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Development of Plant Bioplastic Learning Media Equipped with QR Codes to Improve Students' Understanding of Biodiversity Material

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Abstract

In the Merdeka Curriculum, students are required to explore knowledge and skills from their own experiences. So far, teachers have been using picture, video, and PowerPoint media. Students' understanding of biodiversity is lacking because they do not have direct experience in classifying plants. Therefore, it is necessary to develop plant bioplastic media equipped with QR codes as an effort to improve students' understanding. The purpose of this research is to analyze the validity, practicality, and effectiveness of plant bioplastic learning media equipped with QR codes. This research uses the Research and Development (R&D) method with the ADDIE model (Analyze, Design, Development, Implementation, Evaluation). The research was conducted at SMA N 1 Bawang in the Academic Year 2023/2024. The research design used during the implementation phase was the Non-Equivalent Pretest Posttest Control Group Design. The validity of the media and materials was determined using validation questionnaires. The practicality of the media was determined based on teacher and student response questionnaires. The effectiveness of the media was determined based on student test results and student worksheets. Validity and practicality were analyzed descriptively, while effectiveness was analyzed quantitatively. The results of the validator assessment stated that the plant bioplastic media was highly valid. Teachers found the media to be very practical, and all students rated the media as practical or very practical. The Mann-Whitney test revealed that the learning outcomes of the experimental class were significantly higher than those of the control class. The number of students with medium and high N-gain in the experimental class was greater than that in the control class, namely 59% > 39%. Plant bioplastic media equipped with QR codes is valid, practical, and effective in improving students' understanding of biodiversity.

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INTRODUCTION

The development of the curriculum aligns with the advancement of science and technology (IPTEK), as fundamentally, a supportive factor for the success of education is a curriculum that relates to modernization (Subandrio & Kartiko, 2021). The demands of the times drive educational institutions to continually adapt to the curriculum. The existence of the Merdeka Curriculum can accelerate the pace of modernization and the development of science and technology in learning (Industri, 2020). Technology is used in the field of education as a supporting tool for learning, both as an informational tool or as a learning tool (Mulyani & Haliza, 2021). Learning media is one of the essential components to support learning (Ariyanto et al., 2018). The use of learning media contributes significantly to the effectiveness of the learning process, message delivery, and lesson content. In addition to stimulating students' motivation and interest, learning media can help students improve understanding and facilitate information interpretation (Junaidi, 2019). The utilization of technology in learning media can enhance students' motivation to learn and develop their existing abilities. Students' abilities will grow if teachers can design challenging learning experiences that encourage students to play an active role (Sibagariang et al., 2021).

As facilitators, teachers facilitate students with facilities and infrastructure that support the achievement of learning objectives. Students play an active role in seeking knowledge or their own experiences through media, techniques, and learning methods provided by teachers (Rahmawati & Suryadi, 2019). Teachers must be able to manage learning effectively using available technology to improve the quality of education (Pendi, 2020). Current learning is centered on students or student-centered, involving students' activity in discovering and exploring understanding of a subject matter (Herawati & Muhtadi, 2018). There is a tendency for biology teachers to teach in a textual, verbal, and knowledge transfer manner. This indicates that teachers may not fully understand the appropriate way to teach biology according to the characteristics of the material. If teachers are required to teach abstract material concepts, the use of learning media can be a solution to make it easier for students to understand. In fact, the use of learning media in biology subjects is still relatively low (Sudarisman, 2015).

Based on the results of interviews with biology teachers at SMA N 1 Bawang, it is known that students' understanding of plant classification concepts is not strong. Students face challenges in categorizing plants according to their classifications, thus the learning objectives have not been maximally achieved. The learning objective in question is students' ability in grouping biodiversity based on natural classification. This can happen due to the trimming of material in the Merdeka Curriculum. Teachers encounter difficulties in facilitating students to identify various plants directly in the environment because the required learning process takes longer than the allocated time.

The learning process can utilize engaging learning media that actively involve students without leaving the classroom. Students require media with criteria that include concise and succinct explanations accompanied by clear visualizations for easy understanding. The use of bioplastic can create durable, safe, non-fragile, transparent, and reusable media (Suryana & Putra, 2019). The media that can be developed include parts of a plant preserved with bioplastic so they can be directly observed and reused in each class. Technology utilization is applied to the QR code scan embedded in the media. The QR code contains narration related to the explanation of a preserved plant part. The advantage of using QR codes lies in cost-effectiveness, the amount of information obtained, and the speed of accessing information (Firmansyah & Hariyanto, 2019). Preserved plant parts include roots, stems, leaves, and flowers from 2 examples of Magnoliopsida and Liliopsida plants. The noticeable differences can be observed directly, allowing students to independently grasp the material. Therefore, it is necessary to develop plant bioplastic media equipped with QR codes as an effort to enhance students' understanding.

RESEARCH METHOD

The type of research used is Research and Development (R&D) with the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). The research was conducted at SMA N 1 Bawang in the first semester of the academic year 2023/2024. The population of this study is all students in class X at SMA N 1 Bawang. The sampling technique used is Purposive Sampling. The samples used are 2 classes, namely classes X5 and X6, based on considerations of similarity in material, the teacher who teaches the class, and equivalent class average grades. The data in this research include the validity, practicality, and effectiveness of plant bioplastic media equipped with QR codes. Validity and practicality are analyzed descriptively. Effectiveness is analyzed quantitatively with the help of SPSS. Plant bioplastic learning media equipped with QR codes is considered valid if the assessment results from both validators fall into the valid/very valid category. The practicality of the bioplastic media is measured by the results of managing questionnaires from teachers and students. The media is considered practical if teachers and students rate the media as practical/very practical. It is effective if, in the data processing, the n-gain of the experimental class is higher than the n-gain of the control class and the effectiveness value is > 1.

RESULTS AND DISCUSSION

The development of plant bioplastic media equipped with QR codes is carried out through five stages: analysis, design, development, implementation, and evaluation. The purpose of this research is to analyze the validity, practicality, and effectiveness of plant bioplastic media equipped with QR codes.

The validity of plant bioplastic media equipped with QR codes

Based on the validity assessment results, both validators gave a score of "Very Valid" to the media. The assessment of both validators on plant bioplastic media equipped with QR codes is presented in Table 4.1.

Table 4.1 Assessment of both validators on plant bioplastic media equipped with QR codes

No.	Validator	Total Score	Score (%)	Criteria
1.	Validator 1	44	97,8	Very Valid
2.	Validator 2	42	93,3	Very Valid
Test Decision				**Valid for use after revision**

Based on Table 4.1, it is known that the media is highly valid with percentages of 97.8% and 93.3%. This means that the media is valid and can be used to improve students' understanding. Both validators agree that the learning media has been created in accordance with the learning objectives. Plant bioplastic media equipped with QR codes can help students identify and describe plant classifications based on observed characteristics. Additionally, students are provided with real experiences through direct observation and can present their findings in the form of reports. This is consistent with Dale's opinion that 75% of a person's learning experience is gained through visual perception. Setiawan et al. (2014) stated that the use of preserved specimens and plant worksheets can help students classify plants based on similarities and differences in characteristics.

Both validators agree that the specimens can be clearly observed in terms of shape and color. This is because the media uses bioplastic, making it transparent and allowing the specimens to be seen clearly. Additionally, the media is safe to use as it does not contain formalin, which is carcinogenic, and it is easy to

store. This is consistent with the research by Khasanah et al. (2015), which found that bioplastic media, compared to wet preservation, has advantages such as being easier to observe specimen structures, safe to use, and can be stored for a long time.

The linguistic aspects were assessed differently by the two validators. On the indicator of grammar usage, validator 1 stated that the grammar in the material presented in the QR code is correct. Validator 2 opined that the grammar in the material presented in the QR code is not correct. There are writings that do not adhere to the rules of scientific plant nomenclature, particularly concerning the scientific name of the rose plant. According to the research by Anggraini et al. (2018), good media provides clear presentations, especially in language usage, making it easier for students to understand the intended meaning of the material.

Validator 1 suggests that the moss preserved with bioplastic in the spore part is not clear enough and thus requires the addition of images. The added images are original photos provided by validator 1. Original photos provide a realistic depiction to students and are more suitable for the purpose. The addition of images in the QR code content clarifies the moss spore part. The added images help convey the learning material to students. This aligns with Hasan et al.'s (2021) assertion that photos have concrete properties and are more realistic, thus capable of clarifying a material. Images of spores and young rolled leaves are also added to the bioplastic fern media. The reason being that these parts in the media are too small to be clearly observed. Images should represent how an object appears. According to Anggraini et al. (2018), visuals (images) play a crucial role in the learning process by facilitating understanding and strengthening memory.

Practicality of plant bioplastic media equipped with QR codes

Based on the analysis of questionnaire responses from biology teachers of classes X5 and X6, the practicality score of plant bioplastic media is 96% with the criteria "Very Practical". Regarding language aspects, media completeness, and ease of use of plant bioplastic media, teachers gave maximum scores for each statement. Teachers strongly agree that the language used in the material (QR code) is in accordance with grammatical rules and easily understood by students. This is consistent with Sukirman's research (2020), which suggests that to effectively convey intended meanings, writing materials require the use of appropriate language and punctuation. Teachers believe that plant media equipped with QR codes greatly aids students' understanding of classification. Students can easily classify plants based on observable characteristics. The differences and similarities in plant characteristics are observed well, enabling students to better understand plant classification groups. Khasanah (2015) found that the use of bioplastic media has positive impacts, increasing students' interest and facilitating material understanding. Teachers suggest providing each group with a set of bioplastic media or increasing the quantity and variety to facilitate the learning process. This addition allows students to receive more information and understand concepts better.

The analysis results of practicality show that all students rated it as practical (33%) and very practical (67%). Therefore, plant bioplastic media equipped with QR codes is practical for use in enhancing students' understanding of biodiversity material. Students' responses to the practicality of plant bioplastic media equipped with QR codes in each aspect are presented in Table 4.2.

Table 4.2 Students' Responses to the Practicality of Plant Bioplastic Media Equipped with QR Codes in Each Aspect

No.	Aspect	Score (%)	Criteria
1.	Relevance of content	85	Very relevant
2.	Media quality	83	Very high quality
3.	Language	83	Very appropriate
4.	Media completeness	80	Complete
5.	Ease of media	81	Very easy to use
6.	Media function	86	Very enchancing students' understanding

Based on Table 4.2, it is known that the quality of plant bioplastic media equipped with QR codes has a percentage score of 83% with the criteria of very high quality. All students stated that all parts of the roots, stems, leaves, and flowers can be clearly observed from all sides. Plant bioplastic can be arranged so that the morphological differences of the monocotyledons and dicotyledons groups can be seen. The roots of rose and rice plants can be directly compared so that students understand the structure and shape of the roots of both groups. During the observation process of plant bioplastics, students were able to distinguish the characteristics of monocotyledon and dicotyledon plants. This is because plant bioplastic media can display differences in root systems, leaf veins, and flower ornaments. The clarity of the media is also supported by students' opinions that the bioplastic media has good clarity and minimal bubbles. This is consistent with the research by Handoko et al. (2016) that clear and supportive visuals can help explain the meaning of learning materials in the conceptual understanding obtained by students.

Effectiveness of plant bioplastic media equipped with QR codes

The effectiveness of plant bioplastic media equipped with QR codes is analyzed based on pretest and posttest scores using hypothesis testing and N-gain analysis. To provide an overview of the data distribution, descriptive analysis of the research sample was conducted. Based on the results of descriptive analysis, it is known that the average pretest scores of the experimental class and the control class have a gap that is not significantly different, 27.25 < 27.67. Descriptive analysis of pretest and posttest scores in the experimental and control classes are presented in Table 4.3.

Table 4.3 Descriptive Analysis of Pretest and Posttest Scores in the Experimental and Control Classes

No.	Data	Experimental Class (X6)		Control Class (X5)	
		Pretest	*Posttest*	*Pretest*	*Posttest*
1.	Minimum Score	7	20	7	7
2.	Maximum Score	67	100	60	100
3.	Mean	27,25	58,50	27,67	45,89
4.	Median	27	53	27	40
5.	Modus	27	53	33	33

Based on Table 4.3, it is known that the average posttest scores in the experimental class are higher than those in the control class. This is because the experimental class used plant bioplastic media equipped with QR codes in their learning process. Hypothesis testing was conducted after conducting prerequisite tests,

such as normality and homogeneity tests. The results of the normality and homogeneity tests also indicate that the pretest and final scores of the students are not normally and homogeneously distributed. In this condition, to analyze the difference between the control and experimental classes, the non-parametric Mann-Whitney test is used.

Based on the results of the non-parametric Mann-Whitney test, the significance value Asymp. Sig. (2-tailed) is 0.026 < 0.05. This indicates that there is a significant difference in student understanding between the experimental and control classes in this study. Thus, the use of plant bioplastic media equipped with QR codes is capable of enhancing student understanding.

The N-Gain test is needed to determine the improvement in students' knowledge after receiving treatment in the form of using plant bioplastic media equipped with QR codes in learning. The comparison of N-Gain between the experimental and control classes is presented in Figure 4.1.

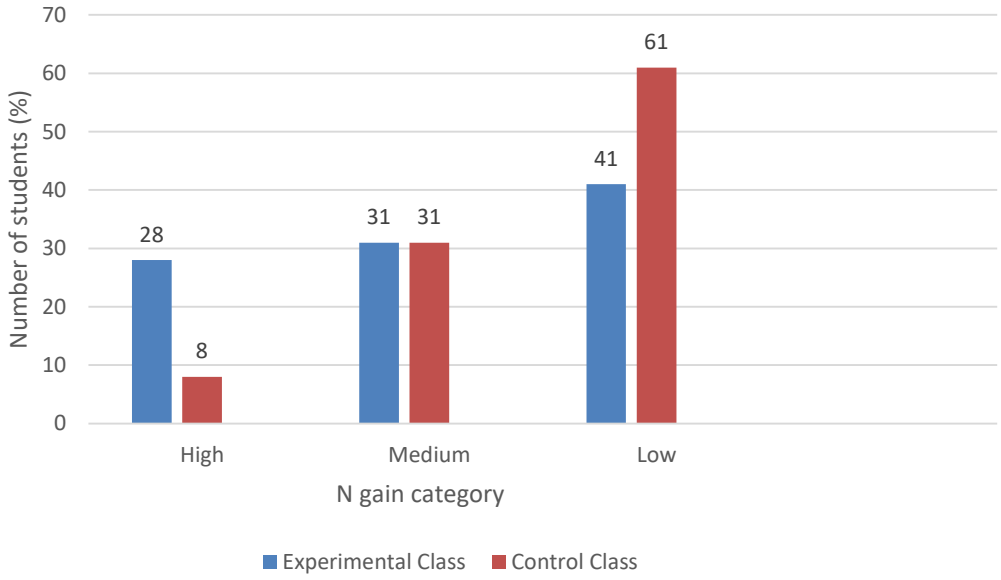

Figure 4.1 N gain for the experimental and control classes

Based on Figure 4.1, it can be observed that the experimental class has fewer students in the low N gain category compared to the control class. The number of students in the high and medium N gain categories is higher in the experimental class compared to the control class, with 59% > 39%. This is because during the learning process, plant bioplastic media equipped with QR codes were used, allowing students to observe plants directly. This aligns with Afifah's (2014) statement that the use of specimens facilitates students in connecting received concepts with direct observations, enabling them to actively participate in the learning process rather than just listening or observing passively. Muharajah & Rahmawati (2019) state that the best way to learn is through experience, not just seeing and hearing.

Based on the N gain scores obtained from the experimental class and the control class, the effectiveness of using plant bioplastic media equipped with QR codes is calculated as follows:

$$\text{Effectiveness} = \frac{\text{N gain of the experimental class}}{\text{N gain of the control class}}$$

$$\text{Effectiveness} = \frac{44{,}1793}{26{,}9115} = 1{,}6$$

The obtained effectiveness value is 1,6 > 1, indicating that the use of plant bioplastic media equipped with QR codes is effective in enhancing students' understanding of biodiversity. Based on the analysis of the effectiveness of plant bioplastic media equipped with QR codes, it is found that there is a difference between the pretest and posttest results of the experimental class students. This shows an improvement in students' scores before and after using plant bioplastic media equipped with QR codes. The average posttest results of the experimental class are greater than those of the control class. This indicates a difference in student learning outcomes between using PowerPoint (PPT) media and using plant bioplastic media. Students in the control class tend to be unresponsive because in their learning process, they only listen to the teacher and view the material on the PowerPoint slides. They lack understanding in classifying plants because they do not directly observe the similarities and differences in plant characteristics. In contrast, students in the experimental class are more active in learning due to the use of plant bioplastic media. They directly observe the characteristics of plant bioplastics for classification. This aligns with Afifah's (2014) research stating that the use of specimens in learning makes students actively participate in the learning process. Safitri et al. (2014) suggest that understanding and mastery are achieved when students discover the concepts they learn on their own, which significantly influences learning outcomes. Active student involvement provides them with opportunities to sharpen their understanding.

The use of plant bioplastic media equipped with QR codes supports students' understanding. Students are able to identify and describe plant classifications based on observable characteristics. Additionally, students are provided with real experiences through direct observation and can present their findings in the form of reports. This is consistent with Setiawan's (2014) research stating that the use of preserved specimens and student worksheets can train observation, classification, and communication skills. Suyanto et al. (2022) mentioned that the use of authentic objects can enhance students' factual knowledge. Irwanto et al. (2017) found that the use of plant bioplastic moss specimens can facilitate students in comparing based on differences in characteristics and enhance students' skills in classification. Several studies such as those by Israri (2016), Handayani (2013), and Januar (2013) have stated that the use of bioplastic as a good learning medium will support conceptual understanding and identification activities.

CONCLUSION

Based on the results of the analysis and discussion, it is concluded that the plant bioplastic learning media equipped with QR codes is highly valid, practical, and effective in enhancing students' understanding of biodiversity. Recommendations based on the discussion and conclusions are that the plant bioplastic learning media equipped with QR codes should be used by high school teachers and students to improve students' understanding of biodiversity. The plant bioplastic learning media equipped with QR codes can be expanded in terms of the number and variety of plants used in teaching.

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