



Proceeding SYMBION (Symposium on Biology Education)

<http://seminar.uad.ac.id/index.php/symbion>

2540-752X (print) | 2528-5726 (online)



Development of E-Unit For Self Learning Activities (UKBM) Based on A STEM Approach with PBL Model on Virus Materials For 10th Grade

Zeaneta Maria Goreti Arnold *

Biology Education, Sanata Dharma University, Sleman, Indonesia

zeanetaarnold@gmail.com*

* Corresponding author

ARTICLE INFO

Article history

Submission Dec 10th, 2022

Revision May 10th, 2023

Accepted May 17th, 2023

Keyword

e-Unit for Self-Learning

Activities (UKBM)

STEM approach

PBL model

Virus

ABSTRACT

Advances in science and technology have made it possible to carry out an online learning system, especially during the Covid-19 pandemic. Based on needs analysis interviews conducted in 5 high schools in Maumere, East Nusa Tenggara, the main problems encountered were related to the lack of supporting facilities for independent learning activities of students and the difficulty of teachers in providing contextual learning on material that was quite abstract. This study aims to develop an e-UKBM learning media design based on the STEM approach with a PBL model on Virus material for 10th grade, as a solution to the main problems encountered. This study used ADDIE R&D methods which was limited to the Development stage. The feasibility of the application was assessed from the material and media aspects by expert validators and teachers as practitioners. The results showed that the e-UKBM Virus application design was "Very Eligible" in terms of material with percentage 86.66% and "Very Eligible" in terms of media with percentage 83.33%. Thus, the e-UKBM Virus application is declared feasible to be tested on a limited scale with modifications suggested by the validators.

This is an open-access article under the [CC-BY-SA](https://creativecommons.org/licenses/by-sa/4.0/) license



Introduction

Learning activities that are not in accordance with the demands of the times have the potential to have a negative impact on students, especially for their future. During the Covid-19 pandemic, which required restrictions on mobility and social interaction in public spaces (including schools), the education delivery model underwent changes as a form of adaptation to the current situation. The learning activities are carried out online or remotely, in other words there is no face-to-face learning at school as usual. Therefore, various parties, especially schools

and educators, need to take quick and appropriate steps in preparing for the implementation of online learning without losing the essence of face-to-face learning.

The transition from face-to-face learning to online learning has more or less caused problems, one of which is for educators. To find out the problems experienced by educators, especially in conducting online learning, a learning needs analysis was carried out by interviewing 5 high school biology teachers in Maumere, East Nusa Tenggara, including SMAK Frateran Maumere, SMAS John Paul II Maumere, SMAN 1 Maumere, SMAS PGRI Maumere and SMAS Seminari Bunda Segala Bangsa Maumere. Based on the results of these interviews, two main problems were found. First, the lack of supporting facilities for students' independent learning activities, especially outside of learning hours. One of the steps that can be taken is to design and develop android-based digital learning media. Digital learning media is a medium developed through the use of software technology that allows students to receive knowledge, skills and attitudes wherever and whenever according to the realities on the ground¹. On top of that, android-based mobile phones have the potential to be created as interactive learning tools that are advantageous to students in addition to being utilized as communication tools². One learning tool that can be used as an android-based digital learning medium to overcome this problem is the Independent Learning Activity Unit (UKBM). UKBM can be defined as a small-scale learning unit based on Basic Competency (KD) which is arranged systematically, from easy to difficult levels with the aim of helping students learn independently, in order to achieve learning competency completeness criteria³. Therefore, this UKBM was chosen as a support for independent student learning activities which were then packaged in the form of digital learning media in the form of an Android-based learning application.

Second, the main problem found is the difficulty experienced by teachers in providing contextual learning on abstract biology materials, one of which is Virus material for 10th grade. One step that can be taken as a solution to this problem is to collaborate on methods and learning models that are able to assist teachers in providing contextual learning (associating the material being taught with real situations in everyday life), especially in abstract material. The collaboration offered is between the STEM approach and the PBL model. The Problem Based Learning (PBL) model is a learning model that exposes students to real problems experienced in their daily lives and makes these problems a source and learning tool by providing learning experiences that aim to develop critical thinking skills, problem solving skills, without ignoring concepts or knowledge formulated in learning objectives⁴. In the process of solving these problems, the STEM approach is also applied which is a learning approach that integrates four aspects, including Science, Technology, Engineering, and Mathematics, with the aim of developing students' creativity in solving problems in their daily lives⁵. In line with this statement, the STEM approach is able to support the development of new products, processes and systems that bridge various disciplines, as well as provide opportunities for students to understand and study various phenomena in the world as a whole⁶.

Based on various previous studies, it was found that UKBM in the form of digital learning media and collaboration between the STEM approach and the PBL model had a positive impact on the learning activities. Khuzaimah's research (2020) show that the use of UKBM in biology learning in class X MIA at MAN 1 Blitar is able to train students to be active and independent in exploring learning resources, including learning resources other than textbooks provided by the teacher, able to complete UKBM independently, enthusiastic in solving problems, and being able to be a colleague for other students⁷. In addition, here is research product in the form of e-UKBM for the Chemistry subject for grade 11th with an android application model that can be operated on various types of mobile phones, and can be accessed both online and offline⁸. Meanwhile, the use of the PBL and STEM models in learning biology on digestive system material for grade 11th is in fact capable of developing critical thinking skills, encouraging student activity, making it easier for students to understand the material being taught, and able

to improve problem solving skills more effectively and efficiently⁹. The use of Edmodo-assisted e-UKBM in biology learning on respiratory system material for grade 11th integrated with the application of the STEM approach shows that the application of the STEM approach in learning is able to increase students' understanding (cognitive domain) regarding the material taught and the e-UKBM model used is considered more practical to use, especially during distance or online learning¹⁰. Based on these studies, gaps in analysis were found that there was no UKBM learning application that was integrated with the collaboration between the STEM approach and the PBL model in biology subjects for 10th grade students, specifically on Virus material.

Therefore, through this research an Android-based e-UKBM Virus application was developed by implementing a collaboration between the STEM approach and the PBL model. The development of this application is considered necessary to be carried out, in order to facilitate students' learning activities independently and also contextually. It is hoped that students will be able to practice problem-solving skills and think critically and creatively in determining appropriate steps to respond to phenomena related to virus material in their daily lives by applying what they have learned.

Method

This research uses the R&D method (Research and Development) with the ADDIE model (Analyze, Design, Development, Implementation, Evaluate). The product developed in this study is an application in the form of e-UKBM learning media, which was developed using a web application maker, Thinkable. This research is limited to the Development stage. The following is a detailed explanation of each step of the ADDIE model.

Analysis

At this stage, real data collection is carried out in the field by analyzing biology learning needs. The needs analysis activity was carried out by interviewing 5 biology teachers at 5 different high schools in Maumere, including SMAK Frateran Maumere, SMAS John Paul II Maumere, SMAN 1 Maumere, SMAS PGRI Maumere and SMAS Seminari Bunda Segala Bangsa Maumere. The needs analysis carried out aims to determine the real conditions in schools by examining various problems experienced during biology learning, including the learning process, class conditions during learning, as well as the use of devices, methods, models, media, and learning evaluation techniques, both online and offline. After conducting a needs analysis, a literature study is then carried out as a reference in product selection to overcome the problems found.

Design

At this stage, product design work is carried out to overcome the problems that have been analyzed previously. Based on the results of the needs analysis and reviewing the literature, the product developed is e-UKBM based on the STEM approach with the PBL model on Virus material for 10th grade. This product is expected to be able to answer the needs of teachers for learning media that are able to support student learning independence and assist teachers in providing contextual learning, especially in biology material which is considered abstract and difficult for students to understand. The product design at this stage begins with the selection of application-making software, the preparation of UKBM content which includes the preparation of learning tools and the preparation of practice questions, up to the creation of the display design for the e-UKBM Virus application.

Development

At this stage, product development is carried out based on the design that has been made before. The product development process starts with making the application and setting the layout of the components in the e-UKBM Virus application, including the Home Window (containing various menu options, such as Application Usage Instructions, UKBM Identity, Learning Activities, Reflections, and Developer Profiles); Application Usage Instructions

Menu (contains steps for using the e-UKBM application for students); UKBM Identity Menu (contains information about subjects, semester, school year, time allocation, Core Competencies [KI], Basic Competencies [KD], indicators, learning materials [factual, conceptual, procedural, and metacognitive knowledge], learning resources [BTP], and concept maps); Learning Activity (KB) Menu (contains an introductory section in the form of problem orientation which is then accompanied by independent practice in the form of giving practice questions that need to be worked on independently and in stages by students, and is equipped with an Ability Test as an exercise for students before taking the Final Test on Virus Material); Reflection Menu (contains students' personal assessment of themselves after working on a series of learning activities in this e-UKBM. This reflection becomes a reference that determines whether students need to repeat material that they have not understood or can ask the teacher for a Final Examination so they can continue to the next UKBM); as well as the Developer Profile Menu (contains photos and personal data of the e-UKBM application developer). At this development stage validation is also carried out by validators, including lecturers and teachers who act as material experts and learning media experts. This validation aims to produce a product that is usable and guaranteed its validity.

The data obtained in this study were analyzed using two analytical techniques, namely qualitative and quantitative analysis. Qualitative analysis was used to analyze the results of the needs analysis interviews which began with writing scripts from the results of the needs analysis interviews which were recorded in audio form to then be recapitulated as data from the needs analysis interviews. While the results of product assessment by the validator, both from material experts, media, and teachers obtained from the validation sheet consist of data in the form of comments and suggestions, as well as scores of product feasibility assessments in terms of learning materials and media. Data in the form of comments and suggestions were analyzed using qualitative analysis which began with separating comments and suggestions from material and media expert validators. Furthermore, the data is presented in tabular form as product validation data. Comments and suggestions from the validators were then checked for relevance to the initial product, followed by a selection process based on the researcher's ability to follow up on these comments and suggestions as a reference for revising the initial product. Meanwhile, data in the form of assessment scores were analyzed using quantitative analysis which was then interpreted in a descriptive form using the equation I¹¹.

$$\text{Percentage of Validity (\%)} = \frac{\text{Total scores of validator answers}}{\text{Total maximum scores}} \times 100\% \quad (\text{I})$$

Furthermore, to find out the average validation value of each expert validator (material and media), the following equation II.

$$P_{\text{final}} = \frac{\Sigma P}{\text{Number of validator}} \quad (\text{II})$$

Information:

P_{final} = Final validity percentage

ΣP = Total validation percentage of the validators

Based on the results of calculations using this formula, the feasibility of a product can be determined using the eligibility and practicality criteria seen in Table 1.

Table 1. Product Validation Criteria

Percentage (%)	Eligibility Criteria
76-100	Very Eligible
51-75	Eligible
26-50	Not Eligible
≥25	Very Not Eligible

Then after being validated, product revisions are carried out according to the suggestions given by the validator.

Results and Discussion

The results of this study were obtained through needs analysis interviews, initial product designs, and product revisions based on suggestions from validators during the product validation stage. The results of this study are discussed in detail as follows.

Needs Analysis Interview Results

Broadly speaking, the problems experienced by all teachers as resource persons in needs analysis interviews were related to the use of learning methods, models and media. The application of online learning in schools requires teachers to be able to manage online learning by utilizing available technology. This is a challenge in itself for teachers, because the switch to online learning requires exploration of appropriate methods, models, and learning media to use when learning online, so that students can take part in learning well, even with a different learning mode than usual. Exploration of learning methods and models is considered necessary to facilitate students' learning needs, one of which is in studying biology materials that are difficult to understand. The results of the interviews show that teachers from the five schools generally experience difficulties in teaching certain materials to students, partly because there are some materials that are considered abstract to be taught, thus making teachers tend to experience difficulties in providing contextual learning so that it is more meaningful for students in solving real problems in everyday life. With the exploration of learning methods and models, and supported by adequate facilities, teachers hope to be able to carry out learning activities that are more varied and contextual, so that students become more interested and motivated in participating in learning activities, and obtain more meaningful learning to deal with problems in everyday life.

Then during the transition to a new normal period when learning was held in limited face-to-face meetings, the reduction in learning hours resulted in not achieving the planned learning indicators in one meeting or in one Basic Competence. One of the teachers interviewed said that the lack of learning hours at the school required students to be able to study independently, one of which was by dividing their study time at home. Therefore, based on the teacher's presentation, students expect that the teacher will also be able to facilitate learning activities at home or outside of learning hours, so that material that has not been taught face-to-face can still be studied independently at home by students. As stated, students actually expect digitization of learning materials, so that they can more easily study independently anywhere and anytime.

Based on the results of the needs analysis interviews that have been conducted, an Android-based learning application was developed in the form of the e-UKBM Virus based on the STEM approach and the PBL model. This learning application is expected to be able to overcome the problems experienced by teachers who become resource persons in needs analysis interview activities. However, it is further hoped that this application will be able to be used by students even after the Covid-19 pandemic is over, in order to practice independent learning activities

and besides that it is also able to assist teachers in providing contextual learning, specifically in virus material for 10th grade.

Initial Product Designs

The preparation of the initial product is based on the results of the needs analysis interviews that have been done before. After analyzing the results of the interviews and finding the product being developed, KD was then chosen with material that the teacher found difficult to teach, namely KD 3.4 and 4.4 for 10th grade with the subject matter of Viruses which includes structure, replication, and the role of viruses in life. The next step is to develop learning tools, such as syllabus and lesson plans (RPP) based on the application of the STEM approach with the PBL model and integrated with the use of learning media in the form of e-UKBM Virus. The STEM approach applied in this study uses an embedded approach, with a focus on learning in Science disciplines (in this case biology), where the disciplines of Technology, Engineering, and Mathematics act as complementary disciplines that demonstrate the application of theories in biology subjects to answer real-life problems related to Virus material. The application of the Science discipline is reflected in the Properties, Structure, and Process of Virus Replication sub-material, while to discuss and study the Role of Viruses in Life sub-material, the discipline of Science (biology) is associated with the application of biotechnology in dealing with diseases caused by viral infections (Technology), engineering manufacture of vaccines (Technique), and effectiveness of vaccines as well as prevention and treatment of diseases caused by viral infections based on interpretation of quantitative data in the form of graphs (Mathematics). The design of the learning media is in the form of learning applications which consist of several main menus, including Application Usage Instructions, UKBM Identity, Learning Activities, Reflections, and Developer Profiles. The display of the e-UKBM Virus application can be seen in Figure 1.

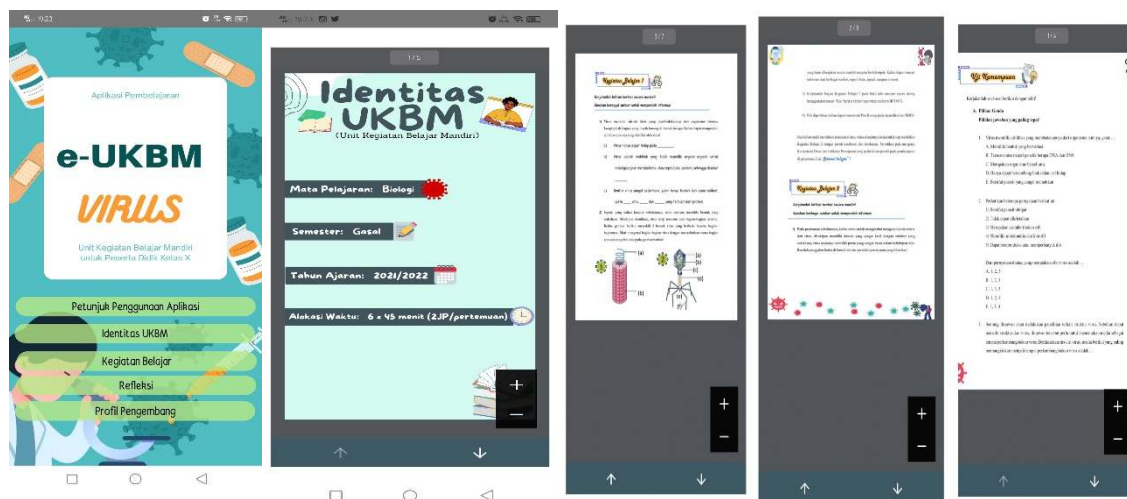


Figure 1. Display of the e-UKBM Virus application

Product Revisions

Validation was carried out by 2 lecturers and 2 teachers, respectively as material experts and media experts who were tasked with assessing the quality and feasibility of the learning media that had been developed in terms of material and media. Product evaluation in terms of material includes 4 main aspects, namely material suitability, material up-to-date, language, and presentation. The recapitulation of the validation results of material experts can be seen in Table 2.

Table 2. Recapitulation of Material Expert Validation Results

Aspect	Material Expert Validation Result			Average Score
	Validator I	Validator II	Validator III	
Material Suitability	13	11	16	13,33
Material Update	12	8	12	10,66
Language	8	6	8	7,33
Presentation	3	3	4	3,33
Total score	36	28	40	34,66
The ideal number of values	40	40	40	-
Validity percentage (%)	90	70	100	86,66
Criteria	Very Eligible	Eligible	Very Eligible	Very Eligible

The results of the average percentage of validity of the three material expert validators are worth 86.66% with very eligible criteria. This shows that in terms of material, the e-UKBM Virus learning media based on the STEM approach with the PBL model is very appropriate for use in learning activities, because the content of the material presented is in accordance with KD, Indicators, learning activities in RPP, the application of STEM and PBL in learning, and in accordance with facts and theories/concepts. The presentation of the material also includes illustrations that are appropriate and up-to-date, and contain explanations that are coherent, clear and easy to understand. Validator III stated that the application was feasible for trials without revisions. While Validators I and II gave a statement that the e-UKBM Virus application was declared feasible for trials with revisions according to suggestions. Table 3 presents the comments and suggestions given by each material expert validator.

Based on the advice from the material expert validator, a revision was made to the contents of the e-UKBM on the suitability aspect of the material, especially in the section on the suitability of the e-UKBM content with KD and Indicators. The advice given is to improve the instructions for working on the questions so that they are in accordance with the cognitive level that is targeted based on KD and the indicator used, namely C4 (analysis). This needs to be done, because the formulation of indicators has an important role in the development of learning and assessment, in this case to write questions for each Learning Activity (KB) in UKBM. Writing questions or instructions for working on these questions should be formulated in sentences according to the Operational Verbs (KKO) guidelines¹². Several instruction questions in KB 1 and 2 were then revised according to suggestions from the validator so that they were right on target, namely targeting the C4 cognitive level. Even so, the formulation of the questions has not been completely changed in its entirety, because according to Hamid (2019), formulating questions, especially at the HOTS level, does not always have to be guided by KKO with an overly rigid impression¹³. The formulation of questions that follow KKO grouping cannot always determine the cognitive level of a question. An example that can be used to illustrate this situation is when a question formulation uses KKO at cognitive level C2 (understanding), but when they want to answer the question, students are required to apply higher-order thinking skills. Therefore, KKO, which was initially at the C2 cognitive level, does not rule out the possibility of being included in the higher order thinking level. If you take one of the questions that have been compiled in the e-UKBM Virus as a concrete example, in question number 2 in KB 2, even though the question formulation uses KKO level C2 to 'determine' the name and disease caused by a virus infection, but when you want to answer

question, students first need to analyze the case examples given, so that KKO 'determines' their cognitive level can be entered at level C5 (evaluate).

Table 3. Comments and Suggestions from Material Expert Validators

VALIDATOR	COMMENTS AND SUGGESTIONS
I	• Material suitability 1) Only 1 indicator fulfills, namely activities in the RPP. KD cognitive level and the targeted indicator is C4. The e-UKBM Operational Verb (KKO) analysis found many work instructions (questions) under C4. Learning Activities 1 (1) Analysis of Virus Characteristics (C4) > Complete C3 (2) Analyze section (C4) > Group C3 (3) Shape analysis (C4) > Match/connect C3 (4) Shape analysis (C4) > Complete C3 (5) Analysis of replication process (C4) > Group C3 & Breakdown C2 Learning Activities 2 (2) Analyze the role of the virus (C4) > Complete C3 & Description = explain C2 (4) Explain how to make vaccines (C2) > determine C2 /describe = describe C2 2) Of the 4 STEM aspects, the engineering aspect is not visible in the material.
	• Presentation The short video in lesson 1 about the animation of how viruses attack host cells is difficult to understand because there is no audio. It is better to replace it with a sound video so that it is easy to understand.
II	• General comments 1) The e-UKBM Virus application that has been prepared is good, only for suggestions, this UKBM can be supplemented with a summary of introductory material for each Learning Activity both KB 1 and KB 2, so that the material in the textbooks (BTP) provided can be an additional reference just. This can be a solution for students who may not have the intended BTP when working on UKBM. 2) The introductory section should be supplemented with a number of questions or case examples as apperceptions and motivations that can motivate children to learn, before being directed to the existing YouTube link. 3) In the core activity section of Learning Activity 2, before entering the practice questions, there should be a brief summary or conclusion section, which is arranged as in Learning Activity 1 the "Keep in mind" section. 4) In the ability test section, the form of the questions is directed at competence C4=Analyze in accordance with the KKO in the Competency Achievement Indicators section, so the questions are not just rote. Also adjusted to the Minimum Competency Assessment (AKM) question model. At least in the ability test section, there are several models of AKM questions. Students are directed to work on questions from low competency levels to high competency levels. 5) In the Reflection section, in addition to containing self-assessments, students can be directed to reflect on the learning that has been followed through questions such as "How do you feel after participating in this learning activity?" and the answers can be written down by students via a link padlet or something else, as material for reflection for improvement for the teacher.

The engineering aspect in STEM is a form of collaboration between the concepts of science, mathematics, and the use of technology-based tools⁵. The main concept in engineering is a process that aims to solve problems based on human needs by forming a product, either

through improvements to existing products, or by creating new products. In line with this, this engineering aspect has been included in KB 2 in the form of questions regarding vaccine manufacturing techniques. Vaccine manufacturing techniques can be categorized as part of the engineering aspect in STEM, because they contain how the vaccine manufacturing process is used as an effort to prevent disease transmission due to viral infections. The vaccine is a product of collaboration between knowledge about viruses and the immune system, as well as the use of technology in overcoming the problem of diseases caused by viral infections. Even so, at this stage revisions were still being carried out according to the suggestions of the material expert validator by adding this engineering aspect to the material summary for meeting 2, specifically on the sub-matter of the advantages or benefits of viruses in life.

Video can be categorized as one of the multimedia learning media, specifically as linear or sequential multimedia¹⁴. This is because video as a medium does not allow for interactive patterns with its users or in other words this type of multimedia runs without any control from its users, so it only goes in one direction. Even though it only goes in one direction, video is still said to be multimedia, because it involves various human sensory organs in the process of receiving information, including the sense of sight to capture visual messages in the form of images and the sense of hearing to capture audio messages in the form of sounds. Therefore, a revision was made to the short video in the Introduction to KB 1 according to the validator's suggestion, because the video has no sound, so it cannot be understood. The video is then replaced with another video that is equipped with images, animations, and audio.

In general, Validator II, who is a biology teacher who is an expert validator, gives suggestions regarding the provision of material summaries. Providing a summary of this material is used as a learning resource when students cannot access the Textbook or BTP (the contents of which are not included in the e-UKBM Virus application) and as a reminder before students work on each KB. In line with that, the existence of a material summary can be used as a means of supporting student learning activities, especially for those who are still unable to understand the material being studied¹⁵. This is because the summary of the material contains statements that explain the learning material being studied more concisely. The summary of the material is generally also identical to the main points of a material which contains concepts, procedures and principles, as well as the relationships between the three which are presented briefly, so that it is easier for students to understand. Therefore, a summary of the material is added as a complement to BTP which is practically used anytime and anywhere (already included in the e-UKBM application), as well as a reminder that is placed before KB 1 and 2, namely in the "Keep in mind" section.

In the PBL model, one of the syntaxes is problem orientation or orienting students towards problems. This stage is the stage that is characteristic as well as the core of the PBL model, because without this stage, of course it cannot be called a PBL model and the learning process cannot occur or be carried out. Furthermore, the problems presented at the problem orientation stage are solved or resolved using critical thinking skills¹⁶. The problem orientation stage is different from the apperception stage, although there is the same tendency for the purpose of its implementation in learning, namely to motivate students. However, one thing that distinguishes it is the location of the problem orientation stage which is in the core learning activity section which functions to focus students' attention on the problems presented, while the apperception stage is at the beginning or introductory part, before starting a series of learning processes with the aim of exploring initial knowledge and prepare students to start learning¹⁷. Based on this theory, a revision was made according to the validator's suggestion by adding case examples in the Introduction section in KB 1 and 2 followed by a stimulus in the form of a video and news headlines as part of the problem orientation stage, not as an apperception stage in the introductory part of the learning activity (this section has been stated in the RPP, not included in the application).

With regard to evaluation questions, currently one assessment model is being developed, namely the Minimum Competency Assessment (AKM). AKM is a model of assessment or evaluation of basic competencies that are necessary and must be mastered by all students without exception, in order to help them develop their own abilities and positive-active participation in society. This AKM is called a basic competency assessment, because it contains 2 basic and main competencies, namely literacy and math (numeration) skills. These two abilities are very important to be mastered by all students, considering that these abilities are skills that will always be used in everyday life¹⁸. Therefore, having AKM questions in the e-UKBM Virus is deemed necessary, so AKM questions are added in the form of essay questions that measure literacy and numeracy skills in the Competency Test section of the application (which will then be used in the final exam questions). Questions to measure literacy skills are formulated in the form of news text with the aim of encouraging students to explore and find information in the text, while questions to measure numeracy skills are presented in the form of infographics containing numerical data in the form of diagrams to improve students' skills related to the interpretation of numerical data. This is in line with the AKM questions used are not required to be made as difficult as possible, in the sense that the level of difficulty can be adjusted according to need, for example, such as literacy questions which measure the ability to gather information and evaluate texts, as well as numeration problems that measure understanding of mathematical applications¹⁹. Of course, it is possible to use difficult types of questions that measure the ability to integrate, interpret, and evaluate data or text. In addition, AKM questions should be linked to real problems, including personal, scientific, or socio-cultural problems.

The revision of the Reflections section on the e-UKBM Virus application was based on suggestions from the validator referring to the absence of reflective questions in that section. The Reflection Section which was compiled previously was only in the form of a self-assessment in the form of a checklist as a triangulation to measure students' cognitive abilities after learning. Giving reflective questions is deemed necessary. That reflective questions given after learning is carried out aim to provide opportunities for students to reconstruct or reflect back on what they have acquired during learning²⁰. This reflection is expected to help students get to know themselves, measure the extent of their understanding, identify the obstacles they are experiencing, so that students can determine the action plans that need to be taken to overcome these obstacles in the future. In addition, students' reflections can also be reflection material for teachers in preparing lessons by considering what students convey.

Product evaluation in terms of media includes 2 main aspects, namely software engineering and visual communication design. The recapitulation of the validation results of media experts can be seen in Table 4.

Table 4. Recapitulation of Media Expert Validation Results

Aspect	Media Expert Validation Results			Average Score
	Validator I	Validator II	Validator III	
Software engineering	12	12	16	13,3
Visual communication design	12	12	16	13,3
Total score	24	24	32	26,6
The ideal number of values	32	32	32	-
Validity Percentage (%)	75	75	100	83,33
Criteria	Eligible	Eligible	Very Eligible	Very Eligible

The results of the validity percentage of the three media expert validators are worth 83.33% with very eligible criteria. This shows that the e-UKBM Virus learning media based on the STEM approach with the PBL model is very suitable for use in learning activities, because the application can be operated easily, both online and offline, and is communicative, thus allowing interaction between teachers and students and interaction between students. The e-UKBM Virus application also has a simple but attractive appearance. Validator III states that the e-UKBM Virus application is feasible for trials without revisions. Whereas Validators I and II stated that the e-UKBM Virus application was feasible for trials with revisions according to suggestions. Comments and suggestions from the media expert validator are presented in Table 5 (for suggestions from Validator II in the media expert validation section the same as those presented in Table 4).

In general, the media expert validator provided suggestions regarding the effectiveness of the e-UKBM Virus application as a mobile application-based digital learning medium. The eligibility criteria for digital learning media can be viewed in terms of practicality, technicality, and cost²¹. A media can be said to be practical if it is easy to access or use, in this case it can also be seen from the size of the application file. The larger the size of the application, the more difficult it will be for users to download it from the internet and burden the Android and iOS operating systems in running the application²². Therefore, a revision was made by reducing the file size of the e-UKBM Virus application, while maintaining the quality of the application. Apart from the file size aspect, a learning application is expected to be used on various operating systems, such as Android and iOS. However, because there are obstacles from Thunkable as an application development service provider, the operating system can only be available on Android. Regarding the technical aspect, one of the criteria reviewed is the media attribute. A digital learning media is considered technically feasible if it does not use excessive media attributes. Based on this, a revision was made to the appearance of KB 1 by uniforming the font used. In addition, when viewed from a technical point of view, the appearance of a learning application should be able to assist users in obtaining information. For example, when using fonts, you must pay attention to the readability of the text, images, and videos presented. In this regard, the e-UKBM Virus application is equipped with a text zoom-in and zoom-out feature, so that it can help students as application users in reading text. However, there are limitations in adjusting the position of this feature which often covers the text, because this feature is a default setting from Thunkable, so it cannot be changed or revised.

In the aspect of visual communication design, precisely related to presentation, revisions were made according to the validator's suggestion, namely the addition of virus history sub-material in the discussion of material and learning activities. This is because the breadth of the material is a component that needs to be considered in the presentation of learning material, so that it is able to assist students in fulfilling predetermined achievement indicators²³. In Virus material for 10th grade, material that needs to be studied in this chapter includes the history of discovery, structure, method of reproduction, and the role of viruses in life. Apart from that, still in the same section, based on the advice of the media expert validator, a revision was made to the contents of the e-UKBM Virus application by adding an Introduction menu. Even though the menu is in a learning application, the introductory word in question is relatively no different from the introductory words that are often used in books and other written works, such as in research reports. The introduction functions as a form of applying ethical values in writing, by 'delivering' the reader to the contents of the report²⁴. In line with this, an Introduction menu was added which contains a brief greeting from the application developer, as well as explaining the purpose of making the e-UKBM Virus application.

Table 5. Comments and Suggestions from Media Expert Validators

VALIDATOR	COMMENT AND SUGGESTIONS
II	• Software engineering 1) The file size of 78 MB is quite large, it can be used without an internet connection except when starting and accessing the link. 2) Cannot be tried in iOS 3) Easy to operate. There are links that cannot be copied. 4) The application is easy to understand and allows teacher-student and student-student interaction • Visual communication design 1) OK. 2) Can be added an introduction before entering the instructions for use. Present what is e-UBKM along with the goals of developing e-UBKM. The + - sign in the application covers the text so it is unreadable. 3) Video 1 “T4 phage replication” without sound and text so it's a bit confusing and unclear. Provide explanatory text. 4) The appearance of the text is small, it can be enlarged. 5) Learning activity 1: there are excessive variations of letters. The form of the font in this section can be uniformed. 6) The image does not have a source and number and description of the image. 7) Questions and stimulus (eg pictures) are separate pages, it's good if they are made as 1. 8) Add an explanation of how to work on the Worksheet. For example, is it done in each book or what. 9) There is no material for the history of viruses, they should have preceded the nature of viruses. 10) The YouTube video link for meeting 2 cannot be copied. 11) Simple. • General Comments 1) Add an introduction that contains development goals and general content. 2) Fix writing links so they can be copied. 3) Adjust the position of the text so that it is not covered by the + - sign 4) Add annotations to the video. 5) Add image numbers and captions as well as image sources. 6) Tidy up the writing of the questions so that as much as possible they are not separated between the stimulus, questions and answer options. The answer options for PG questions start with a lowercase letter.

Media expert validators provide suggestions regarding the presentation of questions in the e-UKBM Virus application, specifically regarding the mechanism of writing questions. The presentation of questions must be communicative and in accordance with the rules of good and correct Indonesian language rules. Question sentences that are not communicative can cause confusion to test takers and can lead to multiple interpretations of the intent of the questions written. In addition, the questions presented need to be accompanied by clear and credible sources²⁵. Because of this, revisions were made to the writing of the questions, especially in the Ability Test section according to suggestions from the validator, by tidying up the writing of the stimulus, questions, and answer options so that they are not separated, writing answer options on multiple choice questions starting with lowercase letters, and including descriptions and image sources.

Conclusion

The design of e-UKBM digital learning media based on the STEM approach with the PBL model on Virus material for 10th grade was developed in the form of the e-UKBM Virus

application with application feasibility based on validation results from material expert validators obtaining an average score of 86.66% with Very Eligible criteria and 83.33% with Very Eligible criteria from the media expert validator. Thus, the e-UKBM Virus application was declared feasible for testing with revisions according to the suggestions. It is necessary to carry out further studies by conducting trials using the e-UKBM Virus application in learning activity to determine the effect of using this application as a learning medium that is able to facilitate student learning activities independently and is also able to assist teachers in providing contextual learning on Virus material.

References

1. Permansah, S. & Murwaningsih, T. (2018). Media pembelajaran digital: Kajian literatur tentang dampak penggunaan media pembelajaran digital di SMK. *Prosiding Seminar Nasional Pendidikan Administrasi Perkantoran*, 3(2), 72-76. <https://jurnal.uns.ac.id/snpap/article/view/27906>
2. Amirullah, G., & Susilo, S. (2018). Pengembangan media pembelajaran interaktif pada konsep monera berbasis smartphone android. *Wacana Akademika: Majalah Ilmiah Kependidikan*, 2(1), 38–47. <https://doi.org/10.30738/wa.v2i1.2555>
3. Majid, M.I. & Linuwih, S. (2019). Pengembangan Unit Kegiatan Belajar Mandiri (UKBM) materi usaha dan energi berbasis pembelajaran kontekstual untuk meningkatkan pemahaman konsep siswa. *Unnes Physics Education Journal*, 8(3), 229-238. <https://doi.org/10.15294/upej.v8i3.35619>
4. Setyo, A.A., Fathurahman, M., & Anwar, Z. *Strategi pembelajaran problem based learning*. (Yayasan Barcode, 2020).
5. Khairiyah, N. *Pendekatan Science, Technology, Engineering, dan Mathematics (STEM)*. (Guepedia, 2019).
6. Mulyani, T. (2019). Pendekatan pembelajaran STEM untuk menghadapi revolusi industry 4.0. *Prosiding Seminar Nasional Pascasarjana (PROSNAMPAS)*, 2(1), 453-460. <https://proceeding.unnes.ac.id/index.php/snpasca/article/view/325>
7. Khuzaimah, S. (2020). *Analisis penerapan Unit Kegiatan Belajar Mandiri (UKBM) pada mata pelajaran biologi siswa kelas X MIA di MAN 1 Blitar* [Skripsi]. UIN SATU Tulungagung Institutional Repository. <http://repo.uinsatu.ac.id/20039/>
8. Madiya, I.W. (2020). Pengembangan aplikasi e-UKBM kimia sebagai media pembelajaran interaktif siswa kelas XI SMAN Bali Mandara. *Indonesia Journal of Educational Development*, 1(2), 142-158. <https://doi.org/10.5281/zenodo.4003785>
9. Ardiansyah, H., Riswanda, J., & Armanda, F. (2021). Pengaruh model PBL dengan pendekatan STEM terhadap kompetensi kognitif peserta didik pada materi sistem pencernaan kelas XI di SMA/MA. *Bioilmi: Jurnal Pendidikan*, 7(1), 46-51. <https://doi.org/10.19109/bioilmi.v7i1.9507>
10. Dwipayanti, N.K.I., Citrawathi, D.M., & Julyasih, K.S.M. (2020). Pengembangan unit kegiatan belajar mandiri berbasis pendekatan STEM pada materi sistem respirasi dengan berbantuan edmodo untuk kelas XI MIPA di SMA. *Jurnal Pendidikan Biologi Undiksha*, 7(2), 81-93. <https://doi.org/10.23887/jjpb.v7i2>
11. Arikunto, S. *Prosedur penelitian suatu pendekatan praktik*. (Rineka Cipta, 2013).
12. Hanum, L. *Perencanaan pembelajaran*. (Syiah Kuala University Press, 2017).
13. Hamid, A. *Penyusunan tes tertulis (paper and pencil test)*. (Uwais Inspirasi Indonesia, 2019).

14. Yuniastuti, M., & Khoiron, M. *Media pembelajaran untuk generasi milenial*. (Scopindo, 2021).
15. Mukhlason, M., Degeng, I.N.S., & Sihkabuden. Pengaruh strategi pembelajaran (peta konsep dan rangkuman) dan motivasi berprestasi terhadap hasil belajar pembelajaran sejarah. *Jurnal Inovasi dan Teknologi Pembelajaran*, **2**, 280-291 (2015). <http://dx.doi.org/10.17977/um031v2i12015p280>
16. Lismaya, L. *Berpikir kritis & PBL*. (Media Sahabat Cendekia, 2019).
17. Purba, A., Asnewastri, Gultom, S., Girsang, S.E.E., Sinaga, D.P., Saragih, R., Tansliova, L., Hulu, I.L., Nasution, T.A., Huda, M.K., Sitopu, J.W., Marini, N., & Ginting, A.M. *Pengajar profesional*. (Yayasan Kita Menulis, 2021).
18. Krissandi, A.D.S., Sudigdo, A., & Nugraha. A.S. *Model pembelajaran inovatif dan soal berbasis AKM jenjang SMA*. (Kanisius, 2022).
19. Sani, R.A. *Pembelajaran berorientasi AKM*. (Bumi Aksara, 2021).
20. Simarmata, D.H. Pendidikan karakter melalui metode refleksi. *Jurnal Pendidikan Penabur*, **31**, 72-82 (2018). <https://bpkpenabur.or.id/media/g0kmjnhq/hal-72-82-pendidikan-karakter-melalui-metode.pdf>
21. Mais, A. *Media pembelajaran anak berkebutuhan khusus*. (Pustaka Abadi, 2016).
22. Surjono, H.D. *Multimedia pembelajaran interaktif*. (UNY Press, 2017).
23. Fauziyah, A., Jalmo, T., & Surbakti, A. Analisis kesesuaian materi virus pada buku teks dengan kompetensi dasar kurikulum 2013. *Jurnal Bioterdidik*, **6**, 1-10 (2018). <http://jurnal.fkip.unila.ac.id/index.php/JBT/article/view/15313/11170>
24. Nisya, K. *PTK jadikan guru profesional*. (Guepedia, 2019).
25. Nofiana, M. Kualitas penulisan butir soal ujian nasional biologi tahun 2014/2015 ditinjau dari aspek teoritik. *Saintifika*, **17**, 13-13 (2022). <http://saintifika.or.id/index.php/saintifika/article/view/106>