Learning model based on discovery learning equipped with interactive multimedia teaching materials assisted by games to improve critical thinking skills of high school students

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Abstract. The low of students’ critical thinking skills has occurred as results of the teaching materials used by teachers have yet to neither accustom students to perform reasoning nor facilitate students in developing critical thinking skills. Both of these conditions can be fulfilled by interactive multimedia teaching materials based on discovery learning with games. Interactive multimedia teaching materials that are developed consist of handout and students worksheet. This research is aimed to develop interactive multimedia teaching materials based on discovery learning with games in linear motion and Newton’s Laws to increase high school students’ critical thinking skills with validity, practicality, and effectiveness criteria. Research and development type with 4D model consists of four steps that are defined, design, develop, and disseminate is adopted in this research. The data types are interactive multimedia validity which is graded by validators, practicality from teacher and students, and effectiveness concerning students’ critical thinking skills after using interactive multimedia teaching materials. Research result showed that interactive multimedia teaching materials were found to be valid, practical, and effective. Furthermore, in disseminating step, the obtained result showed that interactive multimedia teaching materials were found to be effective in increasing students’ critical thinking skills. Therefore, interactive multimedia teaching materials based on discovery learning with games have fulfilled validity, practicality, and effectiveness criteria also can be used in another class.

1. Introduction
Rapid technological development at this time has affected students to experience addiction which causes them to be unable to escape for a long time from the gadgets they have. In addition, the level of needs of students towards gadgets is also higher than that of textbooks. This can be seen from the behavior of students who feel comfortable when physics textbooks are left behind. However, feel uncomfortable when their gadgets are left behind. Other evidence of student addiction to technology can be seen from the level of interest of students in the games that are quite high. This can be seen from the frequency of playing games for students outside learning hours. As many as 43% of 33 students who filled out the questionnaire said they often played games outside of learning hours. As many as 20% said they had played games outside of learning hours, 23% sometimes, and 13% very often. Based on this frequency, it can be seen that students’ free time is used more to play games
compared to learning. With the condition of these students, the goal of physics learning will be difficult to achieve.

One of the objectives of learning physics according to the 2013 curriculum is to develop reasoning in inductive and deductive analysis to solve problems [1]. Consequently, it can be seen that the 2013 curriculum emphasizes the development of critical thinking skills of students. However, the current learning conditions have not been able to achieve these goals. Learning conditions based on a questionnaire filled by 33 students of 10th grade of senior high school (SMA) Don Bosco Padang can be seen that the use of printed teaching materials dominates learning more than non-printed teaching materials. The frequency of use of printed teaching materials according to students is very frequent (51.52%). Meanwhile, most students stated that they had never used non-printed teaching materials (95.46%).

The use of printed teaching materials in learning is less able to develop critical thinking skills and students’ understanding of abstract physical concepts. The mindset of students in learning the concept of physics is less honed because the tasks in printed teaching materials are done monotonically and the limitations of the media can be incorporated into printed teaching materials. In printed teaching materials, images and graphics can only be included so that they can only improve students’ understanding of the material being studied and have not been able to exercise the ability to apply and analyze a problem using physical concepts and principles. In addition, events related to the physics concept that are studied are also only able to be displayed through images in printed teaching materials. However, students do not understand the meaning of the image displayed. In addition, the use of learning models is also not fully implemented in learning activities. Based on the opinions of students, the learning model was never applied in physics learning (44.44%). The learning model is a means of developing students’ mindset of Cognitive Conflict [3]. The steps in the learning model can familiarize students to think in harmony so that the critical thinking skills of students will also develop. With the not optimal implementation of the learning model, the development of critical thinking skills of students will also be hampered.

Low critical thinking skills of students can be seen based on the results of measurements using CCTST (California Critical Thinking Skill Test) in the city of Padang, the score of students in each indicator is only about 20-30% of the ideal score, so it can be concluded that the level of critical thinking skills of students still low for each indicator. Therefore, it needs the effort to increase students’ critical thinking skills. One method that can be used is through the discovery process.

At each step of the discovery made by students can be trained critical thinking skills indicators. Through habituation in carrying out the steps of the discovery process, students will also be accustomed to thinking critically. Therefore, learning activities are needed that guide students in discovering physical concepts and principles. One suitable learning model is discovery learning where students are asked to find physics concepts and principles independently. Discovery learning model is one of learner-centered learning so that it can help them to be more active, critical, creative, independent, and responsible for their own learning.

Discovery learning is preceded by the provision of stimulation by the teacher which is related to the physics concept that will be studied. After that students identify the problem and formulated it in the hypothesis. After that, students do data collection and processing. Then students verify the hypotheses that have been made at the beginning of learning. In the final stage of learning, students draw conclusions about the process that has been carried out by students throughout learning [2], [15]. In order for the learning process to use the discovery learning model to run smoothly, the learning strategy is equipped with interactive multimedia teaching materials equipped with games.

Interactive multimedia teaching materials are teaching materials that combine various types of media (text, images, sound, video, animation, and simulation) and their use can be controlled by students [3], [16, 17]. Interactive multimedia teaching materials developed can provide feedback to students so that they can be actively involved in learning activities. Animation and simulation are able to conclude abstract physical concepts through various phenomena and events that are close in the daily lives of students displayed in animation and simulation. In addition, videos in interactive
multimedia teaching materials can also explain physics concepts that are not understood by students, so students can understand the concept independently.

Interactive multimedia teaching materials developed in the form of handouts and student’s worksheet (LKPD). The structure of the handout consists of core competencies (KI), basic competences (KD), description of learning material, questions, and references [3]. LKPD structure consists of topics of learning, classes, semesters, learning instructions, KI, KD, indicators, learning objectives, supporting information or summary of material, tools/materials needed in learning, work steps, data tables, and tasks or discussion material [3]. Various media that have been interconnected in interactive multimedia teaching materials also work together to improve analytical, evaluation, inference, deductive, and inductive skills which are critical thinking skills indicators [4]. With the increase of the five critical thinking skills indicators, students will be accustomed and able to think critically. In addition, to increase motivation and critical thinking skills of students, interactive multimedia teaching materials are also equipped with games so that fun learning [5] and meaningful will be achieved by students. Games that will be included in this interactive multimedia teaching material are complex problem-solving simulations so that students can immediately observe the application of physical concepts and principles in daily life. In addition, interest in gadgets will also help students to focus more on learning. Thus, the use of interactive multimedia teaching materials based on discovery learning equipped with games will increase critical thinking skills, because it is able to invite students to think systematically in the process of discovering the principles and concepts of physics in real life in a fun way. In this paper, we report the effectiveness of Discovery Learning-based learning models equipped with interactive multimedia teaching materials assisted game to improve critical thinking skills of students.

2. Research Methods
The type of research conducted is research and development with the 4D development model. The 4D development model consists of four stages, i.e define, design, develop, and disseminate.

In the defined phase, there are five steps taken: front-end analysis, student analysis, task analysis, concept analysis, and formulation of learning objectives [6]. There are 3 analyzes carried out at the front-end analysis stage, namely: analysis of needs, performance, and learning difficulties [7]. Analysis of students includes critical thinking skill, motivation in learning, and students’ interest in games analyzed through questionnaires. In task analysis, the main tasks that students must master are analyzed so that students can achieve minimal competence. Furthermore, at the concept analysis stage, KI and KD analysis and learning resources were analyzed so that the distribution of material, facts, concepts, principles, and procedures for each learning material was obtained. Based on the results of task analysis and summarized concepts, learning objectives will be formulated as well as changes in behavior expected after learning with operational verbs [8].

The design phase is divided into four steps, namely: preparation of criteria for testing criteria, media selection, format selection, and initial design. Interactive multimedia teaching materials designed at this design stage are adjusted to the results obtained in the defined stage. In the development stage, the validity, practicality, and effectiveness of interactive multimedia teaching materials are tested. Validity test was carried out by four experts. Validity analysis uses the Aiken equation with valid criteria if the final result of the validity of interactive multimedia teaching materials is greater than 0.6 and is invalid if it is smaller than 0.6 [9]. Practicality tests are carried out through questionnaire responses from teachers and students. Interactive multimedia teaching materials are declared practical if they are in the practical and very practical category.

The effectiveness test is done through essay questions where the answers of students are assessed using the critical thinking skill’s assessment rubric. After that, a graph will be prepared that contains the critical thinking skill of students on the fourth meeting using interactive multimedia teaching materials. Interactive multimedia teaching materials are declared effective if the graph of critical thinking skills achievement of students has increased from the first meeting to the fourth meeting.
After obtaining a valid, practical and effective interactive multimedia teaching material, the development continues to the disseminated stage. The disseminated stage is carried out by socializing teaching materials through limited distribution to teachers and students. This distribution is intended to obtain responses and feedback on the teaching materials that have been developed.

3. Results and Discussion

The research results obtained at the SKL analysis stage at the front-end analysis stage were 56.06% of students having low scientific abilities due to the teacher not optimizing the use of scientific approaches and learning models. Furthermore, the inductive and deductive abilities of students are also not high. Because inductive and deductive are included in critical thinking skills indicators, it can be concluded that critical thinking skills of students still need to be improved. Therefore, it can be concluded that students need learning to use discovery learning steps that familiarize students in using scientific methods in the discovery process. Other results obtained are the distribution of material at each meeting.

The description of learning material at each meeting consists of: irregularly changing straight motion, vertical motion, Newton's law and type of style, and Newton's second law. Based on the results of the performance analysis, it was found that the teacher had not prepared students to deal with the world of work that requires individuals who have the ability to use technology, solve problems, work together, and critically. This happens because the use of printed teaching materials still dominates and the learning steps are not optimal. Therefore, interactive multimedia teaching materials equipped with games are suitable to overcome learning problems because they are able to help familiarize students in using technology. In addition, the discovery learning step also has a regular step so that it is able to familiarize students to think scientifically. Another thing analyzed in the define stage is learning difficulties which consist of students' interests, motivation, and learning habits.

Based on the analysis of students' interests, it was found that 51.52% of students very often played games outside of class hours. In addition, as many as 57.58% of students like interactive multimedia teaching materials equipped with games. Furthermore, the analysis of students is carried out. Analysis of the characteristics of students is done to determine the critical thinking skills of students. These characteristics can be seen from the five critical thinking skills indicators, namely analysis, evaluation, inference, deductive, and inductive. Analysis of the characteristics of students using instruments in the form of questionnaires that are arranged based on grids that refers to critical thinking skills indicators. The analysis shows that students' critical thinking skills are in the range of 63-69% so it can be concluded that the critical thinking skills of students are still quite low. Students need teaching materials that can improve all indicators of critical thinking skills of students. The next analysis carried out is task analysis.

Based on the results of the analysis found that the task of working on learning activities that have been compiled in interactive multimedia teaching materials consisting of handouts, LKPD, and games contained in LKPD. Learning activities in interactive multimedia teaching materials have been adapted to the steps of discovery learning models. The tasks that must be done by students are also adapted to the physical concepts that will be studied each meeting. The final step in the define stage is the preparation of learning objectives. In order for the learning objectives to be fully achieved, learning planning is needed with making a Learning Implementation Plans (RPP). All define results are the basis for development at the design stage.

Based on the design stage, obtained results in the form of validation instruments for interactive multimedia teaching materials. Validation instruments are used to validate the interactive multimedia teaching materials developed. Other results obtained are suitable media for straight motion material and Newton's law in the form of video, animation, simulation, and games used in learning. Based on the two results of this analysis, an interactive multimedia teaching material design was created.

Interactive multimedia teaching materials based on discovery learning equipped with games designed consisting of handouts and LKPD. Making interactive multimedia teaching materials using
Macromedia Flash 8 software and Adobe Photoshop CS3. Interactive multimedia teaching materials are designed using instructions for use and navigation buttons for easy use by students.

The handout has a structure that starts from learning instructions, identity, KI, KD, indicators, learning objectives, discovery learning steps (stimulation and identification of problems), description of material, examples of questions, exercises, and references. There are four writing colors in the handout to emphasize sentences. The green color is given in the sentence in the form of additional information in using handouts. Pink is given on the question sentence and the question. Orange and bold are given to words that can be clicked to bring additional information. As for the other sentences given black.

LKPD has a structure that starts from learning instructions, identity, KI, KD, indicators, learning objectives, learning material, steps of discovery learning (data collection, data processing, verification, and generalization), and references. The way of writing in LKPD is the same as handout. When interactive multimedia teaching materials are used, it is also necessary to guide learning implementation in the form of RPP so that classroom learning activities are in accordance with the interactive multimedia teaching materials developed. In addition, to determine the level of critical thinking skills achievement of students, an assessment is carried out in the form of essay questions. Essay questions were analyzed using an assessment rubric that was compiled based on descriptors that refer to critical thinking skills indicators. After the interactive multimedia teaching materials, RPP, and assessment were completed, the research continued to the develop stage.

The initial step taken at this stage is to test the validity of interactive multimedia teaching materials that have been developed. The validity of interactive multimedia teaching materials was assessed by four lecturers, namely: one education technology lecturer, one physics lecturer, one physics education lecturer, and one language education lecturer.

Validation of interactive multimedia teaching materials consists of two parts, namely handouts and LKPD. Validation of interactive multimedia teaching materials includes components, content feasibility, construction and language. Handout and LKPD were validated by four validators where three validators validated the components, content feasibility, construction and language; while one validator specifically validates the language. The results of validation of handouts and LKPD can has been valid for all three validation criteria with validity varying from 0.83 to 0.94. Therefore, it can be concluded that interactive multimedia teaching materials are valid and can be tested in physics learning. In addition, during validation there are some suggestions given by the validator ranging from layout to language in the interactive multimedia teaching materials developed.

Validator 1 provides suggestions regarding the layout of instructional materials, namely in terms of providing spaces between paragraphs, so that teaching materials look more attractive and the location of the writing becomes more organized. In addition, validator 1 also suggests changing the background color of teaching materials. Validator 1 also provides suggestions for adjusting stimulants in the description of the material in the handout with the concept of discovery learning, so that at the end of giving stimulants, questions are given to students so that students can understand and discover the physical concepts of stimulants given.

Another suggestion given by validator 1 is to hide the answer first and only give the answer key in the sample problem in the handout, so that students will try to answer the sample questions independently in accordance with the concept of discovery learning. The answer to the example problem works so that students can check the answers made correctly or not. Validator 1 also recommends changing the cover design of handouts and LKPD. The suggestions given by validator 1 for LKPD are in the conclusions. Validator 1 suggests that the conclusions are obtained by students through the learning process in the LKPD. Based on these suggestions, the conclusions are given several questions to direct students to make conclusions in accordance with the physics material that has been studied.

Validator 2 gives suggestions to show more interactivity on the handout. Based on this suggestion, an answer box is given in the exercise section of the handout so that students can check the correctness
of their answers after completing the exercise. A dialog box will appear to state that the answers inputted by students are correct or not.

Validator 4 gives advice to pay attention to punctuation marks on the instructional material created. After valid interactive multimedia teaching materials, proceed to the trial stage. The testing phase includes practicality test and effectiveness of interactive multimedia teaching materials based on discovery learning and games developed. The trial was conducted at Don Bosco Padang High School in class X MIA 5 with a total of 31 students. The trial was conducted in four meetings where the first and second meetings were on straight motion material, while the third and fourth meetings were on Newton's law. At each meeting, practicality and effectiveness tests are carried out.

Based on the results of the teacher response questionnaire obtained practicality of interactive multimedia teaching materials is 100% for the fourth meeting. Based on the results of the questionnaire responses of students obtained the practicality of handouts increased from 67.32% to 84.88% and the practice of LKPD increased from 68% to 84.56%. Based on the results of this practicality, it can be concluded that interactive multimedia teaching materials have been practically used in physics learning.

The results of the effectiveness of interactive multimedia teaching materials are obtained from the assessment of students' essay questions for each meeting. Assessment of students' answers is based on the critical thinking skills assessment rubric which is based on critical thinking skills (CTS) indicators. The results of achieving CTS indicators of students at each meeting can be seen in Figure 1.

![Figure 1](image.png)

**Figure 1. Achievement of Critical Thinking Skills Indicators Trial Class Students**

The increase in each critical thinking skills indicator of students from the first to the fourth meeting occurs gradually in figure 1. With the increase in all critical thinking skills indicators at each meeting, it can be said that critical thinking skills of students have increased. Therefore, it can be concluded that interactive multimedia teaching materials based on discovery learning equipped with games can increase critical thinking skills of students and effectively used in physics learning with straight motion material and Newton's law. After being declared valid, practical, and effective, disseminate the interactive multimedia learning materials based on discovery learning and games. The results of disseminate can be seen in Figure 2.

Based on Figure 2, it can be seen that the increase in each critical thinking skills indicator of students from the first to the fourth meeting occurs gradually. With the increase in all critical thinking skills indicators at each meeting, it can be said that critical thinking skills of students have increased. Therefore, it can be concluded that interactive multimedia learning materials based on discovery learning are equipped with games on straight motion material and Newton's law can increase students' critical thinking skills.
Based on the results of validation of handouts, LKPD, RPP, and assessment, it can be seen that the value of validity of content and construct is almost the same, but from the aspect of language is lower. This happens due to lack of thoroughness of the author when developing interactive multimedia teaching materials. Writing errors that often occur are the lack of punctuation on interactive multimedia teaching materials and there are several foreign languages that are not translated.

At the trial stage, the practicality of the teacher and students has a considerable difference because students are less satisfied using interactive multimedia teaching materials [17]. This is because not all students can bring laptops to school so they use laptops with friends in a group. There were some students who complained and stated that he wanted to use his own laptop to be more able to use interactive multimedia teaching materials in accordance with the wishes and learning style. There are three types of learning styles namely visual, auditory, and kinesthetic [11]. When two students who have different learning styles use a laptop together, then both learners cannot learn with their respective learning styles and will cause discomfort and reduce learners’ motivation in learning. In addition to the limitations of laptops, there are also limited time during the study.

Not all media (especially video) can be learned by students in learning. Whereas in the video contains the presentation of the material and sample questions to help students in learning. This reduces the benefits of media that can clarify the presentation of messages and information so as to facilitate and improve the process and achievement of learning objectives [12]. These two things cause low practicality based on student questionnaire responses.

Critical thinking skills achievement in the trial class students at the first meeting is relatively low. This happens because new students begin to use interactive multimedia teaching materials so that they are still in doubt and confused about how to use these teaching materials. The use of interactive multimedia by students requires habituation [13]. Students are also not used to learning to use discovery learning steps so that they still need a lot of teacher guidance in learning. In addition, students are also not used to using analysis in answering essay questions.

Based on the graph of critical thinking skills achievement for students in both the trial and disseminate classes, it can be seen that for the analysis indicator, the first to third meetings increased sharply, but at the fourth meeting the increase was not sharp. This is because there are some students who are less careful in writing units when collecting information from problems (making known), while accuracy is one of the critical thinking skills standards [14]. At this fourth meeting all students have been able to make known, questioned, and conclusions well so that the achievement of inference at the fourth meeting increases sharply.

The lowest achievement of deductive indicators was at the third meeting. This happens because students still do not understand the difference between the coefficient of static and kinetic friction. The increase in the achievement of inductive indicators was also the lowest at the third meeting. This is because students have not been able to fully apply Newton's legal concept in the given problem. In the first question of the third meeting, students were asked to explain Newton's law involved when
someone punched the table. Only a few students were able to relate the three Newton's laws to the event, while others were only able to connect one or two Newton's laws.

4. Conclusion
Learning model based on Discovery Learning equipped with interactive multimedia teaching materials assisted games have been fulfilled validity, practicality, and effectiveness criteria. We found this model can increase students' critical thinking skills.

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