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# Improving the Conceptual Understanding in Kinematics Subject Matter with Hypertext Media Learning and Formal Thinking Ability

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**Abstract**

The purpose of this study was to determine the effectiveness of hypertext media based kinematic learning and formal thinking ability to improve the conceptual understanding of physic prospective students. The research design used is the one-group pretest-posttest experimental design is carried out in the research by taking 36 students on from physics education program in one Institute for teacher education in Medan, Indonesia. The samples are given kinematics conceptual understanding tests before and after the hypertext media based kinematic learning, and also the samples are given test of logical thinking (TOLT) or test of formal thinking before learning. The results show that learning outcomes is significantly improved by using hypertext media based kinematic learning.

**Keywords:** *Conceptual understanding, Hypertext media, Formal thinking ability*

## 1. Introduction

**Kinematics Conceptual Understanding**, Based on such understanding, it can be concluded that the concept is an abstraction that describes the general characteristics and an object or group of objects, processes, events and other phenomena. In line with the understanding of physics that includes the phenomenon, how to work, how to think, and how to solve the problem, it can be said that the concept of physics is an abstraction that describes the general characteristics and group events or natural phenomena obtained through the process because of curiosity to help someone solve the problem. According to Anderson & Krathwohl (2001) build knowledge is the focus of meaningful learning. Meaningful learning by Anderson & Krathwohl (2001) occurs when a person is not only able to remember all the important terms and facts, but also able to use information to solve problems and to understand new concepts. The idea to develop conceptual understanding of physics for students guided by some theoretical conceptions, namely: (1) The concept of physics is a subject that is constantly changing (Wenning & Wenning, 2006). (2) Learning physics is not about memorizing facts, it is about comprehension and mathematics (Zhaoyao, in Santyasa, 2006). (3) Learning physics requires learning to solve problems. (4) Trying to solve problems and apply knowledge meaningfully should be preceded by a positive attitude and effort to understand it. Based on the theoretical explanation, the understanding is the key to learning. Some theoretical conceptions base of conclusions are: (1) The concept of learning refers to a constructivist view, that construct understanding becomes more important than memorizing fact (Brook and Brook, in Santyasa, 2006); (2) The purpose of learning is to develop the ability to transfer, the focus is on understanding, applying, analyzing, evaluating and creating. Of the five cognitive processes, the cognitive process that rests on the ability to transfer and emphasized in schools and colleges is understood (Anderson & Krathwohl, 2001); (3) Understanding is an activity that requires thinking wise; (4) One of the goals of education is to facilitate learners to reach an understanding that can be expressed verbally, numerically, positivistic framework and the framework of life in groups; (5) The understanding is the mental process of adaptation and transformation of science (Gardner, in Santyasa, 2006); (7) The understanding is the foundation for students to build insight; (8) The understanding is an indicator of performance prepared contemplated, criticized, and used by others; (9) Understanding the raw device that reflects the program education competence; and (10) The understanding emerged from the results of the evaluation and self-reflection. Thus, understanding as a representation of the learning outcomes to be very important. According to Anderson & Krathwohl, (2001) understanding is the second level of the cognitive domain. Students said to understand when they can construct meaning from instructional messages, either orally, in writing, or graphics, which is delivered through teaching, books, or computer screen. Students understand when they establish a relationship between the new knowledge with prior knowledge.

The offering of abstract physics concept with the generalization facts requires conceptual thinking and the use of cognitive processes. Many critical problems the in science education can be traced to the inability of students to think logically in the scientific situation (Foster, 2000). Heller & Heller (2000) observed that this difficulty is due to not having the appropriate cognitive level for the purpose of understanding and application. The students' capacity to engage meaningfully in any educational tasks that require higher cognitive functions depend on several factors, including their academic potential. This can be marked by the ability or the level of academic achievement. The level means the characteristic mode functions to indicate that an individual is in a very consistent and persuasive intellectual activity. The results of a preliminary study conducted by Manurung (2010) revealed several weaknesses in learning of Basic Physics. They are: (a) the learning process can not bring the observed Physics phenomenon, (b) lack of discovery process, (c) lack or non-existance of instructional media, and (d) weak conceptual understanding. The reasons mentioned above cause difficulties for students to understand the concepts of Physics presented through graphs, particularly in the topic of Kinematics. Research conducted by Manurung (2010) showed that nearly 75 % of college students have misconceptions of Physics. They also stated that the concept of physics is abstract and difficult to understand. Therefore, students need the formal thinking ability in order to solve the problems of physics.

Formal reasoning skills a part of basic capabilities such as talent possessed by individuals that enable them to achieve a skill, knowledge and special skills. Reasoning skills greatly affect the outcome of learning physics in general, are not real need formal reasoning to understand. A student who is able to think logically in learning to understand the concepts of physics, where students are able to study the structure of science itself, then the student will not be left behind in learning. Thus meaning that, formal reasoning ability possessed by the students play an important role in the control of the physics concepts optimally. The students require formal operational thinking stage, where they can operate logically to the concepts of Physics. They should be able to solve problems of movement which is hypothetical, and perform the proportion and the conservation. Most of what is taught in Physics requires good thinking ability. Tobin and Capie (1982) found that many students consider abstract subjects such as Physics and Chemistry so difficult to learn. It is believed to be related to their cognitive development.

Students who use formal thinking ability obtain better Physics achievement compared to those who do not use it. Noting the characteristics of the stages of intellectual development proposed by Piaget (1972), abstract thinking ability is needed to absorb and develop Science (Physics) from the basic education level. Learning media is a vizualisation tool for the learning process which is often also used in the teaching of Physics. Remembering that Physics is a subject that requires conceptual understanding of with each other are hierarchically interrelated, studying Physics can be understood as an attempt to know the real life. Thus, the teaching needs to be delivered with the suitable media so that the learning objectives can be achieved.

**Kinematics with Hypertext Media Learning**, Based on the non-linear subject matter characteristics, in this study, hypertext serve to illustrate the process of thinking of student in solving ill-structured problems (weak structured). Ill-structured problems are located in different domains of knowledge, especially in its application that will typically face barriers to the achievement of the main objective, for example the ability to independently use the new learning in a situation that requires the ability to establish and build organizing knowledge. These obstacles can be overcome by shifting learning that emphasizes recitation for the utility of tests that emphasizes of memory to emphasize the argument. Such learning can improve cognitive flexibility of learners by using argumentative hypertext learning (Spiro & Jehng, 1990). Science learning takes place essentially linear, which in practice tends to make teacher or learner to deal with non-events irregular, as it is in line with the scientific perspective and the perspective of learning. Rather rare science was introduced as a building that is constructed to follow specific rules. To overcome this, the experts proposed the use of learning technologies to make the process of constructing hypertext is not rigidly follow a certain procedure (linear). Especially in order to cope with learning complex concepts, hypertext provides certain flexibility so that the difference in understanding the basic structure of the science of concepts (case to case irregularity) is not an obstacle (Spiro & Jehng, 1990).

The use of hypertext display information in science learning with flexible characteristic is a potential that needs to be explored in more depth in conveying knowledge. This effort is the latest form of inquiry-based learning. But the inquiry form is not like learning the underlying science that emphasizes hands-on (based on observation), but based on the study of Kennedy (1998) which stressed minds on (based discourse). Science education will be inadequate if using hypertext media because complex concepts can be displayed in full detail in the form of simulation and pedagogy. Seeing this potential, a number of studies on the condition and use of hypertext in teaching various scientific disciplines have been developed (Jonassen & Grabinger, 1990; Jonassen, 1997). The term of hypertext describes linkage units of electronic text that activation is in the hands (fingers) of reader. Smith *et al*, (1987) see hypertext as an approach to information management that specializes in how to store data or information in a network node (nodes) are connected to one another by a link (link). Technical description of hypertext is a bunch of new text (file) non-linear is connected to one another by a certain groove if the reader to call (clicking) the text labels (file). By clicking on a node, the reader who is at a particular node will be taken directly node is clicked. Each node can be connected following various channels as well as a network, not like the text in the book that only offer a particular reading of the groove. Hypertext has the ability to generate an extraordinary amount of information, with each node has dual relationship (as it can be accessed from any node) to display a variety of forms such as text, graphics, audio, video and other data.

The essence of hypertext systems is that users are free to choose whether linearly like a traditional reading text books, or move freely select nodes of the information provided on the screen. The mean, this system allows the user to learn a topic on different levels; for the beginners, the core material is given in the form of a more intact to facilitate navigating because not have specific cognitive structures that have been established, while for advanced users, navigation can be more free in accordance with the interests and the needs and goals of access: whether a scanning (specific information in the form of data , browsing, not just information, but a segment of knowledge, and read longer with the a topic depht aim (Spiro, 1990). In developing hypertext media, researchers need to consider the epistemological foundation of the subject matter in the task of developing the argumentative discourse, one of this is subject matter pedagogy. Educational experts are now realizing that good knowledge of the subject matter and pedagogical knowledge related crucial in a teaching because it is one kondition for learning can improve student understanding (*Cochran et al,* 1993).

Hypertext navigation in the previous section was developed based on the task of building knowledge, but not involve extra-textual strategy. This strategy is cognitive character because its development is more of a thinking reader associated with reading strategies, beliefs, and the reader environment. Examples of learning environments that emphasize academic (quality of understanding) achievement of goal (getting good value, regardless of the demands of academic quality), and utility of the field (conformity with the demands of the skills with the needs of the field). The process of building the information by the reader in hypertext by Mallia (2009) as shown in Figure 1. There is a sequence of cognitive activities in accessing hypertext information as follows: stimulus-perception-understanding-retention (can be recovered or lost). The essence of the process of building a knowledge displayed on the innermost circle in which the process of building is assumed to occur through the processes of: (a) the information stored on the nodes of hypertext or information is also used to respond to these nodes (stripes thin two-way arrows), (b) the information called for processing thought to respond to information from the nodes of hypertext (outer circle labeled 'Retrieval', or information that invoked that fail to respond to the information of the nodes of hypertext and disappeared beyond the circle labeled 'Loss').

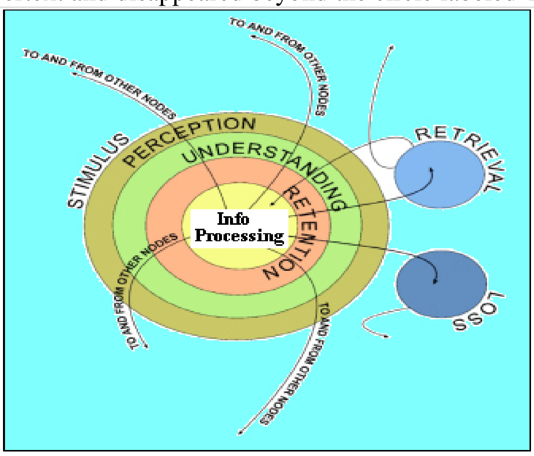


Figure 1. Hypertext information processing by the reader (Mallia, 2009) with the adaptation of the loop process of building information in the innermost circle.

## 2. Method

The method used in this study is a combined method of qualitative and quantitative methods (mixed methods). In this case, use of qualitative data to develop hypertext media in kinematics subject matter, and further implemented. Qualitative methods used in this study prior to quantitative methods. Quantitative methods used to measure the understanding of concepts and formal thinking ability. Furthermore, testing the effectiveness of media hypertext is done with pretest-posttest design. Development of hypertext media is done by using argumentative discourse based Hypertext program. Beginning with the original text quoting from a textbook entitled Fundamentals of Physics by Halliday *et al*, (2011), topics of kinematics subsequently are imparted to establish and to sharp the discourse meaning. Also from the lecturers who teach Physics in particular on the topic of kinematics Hypertext design is established from the analysis and findings at the stage of preliminary studies, literature review, and the global/macro structured. The global/macro structured is derived from three ways, namely: refinement, generalization, and construction. At first, the development of the story board of argumentative discourse and pedagogical problem solving based hypertext media is constructed. Refinement is done according to the criteria of accuracy and clarity. Clarity refers to terminology that does not exceed or reduce the text's meaning that confirms or denies the truth of phenomenon. Clarity also passes on to the using of verbal action with respect to the main predicate that controls a proposition (Siregar, 1994).

As a data collection tool, the instrument in this study consists of two parts. (1) Test of conceptual understanding, and (2) Test of Logical Thinking Test (TOLT). TOLT is originally developed by Tobin and Capie (1981). It is used to determine the formal reasoning ability of the sampled students. TOLT psychometric characteristics have been well documented by previous developers.

**Hypertext as a media of learning**, The area of application of computer-based complex information systems developed so significantly in the recent years. Information systems are no longer used only find information, but also regarded as a promising tool to aid the transfer of knowledge in the context of education and other special task. Complex information systems, such as hypertext information system, are recommended to support the learning and the domain of problem-solving process in history (Jacobson and Spiro, 1992), literature (Spiro and Jehng, 1990), and design (Case, 1990; Fischer et al, 1989). Learning situations which involve students may help in designing educational hypertext application. Designing hypertext applications must also pay regard to the features, so that the instructional goals can be achieved. Therefore, as has been noted by Duffy and Jonassen (1991), the theory of learning is mostily interrelated to the development of educational technology. However, in order to investigate the actual use of complex information systems in situations involving learning and problem solving, research in educational technology must deal with a number of issues. First, research should be directed to build the role that can be played in complex information systems of education practice in order to support specific learning and problem-solving process. Second, in the development of this system, a large portion of design decisions have been taken. This makes the predicition of the results becomes difficult because of the complexity of the learning and problem-solving process. Third, the observation of the students' actual use in educational practice, the evaluation and the assessment of the effectiveness of complex information systems raises a number of theoretical and methodological problems.

Hypertext is a method of delivering information via a computer with textual units stored at random; the line of reading follows the line desired by the reader (Siregar et al, 2009). The fundamental problem in the development of hypertext lies in how the inter-relationship of nodes are assumed to be non-linear, while the large number of random conditions may negatively affect cognitive processing. These negative effects may include disorientation and cognitive load on the user; namely, the loss of navigation and the uncertainty in determining the information nodes that must be visited. By some experts, the problem is coped with macros chunking strategy (Carter, 1997). Describing information sources using a computer-based system (ICT) can be illustrated through Figure 2. The figure shows the process of knowledge building based on the complexity of the phenomena, according to the user's navigation. Simulation provides an opportunity for the user to reconstruct the knowledge, which is needed to improve his confidence. The reconstruction ability and transfer or application of this complex concept is referred to as advanced knowledge (Spiro, et al., 1991). The complexity will be reduced through a simulative study.

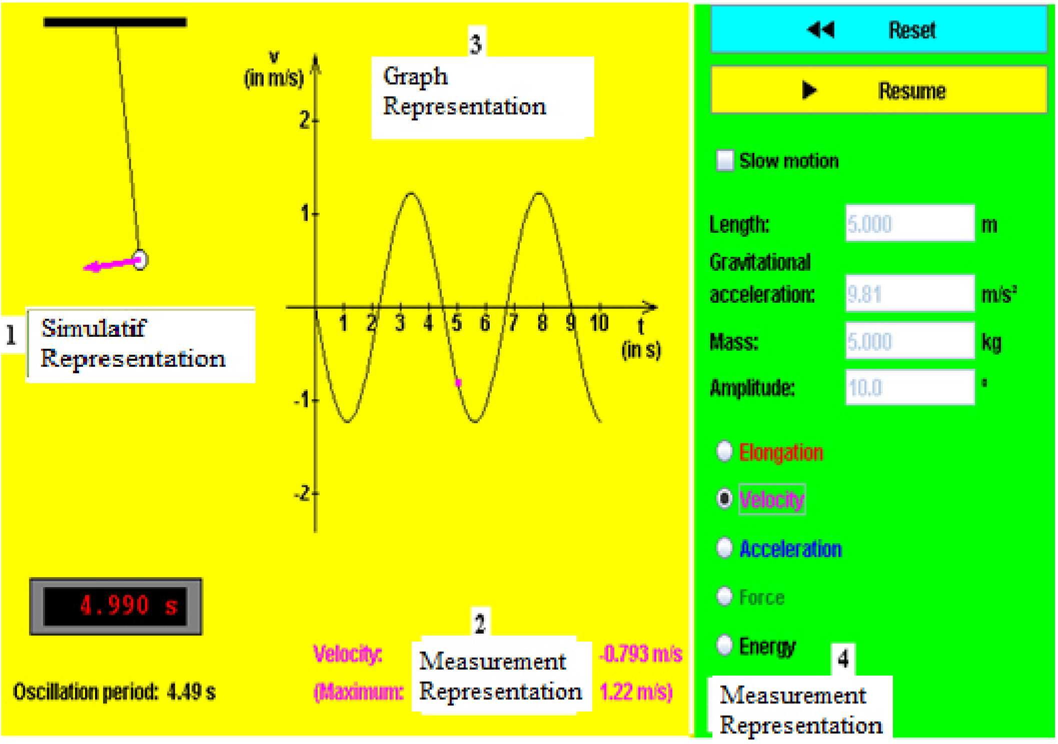


Figure 2. The phenomena of a simple pendulum according to components of knowledge representation that construct the knowledge of simple pendulum.

### 3. Result

The results of the initial study are needed to observe the initial student's ability. The results of the initial test and final test are used to quantify the increase in student results on the topic of Kinematics, which consists of 31 items. The Test of Logical Thinking (TOLT) consists of 10 items. The descriptive analysis of the instrument data is shown in Table 1.

**Tabel 1. Descriptive Statistics of the Research Data**

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Pre Learning Outcomes | 36 | 6 | 20 | 11.83 | 4.545 |
| Post Learning Outcomes | 36 | 12 | 24 | 18.28 | 4.089 |
| Formal_Thinking | 36 | 4 | 10 | 6.56 | 2.223 |

The maximum score of the formal thinking ability is 10, the minimum score is 4, with a mean of 6.56 and a standard deviation of 2.22. The maximum score on the pre-learning outcome is 20, the minimum score is 6, with a mean of 11.83, and a standard deviation of 4.55. The maximum score on the post-learning outcome is 24, the minimum score is 12, with a mean of 18.28 and a standard deviation of 4.09.

**Table 2. ANOVA Test**

Conceptual Understanding

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 747.556 | 1 | 747.556 | 40.000 | .000 |
| Within Groups | 1308.222 | 70 | 18.689 | | |
| Total | 2055.778 | 71 | | | |

From Table 2 shown that the results of the data analysis on the Conceptual Understanding in process learning is F = 40.00 and Sig. = 0.000. Because the value of Sig. (0.000) < 0.05, then the conclusion are shown significant different the Conceptual Understanding Students after treatment is greater than before treatment.

**Table 3. ANOVA Test of The Conceptual Understanding with Formal Thinking Degree**

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 27.222[a] | 1 | 27.222 | 1.659 | .206 |
| Intercept | 12005.000 | 1 | 12005.000 | 731.487 | .000 |
| Degree of Formal Thinking | 27.222 | 1 | 27.222 | 1.659 | .206 |
| a. R Squared = .047 (Adjusted R Squared = .018) | | | | | |

From Table 3 shown that the results of the data analysis on the formal thinking ability group yields F = 1.659 and Sig. = 0.206. Because the value of Sig. (0.206) > 0.05, then the conclusion shown that there aren't effect of formal thinking degree to conceptual understanding Student in learning with treatment or without it.

## 4. Discussion

Hypertext media-based kinematic teaching model in the research and development is improve conceptual understanding, influence on the understanding of the kinematics student teachers can be seen through the test understanding of concepts. It is also supported by the findings of Karnasih (2008) that learning by using ICT (hypertext media) is much more effective and efficient for physics prospective students. By using hypertext media, faculty greatly helped in explaining the material being taught quickly, especially in the depiction of kinematic graphic.

David Dobrin, 1994 and Doug Brent, 1995 (in Brooks, 2002) suggests that "hypertext could be read along generic and conventional lines-just as we often read print texts-but hypertext presented considerable challenges for reading and writing in 1994 and 1995 Because it's conventions were in their infancy". Hypertext media can develop logical thinking skills and understanding of concepts that enable students acquire and apply knowledge and new skills. Analyze of corelation between logic ability and understanding of concepts is conducted to see if the student whose belongs achievements is good on logic tests to obtain good results also in conceptual understanding test. It is mean that formal thinking ability linked to how respondents understand concepts.

Based on these responses, the average 78% of the students stated hypertext display quality and completeness of its features include both categories. Students feel: 1) interested in learning model; 2) window of interface that connects the node with the link text makes it easy to navigate; 3) look attractive and readable text; 4) easy to operate program hypertext; 5) easy to understand the subject of kinematics through the program; 6) the benefits of learning a very high perceived kinematics can understand everyday physical symptoms; 7) the display picture/animation/simulation good; 8) easy to understand instructions animation and simulation; 9) simulation programs improve understanding of the graph; 10) argue very good exercise in learning programs; 11) the ability of the better argument through the program; 12) argues the benefits perceived very well in everyday life; 13) excellent learning programs improve the ability to solve problems in physics; However, the learning program with hypertext media also has its limitations, namely: (1) The model has not been able to optimally arranged improve understanding of concepts, problem solving skills, and understanding of graphics optimally for students in the category of medium and low; (2) Accessing any features in the web is still limited by the deadline that has been set so that the student category were low or inadequate time limit; (3) Feedback is given of the results of the test, is still a result of scoring total for each answer given, yet melatihkan optimal problem-solving ability. The research results show that there is an increase in learning outcomes for both students with high and low formal thinking ability. Bektasli, 2006, Goldberg & Anderson (1989), and Mc Dermott, *et al.* (1987) stated that ther is the contribution of the logic thinking ability to the graph interpration ability. Learning through hypertext is proposed, in which simulation of object motion is provided as a virtual laboratory. Students can be performanced measurements, observations through the phenomenon. Students are expected to solve the problem using graph representation before solving with algebraic methods. Furthermore, Creemersa & Kyriakides (2010) show that school policy on quantity of teaching are taken into account: (1) school policy on the management of teaching time (e.g. lessons start on time and finish on time; (2) there are no interruptions of lessons for staff meetings and/or for preparation of school festivals and other events; (3) policy on student and teacher absenteeism; (4) policy on homework; and (5) policy on lesson schedule and timetable infuence of student learning outcomes in mathematics, language, and religious education.

## 5. Conclusion

Based on the results of research and discussion concluded that: The results show that learning outcomes is significantly improved by using hypertext media based kinematic learning. Students can be performanced measurements, observations through the phenomenon. Students are expected to solve the problem using graph representation before solving with algebraic methods.

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