

META-ANALYSIS: DEVELOPMENT OF TEACHING MATERIALS AND LEARNING MEDIA ON MOLECULAR GENETICS MATERIALS IN SMA

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ABSTRACT

Molecular genetics material is considered difficult and abstract, so it often causes misconceptions in understanding the material. The use of effective teaching materials and learning media can support learning on molecular genetics material. This study aims to determine the effectiveness of using teaching materials and learning media to improve students' understanding of molecular genetics material in high school. This research uses a qualitative descriptive approach with the systematic literature review (SLR) method. Data sources were obtained through a literature review by reviewing various publications from previous journals obtained from Google Scholar and Publish or Perish 8 which are accredited at least sinta 4. The results show that teaching materials in the form of E-LKPD are more effective to use, as seen from the higher average results of validation and feasibility testing, namely 4.19 and 96.85%. Learning media that is more effective to use is interactive multimedia in the form of educational games. This can be seen from the higher pretest and posttest results compared to other media, namely the pretest results of 9.7% and post-test results of 93.5%. The pretest and posttest results received an increase of 83.8%. The use of effective and interesting teaching materials and learning media can improve the understanding of molecular genetics material in high school.

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Introduction

Education is a basic need that is essential and must be fulfilled to undergo the process of life. Quality human resources are produced through the level of education, so the level of education in a country has a significant impact on the progress and development of a nation. One aspect of life that will change as a result of the Industrial Revolution 4.0 is in the field of

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education which requires an increase in superior and quality human resources by considering the balance between information and ability to be able to compete and contribute to the world (Astuti & Asikin, 2019). Humans strive to develop themselves through education so that they can adapt to any changes caused by advances in science and technology.

Education plays an important role in shaping students' ability to adapt to their environment, as well as inspiring changes that are beneficial to society. Through education, students can gain new knowledge and develop the talents and skills they already have. This success is achieved through an effective learning process, which is a series of interactions and communication between teachers and students in an environment that supports educational goals (Ernawati et al., 2017). In school, a structured learning process allows students to experience targeted and significant changes, not only in terms of knowledge and skills, but also in their attitudes.

Forms and efforts to improve the quality of learning in schools can be done by making maximum use of teaching materials and learning media. Teaching materials are a collection of materials and information designed in a structured manner, integrating various tools and resources for learning, with the aim of making the learning process more interesting and effective. This material has been prepared to help students and teachers in the learning process, ensuring that learning takes place optimally

The use of media in the teaching and learning process is no less important than the teaching material itself. This media plays a role in enlivening the learning atmosphere, thereby making students more involved and enjoying the learning process. With media, the information presented becomes more concrete and easier to understand than just using words. The use of learning media in biology learning that is more interesting and varied is expected to increase students' understanding, especially in molecular genetics material.

One of the materials in biology learning in high school is genetics. Most students still consider genetics material to be difficult, abstract and scary, so that students' mastery of genetics material in general is very poor because it cannot be seen directly so it can make it difficult for students to understand it. Because the level of complexity of the material often causes misconceptions, it can increase students' difficulties in understanding and connecting genetic concepts in everyday life (Jannah, 2023). This is in accordance with (Rz et al., 2022) that one of the materials contained in genetics learning is the structure of DNA which is an important material to study but often experiences misconceptions in understanding the material. This can cause students' motivation to learn about genetic material to be less and have an impact on student learning outcomes.

Based on this description, steps have been taken to carry out a meta-analysis of the process of developing teaching materials and learning media on molecular genetics material in high school. The aim of this research is to measure how effective the use of teaching materials and learning media is in strengthening students' understanding of molecular genetics material in high school.

Method

In this research, the approach used is descriptive qualitative with the systematic literature review (SLR) method to identify, review, evaluate and interpret various relevant and published research (Triandini et al., 2019). The data source was obtained through a literature review by examining various publications from previous journals obtained from Google Scholar and Publish or Perish 8 which have been accredited with a minimum of SINTA 4. Based on the results of the search for data sources, 10 related journals were found that were relevant to the keywords teaching materials, learning media, molecular genetics, genetic

engineering and DNA. Furthermore, the results of these findings were analyzed descriptively qualitatively to determine the effectiveness and influence of the development of teaching materials and learning media used in biology learning on molecular genetics material in high school. The data was then analyzed using a thematic analysis approach through three stages, namely reduction, organization and interpretation.

Results

Based on a meta-analysis conducted on 10 journals regarding the development of teaching materials and learning media for molecular genetics material in high schools, the results obtained are presented in the following table.

Table 1. Results of Literature Review on the Effectiveness of Using Teaching Materials and Learning Media for Molecular Genetics Material in High School.

Journal Code	Author	Journal Title	Effectiveness
1	(Ernawati et al., 2017)	Development of Student Worksheets Based on Multiple Intelligences on the Subject Genetic Substance Class XII Science SMA Negeri 16 Makassar	LKS validation results 3.22. Worksheets are worth using.
2	(Bimantari et al., 2014)	Development of Student Activity Sheets (LKS) Based on Basic Process Skills in Class XII DNA Extraction Material	LKS Eligibility Results 94.67% Worksheets are very suitable to use
3	(Zulfiana & Indana, 2022)	Development of E-LKPD Based on Kwl (Know-Want-Learned) Genetic Substance Material to Train Students' Science Literacy Skills	E-LKPD validation result 3.94 Test results 97.2% E-LKPD is suitable for use
4	(Irawan et al., 2023)	Development of E-LKPD Based on a Scientific Approach to the Principles Discussion of Genetic Material for Class XII SMA/MA	Hasil validasi 4.45 Hasil uji coba 96,5%
5	(Bimantara et al., 2020)	Introduction of Cloning Technology Through Interactive Learning Media "Lakon" for High School Students in Yogyakarta City	Pre-test results (45.86%) Post-test results (85.71%)

6	(Riani et al., 2015)	Development of Interactive Multimedia-Based Educational Media to Enhance Students' Understanding of Modern Biotechnology in Grade XII SMA	Pretest results (54,03%) Post-test results (92,36%)
7	(Wibowo & Ramadhani, 2021)	Improve Your Knowledge of Genetics with the Help of This Exciting Educational Game in Biology	Pretest results (9.7%) Post-test results (93.5%)
8	(Wijayanti & Trimulyono, 2019)	Development of Flipbook Based on Multiple Intelligence in Material Genetic Substances to Train Critical Thinking Skills for Class XII High School Students	Hasil pretest (25%) Hasil post-test (82,5%)
9	(Anantyartha & Sholihah, 2020)	Development of Learning Multimedia on Biotechnology Material Using the Autoplay Program	Material validation results 90.62% (very good) The media validation result was 94.4% (very good).
10	(Suryanda et al., 2020)	Development of Inquiry-Based Interactive Multimedia for Virtual Practicum on Biotechnology Material in High School	Material validation results 91.2% (very good) The media validation result was 80% (very good). The trial results in the small group were 78% (very good) Trial results in the large group 82.2% (very good)

Based on the findings of the literature review of 10 relevant journals in table 1, the results of the research analysis carried out can be grouped in table 2 below.

Table 2. Analysis of development research carried out

Development Undertaken	Journal Code	Development Results
Development of teaching materials	1 and 2	LKS
	3 and 4	E-LKPD
Learning Media Development	5	Puzzle-based interactive multimedia
	6	Interactive multimedia based on e-learning
	7	Interactive multimedia based on educational games
	8	Flipbook
	9	Multimedia Autoplay

10	Inquiry-based interactive multimedia for virtual practicum
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Based on the results of the analysis in table 2, 4 journals develop teaching materials and 6 journals discuss the development of learning media.

Discussion

Results of analysis of 10 relevant journals, 4 of which are related to the development of teaching materials. Teaching materials are a collection of information and learning materials that have been designed using a structured method by combining various learning tools and resources with the aim of making learning activities more interesting and effective (Magdalena et al., 2023). According to Anharudin & Prastowo (2023), teaching materials refer to various types of materials used by educators as tools in the learning process, which include materials in written and non-written form.

Table 1 shows the results of the analysis which indicate that the average validation results for developing teaching materials in journals 1, 3 and 4 is 3.87. The average test feasibility results in journals 2,3 and 4 were 93.07%. These results show that the development of teaching materials in the form of LKS and E-LKPD is very feasible and effective for use in learning molecular genetics material. E-LKPD is more effective to use than LKS. This can be seen from the average E-LKPD validation results in journals 3 and 4, namely 4.19 and the average feasibility test result is 96.85%. Meanwhile, the average LKS validation result in journals 1 and 2 is 3.22 and the average feasibility test result is 94.67%.

Electronic Student Worksheets (E-LKPD) are teaching materials designed to take advantage of current technological advances. With E-LKPD, it provides additional alternatives that can enrich learning materials and support the educational process (Irawan et al., 2023). Apart from LKPD, Student Worksheets (LKS) which are designed in an interesting and structured way can support students in increasing their active learning, both when studying alone or in groups (Barlenti et al., 2017). According to (Ernawati et al., 2017) that LKS are designed to support students in understanding the material provided and presenting the material in an interesting way so that it is hoped that it can increase effectiveness in learning. In addition, LKS provides various assignments aimed at developing students' independent learning abilities, especially on abstract molecular genetics material including microscopic objects and processes that students or teachers may not directly experience (Bimantara et al., 2020)

LKS and E-LKPD are teaching materials that play an important role in the process of teaching and learning activities. It is hoped that the use of E-LKPD teaching materials can provide alternative choices that enrich the learning process of the 2013 curriculum and the independent curriculum, especially for biology material (istikharah & Simatupang, 2017). According to (Syafe'i & Efendi (2020) the aim of using teaching materials in the form of E-LKPD is to provide students with understanding in discovering and strengthening concepts in biology learning. The use of E-LKPD not only functions as a learning aid, but is also effective in honing literacy skills scientific (Zulfiana & Indana, 2022).

Apart from using teaching materials, the use of learning media also really supports the learning process. Based on the results of a literature review of 6 relevant journals regarding the development of learning media in table 2, it is known that the average results of students' pretest scores in journals 5, 6, 7 and 8 are 33.64% and the average results of students' posttest scores in journals 5, 6,7 and 8, namely 88.51%. These results show an increase in the average pretest score to posttest score of 54.87%. The average result of material validation in journals 9 and 10

is 92.51%. These results indicate that the learning media applied is appropriate and effective when used for the topic of molecular genetics at the high school level.

Learning media is an instrument or means that functions as an intermediary in the learning process, facilitating interaction between teachers and students and being effective in delivering lesson material to students (Buulolo, 2024). Based on the results of the analysis of 6 relevant journals, the results obtained were the use of learning media in the form of puzzle-based interactive multimedia, e-learning, educational games, flipbooks and autoplay multimedia and inquiry-based interactive multimedia for virtual practicum. More effective media to use is interactive multimedia in the form of educational games. This can be seen from the pretest and posttest results which are higher compared to other media, namely pretest results of 9.7% and post-test results of 93.5%. The pretest and posttest results received an increase of 83.8%. Implementing educational games as a teaching aid for genetics material in high school can be an interesting alternative method for students. With this approach, students get the opportunity to explore genetics concepts through interactive and entertaining experiences, which have the potential to strengthen their understanding and contribute to improving their learning outcomes (Wibowo & Ramadhani, 2021)

Interactive multimedia is a combined media that integrates elements such as text, graphics, images, photos, audio, video and animation in one platform that interact with each other (Safira et al., 2024). The use of Interactive Multimedia is often considered a more efficient method for increasing students' desire to learn, which in turn creates a learning atmosphere where students can more easily acquire the necessary knowledge, skills and attitudes (Gusasi & Ratu, 2024). According to Sari & Utomo (2024), the application of interactive multimedia in the form of puzzles makes it easier to understand the material presented, is fun to use and really attracts students' attention. E-learning is a learning method that utilizes web or internet technology, allowing access to educational material from any location (Mukhibah & Widiensyah, 2024).

According to (Ariyani et al., 2024), e-learning has a positive and significant effect on student learning motivation. According to Hidayatullah et al., (2024) Flipbook is an application consisting of Hyperlinks, Images, Videos, Audio which has several pages and can be flipped back and forth like a real book. The use of learning media in the form of flipbooks has been proven to improve science learning outcomes. Apart from that, flipbook media is an effective tool for developing critical analysis and evaluation skills in class XII high school students (Wijayanti & Trimulyono, 2019). Multimedia Autoplay is an application for creating multimedia by integrating various types of media, such as images, sound, video, text and flash which can accommodate various forms of learning material (Anantyarta & Sholihah, 2020). Interactive multimedia that uses inquiry methods can produce more concrete visualizations related to genetic engineering processes, including nuclear cloning and gene cloning via recombinant DNA technology. This allows teachers to organize practicums that are close to real experiences in the laboratory (Suryanda et al., 2020).

The era of industrial revolution 4.0 in the education sector experienced a transformation using information technology as teaching materials and media in learning (Anantyarta & Sholihah, 2020). Improving the quality of education can be done by choosing appropriate, appropriate and independent teaching materials in accordance with curriculum demands and technological advances (Patekur, 2023). The curriculum currently implemented is the independent curriculum. The concept of an independent curriculum is to develop students' independence during learning activities. To be successful in adopting the Independent Curriculum, an effective teaching module is needed (Ali & Syamsurizal, 2024). The Teaching Module in the Merdeka Curriculum contains identity, basic competencies, Pancasila Student

Profile, supporting facilities and infrastructure, learning objectives for students, learning models, in-depth understanding, questions that stimulate thinking, learning activities, learning evaluation, development and improvement programs, reflection students and teachers, LKPD, reading materials, glossary, bibliography (Safitri & Raharjo, 2024). Learning innovations that are developing and digital-based to support learning in the era of revolution 4.0 can be in the form of E-Modules (Wulandari et al., 2024) and E-LKPD which contain learning materials, relevant questions, as well as work instructions and can be accessed via devices. electronics (Jannah et al., 2023).

Using interactive learning media is an innovative initiative that is suitable for the industrial revolution 4.0 era, because this media is effective in honing the skills needed to face the challenges of the 21st century (Hidayatullah et al., 2024). Interactive learning media provides many benefits for students in expanding their knowledge, which is then developed to be able to overcome concrete problems. Thus, interactive learning media has the potential to be a solution to learning challenges in this digital era (Apriani et al., 2024). According to (Hutagaol et al., 2022) that media that is attractive to students is media that is not monotonous and has an attractive appearance. The use of effective learning media in teaching and learning activities plays an important role in generating students' desire and enthusiasm for learning (Nengsih et al., 2021). Ariyani et al., (2024) also emphasized that the attractiveness of the chosen learning media is directly proportional to the increase in learning motivation experienced by students.

Conclusion

Based on the results of the literature review, the development of teaching materials in the form of E-LKPD is more effective to use. Interactive multimedia learning media in the form of educational games are the most effective for use in learning molecular genetics in high school. The application of effective and educative learning methods and media can increase high school students' understanding of molecular genetics material.

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