



Development of Interactive Flipbook Teaching Supplement Mechanism of Heavy Metal Toxicokinetic Based on Laboratory Research

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Abstract

This study aims to describe the characteristics and analyze the feasibility of interactive flipbook teaching supplements on heavy metal toxicokinetic mechanisms based on laboratory research as supporting teaching materials in the learning process. This research was conducted at the Laboratory of the State University of Semarang and SMA N 12 Semarang. The type of research is research and development (RnD). The subjects of this study were material experts and media experts to assess the feasibility of materials and designs of laboratory research-based interactive flipbook teaching supplements, as well as students of class XII MIPA 4 and teachers of biology subjects at SMA N 12 Semarang to see the effectiveness of teaching supplements through response questionnaires response. The results showed that the characteristics of the interactive flipbook teaching supplement were developed to contain the results of the latest laboratory research as a learning resource for students, easy to use and exciting, and could help understand the material. The feasibility of interactive flipbook teaching supplements based on laboratory research is based on assessing material expert validators at 88.86% and media expert validators at 93.75%. Based on the responses of students and teachers, teaching supplements are considered exciting and suitable for use, with percentages of 86.39% and 96.25%, respectively. It shows that the interactive flipbook teaching supplement based on laboratory research produced in this study is considered to meet the characteristics of an interactive teaching supplement containing research and is suitable to be used to support the fulfillment of KD material on the digestive system and excretory system.

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INTRODUCTION

The object of biological study has a fairly broad scope, namely everything in the natural surroundings. In biology learning, students are required to understand and analyze conceptual and procedural knowledge and apply it in solving problems (Aqil, 2017). In addition, as a world community in the 21st century, students must also be able to use life skills to make them more competent (Fauzi & Islami, 2020). The 21st-century skills that need to be mastered are critical thinking skills, communication, collaboration, creativity, and innovation. In addition to students, teachers are also required to visualize and communicate learning so students can easily understand the information and knowledge related to the biological material presented.

Biology is a subject that requires several components to support the learning process, one of which is a learning resource. The scope of the discussion is quite broad and the limitations of the learning resources used can make some students have difficulty learning biology material. Çimer (2012) revealed that the lack of available learning resources is one of the basic reasons that make students find it difficult to learn biology. Therefore, learning resources greatly affect the achievement of learning objectives. The more learning resources used, the more knowledge that can be obtained by students.

Learning biology today is not enough to rely on understanding the material, but must be able to link the content of the material with benefits in everyday life, one of which is by utilizing the latest findings. Teachers can combine material content with research results to be used as learning resources to make it more meaningful. Hafsa (2015) states that learning combined with research is believed to increase and expand students' knowledge and can be used to improve the quality of learning.

Based on the results of initial observations made in one of the schools, namely SMAN 12 Semarang, it was found that the average teaching materials used in biology learning were in the form of textbooks, student worksheets, and the internet. The essential material KD 3.7 and 3.9 regarding the structure and function of the digestive system and the excretory system has been found in the primary teaching materials of students. However, specifically for indicators regarding disorders or abnormalities in the digestive and excretory systems, they are still too narrow and not varied, so other supporting teaching materials are needed. According to Auwaliah's research (2017), it is known that there are misconceptions about digestive system disorders caused by limited learning resources and incomplete discussion. Such obstacles can be suppressed through the facilities of supporting teaching materials in the form of teaching supplements in the form of interactive flipbooks. An interactive flipbook teaching supplement inserted with the results of the latest laboratory research can be used as additional teaching material for the digestive system and excretory system material, which can provide broader knowledge about the disorders in the system.

The published laboratory research revealed how much toxic heavy metal lead (Pb) was in the blood of rats exposed to Pb acetate and its toxicokinetic mechanism in the body. Disorders caused by high levels of toxic substances in the body are systemic and involve more than one organ system. It is evidenced by research conducted by Almunjiat et al. (2016) that absorbed lead into the blood circulation will be carried to various organs in the body and cause systemic effects. The effects of lead (Pb) can damage various human body organs, especially the nervous system, blood formation system, kidneys, heart system, and reproductive system (Ardillah, 2016). In addition, lead can cause other systemic effects, such as gastrointestinal symptoms (Gusnita, 2012). The results of this study have the potential to develop into one of the supporting teaching materials or teaching supplements to study the material of the digestive system and the excretory system.

Teaching supplements are made by taking into account technological developments. The material included in the supplement is presented as exciting and fun so that students do not get bored quickly and increase their interest in learning. Rahmawati et al. (2013) stated that thick textbooks make students less interested in learning the content of the material and tend to be lazy to carry it. Therefore, an interactive flipbook was developed as a medium that can attract students to learn new

things. With unique flipbook features and diverse content, flipbooks can increase student learning motivation (Hardiansyah & Sumbawati, 2016).

Based on this background, research and development are carried out on interactive flipbook teaching supplements for the material on the digestive system and the excretory system, especially the sub-chapter of disorders or abnormalities in the body system toxicokinetic mechanisms of heavy metals. This study aims to describe the characteristics of an interactive *flipbook* teaching supplement based on laboratory research and to analyze its feasibility level.

RESEARCH METHOD

This research was conducted at SMA Negeri 12 Semarang in 2022. The subjects in this study were material and media experts to obtain an assessment of the validation of interactive flipbook teaching supplements, students of class XII MIPA 4 with a total of 36 students, as well as teachers of biology subjects at SMA Negeri 12 Semarang to test the feasibility of an interactive flipbook teaching supplement. This research procedure includes eight stages: the potential and problem stage, data collection, product design, design validation, design revision, small-scale product testing, and product revision stage.

Data collection techniques in this study used documentation and questionnaire methods. The data analysis carried out included an analysis of the characteristics of the interactive flipbook teaching supplement and the feasibility analysis of the interactive flipbook teaching supplement based on validation by material experts and media experts, high school biology teachers' responses, and student responses. The characteristics of the interactive flipbook teaching supplement were analyzed by describing the feasibility assessment from the experts. The feasibility of interactive flipbook teaching supplements was analyzed descriptively quantitatively, and the readability of teachers and students as a product trial stage (small scale) was analyzed descriptively quantitatively.

RESULT AND DISCUSSION

This study analyzed the characteristics and feasibility of an interactive flipbook teaching supplement for heavy metal toxicokinetic mechanisms based on laboratory research. The data on the characteristics of the interactive flipbook teaching supplement was obtained from the results of a feasibility assessment by experts and the responses of teachers and students who were analyzed qualitatively. The data on the interactive flipbook teaching supplement's feasibility was obtained from material and media experts' validation results. The results of the validation of interactive flipbook teaching supplements by material and media experts are presented in Table 1.

Table 1 Material and Media Expert Validation Results

Validator	Rated aspect	Percentage (%)	Eligibility Criteria
Material Expert	Quality of Content or Material	91.6	Extremely valid
	Presentation	87.5	Extremely valid
	Language	87.5	Extremely valid
	Average	88.86	Extremely valid
Media Expert	Display Design	93.75	Extremely valid
	Software engineering	87.5	Extremely valid
	System Eligibility	100	Extremely valid
	Average	93.75	Extremely valid

Table 1 shows the results of the assessment from material experts, the results obtained are 88.86% with the "very valid" criteria. Assessment from media experts obtained the results of 93.75% with the criteria "very valid". The results of teacher and student responses are presented in Tables 2 and 3.

Table 2 Results of Student Responses

No	Aspect	Percentage (%)	Criteria
1	Research-based interactive flipbook teaching supplement display of heavy metal toxicokinetic mechanisms	86.33	Very Decent
2	Presentation of research-based interactive flipbook teaching supplement materials for heavy metal toxicokinetic mechanisms	86.94	Very Decent
3	Interests in using research-based interactive flipbook teaching supplements for heavy metal toxicokinetic mechanisms	85.92	Very Decent
Average		86.39	Very Decent

Table 3 Results of Teacher Responses

No	Aspect	Percentage (%)	Criteria
1	Research-based interactive flipbook teaching supplement display of heavy metal toxicokinetic mechanisms	95.00	Very Decent
2	Research-based interactive flipbook teaching supplement content design of heavy metal toxicokinetic mechanisms	100	Very Decent
3	Quality of research-based interactive flipbook on heavy metal toxicokinetic mechanisms	100	Very Decent
4	Ease of teaching supplement interactive flipbook of research-based heavy metal toxicokinetic mechanisms	90.00	Very Decent
Average		96.25	Very Decent

DISCUSSION

Characteristics of Interactive Flipbook Teaching Supplements

The characteristics of the interactive flipbook teaching supplement were obtained from the results of a feasibility assessment by experts, that the developed interactive flipbook teaching supplement contained laboratory research on the levels of toxic substances in the body and their mechanisms used as teaching materials to support the digestive system and excretory system. Primiani (2014) states that research-based teaching materials can be used as an activity to expand and deepen the material in an applicative manner.

The selection of interactive flipbook media is based on changes in mindset and habits due to the development of the times and technology that make every teacher and student choose the conveniences in the learning process. For some students, textbooks are too thick and heavy, making them inconvenient to carry. Therefore, soft files are needed because they are considered practical and easy to access, so there is no need to carry textbooks. Digital books in the form of interactive flipbooks based on computer technology can produce material using microprocessor-based sources, or in other words, the material delivered can be stored in digital form and not in print (Pramana & Dewi, 2014).

In the interactive flipbook teaching supplement based on laboratory research that was developed, there is a controller that can be operated by the user so that users can freely choose what they want for the following process. It has been proven by the assessment of material expert validators and media expert validators, as well as the responses of teachers and students, who consider this teaching supplement very feasible to use because it is considered exciting and can provide convenience in understanding the content of the material. According to Daryanto (2013), interactive learning media has the following characteristics: 1) has more than one convergent media, 2) is interactive, and 3) is

independent. The interactive flipbook teaching supplement that has been developed has fulfilled these three characteristics where there is more than one convergent media, namely the combination of audio and visual elements. In addition, this flipbook teaching supplement is also interactive because it can accommodate user responses and is independent, providing convenience with complete content arranged so that users can use it without the guidance of others. In addition, the presence of illustrated images and videos linked to the topic can help users understand the material presented. Werimon et al. (2017) stated that media that has illustrations with attractive colors could help students understand complex material, increase interest in learning and help restore knowledge that has been obtained by students previously.

Eligibility of Interactive Flipbook Teaching Supplement

The interactive flipbook teaching supplement for heavy metal toxicokinetic mechanisms based on laboratory research can be said to be feasible if all experts who assess the feasibility of the product declare it feasible. This opinion follows the statement of Sawitri et al. (2014) that quality and appropriate teaching supplements are those that meet the percentage of eligibility based on the results of expert or expert assessments.

In the validation of the interactive flipbook teaching supplement material, it was considered very suitable because the presented material followed the KD formula, indicators, and learning objectives adapted to the digestive and excretory system material. The systematics in the presentation of the developed teaching supplements were also considered to be logical, coherent, clear, and detailed. In addition, the material is also presented sequentially from simple to complex so that the concept of toxicokinetic mechanisms can be conveyed more clearly and easily understood.

This teaching supplement also contains research results that can help students understand learning material. This opinion is reinforced by the results of Hafsa's research (2015), which states that learning combined with research is believed to be able to increase students' knowledge and can improve the quality of learning. The use of language is adjusted to the student's level of understanding and ability to understand the material's content. The information contained in the supplement is presented clearly and easily understood using clear and straightforward language. It is by Suswina's (2016) statement, which states that the choice of language in the development of teaching materials is an essential factor because it can make teaching materials more meaningful.

In the validation of the interactive flipbook teaching supplement media, it is considered very feasible to use because the presentation of the display design has been adjusted to the needs, such as accuracy in choosing letters, suitability of color selection, suitability of images, videos and audio displayed, as well as the attractiveness and ease of the designs made. The design of teaching supplements is designed so that students are interested in learning the material presented. A good design must be able to make the reader move to take a specific action (Widya, 2020).

The developed interactive flipbook teaching supplement can be operated easily via a laptop or PC; besides that, this application is considered easy to use because users can freely access the menu they want to choose for further operation. However, this flipbook application also needs improvement, one of which is increasing interactive elements so that the interaction between students and the media can be more visible and make students more active. Indartiwi et al. (2018) in their research, states that the interactive element in learning media, especially digital-based learning media, is something important because it can make it easier for teachers to convey information to students effectively and efficiently and can make the learning process more active and fun.

This interactive flipbook teaching supplement developed is also user-friendly, where the features can be easily accessed and have high effectiveness and practicality, and terms used in the

media also use general terms that everyone commonly understands. According to Daryanto (2013), one of the characteristics of learning media is that it must have a user-friendly nature, where each presentation or instruction is made using simple, easy-to-understand language and uses general terms, so that it can help provide convenience for users to respond and access according to their needs with his wish.

The results of the responses of teachers and students on a small scale give an excellent assessment of the laboratory research-based interactive flipbook teaching supplement. Students' interest in interactive flipbook teaching supplements is due to the latest research in teaching supplements as additional knowledge. Students also like the interactive flipbook teaching supplement because it is packaged in digital form so that it can be accessed easily; in addition to the developed teaching supplement, there are videos and supporting pictures so that students do not get bored quickly when learning it. The same statement was also made by Rahmawati et al. (2013) that students tend to like interesting readings with lots of pictures or colors and short descriptions. Meanwhile, the teacher's response to the interactive flipbook teaching supplement that was developed was excellent because the teaching supplement was equipped with research results that could help students understand the material and increase learning motivation. Teachers also like the interactive flipbook teaching supplement because it is packaged in digital form, whereas currently, students prefer digital media learning. In addition, the teacher considers this interactive flipbook teaching supplement is user-friendly because users can use it anytime and anywhere, both online and offline, so users do not have to worry about network conditions. Firdaus et al. (2021) stated that media that can be accessed online and offline can minimize lost connection problems and can provide convenience for users if the user does not have internet access.

CONCLUSION

Based on the results of data analysis and discussion of research results, it is concluded that the interactive flipbook teaching supplement developed presents the results of the latest laboratory research with an attractive appearance, easy to use and can help understanding the material. The interactive flipbook teaching supplement based on laboratory research is considered very valid and feasible to be used in learning activities

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