
Development of Problem Based Learning Worksheets on Class XI Body Defense System Material to Improve Science Literacy

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Abstract. In the 21st century, the use of student worksheets (LKPD) must be integrated with technological developments or electronic media. Teaching materials are known as e-LKPD. The use of e-LKPD teaching materials can be supported by appropriate learning strategies to support the learner-centered learning process, one of which is the problem-based learning model. This study aims to determine the feasibility of e-LKPD based on the PBL model on the immune system material of students of class XI. The type of research carried out is research and development using the ADDIE model. Data collection techniques using non-test in the form of a closed questionnaire. Questionnaires are used to measure the feasibility of e-LKPD media experts, material experts, and biology teachers, as well as student responses. The data analysis technique used is by calculating the average value (mean) and converted to determine the feasibility category. The results of this study show that the average e-LKPD product feasibility assessment results by material experts 92,192 include the very feasible Category, the average e-LKPD product feasibility assessment by media experts 85.1 including the category is very feasible, the e-LKPD product feasibility assessment by biology teachers 98.24357 includes the very feasible category, and the product feasibility assessment results based on student Responses 96,375 belong to the very feasible category. The conclusion of this study shows that PBL-based e-LKPD teaching materials on body defense system materials are suitable for use in biology learning for class XI students.

Keywords: Development, e-LKPD, Problem Based Learning

Introduction

The development of science and technology in the 21st century has had a very broad impact in all fields, one of which is the field of education, where currently education in Indonesia continues to experience developments to increase success in the learning process. Several devices can support the learning process, one of which is student worksheets LKPD (2022; Mutlu, 2020; Puspasari, 2019). According to Prastowo (2015) revealed that LKPD is one of the learning tools that play an important role in the learning process so that it can be implemented properly. LKPD is a learning tool that can

be used by teachers in increasing student involvement or activities in the teaching and learning process (Julian et al., 2020; Nasution et al., 2021). Student worksheets play a role in helping to improve and deepen students' understanding of the material presented because in LKPD there is a component that motivates in the form of questions related to daily activities (Muthoharoh et al., 2017; Pratama & Saregar, 2019; Nasrullah et al., 2018). LKPD contains activities that must be carried out by students to maximize understanding as an effort to form basic abilities by indicators of achievement of learning outcomes (Lerian et al., 2022; Nurhayati et al., 2022; Hairun et al., 2020). Hiroh et al. (2019) reveals that the LKPD validation results obtained can be stated in the category of valid. The feasibility component of presenting LKPD includes aspects of content construction, presentation techniques, completeness of presentation, selection of time, language, and benefits or uses. The percentage of completion of student learning outcomes is that 20% of students are considered incomplete and 80% of students are considered complete. The data shows that students who use LKPD are said to have high learning outcomes.

In the era of the 21st century, the use of LKPD teaching materials must be integrated with technological developments or electronic media. Educators are required to present interesting and innovative teaching materials packaged in online form so that students are not bored following the learning process, and can be accessed without the limits of time and space. The teaching material is known as electronic LKPD (e-LKPD). Hafsa, et al. (2016) explained that e-LKPD is a computer-aided media equipped with images, animations, and videos so that students do not get bored. E-LKPD is expected to be very supportive of learning so it needs to be applied in schools, especially schools that are still experiencing problems in learning. Based on the results of a survey conducted by students of SMA N 2 Temanggung, as many as 65.5% of students felt difficulties in understanding the concepts of biology learning and 56.3% of students experienced difficulties or obstacles in understanding learning the material of the body's defense system. The material of the body's defense system that is abstract and has complex mechanisms makes it difficult for learners to learn it. According to Jayanti et al. (2017) Another difficulty that is obtained when studying the body's defense system is that it is not possible to have a practicum or present torso or human limb media so students are less able to understand this material conceptually.

The subject matter of the body defense system is taught in class XI of high school even semester with basic competence (KD) 3.14 analyzing the role of the body's defense system and immunization against physiological processes in the body and KD 4.14 conducting campaigns on the importance of various programs and types of immunization as well as abnormalities in the body's defense system in various forms of information media. Referring to KD 3.14 and 4.14, students are required to understand the structure and function of the body's defense mechanisms in the form of physiological processes and the role of the body's defense system, immunization, and abnormalities that can be applied in the form of campaigns to help solve problems in everyday life. Based on this, learning biology on the material of the body's defense system needs to be supported by appropriate strategies so that students can understand the concepts of the body's defense system material. One of them is by applying the right learning model to support the student-centered learning process. The learning model is a problem based learning (PBL) model. PBL can help students work in real-life situations (Hursen, 2021). This is reinforced by the statement Schaefer & Gonzales (2013) which reveals that the PBL learning model has characteristics of presenting problems that are contextual and encourage learners to solve problems, acquire knowledge, and think critically. PBL is innovative learning that has the potential to create effective learning (Lukitasari et al., 2019; Kim et al., 2018).

PBL is a learning model oriented towards constructivist theory so that students' concepts become better. The focus of PBL learning lies on the chosen problem so that it not only requires students to learn concepts related to the problem but also the scientific method to solve the problem (Hasanah et al., 2021; Zhao et al., 2020). Farisi et al. (2017) revealed that the main objective of the PBL model is the development of critical thinking skills and problem-solving abilities while developing the ability of learners to actively build their knowledge. The PBL model is a learning model that is based on problems and presented systematically by educators about real life. The material of the body's defense system relates a lot to problems or phenomena that occur around students, for example, coronavirus disease (covid) problems, inflammatory reactions, and fever which can be described as problems related to the causal factors of these diseases, What are the stages of infection, how is the prevention. Students are expected to be able to solve these problems from various perspectives, for example providing information related to how to prevent these diseases and being able to decipher the mechanism of action of the body's defense system against foreign microorganisms that enter the body. This is intended so that students can compile their knowledge about critical thinking, and problem solving skills, obtaining essential knowledge, and concepts from the subject matter studied. The contextual PBL model can be applied to e-LKPD teaching materials to support the learning process, especially in the body's defense system material.

The PBL model combined with LKPD is a teaching material that contains a description of learning activities whose steps are adjusted to the PBL syntax which includes: (1) problem orientation; (2) learning organizations; (3) guiding the investigation; (4) develop and present results; and (5) evaluate the troubleshooting process (Fatmawati et al., 2017). The steps of the PBL model are enough to stimulate the critical thinking of learners on each problem topic that requires a solution according to the material being taught. PBL facilitates the delivery of messages to learners through the use of observation and identification techniques. This technique trains learners to find broader and more comprehensive solutions to problems (Mustofa & Hidayah, 2020). LKPD PBL makes students more able to explore their ability to find their concepts while helping students to solidify the concepts of the material they are studying (Jasperina & Suryelita, 2019). The application of the PBL model in LKPD is supported by the results of interviews with biology teachers, where in learning the body's defense system so far teachers still use package books as the main guidelines in delivering material and still use old methods such as lectures and the use of power points.

The learning process of biology in the material of the body's defense system has not contained interactive activities, furthermore, it is also not optimal to support the activeness of students in solving problems, thinking critically, literacy, and conducting scientific investigations. The development of PBL based e-LKPD teaching materials is useful in improving learning activities that were originally only conceptual and monotonous to experiment based so that students become more active and independent and can improve scientific investigation activities. This study aims to determine the feasibility of e-LKPD based on the PBL model on the immune system material of students of class XI.

Methods

The type of research used is research and development (R & D). The research produced teaching materials in the form of android based e-LKPD on the body's defense system material, then tested the effectiveness of the product. Test subjects from PBL-based e-LKPD research and development activities include expert lecturers in the field of media, material fields, biology teachers, and class XI students. The development model used is the ADDIE development model. There are five stages in the ADDIE model,

namely: (analysis, design, development, implementation, and evaluation), by the stages of design and development (Richey & Klein, 2007).

The analysis stage aims to find out the problems faced by students and the needs needed in achieving learning objectives. The activity was carried out by interviewing and filling out questionnaires by students and teachers at SMA Negeri 2 Temanggung. After conducting the analysis, several important things were designed, namely: (1) the design of the basic framework of e-LKPD includes the creation of application framework and the creation of flowcharts, including the selection of images and photos. The e-LKPD application framework includes instructions for using e-LKPD, student learning activities, curriculum, glossary, concept map, application developer profiles, and bibliography; (2) systematic preparation of teaching materials in e-LKPD in the form of defense system materials which include the functions of the body's defense system, body defense mechanisms, factors affecting the body's defense system, and disruption of the body's defense system. The preparation aims to make the material presented and structured so that students can easily learn and understand the material. The development stage emphasizes the process of making PBL-based e-LKPD into products that are suitable for application in schools. The creation of PBL-based e-LKPD is done with an android studio application in the Java programming language. The development stage is the stage of preparing e-LKPD starting from the preparation of a draft covering the material contained in the LKPD product which includes instructions for using LKPD, student learning activities, curriculum, glossary, application developer profiles, concept maps, and bibliography. After going through the development stage, the PBL-based e-LKPD product was validated by several experts, namely material experts, media experts, and 2 biology teachers in class XI. Furthermore, it was implemented in a limited trial of 20 students in class XI MIPA students. The evaluation stage, namely the data processing stage, is carried out to analyze the implementation results as material for the improvement and to determine the feasibility of e-LKPD. The data processing aims to determine the feasibility of PBL-based e-LKPD on the body defense system material for class XI.

The data collection technique uses non-tests in the form of closed questionnaires, respondents can only choose one answer provided in the questionnaire. The results obtained are analyzed using qualitative descriptive analysis. The questionnaires used with the criteria are very feasible (5), feasible (4), sufficient (3), less feasible (2), and very less feasible (1). Questionnaires are used to measure e-LKPD eligibility by media experts, material experts, and biology teachers, as well as student responses. The criteria for selecting validators and respondents are: material and media experts are lecturers who are experts in their fields, biology teachers who have served $\pm$ 5 years, and students consisting of 20 people. The sampling of learners was carried out using the cluster random sampling method. The assessment results obtained from the questionnaire are calculated as the average score using the following calculation formula:

$$M = \frac{\sum fx}{N}$$

Information:

M : Average per aspect
 $\sum fx$: Number of scores per facet
 N : Number of components

After getting the average data per aspect, the average score is converted to a value of 100 by means of:

$$\text{The value of each aspect} = \frac{\text{Average score}}{\text{Maximum score}} \times 100$$

Furthermore, the interpretation of these aspects can be known by referring to the value categories conveyed by Riduwan (2013). The eligibility categories referred to are as follows:

Table 1. Product Eligibility Categories

No.	Value	Category
1.	81 – 100	Very Decent
2.	61 – 80	Proper
3.	41 – 60	Enough
4.	21 – 40	Less Viable
5.	≤ 20	Very Less Feasible

Results and Discussion

The results of this research and development produce a product in the form of PBL-based e-LKPD on the body defense system material that can be accessed by class XI students through android-based smartphones. Based on the results of interviews and questionnaires that have been given, several important aspects of concern were found, including the learning methods used by teachers that are still dominant in implementing the lecture and discussion method. Apart from the learning method, the delivery of material still uses power point and package books as learning resources, so students do not actively participate in learning activities, especially in biology learning. Based on the interview results, it was found that the learning process once used LKPD as a learning resource, but it did not interest students because it consisted of a lot of text and minimal images and videos. Low student interest will affect student learning outcomes, so the need for learning resources with an attractive appearance (Čipková, et al., 2018; Dahliani, et al., 2020).

The learning process in the classroom is also still teacher-centered, causing students to only hope and wait for the concepts of the material to be given by the teacher without trying to find them from various sources. This is very unfortunate because the use of the 2013 curriculum in Indonesia has the characteristic of student-centered learning (Kemendikbud, 2013). Apart from the learning process, the school has also not presented learning resources related to the concept of a contextual body defense system. Limited time at school makes the learning process not optimal, so the material has not been delivered as a whole. The use of the internet in learning activities is only at certain times, even though the internet network facilities provided by the school are very adequate so that they can be utilized by students in the learning process. Based on the results of the questionnaire survey, shows that 65.5% of students have difficulty understanding the concepts found in biology learning and 56.3% of learners experienced difficulties or obstacles in understanding the material of the body's defense systems.

The material of the body's defense system that is abstract and has complex mechanisms makes it difficult for learners to learn it. This is in line with the statement Jayanti et al. (2017), Where another difficulty obtained when studying the body's defense system is that it is not possible to have a practicum or present torso or human limb media so students are less able to understand this material conceptually. It is necessary to develop integrated learning resources with technology that can help create student-centered learning, one of which is PBL-based e-LKPD. This is also supported by a very high percentage of smartphone users among students, therefore, there is the potential to develop LKPD that can be accessed by students through their respective android-based

smartphones. The development of PBL-based e-LKPD teaching materials is useful in improving learning activities that were originally only conceptual and monotonous to be experiment-based so that students become more active and independent and can improve scientific investigation activities.

The design stage is the stage in designing e-LKPD products and evaluation tools. This stage is carried out so that the order of the material presented is clear and structured so that students are easily using and learning e-LKPD. This is in line with the research conducted by Bulkani, et al. (2022) that the systematics of structured material arrangement helps facilitate students' understanding. The systematics of e-LKPD are as follows: (1) learning activities 1 contain material related to the understanding and function of the body's defense system, non-specific mechanisms, and specific mechanisms of the body's defense system; (2) learning activities 2 contain material related to the role of immunization in the body's physiology correctly and factors affecting the human body's defense system; (3) Learning activity 3 contains material related to disturbances in the body's defense system, then students can later conduct a campaign in the form of making TikTok videos that can be uploaded on e-LKPD related to the importance of health protocols and vaccines. Based on these learning activities, the arrangement of menus or sections in the e-LKPD design is presented in Figure 1.

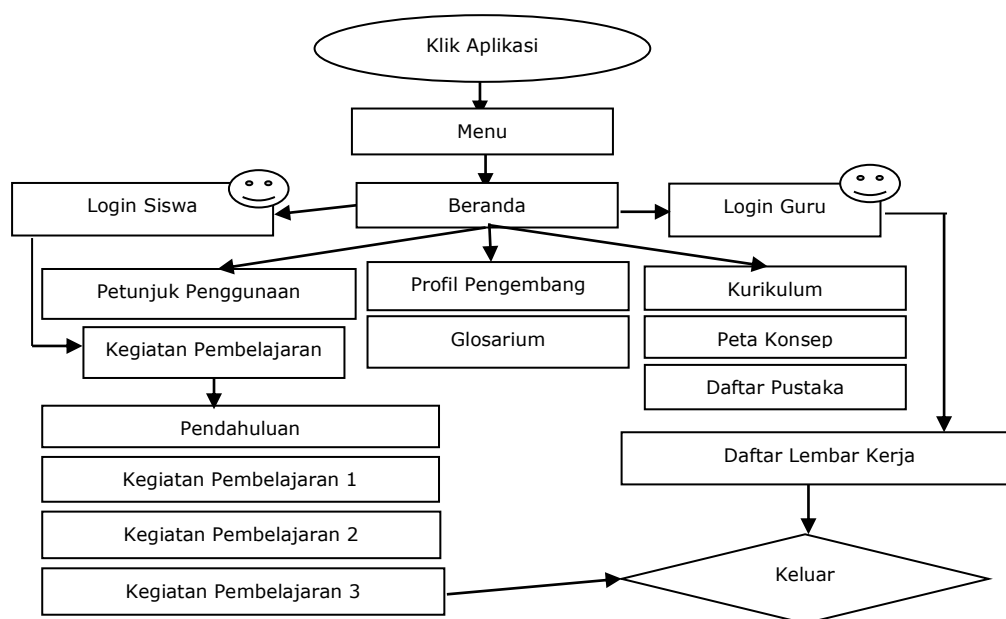


Figure 1. PBL-Based e-LKPD Design Arrangement

The novelty of this research's e-LKPD design is that its appearance is presented with a combination of images, videos, and article links as additional information that aims to be interesting and not boring for students. According to Arsyad (2017), LKPD has a combination of text and images that can increase attractiveness to facilitate the presentation of information presented in verbal and visual formats. LKPD, which is presented in the form of an android-based application, makes it easier for students to analyze the material, helps students to access the material, and encourages active participation in students.

The e-LKPD development stage emphasizes the process of making PBL-based e-LKPD into a viable product. The development of PBL-based e-LKPD was made using the android studio application in the form of a .apk format with its programming language,

namely Java, then e-LKPD was shared through the whatsapp group application on the smartphones of each student based on Android. According to Nasution et al. (2019), android studio is an integrated development environment (IDE) for application development on android, besides that android studio is also an efficient developer tool because it has provided several features that can increase productivity in developing android applications. The product is then validated by several experts, namely material experts, media experts, and biology learning practitioners in schools, namely biology teachers and students who will be the subject of limited trials. This stage is the product validation stage to determine the feasibility of the e-LKPD product. Validation is a process that requires approval or validation that a product meets the requirements to be declared eligible and suitable for study (Desmiwati et al., 2017). Based on the validity test, further evaluation is carried out (data processing on the implementation results and revising the product).

The feasibility assessment of PBL-based e-LKPD products by material experts is in the category of very feasible in all aspects, both in terms of material feasibility, material accuracy, activity, construction, and technical, so that overall the PBL-based e-LKPD quality assessment in terms of material is in the category of very feasible to use in learning the material biology of the body defense system with an average value of 92.19 (Table 2). The material presented is by the basic competencies and learning objectives to be achieved, the material presented is emphasized easy to complex concepts, making it easier for students to relate between concepts into complete knowledge. In line with the statement (Mutia et al., 2017; Panjaitan et al., 2020; Daniel, 2020), the suitability of the material with the learning objectives will greatly help students acquire basic concepts and initial knowledge, thus later helping students' understanding of more complex concepts. In addition, this PBL-based e-LKPD contains additional information links that can be directly accessed by students on e-LKPD in the form of cases that often occur among students related to body defense system materials that must be worked on with members of their group. The presentation of cases in teaching materials can help students to reactivate initial knowledge and then relate it to new knowledge, to be able to analyze and solve problems (Fadilah et al., 2022; Amar et al., 2021; Dewi, et al., 2021). The assessment is inseparable from the record of improvement, therefore there are several suggestions and inputs from material expert lecturers regarding the presentation of material on PBL-based e-LKPD products as follows: (1) what is written in the narrative is adjusted to the content of the video; (2) there are still some sentences that need to be corrected, e.g. writing "inflammatory" to "inflammatory reaction"; (3) the question in material 1 number 2 which is not related to the image given; (4) question number 3 about covid, it is better if it is associated with vaccinations that are more related to the material of the immune system.

Table 2. Results of e-LKPD Product Feasibility Assessment by Material Experts

Assessment Aspects	Average Score	The Value of Each Aspect	Category
Eligibility of Materials	3,25	81,25	Very Decent
Accuracy of the Material	3,8	95	Very Decent
Disabled	3,83	95,83	Very Decent
Construction	3,55	88,88	Very Decent
Technical	4	100	Very Decent
Average		92,192	Very Decent

Furthermore, the assessment of product feasibility in the media aspect is carried out by expert lecturers in the media field. The feasibility assessment of PBL-based e-LKPD

products by media experts is in a very feasible category in 5 aspects, namely software engineering aspects, ease of operation, application reliability, illustration quality including articles, images, and videos, as well as ease of use, while the other 3 aspects such as visual communication, display quality, and language are in the decent category, but overall the PBL-based e-LKPD quality assessment in terms of media is in the category of very worthy of use in the study of material biology of the body's defense systems with an average value of 85.1 (Table 3). The assessment is inseparable from the record of improvement. Therefore, there are several suggestions and inputs from media expert lecturers regarding the presentation of applications on PBL-based e-LKPD products as follows: (1) the typeface and font size of the application needs to be corrected with a more formal and larger one; (2) the background color should be replaced with a more contrasting one; (3) the basic ideas of LKPD need to be reviewed/strengthened: why LKPD begins with a material review and whether it aligns with the basic framework of PBL. The e-LKPD display is attractive because it combines colors, images, sizes, and font types accordingly. The elements of attractiveness presented create fun and interesting learning (Wahyuni, et al., 2022; Utomo, et al., 2020; Suciati & Adian, 2018). The accuracy of the selection and use of images, videos, and text has an important role in helping to provide an understanding of the material. For this reason, the text used should be able to minimize misconceptions or double understanding, besides that the language used should be adjusted to the intellectual level of students (Widiyanti, et al., 2018; Erna, et al., 2021). In line with this, (Syamsurizal, et al., 2021; Lewar & suhartini, 2023) states that the text of the case and the material presented are arranged using simple and concise sentences so as not to confuse the learner.

Table 3. Results of e-LKPD Product Feasibility Assessment by Media Experts

Assessment Aspects	Average Score	The Value of Each Aspect	Category
Software Engineering	3,6	90	Very Decent
Visual Communication	3	75	Proper
Display Quality	2,8	70	Proper
Language	3	75	Proper
Ease of Operation	3,66	83,3	Very Decent
Application Reliability	4	100	Very Decent
Illustration Quality includes Articles, Images, and Videos	3,5	87,5	Very Decent
Ease of Use	4	100	Very Decent
Average		85,1	Very Decent

The feasibility assessment of PBL-based e-LKPD products by biology teachers is in the category of very feasible in all aspects, both from software aspects, visual communication, material feasibility, material accuracy, didactics, construction, and technical, so that overall the PBL-based e-LKPD quality assessment according to biology teachers is in the category of very feasible to use in learning the biology of body defense system materials with a final average score of 98.24 (Table 4). This is because the material presented is appropriate and the learning objectives to be achieved. In addition, learning materials are associated with examples of cases that are often encountered in everyday life, to provide an overview for students to analyze and discover a concept. This is in line with the research conducted by (Prawita, et al., 2019; Fajarianingtyas & Hidayat, 2020) Students' conceptual knowledge can be built by connecting known information in everyday life with new concepts known during learning.

Table 4. Results of e-LKPD Product Feasibility Assessment by Biology Teachers

Assessment Aspects	Average Score	The Value of Each Aspect	Category
Software Engineering	3,83	95,83	Very Decent
Visual Communication	4	100	Very Decent
Eligibility of Materials	4	100	Very Decent
Accuracy of the Material	3,875	96,875	Very Decent
Disabled	3,8	95	Very Decent
Construction	4	100	Very Decent
Technical	4	100	Very Decent
Average		98,24357	Very Decent

Furthermore, the product feasibility assessment is based on student responses to limited trials. The feasibility assessment of PBL-based e-LKPD products based on student responses is in the very feasible category in all aspects, both from the presentation aspect, linguistic aspects, visual communication aspects, and benefits aspects, so that overall the PBL-based e-LKPD quality assessment based on student responses is in the category of very feasible to use in learning the biology of body defense system materials with a final average score of 96.37 (Table 5). This is because the concepts presented in e-LKPD are clear, easy to understand, and do not cause double interpretation. In addition, the material is arranged systematically so that it makes it easier for students to understand the concept of the material. The presentation of cases at the beginning of learning activities on teaching materials aims to, train students' ability to find solutions using knowledge and information from various sources (Yuningsih, et al., 2022). There are suggestions from students regarding the e-LKPD being developed and most students think the same that the writing and background color should be replaced with a more contrasting one to make it visible.

Table 5. Product Eligibility Assessment Results based on Student Responses

Assessment Aspects	Average Score	The Value of Each Aspect	Category
Serving	3,88	97	Very Decent
Linguistics	3,95	98,75	Very Decent
Visual Communication	3,89	97,25	Very Decent
Benefits	3,7	92,5	Very Decent
Average		96,375	Very Decent

Based on several suggestions and inputs from material expert lecturers, media experts, biology teachers, and students, therefore it is necessary to follow up by revising the e-LKPD according to the suggestions and inputs above. Suggestions and input from experts, teachers, and students can be the basis for improvement to producing products that are appropriate during the implementation process and useful for improving product quality so that the implementation process can run optimally. According to Padmo et al. (2004), good teaching materials, are developed with due regard to the principles that the material is appropriate and appropriate, the scope of the material is adequate, and the material is presented systematically and for instructional, accurate, and up-to-date purposes. According to Bachri, et al. (2021) Learning outcomes improve if students focus during the learning process supported by teaching materials or media that have an attractive appearance. LKPD, which is presented in the form of an android-based application, makes it easier for students to analyze material, helps students to access material, and encourages active participation in students. This is in line with the

statement (Sarrab et al., 2012; Pada et al., 2021), The use of electronic LKPD in learning activities can support students to participate optimally, because learning activities are student-centered or student-centered learning. Shimizu et al. (2019) the use of technology in accessing information can help the effectiveness of problem solving capabilities. The development of e-LKPD equipped with additional information aims to increase knowledge and information on daily problems regarding the body's defense system experienced by students.

Conclusion

PBL-based e-LKPD teaching materials on body defense system materials suitable for use in biology learning for class XI students have met the feasibility aspects based on assessments from material experts, media experts, biology teachers as practitioners, and students.

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