Revolutionary Biology Education: Development of Advanced Biology Learning Through Websites and Learning Kits

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Abstract

Biology education has become essential in developing students' scientific understanding and skills in facing global challenges. Advanced biology learning can be introduced to students as an effort to apply science in everyday life and innovative research. This field of biology has opportunities for promising career paths and jobs in science and technology. However, this learning has yet to be widely introduced regarding innovations in the field of biology in various aspects so that it can deepen students' understanding and competence in solving problems. This research aimed to develop websites and learning kits in advanced biology education. The method used was ASSURE, including analysis of student characteristics, setting performance targets, media development, material exploration, evaluation, and revision. The results obtained in the research, covering the validation analysis of biological material, had met the aspects of depth, feasibility, clarity, suitability for purpose, and use of language. Validation analysis of video-based learning media had fulfilled the aspects of video quality, audio clarity, content suitability, text readability, and context connectedness. The learning platform validation analysis had met user experience, content availability, and visual quality. Recommendations for further research include a validation process by experts and field implementation to determine the effectiveness of learning media.

Keywords: *Biology Education, Advanced Biology, Website, Learning Kit.*

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A. INTRODUCTION

21st-century education refers to the transformation of education to prepare students with skills, knowledge, and understanding relevant to the needs and challenges of society and the world of work in the 21st century (Taar et al., 2023). This education moves beyond theoretical knowledge and focuses on developing 21st-century skills essential for personal and professional success in an ever-changing environment. One of the goals of 21st-century education is to develop students' critical thinking skills in learning so they can solve problems faced in real life (Barta et al., 2022). Students' success in constructing their knowledge comes from more than achieving predetermined learning goals (Jodoi et al., 2021). However, students must be able to apply the knowledge concepts obtained at school to solve problems faced in everyday life in a relevant, meaningful, and contextual manner (Liu & Pásztor, 2022).

Biology is a science that studies living things and their environment (Møgelvang et al., 2023). Learning biology at school requires students to be able to understand, apply, and analyze conceptual and procedural knowledge and apply it

to solve problems (Qin et al., 2022). As the biological industry advances, it has a crucial role in encouraging innovation (Mandikonza, 2022). However, this learning has not been widely introduced regarding innovations in the field of biology in various aspects so that knowledge can be deepened through further study in advanced biology (Kaess et al., 2021). Advanced biology refers to the deeper study of complex and in-depth biological concepts. It involves a deeper understanding of the biological mechanisms and processes underlying life, organisms, ecosystems, and the interactions within them. Advanced biology covers a broader range of disciplines and topics in more depth than a basic understanding of biology.

Technology-based learning websites have changed the educational landscape by allowing more comprehensive access, flexibility, and interactive learning experiences. Websites allow students to learn independently (Gong et al., 2020). Students can tackle the material independently and practice time management and self-discipline skills. The use of interactive websites provides a new dimension in biology learning. This website provides access to various content, from visualizations of complex biological processes to interactive simulations that allow students to explore independently (Kim et al., 2022). Meanwhile, using learning kits brings a physical dimension to the learning process, allowing students to conduct experiments and direct observations that enrich their understanding of complex biological concepts (Borchert et al., 2022).

The existing learning solution is digital-based biology learning, as has been done by Oktavia in 2022, namely the use of information technology as mobile learning in biology learning. Apart from that, it is an information database that shows the increase in digital iterations of biology learning among high school students in Kuala District (Oktavia & Hardinata, 2020). There are still few studies that apply critical thinking in the formation of research in advanced biology, especially in high schools, which is an essential provision in providing an overview of advanced studies in this field (Ligabo et al., 2023).

The introduction of advanced biology as an application of science to society and innovative research needs to be carried out for high school students because they see promising job prospects and career paths in this field of science and technology (Roth et al., 2022). Career opportunities for biology graduates can become professionals or experts such as scientists (researchers), pharmacologists, biotechnologists, biologists, and ecologists (Ouyang et al., 2023).

Apart from that, the flow of research in the field of biology has continued to develop over the last 16 years. Based on Indonesian Institute of Sciences (LIPI) data, it shows that 60 percent of Indonesian and foreign research collaborations are in the field of biology, the scope of which includes ecology (studying the environment in which organisms live), zoology (animals), primatology (primates), and natural resource management (Harst et al., 2022). The potential for advanced biology learning has a bright future for high school students (Chief Moon-Riley et al., 2019). Based on these problems, researchers initiated revolutionary biology education to advance competence and understanding of biology through websites and learning kits.

This research aims to develop websites and learning kits in advanced biology education. Therefore, this development can be an alternative biology learning media that is research-oriented and has knowledge of career paths and insight into further studies in the field of advanced biology. Students improve the challenges of the world of research, industry, and incredibly advanced biology. This research has a role in developing research-based advanced biology that can encourage students to think critically, find ideas, answer the challenges of the times, develop skills, and develop student innovation (Seibert, 2021). This research is fundamental to support improving the quality of expert workers and researchers in the field of advanced biology to be able to compete directly in the industrial world in particular and the creation of appropriate technology based on applied science (Sachsenmeier, 2016).

B. METHOD

This development used the ASSURE model, which was one way to develop learning media that combined the use of technology and learning media and was developed through the selection and use of methods, teaching materials, and the role of students in the learning process (Baharun, 2016). The following is a description of the method used:

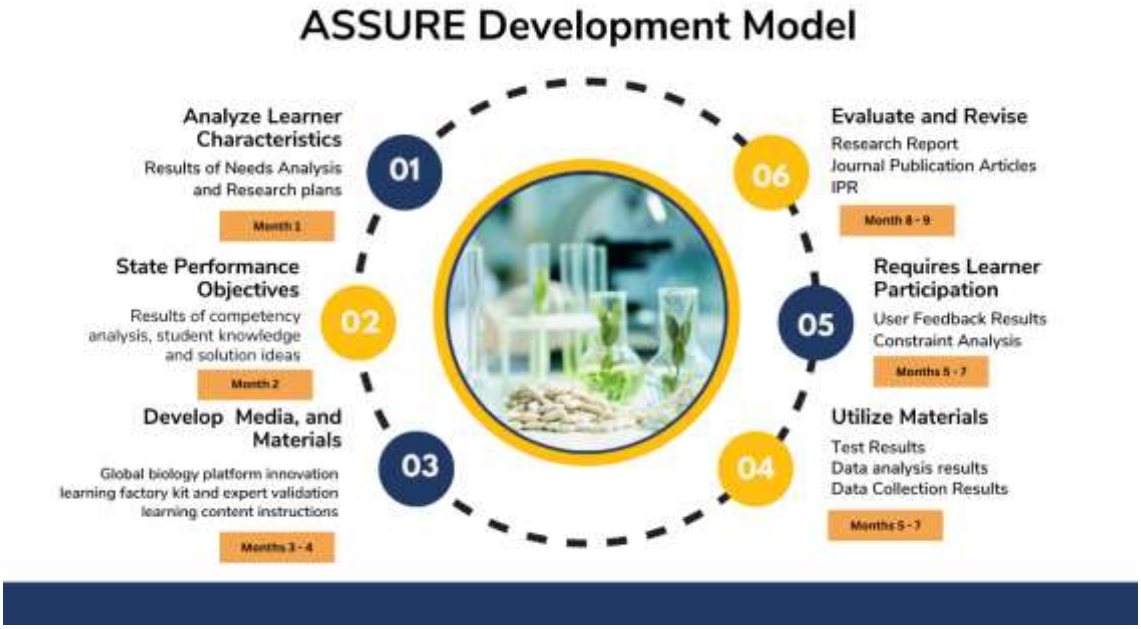

Figure 1. Research Method

1. Analyze Learner Characteristics

The first step in development was analyzing students, and the aim was for teachers to recognize the characteristics of students who would carry out the learning process. Each student had a different character. At this stage, we would obtain the results of an analysis of student needs related to research-based biology learning. A grand research design can be created (Baharun, 2016).

2. State Performance Objectives

In this step, researchers determined objectives following the syllabus or curriculum. This goal described students' competencies, knowledge, skills, and attitudes after the learning process. This goal also led to evaluation and student learning outcomes. At this stage, the solution was formulated, the advanced grand design of the solution was created, and the interface on the device was created. It was expected to produce user flow charts and validate expert designs (Purwanti, 2015).

3. Develop Media and Materials

In this step, researchers developed suitable media and teaching materials for students. This suitability could be seen from the characteristics of the students. The learning media that was used could influence the effectiveness and attractiveness of students in learning. This stage executed media creation and the creation of guidebooks and content so that at the end of this stage, an analysis was produced regarding media criteria that are suitable for use (Purwanti, 2015).

4. Utilize Materials

In this step, researchers would design the use of teaching materials and learning media. Media utilization refers to how educators integrate various learning resources into the learning process. The main goal was to increase the effectiveness and efficiency of learning and activate student involvement in understanding and applying learning concepts. This stage compared learning media developed according to the feasibility criteria that had been determined (Iskandar & F, 2020).

5. Requires Learner Participation

The learning process will be effective, efficient, and attractive when students participate. Suppose students were active in the learning process. In that case, it would make it easier for students to understand the material provided by the teacher and increased student motivation to learn. At this stage, the feedback potential users would give was essential and valuable as a guide to improvement. However, users' needs and desires sometimes vary or contradictory (Iskandar & F, 2020).

6. Evaluate and Revise

After carrying out the learning process, evaluation and revision were carried out. This stage aimed to assess the learning program's effectiveness and efficiency and the achievement of student learning outcomes. In the evaluation to assess the effectiveness of the learning process, namely the answer to whether the learning process achieved the objectives, learning media could help the learning process, and whether students are actively involved in the learning process (Rosmalia Eva, 2015).

C. RESULTS AND DISCUSSION

The preliminary stage began with a literature study and continues with field studies (Zhao, 2021). The literature study was carried out by looking for references regarding innovations in the field of biology in various aspects to deepen knowledge through advanced biology studies for students' future career needs. On the other hand, field studies were carried out by observing biology learning patterns carried out by teachers at school to their students. Field observations were carried out to

explore biology learning materials and media with a critical thinking and problem-solving-oriented approach that can help students improve the challenges of the world of research and industry (Zubaidah, 2019).

Apart from conducting empirical studies on learning media patterns that have been widely developed, researchers also analyzed similar products used by schools. Analysis of biology learning materials and media showed that several institutions and universities had provided direct learning facilities without using learning kits (Kusumaningrum et al., 2022). Integrated learning still needed to introduce advanced biology based on applied science. The following was an analysis of learning patterns, including materials and media that had been carried out:

Figure 2. Existing Product Analysis

Advanced biology learning products are experiencing many developments and are becoming increasingly accurate to learn. One of the learning products is "Cytosis: A Cell Biology Game". In an era where biology-related research and education play an important role, this innovative game has emerged as a transformative tool. By immersing students in an interactive virtual world, it provides complex biology concepts and cultivates their curiosity, critical thinking, and problem-solving abilities. Through "Cytosis," students gain direct exposure to cellular processes and complex mechanisms, cultivating a deep understanding essential for their future studies and research endeavors in biology.

Biology Global Innovation Learning Kit Concept

The innovation in the global innovation learning factory kit contains more in-depth and complex learning material about advanced biology. This innovation also explains its application in relevant biological research. Students will be integrated with a learning platform that can improve their abilities. This innovation collaborated with interactive learning and used the latest technology. The following is an explanation of the global innovation learning factory kit, as follows:

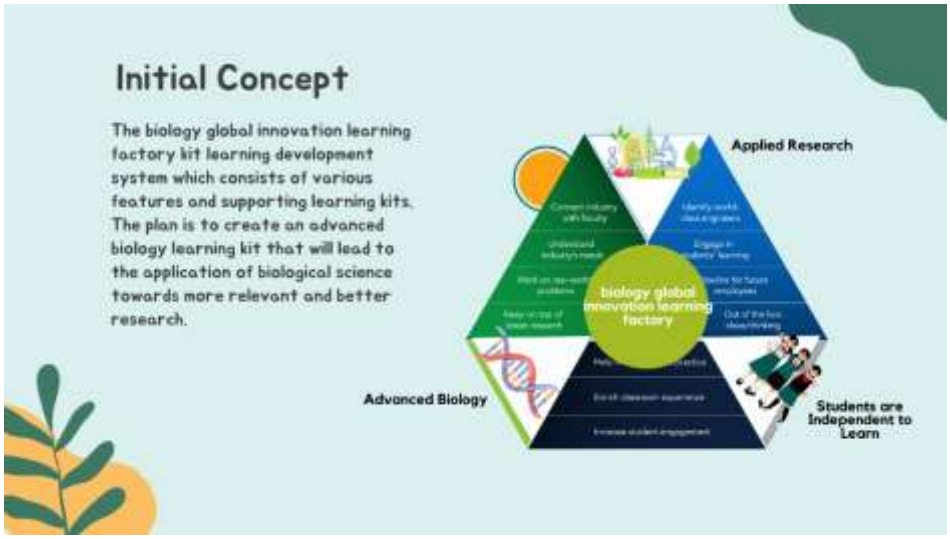

Figure 3. Learning Kit Concept

Developing a game card-based learning kit is a creative approach to bringing interactive and exciting learning into the classroom. Game cards combine game elements with learning concepts, creating a fun environment while promoting deep understanding. The kit consisted of question cards: these cards can contain questions about key concepts, facts, definitions, or application-based questions to understand the application of the concept. Answer cards: These cards contain answers that correspond to the question cards. Game-based learning allows students to test their knowledge directly. Game cards stimulated direct interaction between students, creating an interactive environment and supporting the exchange of ideas. A game-based approach increased students' motivation and interest in learning due to the fun aspect of games. The following learning kit in the form of cards had been developed:

Figure 4. Learning Card

Preparation of Biology Global Innovation Learning Materials and Videos

Researchers develop learning materials and videos based on data collected and supported by supporting theories regarding the biology of global innovation. The material had been adapted to students' needs and was packaged so that it was easy to understand. The following were design materials and learning videos for learning websites:

Design of Learning Materials and Media Related to Molecular Cellular Biology and Genetics

Cellular, molecular biology and genetic material were interrelated materials. Genetic material involved molecular processes in cells and genetic information was expressed and inherited. Material on Molecular Genetics discussed the interaction, reproduction and coordination processes of living cells. Genetic material was concerned with the structure, function and regulation of genes and how to control the genetic properties of organisms. The molecular and cellular material on the learning website used references from Alberts et al., which included sub-material, including cellular biology, molecular biology, genetics, biochemistry, developmental biology, immunology, evolutionary biology, microbiology and virology. Genetic material was taken from the Pierce reference, which contains sub-materials, including genetics and evolutionary biology. Molecular genetics, humans and genomics, genomics and proteomics, bioinformatics and computational biology, epigenetics and gene expression, population genetics, evolutionary developmental biology, biotechnology and genetic engineering, and cancer genetics and genomics. These materials were well organized to make them easier to understand. The following were learning materials and videos about molecular, cellular and genetic biology:

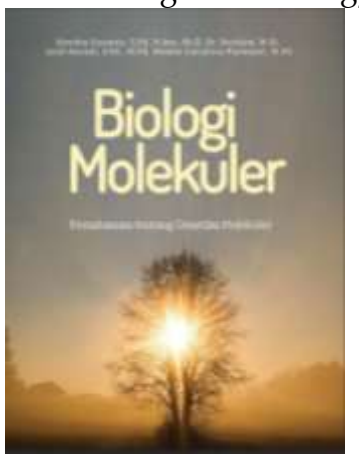

Figure 4. Molecular Cellular Biology and Genetics Learning Materials

The material that had been prepared was made into an interactive learning video to help students understand the learning material. The following was an interactive learning video related to cellular, molecular biology and genetics material:

Figure 5. Molecular Cellular Biology and Genetics Learning Video

Preparation of Learning Materials and Media Related to Ecology and Conservation Biology

Ecology and conservation biology materials had interrelated functions: understanding interactions between organisms and the environment, maintaining diversity and biodiversity, and protecting the habitat of living creatures. Ecology material increased understanding of the interactions of organisms with natural abiotic components such as water, air and soil and shapes ecosystem function. Conservation biology material discussed degraded ecosystems and threats to their environment. Conservation biology showed the importance of sustainable maintenance of biodiversity. Ecology material contains sub-materials, which include basic ecology, organism ecology, population ecology, community ecology, landscape ecology, functional ecology, global ecology, biogeography, and conservation management of Natural Resources. The conservation biology material contained sub-materials, including an introduction to conservation biology, biodiversity, population and community biology, methods for collecting biodiversity data, soil and water conservation, forest conservation, and ethics in conservation. The material was structured well to make it easier to understand. The following were learning materials and videos about conservation ecology and biology:

Figure 6. Ecology and Conservation Biology Learning Materials

The material that had been prepared was made into an interactive learning video to help students understand the learning material. The following shows an interactive learning video related to ecology and conservation biology material:

Figure 7. Ecology and Conservation Biology Learning Video

Design of Learning Materials and Media Related to Protein Biology and Nutritional Biology

Protein and nutrition biology material was knowledge about the process of food that contained protein and nutrients for the body. Protein biology deals with proteins such as enzymes to structural proteins in the framework of cells and body tissues. Protein biology contributed to developing nutritional policies, dietary strategies, and overall health. Protein biology material had sub-materials, which included protein structure and function, protein purification techniques, protein molecular biology, protein interactions, enzymology, proteomics, and proteomic analysis. The sub-material in nutritional biology explained nutrition, human metabolism, nutrition in the life cycle, nutritional status assessment, functional food nutrition, global nutrition and food security, and food security and nutrition. The material was structured well to make it easier to understand. The following were learning materials and videos for protein biology and nutritional biology:

Figure 8. Learning Material for Protein Biology and Nutritional Biology

The material that had been prepared was made into an interactive learning video to help students understand the learning material. The following is an interactive learning video regarding the biology of protein and nutrition.

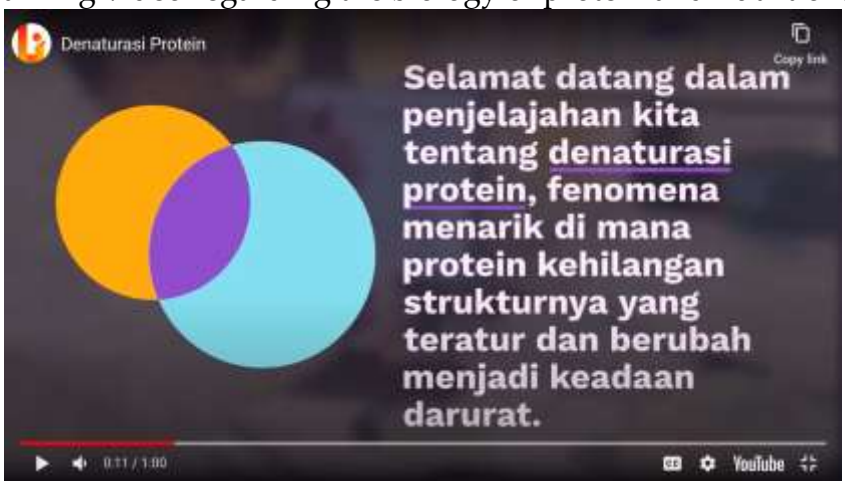

Figure 6. Biology Learning Video on Protein and Biological Nutrition

Biology Global Innovation Website Development

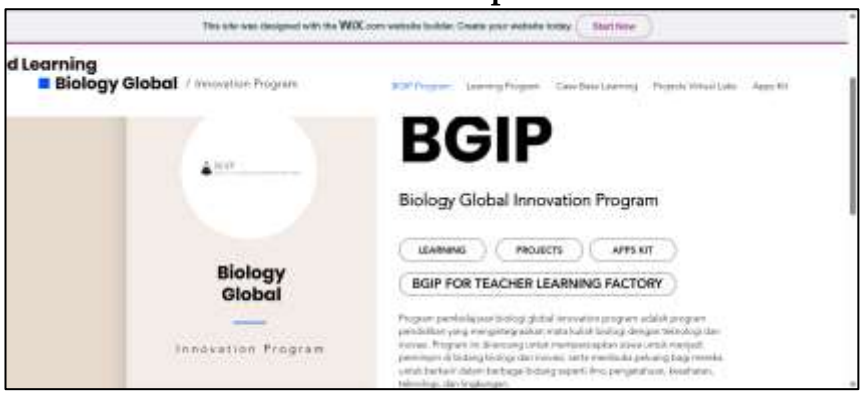

Figure 7. BGIP Program Display

This section contained services that supported the biology learning experience. This comprehensive feature set consisted of several carefully designed menus, each catering to a different educational aspect (Harahap et al., 2020). This display contained several menus: learning videos, learning interface, projects, Apps kit, and BGIP (Biology Games for Interactive Pedagogy). Learning features were emerging as a foundation for seamlessly guiding students through the intricacies of biological concepts and principles (Lopez et al., 2022). Simultaneously, the project feature provided a dedicated platform for students to learn project-based material, a common approach in the field, cultivating a practical understanding of real-world applications (Muslim et al., 2020). Apps kit introduced a dynamic dimension, housing a carefully curated set of specialized learning tools to aid comprehensive understanding. Additionally, the BGIP component provided educators with invaluable resources to enhance understanding and pedagogical techniques. This multifaceted approach caters to students' diverse learning styles and empowers educators to improve their teaching methodologies, collectively fostering a holistic biology learning ecosystem (Serdyukov, 2017).

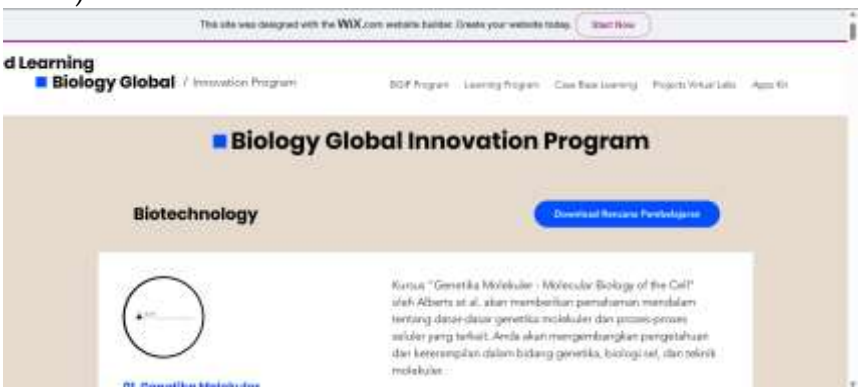

Figure 11. Learning Program Display

Special features on this learning website included a carefully selected selection of study materials specifically tailored to the field of biology, in line with the prepared curriculum. These materials included a variety of sources, including textbooks, articles, interactive simulations, and multimedia presentations, all aimed at enriching the learning experience. In addition, students were given access to downloadable lesson plans to facilitate a comprehensive understanding of the lesson material. This

detailed plan offered a comprehensive overview of the topics to be covered, learning objectives, and suggested teaching methodology (Darling-Hammond et al., 2020).

Figure 12. Display of Case Study-Based Learning

This feature was an essential component of a biology education approach that allows students to study real-world cases that could be easily downloaded for in-depth study. This feature was not just access to cases; interactive discussion elements further enrich the learning experience (Fromm et al., 2021). This mechanism facilitated a thorough review of students' selected answers, allowing them to validate their understanding and refine their insights. After completing these discussions, students received insightful feedback, increasing their understanding of the course material and encouraging a more immersive learning journey (Seo et al., 2021).

Feasibility Analysis of Learning Media That Has Been Developed

The existing learning website had shown that its compatibility could run well through feasibility analysis of advanced biology material, comprehensive learning media analysis, and analysis of attractive learning platform services. This evaluation effectively showcases the ability of learning media to integrate various materials seamlessly, ensuring optimal performance in innovative processes (Kamińska et al., 2019). Additionally, media validation tests confirmed its proficiency in conveying information and insights through diverse communication channels, enhancing the learning experience. Additionally, successful platform validation analysis underscored the website's ability to utilize advanced technology, strengthening its position as a leading learning medium for global innovation and learning (Mathieu, 2023). The feasibility of learning media in the form of websites and kits was seen from material, media and technology (platform).

Analysis of the feasibility of biology material was essential in ensuring that the material presented to students met the desired learning standards. A suitable material feasibility analysis could fulfill the aspects of appropriateness, depth, clarity, suitability for purpose, and use of language. The feasibility analysis should have ensured that the biological material presented had sufficient depth. Biological material means the content must cover relevant and essential concepts in the field of biology, from the basic to the complex. The material must meet academic standards and be in-depth, according to the educational level aimed at (Rosen & Kishawy, 2012). Content appropriateness was related to the relevance and topicality of the material.

Biological materials should reflect the latest scientific developments and consider their practical applications in the real world. Material that needs to be updated or relevant to learning objectives will reduce the quality of learning (Daryanes et al., 2023). Biological material should be presented in a clear and structured way. Users should easily understand the sequence of concepts and information presented. Appropriate use of subheadings, essential points, and illustrations can help increase the clarity of the material (Darling-Hammond et al., 2020). The feasibility analysis must ensure that the biology material is appropriate to the learning objectives. Each material component must support the achievement of learning objectives and direct students to achieve the desired understanding (Muslim et al., 2020). The language used in biology material must be by students' understanding at the intended educational level. Language should be clear, understandable, and free from confusion or ambiguity. Scientific terms must be well explained or accompanied by a relevant glossary (Nowell et al., 2017).

Analysis of the feasibility of media in the form of learning videos is an essential step in ensuring that the videos effectively convey educational messages. Implementing media appropriateness values can yield invaluable benefits that significantly improve its operational capabilities. A good media suitability analysis can fulfill several aspects: video quality, audio clarity, content suitability, text readability, and context connectivity (Firdaus et al., 2023). Learning videos must have good visual quality. Learning videos include proper resolution, the use of colors that are comfortable for the eye, and clear visualization of the concepts presented. Videos that could be better in quality can interfere with student understanding and reduce the attractiveness of learning (Hunn, 2023). The audio in the video should be clear and easy to hear. The sound should be free from noise or distortion that could interfere with understanding. If there is a narrator, the intonation and speed of speech must be easy to understand (Liao, 2023). Learning videos must be by the learning objectives that have been set. Content must be relevant, accurate and in-depth. Videos must include information relevant to the discussed topic and the applicable curriculum (Ingram et al., 2022). The text should be easy to read if the video uses text (for example, as a title, notes, or additional explanation). The size, type, colour, and contrast must be chosen so that students can read the text comfortably and without difficulty (Fromm et al., 2021). Learning videos must have a clear and organized storyline or structure. Each section must be connected so that students can follow the development of the material well (Seo et al., 2021).

Technology validation analysis for learning websites was an in-depth evaluation process to ensure optimal user experience. Comprehensive validation analysis, learning websites can be designed and developed to provide an optimal experience to users, ensure easy access to relevant content, and provide supporting visual quality learning (Nowell et al., 2017). A good media feasibility analysis can fulfill several aspects, namely user experience, content availability, and visual quality. Users should be able to easily navigate the site with a logical layout and easy-to-understand menus. Straightforward navigation helps users find content quickly

(Coman et al., 2020). All content must be accurate and well-verified. Inaccurate information can harm the learning experience and create false understanding. Content must be relevant to the set learning objectives. Each material must support the achievement of student learning goals (Zhao, 2021). The website design must be attractive and appropriate to the content presented but not distract from the learning focus. The use of colour and design elements must support the learning objectives. If any graphics, images, or videos are used, ensure the visualization is clear and helps explain the content (Lopez et al., 2022).

D. CONCLUSION

The website and learning kit had been completed. The innovation in the global innovation learning factory kit contained more in-depth and complex learning material about advanced biology. The Biology Global Innovation Program learning website consisted of displays, namely learning videos, learning interfaces, projects, app kits, case studies, and case study discussions. The results obtained in the research, namely the validation analysis of biological material, have met the aspects of depth, feasibility, clarity, suitability for purpose, and use of language. Validation analysis of video-based learning media had fulfilled the aspects of video quality, audio clarity, content suitability, text readability, and context connectedness. The learning platform validation analysis had met user experience, content availability, and visual quality.

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