ISSN 2685 - 6190 (p)
ISSN 2714 - 7746 (e)
Physics Education Research Journal
Department of Physics Education
Faculty of Science and Technology
UIN Walisongo Semarang-Indonesia

Design and Validity of Interactive Multimedia Based on Cognitive Conflict Using Adobe Animate CC on the Concept of Circular Motion

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ARTICLE INFO

Article history:
Submitted : August 25th, 2022
Revised : January 13th, 2023
Accepted : February 28th, 2023

Keywords:
Adobe Animation; Circular movement; Cognitive Conflict; Misconceptions; Interactive Multimedia

ABSTRACT

High school students' understanding of circular motion material is still low. One solution to this problem is to design interactive multimedia based on the cognitive conflict in the theory of circular motion to enhance the conceptual understanding of high school students. This study aims to determine the characteristics and validity of interactive multimedia based on cognitive conflict. The research follows the development research approach using the Plomp model. This study is limited to the preliminary study phase and the development phase, up to the validity test through expert review. The learning instruments include journal analysis sheets, teacher questionnaires, self-evaluation sheets, and expert review sheets. Data were analyzed using the percentage technique and the V-Aiken formula. The introductory study identified several issues in teaching circular motion, such as low understanding levels, teacher-centered physics instruction, lack of experimental activities, and a lack of interactive multimedia teaching materials. During the development stage, multimedia was designed with the following characteristics: the use of Adobe Animate CC 2019 application to support interactivity through students' smartphones. The multimedia was also structured according to the four learning model syntax based on cognitive conflict (CCBL model). The results of the self-evaluation test met the criteria for a very good rating, while the expert review test indicated a valid category. It can be concluded that the cognitive conflict-based interactive multimedia on circular motion material is valid and can proceed to the practical and effective testing stage.

Introduction

The development of technology and information in the 21st century is progressing rapidly. This era is characterized by competition and challenges leading to the creation of various technological products to facilitate human life and work (Permatasari & Trisnawati, 2021; Roche et al., 2021). The advancements in the 21st century align with the fourth industrial revolution, also known as the Internet of Things (IoT) (Yurnetti et al., 2021). To keep up with the highly advanced 4.0 revolution, the national education goals require the education system to adopt more efficient approaches (Yurnetti et al., 2021). Technological developments in the fourth industrial revolution era necessitate students to enhance their understanding of the increasingly solid and complex forms of competition (Yurnetti et al., 2021). This understanding is categorized as conceptual understanding, a crucial aspect of student learning that enables them to solve problems independently (Subagiyo, 2019). Understanding involves mental processes that entail interaction and transformation of knowledge (Sugita et al., 2020). Common conceptual understanding can impede students' learning and comprehension of the taught subjects, leading to misconceptions (Mufit et al. 2018). Misconceptions are beliefs contradicting accepted scientific theories (Eryilmaz, 2002). They arise when students use concepts that do not align with those recognized by

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doi: 10.21580/perj.2023.5.1.12773

experts or scientifically established (Mufit et al., 2020; Fauziah et al., 2021). Students' misconceptions often stem from practical experiences (Kuczmann, 2017). It is necessary to enhance students' conceptual understanding through interactive teaching materials to address misconceptions.

Teaching materials are utilized as learning resources and communication tools in education (Ministry of National Education, 2010). Engaging teaching materials can capture students' attention and stimulate their perception, senses, thinking abilities, imagination, and inner motivation toward learning materials and activities, leading to greater student acceptance (Widada, 2017). Interesting teaching materials can actively involve students in learning, making learning more student-centered. This can be achieved through the use of interactive multimedia. Interactive multimedia combines images, videos, animations, and sound in software that allows users to interact directly. It can improve students' conceptual understanding (Shi et al., 2021). Interactive multimedia can also clarify physics concepts that students may struggle to comprehend, enabling them to independently grasp them (Festiyed et al., 2019). The positive impact of multimedia greatly assists the digital learning process.

Interactive multimedia can help students develop a deep understanding of concepts and foster independence. Positive student feedback can promote a student-centered learning approach, enhancing students' comprehension of concepts within the learning materials following the 2013 curriculum requirements (Zubaidah, 2018). Therefore, interactive multimedia allows students to engage in self-directed learning, which aids their understanding of the concepts covered in their studies. The use of interactive multimedia aligns with the student-centered learning approach mandated by the 2013 curriculum. This interactive multimedia is designed using Adobe Animate software.

Adobe Animate is a multimedia software that functions as a tool for creating animations (Green & Labrecque, 2017). The Adobe Animate program was formerly known as Adobe Flash from Adobe Systems, and Adobe Animate is an updated version. The Adobe Animate application creates vector graphic designs and animations for television projects, online videos, websites, web applications, internet applications, and even video games. This program also supports creating graphics through raster, text, audio, video embedding, and ActionScript. The software is designed to create attractive multimedia (Green & Labrecque, 2017). Adobe Animate CC has several advantages over other product development applications: (1) it allows selecting templates for electronic products created, (2) it offers three types of command codes that can be used on different electronic product templates, namely ActionScript, HTML5 Canvas, WebGL, and (3) it can create animations. Adobe Animate CC offers various output types for electronic product specifications based on the selected Adobe Animate CC template. The electronic product templates provided by Adobe Animate CC include Android, Apple iOS, Apple TV, Windows, and Mac OS desktop (Green & Labrecque, 2017). Therefore, this software is recommended for creating interesting multimedia teaching materials following the demands of the 2013 curriculum in Indonesia.

The conditions in the field are not in line with the requirements of the 2013 curriculum. It is known that the problems in the learning process indicate that: (1) in the physics learning of circular motion, the teacher still uses direct learning models or teacher-centered approaches to explain the material, (2) experimental activities are not conducted to discover concepts, and (3) interactive multimedia that support concept understanding is not available. In addition, the understanding of circular motion is still relatively low. This is supported by journal analysis, which states that the percentage of students with misconceptions and a lack of understanding of the concept is higher than that of students who understand the concept of circular motion.

The solution to this problem is to use teaching materials in the form of interactive multimedia, which can help teachers guide students to actively explore concepts and prevent teacher-centered learning. From a student perspective, interactive multimedia can also help students deepen their understanding and develop independence. Interactive multimedia, providing positive feedback to students, can promote a student-centered learning approach, encouraging students to better understand the concepts in the learning materials following the requirements of the 2013 curriculum (Zubaidah, 2018).

Interactive multimedia uses a cognitive conflict-based learning model structured with a syntax model of cognitive conflict-based learning. The cognitive conflict-based learning model consists of four syntaxes: (1) activation of preconceptions and misconceptions, (2) presentation of cognitive conflicts, (3) discovery of concepts and similarities, and (4) reflection (Mufit, 2018). The cognitive conflict-based learning model is used because it positively impacts increasing concept understanding, correcting misconceptions, and enhancing student learning motivation (Mufit, 2018). Using the cognitive conflict-based learning model can also improve conceptual understanding and correct misconceptions, especially for students with high academic abilities (Mufit & Fauzan, 2019). The cognitive conflict learning model improves conceptual understanding and minimizes student misconceptions (Rahim et al., 2015).

Previous studies have developed cognitive conflict-based teaching materials in the form of worksheets for linear motion and parabolic motion but not yet for circular motion (Fadhilah et al., 2020). Teaching materials for circular motion have been developed using an authentic learning model (Ridho et al., 2020). However, neither of these studies has utilized interactive multimedia that can be accessed on smartphones. Therefore, it is crucial to research the development of interactive multimedia based on cognitive conflict for the concept of circular motion to address the issue of students' shared understanding of concepts. This study aims to describe the characteristics of interactive multimedia that can enhance conceptual understanding of circular motion and determine its validity.

Methods

This research is development research. Interactive multimedia based on cognitive conflict for the concept of circular motion is designed and created using a development model (Plomp, 2013) because the Plomp (2013) development model consists of three steps: (1) preliminary research, which includes needs analysis and literature review; (2) development stage; and (3) assessment stage (Plomp, 2013). The design process in this study is limited to the development stage, specifically up to the validity testing stage.

The preliminary research stage includes a needs analysis and literature review. The needs analysis involves surveying physics teachers and students. Two physics teachers were given a questionnaire regarding the learning process for circular motion material. The questionnaire consists of six indicators, which include the use of learning models, identification of conceptual understanding, use of teaching materials and media, implementation of experiments, and use of supporting facilities and equipment. Additionally, the problems related to high school students' understanding of the concept of circular motion were identified by analyzing three journals. This analysis provided insights into the problems in circular motion learning, which served as considerations for developing interactive multimedia based on cognitive conflict for the concept of circular motion. Following the needs analysis, a literature review was conducted to determine appropriate solutions for the problems identified.

The development stage involved designing interactive multimedia products to address the identified problems from the preliminary research stage. The development phase consisted of prototype design and formative evaluation, limited explicitly to expert review. The interactive multimedia was designed for smartphones or Android devices, allowing users to select and input answers to given questions based on the cognitive conflict learning syntax. It also provided the ability to perform virtual laboratory experiments and real experiments. After designing the interactive multimedia, the next stage involved formative evaluation and revising the prototypes. This stage included two assessment stages: self-evaluation to check the completeness of the multimedia prototype components and interactive design, and expert review conducted by three lecturers who were physicists and physics learning experts to test the validity of the prototype.

The data collection instruments included a journal analysis sheet, a teacher questionnaire consisting of six indicators related to learning models, students' conceptual understanding, teaching materials and media, implementation of experiments, and use of facilities and equipment for circular motion material, as well as online learning problems during the COVID-19 pandemic. The indicators were developed into several questions. Self-evaluation instruments for the prototypes and expert validation sheets were created based on the guidelines for developing IT-based teaching materials (Depdiknas, 2010). The guidelines for developing ICT-based teaching materials included four components: materials, learning design, visual communication display, and software utilization (Depdiknas, 2010). These components were further developed into several question indicators for each component on the validation instrument sheet. The questionnaire instrument sheet utilized a Likert scale with five categories: (a) a score of five = strongly agree, (b) a score of four = agree, (c) a score of three = sufficient, (d) a score of two = disagree, and (e) a score of one = strongly disagree.

The preliminary research data were analyzed descriptively using percentage techniques. The expert review validation data were analyzed using the V-Aiken Formula. The journal analysis data and self-evaluation were conducted using Equation 1.

$$P = \frac{f}{N} \times 100\% \quad (1)$$

The data obtained underwent a validity test analyzed using the V-Aiken validity index in Equation 2.

$$V = \frac{\sum s}{n(c-1)} \quad (2)$$

The results of the valid values are interpreted using Aiken's *V* index, which ranges from 0 to 1. The validity index criteria for the product are as follows: a validity index of $0.4 > V$ falls into the invalid category, $0.4 < V < 0.8$ falls into the valid category, and $V > 0.8$ falls into the very valid category (Retnawati, 2016). The created product can be considered usable if its validity falls within the valid and very valid range.

Result and Discussions

The preliminary research results encompass two aspects: distributing a questionnaire on the physics learning process to two high school physics teachers and analyzing high school student's understanding of the concept of circular motion obtained from journal analysis. The questionnaire distributed to the physics teachers revealed several problems related to circular motion material in physics learning. It was found that teachers still predominantly use direct learning models, resulting in a teacher-centered approach. Additionally, experimental activities to explore the concept of circular motion are not emphasized, and there is a lack of interactive and engaging multimedia-based teaching materials.

The analysis data indicated low conceptual understanding among high school students regarding circular motion material. The results showed that only 8.6%, 22.4%, and 18.8% of the students demonstrated good conceptual understanding. On the other hand, the percentage of students who held misconceptions was 30.7%, 39.2%, and 44.7%, while the percentage of students who did not grasp the concept reached 54.5%, 28.6%, and 36.5% (Annisa et al., 2019; Firmansyah & Wulandari, 2016). The percentage of students with misconceptions and those who did not understand the concept was higher than that of students who clearly understood circular motion.

The results of this development research encompass three aspects: product designs, self-evaluation, and expert reviews. The product design phase involved creating interactive multimedia as an APK (Application Package File) for Android devices, compiled with the syntax of a cognitive conflict-based learning model (Mufit & Fauzan, 2019).

Figure 1 depicts the interactive multimedia cover display, including the title, compiler, title, and class information. Figure 2 illustrates the activation stage of preconceptions and misconceptions. This stage aims to assess students' initial knowledge regarding the relationship between quantities in a circular motion before delving into the learning topic. Students can interact by clicking on answer options or statements categorized as true (B), false (S), or don't know (T) to demonstrate their understanding of the concept. Figure 3 represents the second stage, namely the presentation of cognitive conflict. In this stage, students can provide hypothetical answers to questions that present contradictory phenomena related to objects moving in circular patterns. Students are encouraged to determine the relationship between quantities in a circular motion, such as angular velocity, radius, and linear velocity. Both the first and second stages are interactive, allowing students to write and click their answers and instantly see the results of their conceptual understanding in the first stage and the correct answer after typing their hypothesis in the second stage.

Figure 1
Cover View

Figure 2
Preconception and Misconception Activation Display

Figure 3
Cognitive Conflict Presentation Display

Figure 4
Reflection/Evaluation Display

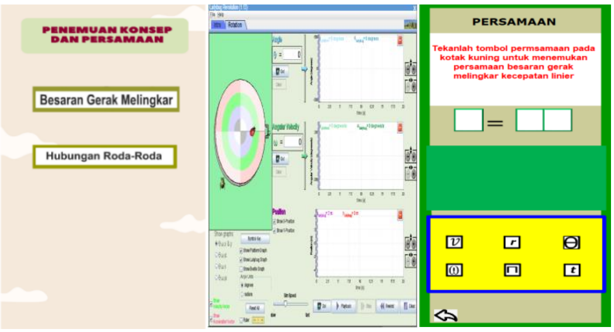


Figure 4 illustrates the stages of concept and equation discovery. This stage involves conducting experiments, both virtual and real. An integrated virtual laboratory titled "The Ladybug Revolution" was developed for the virtual experiments to simulate circular motion. In this virtual laboratory, students are expected to fill in data tables provided within the interactive multimedia. The collected data raises several concept-related questions regarding the quantities involved in a uniform circular motion presented through virtual laboratory experiments. Once the students have identified the concepts, they are prompted to determine the corresponding equations by clicking the formula symbol button in the interactive multimedia. This stage encourages students to independently discover concepts and equations. The interactive nature of this stage allows students to input their answers for concept discovery and click the equation symbol button to find the equations. Additionally, this stage integrates a virtual laboratory that requires internet access.

Figure 5
Concept and Equation Discovery View

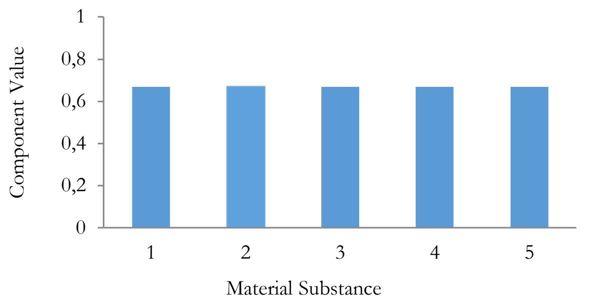
Figure 5 illustrates concept and equation discovery view. At this stage, a set of questions that have been previously covered is presented. Students can assess their understanding of the concepts through reflection and evaluation questions. A question regarding the relationship between quantities in circular motion is provided, and students can click on the answer below the question to provide their immediate reflection. The questions can be scrolled up and down on the left side of the screen. Once students have answered all the questions, they can click the finish button to view their score results.

The self-evaluation results indicate that the product has undergone self-assessment and expert reviews. The self-evaluation assessment covers six components, which include the structure of the interactive multimedia following the guidelines for developing ICT educational materials, the implementation of a cognitive conflict-based learning model syntax, the inclusion of virtual laboratory integration, explicit language usage, attractive display, and the utilization of other supporting software (Mufit & Fauzan, 2019). The self-evaluation stage resulted in a rating of "very good" as the researcher ensured the completeness of the multimedia. The interactive program was developed following the guidelines for developing ICT-based teaching materials, and errors related to language use, writing clarity, and navigation were corrected following the guidelines. Illustrations, pictures, and equations in the interactive multimedia are displayed.

After the self-evaluation, an expert review assessment was conducted. The expert review stage involved validating the product by three physics lecturers serving as validators. The assessment criteria used by the expert validators comprised four components:

material substance, learning design, visual communication display, and software utilization. The material substance component included five indicators: 1) alignment with the 2013 curriculum, 2) alignment with Basic Competencies (KD), 3) alignment of indicator formulation with Basic Competencies (KD), 4) language conformity with the General Guidelines for Indonesian Spelling (PUEBI), and 5) language clarity. The expert reviewers evaluated each indicator within the material substance component, and the results are depicted in the data plot shown in Figure 6.

Figure 6
Material Substance Validation Results

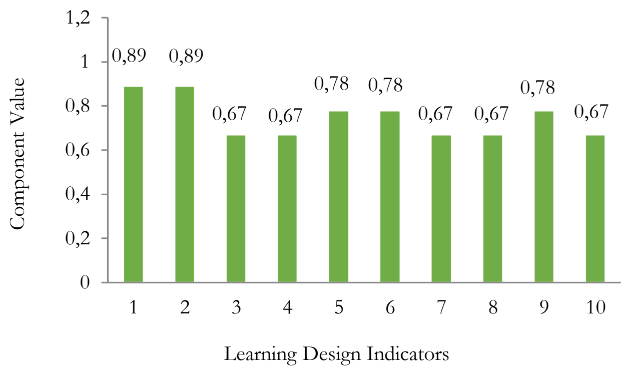


The value of the components in the material substance is 0.67 for all five indicators, which falls within the valid category. The average value obtained is also within the valid category, with a value of 0.67.

The second component is learning design, which consists of ten indicators as follows: 1) title display, 2) inclusion of KI and KD (Core Competencies and Basic Competencies), 3) alignment of learning objectives with KD, 4) multimedia material interactivity in line with learning objectives, 5) alignment of learning objectives with indicators, 6) inclusion of a stage presenting cognitive conflicts in interactive multimedia, 7) inclusion of a stage for concept and similarity discovery in interactive multimedia, 8) inclusion of a reflection stage in interactive multimedia, aligned with the material, 9) inclusion of composer identity in interactive multimedia, 10) appropriate citation of works of others as references. Each indicator within the learning design component, which assesses the validity of the expert review stage, has its respective data values. The data values for each indicator within the learning design component are presented in the graph plot shown in Figure 7.

The validity results of the learning design component range from 0.67 to 0.89. Two indicators obtained a value of 0.89, categorized as very valid, while the remaining eight obtained values ranging from 0.67 to 0.78, categorized as valid. The average validity result for this component is 0.75, falling within the valid category. This is because the interactive multimedia already has a title, includes KI and KD, the learning objectives align with the stated KD, circular motion material is included and has been revised, and the questions are based on the cognitive conflict-based learning model syntax (Mufit & Fauzan, 2019). The researcher made revisions to the indicators and learning objectives, changing the discussion from centripetal acceleration to the direction of uniform circular motion. Additionally, the previous video-assisted experiments were replaced with real or direct experiments. Pictures were added to the introductory material, and questions were included for all stages/syntax of cognitive conflict.

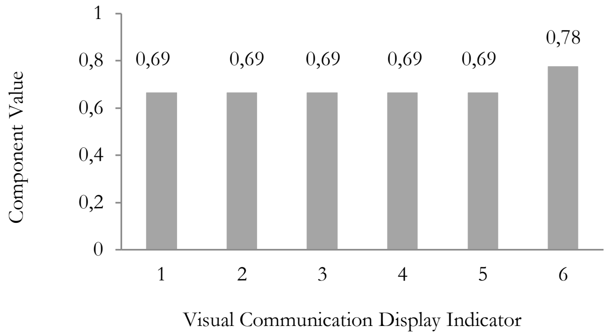
Figure 7
Learning Design Results



Moving on to the visual communication display component consists of six indicators: 1) interactive multimedia with functional and adequately working primary navigation and hyperlinks, 2) legible, proportional, and attractive fonts in the interactive multimedia, 3) utilization of images, animations, graphics, and sound in the interactive multimedia, 4) harmonious and attractive color combinations on the cover and each slide, 5) interactivity, and 6) clear and precise instructions for use. The data results for each indicator in the visual communication display component can be observed in the graph plot presented in Figure 8.

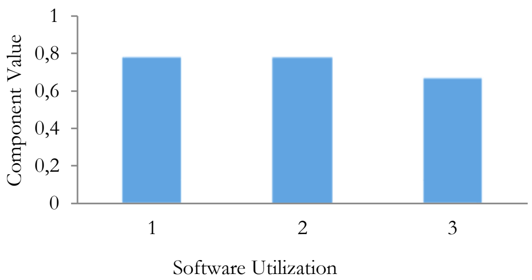
The values within the range of 0.67 to 0.78 for the third component are categorized as valid, and the average validation value for the visual communication display component is 0.69, which is also classified as valid. This is because the interactive multimedia utilizes basic navigation and functional hyperlinks after undergoing revisions, the fonts used in the interactive multimedia are legible, proportional, and attractive. The interactive multimedia incorporates images, animations, and sound, which have been revised. The color combinations on the cover and each slide are now harmonious and attractive, and the overall design layout is proportional and appealing. The instructions for use in the interactive multimedia are clear and precise after undergoing a single revision. The researchers have revised the instructions for use, particularly in the added image instructions.

Figure 8
Validation Results Visual Communication Display



Moving on to the fourth component, it pertains to the use of software and consists of three key indicators: 1) the interactive multimedia provides feedback to users, 2) supporting software is utilized in creating the interactive multimedia, and 3) the interactive multimedia is the result of one's own work. The visual communication display indicator for this component can be seen in Figure 9.

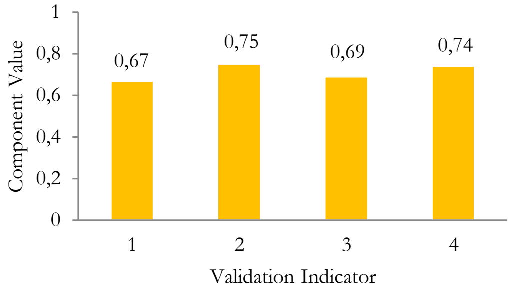
Figure 9
Results of Validation of the Use of Software



The value of the fourth component ranging from 0.69 to 0.78 is classified as valid, and the average validation value is 0.74, which is also considered valid.

Based on the evaluation of the four components, including n, an analysis of the average validity value for each interactive multimedia component is obtained, as shown in Figure 10. Based on the figure, the validation values are 0.67, 0.75, 0.69, and 0.74, with an average value of 0.71. The values above indicate that all components in the multimedia are classified as valid, valid in terms of content, instructional materials, learning design, visual communication display, and software utilization. (Depdiknas, 2010).

Figure 10
Interactive M ultimedia validation results



In the preliminary research conducted, through the analysis of three journals, it was found that students had a low understanding of concepts, resulting in conceptual misunderstandings and a lack of comprehension of the concept of circular motion with a high percentage. The evidence for this comes from the results of a questionnaire administered to two physics teachers involved in high school physics learning processes. The findings revealed that the learning approach in physics was still teacher-centered, with direct teacher-led material presentations. Moreover, there was a lack of emphasis on experimental activities to facilitate concept acquisition and a scarcity of teaching materials based on interactive multimedia. These findings align with a study conducted by (Hanum et al., 2020) on the development of physics learning, which emphasized the need to shift from a teacher-centered approach. Additionally, (Puspitasari et al., 2021) conducted research during the COVID-19 pandemic, focusing on students' understanding of concepts. They also found that the low understanding of motion concepts was due to a lack of discussion and experiment activities that engage students actively, as well as a shortage of IT-based teaching materials to support the learning process.

As a response to the problems identified in the preliminary research, one of the proposed solutions is to develop multimedia specifically designed for the concept of circular motion. An interactive multimedia tool was created, incorporating four cognitive conflict-based learning models. The third model involved the discovery of concepts and the integration of equations through a virtual laboratory, which served as an online experiment. This virtual laboratory included an experiment involving a small beetle, commonly called the beetle evolution experiment. The interactive multimedia was developed using Adobe Animate CC 2019, chosen for its compatibility with smartphones. This choice was influenced by previous research conducted by Delvia et al. (2021), which explored the design of cognitive conflict-based teaching materials integrated with virtual laboratories, explicitly focusing on the concept of atoms. Similarly, Ilahi et al. (2021) and Saputri et al. (2021) also researched the design of cognitive conflict-based teaching materials incorporating virtual laboratory integration. Yuli & Mufit (2021) also utilized the Adobe Animate CC 2019 application in their cognitive conflict-based multimedia development research.

A self-evaluation process was performed to test the interactive multimedia. The self-evaluation stage involved using a self-assessment sheet, which indicated that the interactive multimedia based on the cognitive conflict in circular motion material performed exceptionally well. This assessment was based on a thorough examination of all multimedia components. The interactive learning model created consisted of four models based on the cognitive conflict syntax applied to circular motion material. The circular motion interactive multimedia structure aligned with the guidelines for developing ICT-based teaching materials established by the (Ministry of National Education, 2010). The cognitive conflict-based learning model encompassed four syntaxes: activation of preconceptions and misconceptions, presentation of cognitive conflict, discovery of concepts and similarities, and reflection, as outlined by (Mufit & Fauzan, 2019). The virtual laboratory for the circular motion concept was integrated into three cognitive conflict-based learning models, including the ladybug evolution experiment and clear instructions written in proper Indonesian. The multimedia presentation included easily legible text, clear visuals such as pictures, illustrations, and photographs, and well-functioning navigation buttons. While references were included for image and video software, there was a lack of information on software utilization to support the creation of interactive multimedia based on cognitive conflict for the concept of circular motion. This finding aligns with the research conducted by (Hanum et al., 2020), emphasizing the need for materials designed in line with learning objectives, as well as the study conducted by (Delvia et al., 2021) on the design of conflict-based teaching materials integrated with virtual laboratories for atomic materials.

The interactive multimedia was subjected to expert review, with three physics lecturers validating the product. The expert review results classified the interactive multimedia as valid across four components: material substance, learning design, visual communication display, and software utilization. In terms of material substance, the circular motion material was deemed valid, as it adhered to the 2013 curriculum and covered the required basic competencies and indicators. The language used in the interactive multimedia mostly conformed to the General Guidelines for Indonesian Spelling (PUEBI) and was generally understandable and standard. These findings support the research conducted by Hanum et al. (2020) and Divine et al. (2021), emphasizing the importance of accurate and appropriate content.

The learning design component, the second component, yielded valid validation results. This categorization is based on several factors: the presence of an interesting title, the inclusion of the KI (Core Competencies) and KD (Basic Competencies) for circular motion in the interactive multimedia, clear learning objectives for basic circular motion and complete KD circular motion, material alignment with the purpose of circular motion learning, and the completion of the section. Furthermore, there is a stage for activating students' preconceptions and misconceptions by presenting questions and phenomena related to circular motion, such as quantities in circular motion, regular circular motion, and the relationship between wheels. This stage aims to explore students' initial knowledge and has been revised based on suggestions and input from the validator. Additionally, the interactive multimedia incorporates stages of presenting cognitive conflicts through appropriate questions and phenomena, particularly regarding the circular motion of bicycle wheels, which are presented via video. However, it is noted that the video cannot be directly played on Android devices within the interactive multimedia. The solution is to provide video links that require internet access. Although Adobe Animate CC 2019 offers advantages, it also has limitations. This stage follows the activation stage of preconceptions and misconceptions, where students form hypotheses based on the presented phenomena.

The interactive multimedia further includes stages of discovering concepts and equations. Students are guided to identify concepts and equations by utilizing the integrated virtual laboratory, which involves experiments related to circular motion. These experiments utilize both virtual and real laboratories (real lab). In the virtual lab experiment called "ladybug revolution," students are encouraged to grasp the concept of magnitude in a circular motion and explore the relationships between various quantities. Students can derive equations from understanding the concept of magnitude and its relationships. This experiment also utilizes a virtual lab access link that requires an internet connection. It should be noted that the Adobe Animate CC 2019 application is not solely an online tool, as it also necessitates an internet connection for playing videos, accessing virtual labs, and similar activities. Additionally, students engage in a direct experiment using a bicycle to investigate the relationships between concentric wheels and their connection through ropes/chains. Through this experiment, students can identify similarities based on their findings of the concepts.

This aligns with previous research conducted by Delvia et al. (2021) on the design of integrated virtual laboratory teaching materials based on conflict-based cognitive conflicts on atomic materials. It is also supported by the research conducted by Yuli & Mufit (2021) on the design of cognitive conflict-based teaching materials integrating a virtual laboratory for improving students' conceptual understanding. Similarly, Dhanil & Mufit (2021) utilized the Adobe Animate CC 2019 application to create cognitive conflict-based multimedia. The interactive multimedia includes stages of reflection and evaluation related to the circular motion material, providing feedback on understanding concepts and addressing misconceptions. This stage presents various concepts and calculations studied in the subsequent stage. The interactive multimedia also features a complete and engaging author and supervisor identity, along with quotations from other works that are properly cited and referenced.

The third component focuses on visual communication display. After revising the section, the validation results for the visual communication display fall under the valid category. The revisions ensure the interactive multimedia employs basic and effective navigation and hyperlinks. The font selection is legible, proportional, and appealing. Images, animations, videos, and sounds are appropriately used in line with the circular motion material. The color combinations on the cover and slides are harmonious and engaging. The design layouts are proportional and attractive, while the instructions for use in the interactive multimedia are clear and concise. These revisions align with the research conducted by Mufit, Asrizal, Hanum, et al. (2020), emphasizing the importance of visually appealing teaching materials to captivate users.

The fourth component pertains to the use of the software. The validation results for software utilization indicate that interactive multimedia falls within the valid category. Each stage of cognitive conflict-based learning in the circular motion material incorporates interactivity and feedback. The researcher entirely produces the interactive multimedia. However, there is a limited utilization of other supporting software in the development process of the interactive multimedia based on cognitive conflict for the circular motion material. This finding is consistent with the research conducted by Puspitasari et al. (2021), which revealed that students' low understanding of motion concepts and the occurrence of misconceptions could be attributed to the lack of interesting teaching materials, including IT-based resources. Therefore, the development of interactive multimedia products becomes essential.

The overall validity test results for the four components of interactive multimedia fall within the valid category in terms of material substance, learning design, visual communication display, and software utilization. The structure of this interactive multimedia follows the components outlined in the guidelines for developing teaching materials (Depdiknas, 2010). These components include titles, study instructions, achievable competencies, supporting information, practice questions, work procedures, and evaluations. The findings of this study also align with the research conducted by Pratama et al. (2021) on the design and validity of cognitive conflict-based interactive e-modules for the remediation of students' misconceptions. The cognitive conflict-based e-module demonstrated a valid level of validation regarding the concept of force. This aligns with previous studies conducted by Delvia et al. (2021) on developing cognitive conflict-based teaching materials for atomic materials and the research conducted by Yuli & Mufit (2021).

Based on the research conducted by Syafi'i and Nasir (2021), it can be observed that this study shares similarities with previous research. Both studies involve designing and developing multimedia materials for the concept of circular motion. However, the difference lies in the learning model used. Syafi'i and Nasir (2021) employed the ADDIE ID model, while this research utilized the cognitive conflict model. Moreover, different software applications were employed, with the researcher utilizing Adobe Animate CC software and Syafi'i & Nasir (2016) utilizing Macromedia Flash software. In Syafi'i and Nasir's (2021) research, the interactive multimedia received a valid rating in the expert review assessment, with a score of 0.76. In this research, the expert review assessment categorized the interactive multimedia as valid, although with a slightly lower score of 0.71 due to several obstacles, such as the lack of appropriate supporting software. These findings are consistent with the research conducted by Arifin et al. (2021) on the development of printed teaching materials using a cognitive conflict-based learning model for thermodynamics and wave mechanics. One notable advantage of this research is the production of electronic teaching materials that can be used on smartphones and computers.

The research conducted did not yield perfect results easily, so inputs were obtained from physics lecturers.

These inputs were in the form of expert suggestions to improve and refine the created interactive multimedia. The first validator suggested that the exploration of strategy stages should be more in-depth from the beginning. The presentation of conflict strategies should refer to the findings in the early stages. The formula for finding the formula should be more systematic and clear, and videos should be included in the media instead of using links. The second validator suggested adjusting the questions about understanding the concept to align with the indicators that have been established. Currently, the questions included in the evaluation are not in accordance with the indicators.

Based on the expert's advice, the researcher revised the interactive multimedia in the indicators and learning objectives section. Previously, the discussion on centripetal acceleration was changed to a discussion on the direction of uniform circular motion, replacing KD 4 with video-assisted experiments with real experiments or direct experiments. The introductory material was also revised, adding some pictures to enhance comprehension. The practice questions were revised to incorporate the four syntaxes of cognitive conflict models and improvements made in the video section.

Conclusions

Interactive multimedia based on cognitive conflict has been developed for circular motion. The interactive multimedia possesses characteristics created using the Adobe Animate CC 2019 application and is based on the four syntaxes of cognitive conflict-based learning models. These four syntaxes include 1) activation of preconceptions and misconceptions, 2) presentation of cognitive conflicts, 3) discovery of concepts and similarities, and 4) reflection. In the third syntax, the cognitive conflict-based learning model integrates a virtual laboratory titled "Ladybug Revolution," which allows users to explore concepts and equations related to the quantities of circular motion. The validation results for the interactive multimedia based on the cognitive conflict in the circular motion material fall within the valid category for the components of material substance, learning design, visual communication display, and software utilization.

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