



Development of a Biology Magazine as Learning Material for the Human Regulatory System: Validity and Student Attractiveness Evaluation

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ABSTRACT

Purpose of the study: This study aims to develop a magazine-shaped biology learning media on the regulatory system material and to determine the level of feasibility and attractiveness of the product based on expert validation results and student responses so that it can be used as teaching material in biology learning.

Methodology: This study employed the Research and Development (R&D) method with the Sugiyono development model, extending to the product revision stage. Data collection was conducted using a validation questionnaire and student response questionnaire. The instrument was validated by subject matter experts, media experts, and language experts. Data analysis used descriptive statistics in the form of percentages on a five-level Likert scale to determine the product's feasibility and attractiveness.

Main Findings: The results of the study showed that the magazine-based learning media received a feasibility rating of 83% from material experts, 90% from media experts, and 93% from language experts, all of which were categorized as very feasible. Student responses in the trial averaged 88%, categorized as very interesting, thus the media was declared suitable for use as teaching material for the regulatory system topic.

Novelty/Originality of this study: This research has produced a biology learning medium in the form of a magazine that integrates the presentation of regulatory system material with colorful illustrations, communicative language, and contextual information in one engaging printed material. The developed product not only meets the feasibility criteria but also enhances student learning engagement, making it an innovative alternative in biology instruction.

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1. INTRODUCTION

Advances in science and technology have driven a paradigm shift in learning toward a more active, interactive, and student-centered process [1], [2]. Biology learning no longer emphasizes solely conceptual mastery but also students' ability to understand biological phenomena contextually through meaningful learning experiences [3], [4]. Therefore, teachers are required to provide innovative, engaging, and tailored teaching materials tailored to student characteristics [5], [6]. Creatively designed teaching materials can increase learning

motivation while facilitating students' understanding of abstract biological concepts. Therefore, developing learning media is a crucial strategy for improving the quality of biology learning in schools.

Learning media plays a strategic role in creating a more effective learning experience because it integrates visual information, text, and illustrations to support the process of knowledge construction [7], [8]. The use of appropriate media has been proven to increase student attention, motivation, and engagement during the learning process [9], [10]. One form of learning media that can be developed as teaching material is learning magazines, due to their attractive appearance, communicative presentation, and richer information content than conventional textbooks [11], [12]. Learning magazines also allow for the presentation of material through images, infographics, popular scientific articles, interesting facts, and learning activities that can increase students' interest in reading. Therefore, developing magazine-based media has the potential to become an effective alternative teaching material in Biology.

The regulatory system is a highly complex subject in Biology, as it discusses the interrelationships between the nervous system, the endocrine system, and the senses in maintaining balanced bodily functions [13], [14]. Students often struggle to understand the working mechanisms of various organs and the simultaneous physiological processes occurring in this material. The lecture-based delivery method and the use of textbooks often make abstract concepts difficult to fully grasp. This results in poor conceptual understanding and diminished student interest in learning the regulatory system [15], [16]. Therefore, teaching materials that present concepts in a more engaging, systematic, and contextual manner are needed to enhance the learning process [17], [18].

An analysis of previous research indicates that there are still several gaps that require attention in the development of biology learning media. Recent research has focused more on the development of digital media, such as e-modules, interactive multimedia, learning videos, and electronic-based e-magazines. While the development of learning magazines as teaching materials that can be used flexibly in both print and digital formats is still relatively limited [19]. In addition, research that develops media in the form of magazines generally only emphasizes aspects of validity, practicality, or product effectiveness, while evaluations that combine product feasibility based on expert assessments with the level of attractiveness based on student responses are still rarely carried out [20]. Another gap is the limited research that specifically develops magazine media on regulatory system material, even though this material has a high level of conceptual complexity and requires attractive visualizations to make it easier for students to understand [21]. Therefore, research is needed to develop a learning magazine on the material of regulatory systems while comprehensively evaluating its feasibility and attractiveness so that it can become an alternative teaching material that is more innovative and appropriate to the needs of Biology learning.

An analysis of previous research reveals several gaps that require further study. First, most research focuses on developing application-based or multimedia media, while developing magazine-style media as teaching materials is still rare. Second, research on the development of biology magazines generally focuses on ecosystems, biodiversity, or the digestive system, while regulatory systems remain underexplored. Third, previous research has primarily evaluated product validity without comprehensively combining feasibility assessments with student responses or perceived appeal [22], [23]. Therefore, there is still research potential to develop magazine-style learning media specifically designed for regulatory systems, while simultaneously testing their feasibility and appeal as teaching materials.

The novelty of this research lies in the development of magazine-style learning media for biology specifically designed for regulatory systems, integrating the presentation of scientific concepts, colorful illustrations, infographics, scientific facts, learning activities, and evaluation exercises into one engaging teaching material. The developed media focuses not only on material delivery but also on visual aspects, readability, systematic presentation, and ease of use for both students and teachers [24], [25]. This study also evaluated the product through assessments by media experts, material experts, linguists, and student responses, resulting in more comprehensive information regarding product quality. This approach contributes to the development of Biology teaching materials that are practical, engaging, and appropriate to the needs of 21st-century learning [26], [27]. Therefore, this research is expected to enrich alternative learning media that can be used in Biology instruction at the secondary school level.

The development of appropriate and engaging learning media is an increasingly pressing need in line with the increasing demands for student-centered learning and the strengthening of 21st-century competencies. Providing innovative teaching materials is expected to increase learning motivation, strengthen conceptual understanding, and create more meaningful learning experiences in the regulatory system topic. In addition to providing practical benefits for teachers in providing varied learning resources, learning media in the form of magazines also has the potential to increase students' reading interest and independent learning [28], [29]. The results of this study are expected to serve as a reference for learning media developers and future researchers in developing more innovative Biology teaching materials [30]. Based on this description, this study aims to determine the feasibility and attractiveness of magazine products as teaching materials for the developed regulatory system topic.

2. RESEARCH METHOD

2.1. Type of Research

This research employed the Research and Development (R&D) method, aimed at producing a product and testing its feasibility before use in the learning process [31], [32]. The product developed in this study was a magazine-style biology learning medium on the topic of regulatory systems. The development model employed was based on the Sugiyono model, which consists of ten stages: (1) identification of potential and problems, (2) data collection, (3) product design, (4) design validation, (5) design revision, (6) product trial, (7) product revision, (8) usage trial, (9) final product revision, and (10) mass production.

This research was limited to the seventh stage, product revision after a limited trial. The limited trial was conducted to obtain input and feedback from validators, teachers, and students regarding the developed learning media [33], [34]. This limitation was implemented because the primary objective of this research was to produce a product suitable for use as teaching materials, not for mass production. Furthermore, this limitation aligns with Borg and Gall's opinion that limited-scale development research can be discontinued once the product is deemed feasible through validation and limited trials. Therefore, the output of this research is a magazine-style learning medium that has been revised based on expert validation and user feedback, thus meeting the eligibility criteria for teaching materials on regulatory systems.

2.2. Research Population and Sample

The population in this study were 10th grade Science students at State Senior High School 15 Bandar Lampung. The sample was determined using a purposive sampling technique, which is the selection of samples based on certain considerations that are in accordance with the objectives of the development research [35], [36]. In the needs analysis stage, the sample consisted of 12 students to obtain initial information regarding the need for learning media on the regulatory system material. Next, product validation was carried out by two media experts, three material experts, and one language expert who have competencies according to their fields to assess the feasibility of the developed product [37], [38]. The product trial was carried out in two stages, namely a limited trial and a field trial. The limited trial involved 1 Biology teacher and 12 students to obtain initial input on the developed media. After revisions were made, a field trial was conducted on 31 students at the same school to determine the level of product attractiveness. Thus, the total number of students involved in the product trial was 43 students, consisting of 12 students in the limited trial and 31 students in the field trial.

2.3. Data Collection Techniques and Research Instruments

The data collection technique in this study used a questionnaire. The questionnaire was used to obtain data regarding the level of feasibility and attractiveness of the developed learning media. The instrument was given to validators consisting of material experts, media experts, and linguists after the product was developed. In addition, the questionnaire was also given to students during the limited trial phase to determine responses to the use of magazines as teaching materials for the regulatory system material [21], [39]. The research instrument was a questionnaire with a rating scale compiled based on aspects assessed by each respondent. The instrument consisted of four types, namely the material expert validation questionnaire, the media expert validation questionnaire, the linguist validation questionnaire, and the student response questionnaire. Data obtained from all instruments were used as a basis for revising and refining the developed product.

Table 1. Grid of Material Expert Validation Instruments

Aspect	Indicators
Content Suitability	Suitability of material to learning outcomes, conceptual accuracy, breadth and depth of material, presentation structure, practice questions, and appropriateness of illustrations to the material.
Language	Language clarity, communication, effective sentence usage, and appropriateness of language to student characteristics.
Learning	Suitability of material to learning objectives and student abilities.

Table 2. Media Expert Validation Instrument Grid

Aspect	Indicators
Media quality	Ease of use, design quality, text readability, and clarity of illustrations.
Effectiveness	Suitability of media to learning objectives, ease of independent learning, interactivity, and usefulness of media.
Graphics	Layout, image proportions, illustration quality, color combinations, and font size.
Presentation	Ease of use, clarity of instructions, systematic presentation, and visual appeal.

Table 3. Grid of Language Expert Validation Instruments

Linguistic Aspects	Indicators
Language Suitability	Accuracy in spelling, sentence structure, clarity of information, communication, and readability.
Linguistic Aspects	Language is appropriate to the student's developmental level and does not create ambiguous meanings.

Table 4. Student Response Instrument Grid

Aspects	Indicators
Ease of use	Ease of understanding the instructions, materials, and use of the magazine.
Material presentation	Clarity of the material, usefulness of the content, and ease of understanding the concepts of the regulatory system.
Appearance	Attractiveness of the design, illustrations, colors, layout, and image quality.
Attractiveness	Interest in using media, motivation to learn, and satisfaction with the magazine as a teaching material.

2.4. Data Analysis Techniques

The data obtained in this study consisted of quantitative assessments from subject matter experts, media experts, language experts, teachers, and student responses via questionnaire. The data were analyzed using descriptive statistics by calculating percentage scores to determine the feasibility and attractiveness of the developed learning media [40], [41]. The percentage scores were calculated using the following formula:

$$\bar{x}_i = \frac{\sum x}{s_{max}} \times 100\% \quad \dots (1)$$

The assessment instrument uses a five-level Likert scale, with a score of 1 indicating strongly disagree/very unsuitable, and a score of 5 indicating strongly agree/very suitable. The percentages obtained are then interpreted based on the eligibility criteria as presented in Table 5.

Table 5. Product Eligibility Interpretation Criteria

Percentage (%)	Category
81–100	Very suitable
61–80	Suitable
41–60	Quite suitable
21–40	Less suitable
≤20	Very less suitable

3. RESULTS AND DISCUSSION

3.1. Product Validation

3.1.1. Description of Design Validation Results by Subject Matter Experts

Validation by subject matter experts was conducted to assess the content and linguistic feasibility of the magazine-style learning media for the regulatory system. The validation process involved three validators: two lecturers from the Biology Education Study Program at Raden Intan State Islamic University, Lampung, and one biology teacher at State Senior High School 15, Bandar Lampung. The validators' assessments were used as a basis for revising and refining the product before the trial phase with students.

Table 6. Results of Material Expert Validation

Validator	Content Aspect	Linguistic Aspects	Percentage (%)	Category
Validator 1	43/50 (86%)	20/25 (80%)	84	Very worthy
Validator 2	42/50 (84%)	19/25 (76%)	81	Very worthy
Validator 3	43/50 (86%)	20/25 (80%)	84	Very worthy
Average	85.33%	78.67%	83.00%	Very worthy

Based on the validation results, the percentage of assessments given by the first, second, and third validators were 84%, 81%, and 84%, respectively. The overall average percentage reached 83.00%, so the developed learning media was included in the very feasible category. These results indicate that the material presented was in accordance with learning outcomes, had good conceptual validity, used communicative language, and was in accordance with the characteristics of students. Although the product had met the very feasible criteria,

several inputs from the validators were still used as a basis for refining the material content, use of terms, and presentation of information to optimize the product quality before being tested on students.

3.1.2. Description of Design Validation Results by Media Experts

Media expert validation was conducted to assess the quality of the appearance and presentation of the developed learning media. The validation process involved two validators, both lecturers with expertise in learning media and instructional design. The assessment covered four aspects: media quality, effectiveness, graphics, and presentation. The validation results were used as a basis for refining the product before implementation in the trial phase.

Table 7. Media Expert Validation Results

Validator	Quality	Effectiveness	Graphics	Presentation	Percentage (%)	Category
Validator 1	12/15 (80%)	22/25 (88%)	12/15 (80%)	18/20 (90%)	85	Very worthy
Validator 2	13/15 (87%)	25/25 (100%)	15/15 (100%)	18/20 (90%)	95	Very worthy
Average	83.50%	94.00%	90.00%	90.00%	90.00%	Very worthy

3.1.3. Description of Design Validation Results by Linguists

Validation by a linguist is conducted to assess the appropriateness of language use in the developed learning media. The validation process involves a validator with expertise in linguistics. The assessment focuses on two aspects: the quality of language use and the appropriateness of sentence placement. Validation results are used as a basis for improving the wording and language presentation to make it more easily understood by students.

Table 8. Results of Validation by Linguists

Assessment Aspects	Score	Maximum Score	Percentage (%)	Category
Quality of Language Use	38	40	95	Very worthy
Suitability of Sentence Placement	18	20	90	Very worthy
Total	56	60	93	Very worthy

The validation results showed that the learning media achieved a 95% score for language quality and a 90% score for sentence placement. Overall, the media achieved a 93% score, making it highly suitable. These results indicate that the language used meets the rules of good and correct Indonesian, uses communicative sentences, and has a readability level appropriate to the characteristics of the learners. Furthermore, the use of terms, sentence structure, and presentation of information were deemed to facilitate learners' understanding of the regulatory system material. Input from the validator was used to refine several linguistic aspects, making the media more effective as a teaching material.

3.2 Limited Trial

3.2.1. Limited Trial Result Data

After the learning media was declared suitable based on validation results from material experts, media experts, and language experts, the next stage was a limited trial. This trial aimed to determine students' initial responses to the use of magazines as teaching materials for the regulatory system topic. The limited trial involved 12 students from State Senior High School 15 Bandar Lampung who were selected using a purposive sampling technique. The assessment was conducted through a student response questionnaire covering aspects of ease of use, material presentation, appearance, and media appeal.

Table 9. Limited Trial Results

Number of Respondents	Score Obtained	Maximum Score	Percentage (%)	Category
12 students	527	607	87	Very interesting

The results of the limited trial showed that the learning media obtained a score of 527 out of a maximum score of 607, with a percentage of 87% included in the very interesting category. This percentage indicates that students gave a positive response to the developed media. The magazine's appearance using full-color illustrations, systematic layout, and communicative presentation of material was considered capable of increasing students' interest in reading and studying the regulatory system material. In addition, the media was also considered easy to use and helped students understand complex concepts. The results of this limited trial indicate that the developed magazine has met the aspect of interestingness so it is worthy of being continued to the field trial stage.

3.2.2. Revision of Limited Field Trial Results

The results of the limited trial showed that the learning media received an excellent response from students. However, several suggestions were provided for product improvement before the field trial. These

suggestions included improving the resolution of several images for clearer images, adding illustrations of regulatory system organs with captions, and adding supporting information and more up-to-date materials to enrich the magazine's content. All of these suggestions were accommodated through a revision process, resulting in improved visual quality, more comprehensive presentation, and a more attractive appearance. This revision is expected to increase the media's effectiveness in helping students understand the regulatory system material.

3.3 Wider Trials

3.3.1. Broader Trial Result Data

After revisions based on the results of the limited trial, the learning media was further tested in a field trial to gain a broader understanding of the product's appeal. The field trial involved 31 11th-grade Science students at State Senior High School 15 Bandar Lampung. The assessment used a student response questionnaire covering aspects of ease of use, material presentation, appearance, and media appeal.

Table 10. Field Trial Results

Number of Respondents	Score Obtained	Maximum Score	Percentage (%)	Category
31 students	1,510	1,705	89	Very interesting

The results of the field trial showed that the learning media obtained a score of 1,510 out of a maximum score of 1,705, with a percentage of 89% included in the very interesting category. This percentage indicates that students gave a very positive response to the developed learning media. The systematic presentation of the material, the use of colorful illustrations (full color), an attractive layout, and the delivery of concepts related to everyday life were considered able to increase learning interest and make it easier for students to understand the material on the regulatory system. In addition, these results indicate that the revisions made after the limited trial succeeded in improving the quality of the media, so that the product was considered suitable for use as a teaching material in Biology learning.

3.3.2. Wider Revision of Trial Results

The field trial is the final stage in the learning media development process. Based on the results of the trial involving 31 students, no substantive criticism or suggestions were found regarding the product being developed. This indicates that the revisions made after the limited trial have successfully improved the quality of the media, both in terms of content, appearance, and presentation. The percentage of student responses in the field trial reached 89%, higher than the results of the limited trial which obtained a percentage of 87%. This increase indicates that the revision process based on student input in the previous stage has a positive impact on product quality. Thus, the developed Biology magazine is declared very interesting and suitable for use as teaching material on the regulatory system material for high school students. To provide a clearer picture of the improvement in the trial results, a comparison of the percentage of student responses in the limited trial and the field trial is presented in diagram form.

The findings indicate that the developed biology magazine possesses characteristics of an effective learning resource because it integrates scientific content with visual communication principles and contextual learning. Rather than functioning merely as a printed source of information, the magazine presents biological concepts through illustrations, infographics, scientific facts, and structured learning activities that facilitate knowledge construction. According to cognitive learning theory, meaningful learning occurs when learners are able to connect new information with prior knowledge through multiple forms of representation [42], [43]. The combination of text and visual elements in the developed magazine therefore provides opportunities for students to process abstract concepts of the regulatory system more systematically, reducing cognitive burden while promoting deeper conceptual understanding. This finding is consistent with previous studies reporting that visually rich instructional materials improve learners' attention, comprehension, and retention of biological concepts.

The positive evaluation from experts also reflects the importance of integrating pedagogical, content, and design quality during instructional material development. High-quality teaching materials are not determined solely by the accuracy of scientific content but also by their organization, readability, visual consistency, and suitability for learners' developmental characteristics [44], [45]. The systematic organization of concepts, communicative language, and balanced use of illustrations in the developed magazine demonstrate that instructional media should simultaneously address cognitive, linguistic, and aesthetic dimensions. Such integration enables learning resources to support teachers in presenting complex biological concepts while helping students navigate information more independently. Similar conclusions have been reported by previous development studies emphasizing that comprehensive expert validation contributes significantly to the production of reliable educational media.

Student acceptance of the magazine further suggests that attractive learning materials may strengthen learning motivation and engagement. Interest in learning is frequently influenced by the quality of instructional media, particularly when students perceive learning resources as enjoyable, relevant, and easy to understand [46].

[47]. The contextual presentation adopted in this magazine allows students to relate the regulatory system to everyday experiences, thereby increasing the perceived relevance of the material. This supports constructivist perspectives stating that learning becomes more meaningful when students actively connect scientific concepts with real-life situations. Previous research has likewise demonstrated that engaging instructional media encourage greater participation, increase reading interest, and improve students' willingness to explore learning materials independently.

Another important contribution of this study lies in demonstrating that magazine-based learning materials remain relevant despite the rapid growth of digital educational technologies. While many recent studies have focused primarily on e-modules, interactive multimedia, or mobile learning applications, printed or printable magazines continue to offer practical advantages, particularly in educational settings with limited technological infrastructure. Magazine-based media require minimal technological support, are easy to distribute, and can be used flexibly during classroom instruction or independent learning. Consequently, this study broadens the range of instructional media available for biology education by providing an alternative resource that complements rather than replaces digital learning materials [47], [48]. This finding supports recent literature suggesting that educational innovation should prioritize instructional effectiveness and accessibility rather than relying exclusively on technology integration.

From a practical perspective, the developed magazine has implications for both teachers and curriculum implementation. Teachers can utilize the magazine as supplementary teaching material to enrich classroom instruction, facilitate discussion-based learning, and encourage independent reading activities [49], [50]. The structured presentation of concepts, supported by illustrations and contextual information, may reduce students' misconceptions regarding complex physiological processes while promoting scientific literacy. Furthermore, the magazine aligns with student-centered learning approaches by providing opportunities for learners to explore concepts independently before classroom discussion. Such characteristics are consistent with current educational reforms emphasizing active learning, scientific literacy, and the development of twenty-first-century competencies.

Despite these promising findings, several limitations should be acknowledged. The development process was conducted only up to the product revision stage following field testing and involved participants from a single school, limiting the generalizability of the findings. Furthermore, this study primarily evaluated product feasibility and student attractiveness without examining its effectiveness in improving learning outcomes, conceptual understanding, critical thinking, or long-term knowledge retention. Future research should therefore implement experimental or quasi-experimental designs involving larger and more diverse populations to investigate the educational effectiveness of the magazine compared with other instructional media. In addition, integrating digital features such as QR codes, augmented reality, or interactive online resources may further enhance the flexibility and instructional value of magazine-based biology learning materials.

4. CONCLUSION

This research successfully developed a magazine-shaped Biology learning media on the regulatory system material that met the eligibility criteria for use as teaching materials. The validation results showed that the media obtained a feasibility percentage of 83% from material experts, 90% from media experts, and 93% from language experts, all of which were included in the very feasible category. In addition, the results of the trial with students showed an average response percentage of 88%, which was included in the very interesting category. These findings indicate that the developed magazine has good quality content, appearance, and language use so that it is able to support the Biology learning process on the regulatory system material. Thus, the magazine-shaped learning media is declared feasible and interesting to be used as an alternative teaching material in Biology learning at the Senior High School level. Future research is recommended to evaluate the effectiveness of the developed biology magazine through experimental or quasi-experimental studies involving larger and more diverse student populations to determine its impact on learning outcomes, conceptual understanding, scientific literacy, and higher-order thinking skills. Furthermore, future studies may integrate digital features such as QR codes, augmented reality, or interactive multimedia to enhance student engagement and expand the applicability of magazine-based learning materials in technology-supported learning environments.

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AUTHOR CONTRIBUTIONS

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

Not applicable.

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