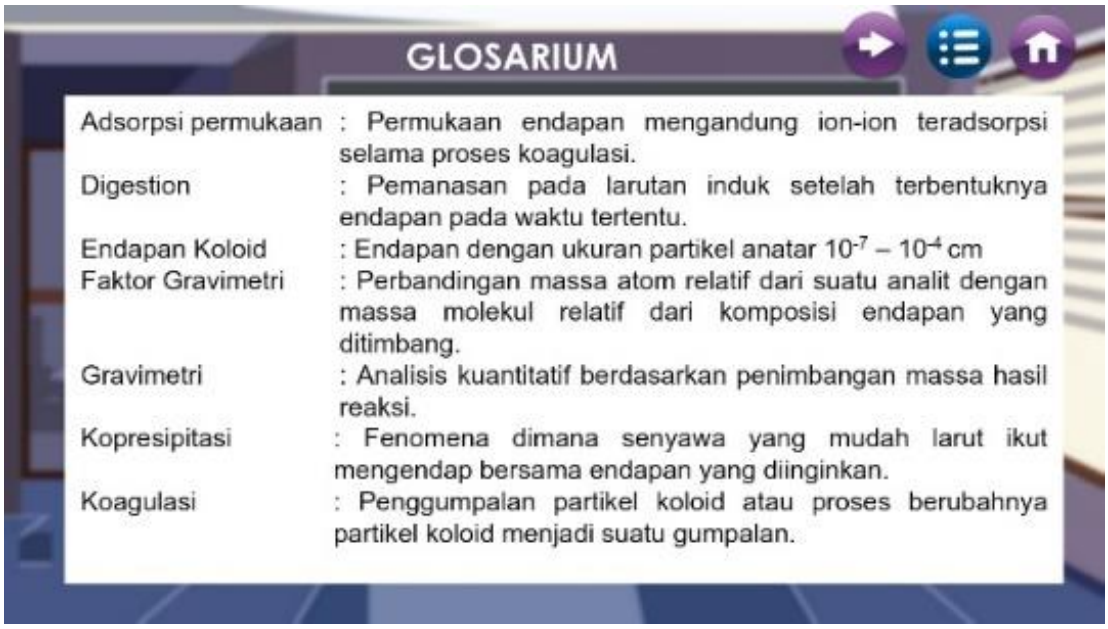

FIGURE 9. Glossary Menu

The guide menu contains guidelines for the use of this gravimetric analysis teaching material. Guidelines consist of: general guides, student guides, and teacher guides. The guide for students contains directions for sedimentary gravimetric analysis learning activities. The teacher's guide contains the teacher's guide in carrying out gravimetric analysis learning with this teaching material. The guide menu display is shown in Figure 10.

FIGURE 10. Guide Menu

Teaching materials for teachers are the same as teaching materials for students, namely one unified application. The difference between teaching materials for students and for teachers is the access they have, for teachers can access the guide menu for teachers while students cannot. On the teacher guide menu, there are guidelines for the implementation of learning and there are RPP files, assessment guidelines, question grids, and whole experimental procedures. To access this teacher's guide, a predefined password is required. The explanation of the components on the teacher guide menu is as follows:

Rencana Pelaksanaan Pembelajaran (RPP) is a teacher guide in carrying out learning activities using this Android-integrated gravimetric analysis teaching material. This RPP is presented and adapted to the RPP format from the government. The RPP display in the application is shown by the screenshot in Figure 11.

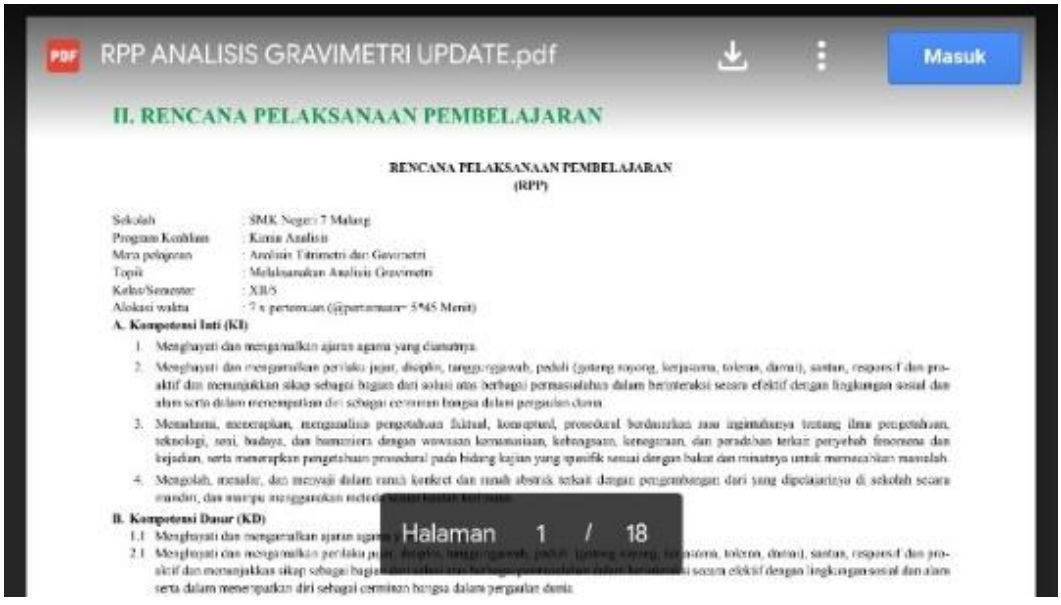

FIGURE 11. Display of RPP

Assessment guidelines contain guidelines for teachers in the implementation of student assessment. Assessment which includes assessment of attitudes, knowledge, and skills. The display of the assessment guidelines in the application is shown by the screenshot in Figure 12.

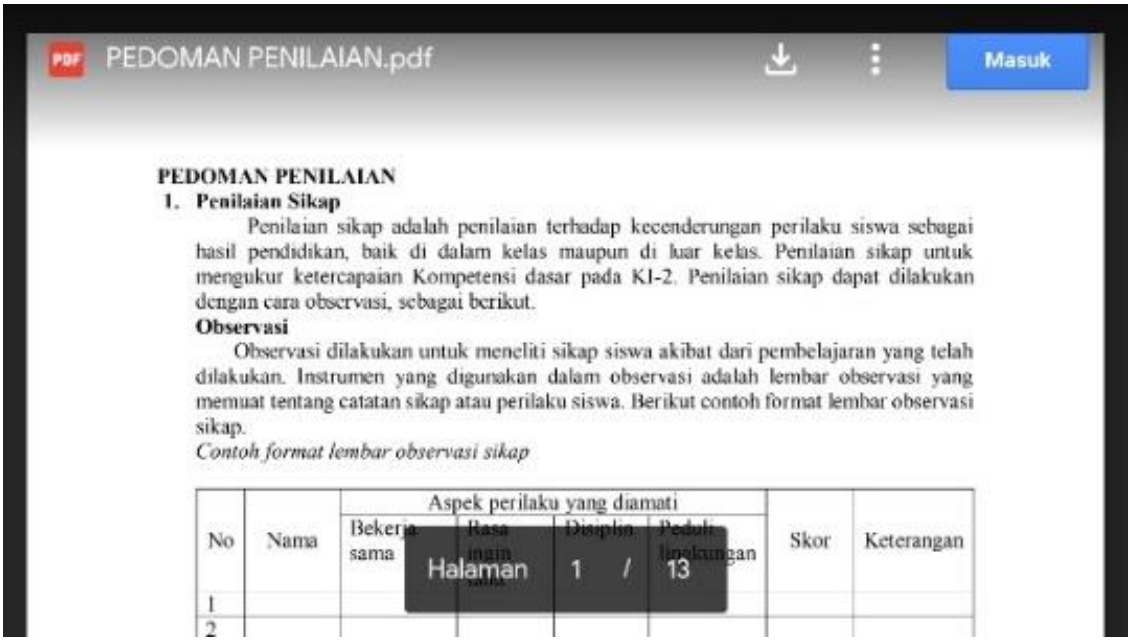

FIGURE 12. Display of Assessment Guidelines

The question grid contains the questions contained in the teaching material application accompanied by the answer key for each question. Students can access the questions on the instrument menu. The display of the question grid in the application is shown by the screenshot in Figure 13.

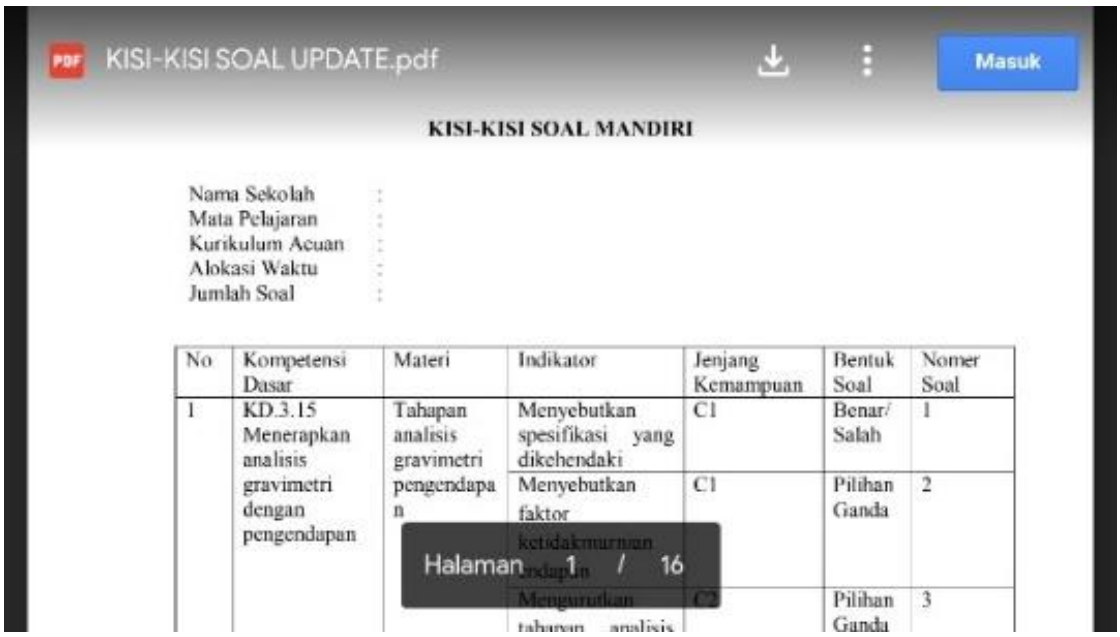

FIGURE 13. Display of Problem Grid

Practicum activities contain experimental tools, materials, and procedures as teachers' guides in carrying out practicum. In this practicum activity, tools, materials, and procedures are arranged coherently according to the flow of the gravimetric analysis practicum with deposition. The display of practicum activities in the application is shown by the screenshot in Figure 14.

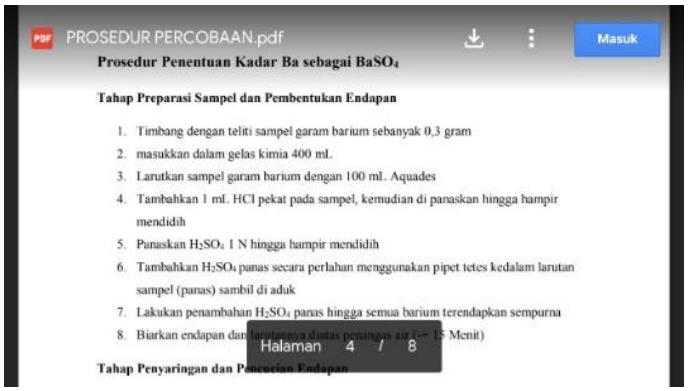

FIGURE 14. Display of Practicum Activity Files

Result of Qualitative Analysis

Readability test results

After the validation process of teaching materials was carried out and it was declared valid, the next step was to carry out the legibility trial stage to determine the level of validity of the teaching materials carried out by students. The legibility test was carried out by 29 students of class XII Chemical Analysis at SMK Negeri 7 Malang. Students are asked to provide an assessment and provide suggestions/input on the developed android-integrated gravimetric analysis teaching materials. The procedure for the readability trial stage is to direct students to try, read teaching material, and do some practice questions. Then asked to provide an assessment through a questionnaire on the content of teaching materials. The questionnaire contains questions with answer options in the form of a Linkert scale (values 1 - 5). The results of the legibility trial are shown in Table 4.

TABLE 4. Readability Test Recapitulation Results

Percentage of Readability Validity by Students	Criteria
87.3 %	Very Worthy

The data in Table 4 shows that the readability test of Android-integrated gravimetric analysis teaching materials obtained a percentage of 87.3% which can be categorized as very feasible according to Riduwan [14] which is in the range of 81%-100%. Interpretation in the very feasible category actually does not require revision. However, 12.7% indicates the percentage that is considered for revision so that the teaching materials developed are better.

Result of Quantitative Analysis

Data analysis of the validation of teaching materials

The validation test was carried out by a validator consisting of 2 expert validators from a chemistry lecturer at Universitas Negeri Malang and 2 analytical chemistry teachers at SMK Negeri 7 Malang who had more than 5 years of teaching experience. The validator test questionnaire consisted of a content validation questionnaire, an android media questionnaire, a construct validation questionnaire, a language feasibility questionnaire, an RPP feasibility questionnaire, and a conformity validation questionnaire with the PjBL learning model. The recapitulation of the results of the validation of teaching materials is shown in Table 2.

TABLE 2. Recapitulation of the Results of the Validation of Teaching Materials

Rated aspect	Validator				Maximum total score	Empiris total	Percentage (%)	Criteria
	V1	V2	V3	V4				
Teaching material content	112	112	133	115	560	472	84.3	Very Worthy
Media	56	56	60	63	280	235	83.9	Very Worthy
Construct	36	36	39	36	180	147	81.7	Very Worthy
Language	24	24	26	21	120	95	79.2	Worthy
Compliance with PjBL	44	44	46	44	220	178	80.9	Very Worthy
Percentage of Eligibility of Teaching Materials							**82.87**	**Very Worthy**

Information:
V1: Chemistry teacher (Teacher 1)
V2: Chemistry teacher (Teacher 2)
V3: Chemistry Lecture (Lecture 1)
V4: Chemistry Lecture (Lecture 2)

Based on Table 2. Above, the results of the validation test of teaching materials obtained a percentage of 82.87% which can be categorized as very feasible according to [14] which is in the range of 81%-100% [19]. Interpretation in the very feasible category actually does not require revision. Even so, 17.13% shows the percentage that is considered in making revisions. The revision process was not carried out thoroughly, but in certain parts based on suggestions/comments/input from the validator.

Data analysis of RPP validation results

The results of the RPP validation were obtained from the validator which included eight aspects of assessment. Data validation results were analyzed using percentage techniques. The recapitulation of the RPP validation results is shown in Table 3.

TABLE 3. Recapitulation of RPP Validation Results

Rated aspect	Validator				Maximum total score	Empiris total	Percentage (%)	Criteria
	V1	V2	V3	V4				
Subject Identity	4	4	5	4	20	17	85%	Very Worthy
Competence	8	8	10	8	40	34	85%	Very Worthy
Indicators of Competence Achievement	8	8	10	8	40	34	85%	Very Worthy
Learning materials	8	8	9	8	40	33	83%	Very Worthy
Learning model	4	4	5	4	20	17	85%	Very Worthy
Learning Steps	4	4	5	4	20	17	85%	Very Worthy
Learning Resources	4	4	5	4	20	17	85%	Very Worthy
Assessment	8	8	10	8	40	34	85%	Very Worthy
Percentage of Eligibility of RPP							**84.58%**	**Very Worthy**

Information:
V1: Chemistry teacher (Teacher 1)
V2: Chemistry teacher (Teacher 2)
V3: Chemistry Lecture (Lecture 1)
V4: Chemistry Lecture (Lecture 2)

Based on Table 3. Above, the results of the validation test for teaching materials obtained a percentage of 84.58% which can be categorized as very feasible according to Riduwan [14] which is in the range of 81% - 100%. Interpretation in the very feasible category actually does not require revision. Even so, 15.42% shows the percentage that is considered in making revisions. The revision process was not carried out thoroughly, but in certain sections based on suggestions/comments/input from the validator.

CONCLUSION

Android-integrated gravimetric analysis teaching materials based on project-based learning for vocational chemical analysis skills competencies have been developed into interactive teaching materials and easy to use by students and teachers. Based on the results of the validation test from the validator, the gravimetric analysis teaching materials developed were categorized as very feasible with a percentage of 82.87% for validating teaching materials, and 84.58% for validating lesson plans. Then, based on the legibility test results of the XI grade students of chemical analysis of teaching materials developed, they got a very feasible category with a percentage of 87.3%. Android-integrated gravimetric analysis teaching materials based on project-based learning are very good, technology-based, and can be used in the learning process.

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