DEVELOPING OF CONCEPTUAL CHANGE TEXTS (CCTs) BASED ON CONCEPTUAL CHANGE MODEL TO INCREASE STUDENTS' CONCEPTUAL UNDERSTANDING AND REMEDIATE MISCONCEPTIONS INKINEMATICS

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Abstract

The main objectives of this research are to develop a valid and practical Conceptual Change Texts (CCTs) material related to Newtonian Mechanics and to test the influence of the CCTs in order to increase students' conceptual understanding and overcome their misconceptions in the relevant topics. The research is divided in to two years comprising of three steps, namely 1) preliminary study, 2) design development, and 3) product testing. This article reports some result of the first year research for kinematics materials. The method for the first and the second steps are descriptive qualitative and development research, respectively. Based on the analysis of the preliminary data it is found the weakness of the basic and standard competencies for Newtonian Mechanics materials in Basic Physics 1 course and it has been changed from 7 to 9 standard competencies. It was also arranged essential material and found 9 common misconceptions in kinematics, namely velocity and acceleration are considered equal, position and velocity are considered equal, velocity is not as vector quantity, ego-centered reference frame, heavier objects fall faster, gravity increase as an object falls, acceleration differs along the trajectory of a projectile motion, an object thrown vertically upward from a linier moving object will land behind this moving object, and a bullet will not hit a target if the target falls downat the same time the bullet is fired. These findings are basis to develop the CCTs. It is developing the CCTs for kinematics comprises of: case, question(s), space to answer and reason, kinds of misconceptions, and explanation of the right concepts. The CCTs in turn can be utilized to improve learners' conceptual understandings and to remediate their misconceptions toward the truer concepts in the Kinematics topics.

Keywords: Conceptual Change Texts, misconception, Kinematics.

1. Introduction

Learners come to physics classrooms with their own concepts and not necessary whether their concepts are correct or not. Their conceptions are constructed based on their own experiences from the beginning of their life, which may be include observation, perception, culture, langguage, prior teachers' explanation, and prior instructional materials (Lin, 2004). Constructivism believes that people construct their understanding about nature based on their interaction with other objects or what they look in daily activities. The restriction of human senses and reasoning cause people construct different conceptions and it may differ from what the true conception is. Through experience, students develop explanations for what they know; some of these explanations may be incorrect or naive, but nevertheless they form the basis for the foundation of their knowledge. This pre-conception is resistant to change. Moreover, the conception will influence in acquisition for the next concept. Students' prior conceptions have a substantial influence on their future learning, in terms of both conceptual accumulation and conceptual change (Tomita, 2009).

Misconception phenomena are commonly in science such as in physics, astronomy, biology, chemistry, and earth science. A number of alternative conceptions appear across a wide variety of culture, countries, and ages (Grayson, 2004). In a variety of science topics, a growing number of studies have shown that students from different ages have a wide spectrum of alternative (Yürük, 2007). Research has shown that the same misconceptions are held by students from different countries and cultures. For instance, Bayraktar (2009) Studied comparing different cultures from different countries as to misconceptions of studentsabout various topics of physics suggest that they are universal in nature. It can happen to all level of students from elementary school to university, it is known that students of all ages (elementary, secondary, and undergraduate) can have alternative conceptions in all areas of science (Pinarbaşi, Canpolat, Bayrakceken, &Geban, 2006) even thought to teachers.

Kinematics is importance topics in physics. It is the main concept that students need to have an adequate understanding in order to move to next steps of physics study. It is usually given in the beginning of physics study.In Curriculum of Physics Education Department of Faculty of Teacher Training and Education of Sriwijaya University, kinematics is firstly given in *FisikaDasar 1* (Basic Physics 1) course, in the first semester. However based on researcher observation so far, it is found that many students have serious problem with their conception in this mechanics area. Students, for example, can calculate time needed by a stone to reach the ground in free fall motion, but unfortunately they give wrong answer when they are asked how two different weigh stones released from the same height reach the ground. It is a paradox. Based on preliminary research using FCI to Physics Educational Department students enrolled in 2010, it is found that students' mean scores are 20.17% and 15.33% for regular class and for extension class respectively. It is far under Newtonian mastery threshold 85% or even for entry threshold for Newtonian physics 60% (Hestenes&Halloun, 1995).

Therefore, the efforts to improve the mastery of concepts and overcoming misconceptions held by learners need to be done. Various strategies of learning oriented to this conceptual change, such as analogies, bridging analogy, Conceptual Change Text (CCT), the substitution concept, modification of the learning cycle, Observed Predict-explain (Syuhendri, 2010) can be used. Each strategy has its advantages and limitations. The Conceptual Change Text can be used flexibly by students both in class and outside of class. The CCT also be used as a supplement teaching materials that can be read by students repeated at home.Various studies on the chemistry materials have already widely tested in various countries and get satisfactory results e.g. by Yürük (2007) for an electrochemical cell and Ozmen (2007) for chemical equilibrium. However, the CCT is still a bit used in physics learning. Based on the description above, the problem solved in this research is how to develop the CCT on topics of Kinematics that is valid and practical to improve the mastery of concepts and remediate misconceptions physics students.

2. Theoretical Backgroud

Misconception and identifying

Misconception is believed as a result of individual's long experience in his/her life influenced by word around him/her. Many researchers agree that most preconceptions emerge as a result of experience in interacting with the environment. Through continues use, this preconceptions become readily available and whenever need ready to interpret the events. So, misconceptions star being constructed from the birth and then continue developing as a result of day to day experience. In other words, misconceptions are an accumulation of individual's experience in the environment, not because of “yesterday” teaching. Furthermore, misconceptions are mostly not the fault of students themselves, nor that they learn wrongly, and no because they difficult to understand or because of difficult subject-matter, but rather they are misled by their experience that construct their conception as a result of interacting with the environment.

Whenever misconceptions want to be overcome, the first step that has to be done is to identify them. Identification of misconception and distinguishing them from a lack of knowledge is a fertile area in education research (Hasan, Bagayoko, & Kelley, 1999). However, some researchers say that an effort to identify misconception is difficult. One of the difficulties is how to differentiate between students who have misconception and students who really do not know the concepts. If researchers do not identify the misconception correctly, the researchers will not be able to overcome it. There are several ways to identify misconceptions, for instance diagnostic interview, concept mapping, class discussion, question-answer practicum, essay test, multiple choice test with reasoning. In addition, there are other ways that also can be used to identify the misconception, such as 1) giving diagnostic test in the beginning or in the end of learning process. The diagnostic test can be in terms of multiple choice or other tests such as using physical diagram, vector, or graph, and explanation in words. 2) using structure assignment such as individual or group task in the end of learning or as a homework. 3) giving open-ended questions, reverse question, and context-rich problems. 4) analyzing each step students do to solve essay physics problems. 5) giving open-ended questions to students, and 6) interviewing by using a tool such as question card.

The Model of Conceptual Change

Overcoming a misconception means a process to shift status of conception on students’ mind. That is a process of how a new conception can be replace the old one. In other words, it is a process how to change someone belief, truth, or view of point that are rooted far in his/her mind with a new paradigm. This is of course not a simple case. The science education literatures suggest that how to conceptual change takes place is not a simple thing (Baser, 2006; Pinarbaşi, Canpolat, Bayrakceken, & Geban, 2006), for instances; it is not enough to simply inform students of scientific conceptions (see e.g. Hakkarainen & Ahtee, 2006).

To discuss conceptual change it is essential to back to constructivism paradigm about how conceptions are constructed. Constructivism is a philosophy of learning founded on the premise that, by reflecting on our experiences, we construct our own understanding of the word we live in. Any discussion of conceptual change needs to consider the nature of conceptions (Treagust & Duit, 2008). Conceptual change strategies based on cognitive conflict are grounded on Piaget's notion of disequilibrium (Baser, 2006).

Jean Piaget asserted that the basic principles of cognitive development are the same as those of biological development (Wardsworth, 1984). He believed that the mind has structures such as the same way of the body does. He called this cognitive or mental structure as schema (plural: schemata) that adopts individual to and organize his//her envoronment. Schema can be simplistically thought of as *concepts*or categories (Wardsworth, 1984) stored in the mind. As an analogy, schema might be an index card in a file. These schemata continue growing and developing. It never stops changing or becoming more refined. The index cards in the file gradually growth based on time and needs.

Influenced by Piaget's work (see Hakkarainen&Ahtee, 2006; Pinarbaşi, Canpolat, Bayrakceken, & Geban, 2006; Greiffenhagen & Sheram, 2008) Posner, Strike, Hewson, & Gertzog (1982) explained a *general model of conceptual change* in learning which is largely derived from philosophy of science. They are known as initiators of *Conceptual Change Model* of learning *(CCM)* (Hewson, Beeth, & Thorley, 1998; Park, Hewson, Lemberger, & Marion, 2010). The central concepts of the CCM are status and conceptual ecology (Hewson, Beeth, & Thorley, 1998). The status is an indication of the degree to which a person knows and accepts his/her holding idea. Meanwile, conceptual ecology deals with all the knowledge that a person holds.

Posner, Strike, Hewson, & Gertzog (1982) argued that there are analogous patterns of conceptual change in science and conceptual change in learning. They stated there are two phase of conceptual change in learning such as in science. The first phase they called as assimilation, that is when students use their existing concepts to deal with new phenomena. However, if the students' current concepts are inadequate to allow them to grasp some new phenomena, then the students must replace or reorganize his central concept. This second phase of conceptual change they called as accomodation, a radical form of conceptual change. Nevertheless, Posner, Strike, Hewson, & Gertzog (1982) only focus their work on the kinds of radical conceptual change, i.e. accomodation. They didn't discuss and no more information about assimilation. What happen? Indeed, Wardsworth (1984) stated that assimilation does not change the schemata, it places new stimulus events into existing schemata.

Posner, Strike, Hewson, & Gertzog (1982) expressed their theory about accomodation under two questions, (1) what condistions does central concept come to be replace by another? and (2) what are features of conceptual ecology which govern the selection of new concpts? The CCM assumes that learning is a rational process in which lerners use their existing knowledge (their conceptual ecology) to evaluate the status of new information and experiences, relative to the status of their existing knowledge (Park, Hewson, Lemberger, &Marion, 2010). Answering two questions above, Posner, Strike, Hewson, & Gertzog (1982) sated that there are four important conditions in order to accomodation take place. Fisrtly, the existing concepts must be dissatisfaction; students must have experiences which load them to lose faith in the ability of their current concepts to solve problems. Secondly, the new concept must be intelligible; the student must be able to understand sufficiently how experience can be structured by the new concept. Thirdly, the new concept must appear plausible; any new concept adapted must be least appear to have the ability to solve the problems generated by its predecessor. Finally, the new concept must be fruitful; it should have the capability to open up new areas of inquiry. There are five features of conceptual ecology related to the four conditions of a conceptual change above, i.e. (1) anomalies, (2) analogies and metaphors, (3) epistemological commitments, (4) metaphysical beliefs and concepts, and (5) other knowledge.

3. Method

The method of this research is education research and development). Research and development is a process to develop a product in the field of education with a validation. The study was conducted in three stages, namely 1) the preliminary stage or preparation, 2) the development stage of design, and 3) the testing phase (Nieveen&Plomp, 2007). The introductory phase is done with a qualitative descriptive approach, whereas the design development phase is in the form of validation and revision of Conceptual Change Text (CCT) of kinematics materials with expert validation and continued with limited testing. The testing phase will be done in year 2 by taking a sample of two groups to treatments with pre-test and post-test before and after treatment.

At the preliminary study stage or preparation of the research, the studies focused on: 1) the study of literature to analyze competence, essential materials, the analysis of the concepts and misconceptions experienced by respondents in Newtonian mechanics. 2) a field study to collect documents, materials, methods, media, evaluation techniques and other activities in the lecture Physics 1. 3) describe the findings of misconceptions in kinematics so far.

At the development stage design, the CCT for the material of kinematics was developed. Development begins with an analysis of the materials and concepts of Kinematics, followed by making a prototype of the CCT and then doing the next steps to gain a valid and practical CCT as recommended by Tessmer (1993).

The research was conducted in Science and Mathematics Department of Faculty of Teacher Training and Education of UniversitasSriwijaya. Subjects were student teachers who are taking courses Physics 1. The instruments used in this study are (1) Validation Expert Sheets: sheets granted to experts in order to validate the CCT products that are being developed. This sheet will be obtained from the assessment and the advice and recommendations from experts to improve the CCT, (2) Questionnaire: The questionnaire used to determine the opinions of students and lecturer about Kinematics materials supplement CCT of Kinematics materials. In accordance with the research question in Introduction session, the data was analyzed to answer the research question by a qualitative analyst of the instrument used (Sheet Validation Expert, Questionnaire) with descriptive statistical analysis. Data were obtained through a questionnaire in the form of qualitative scale is converted into a quantitative scale.

4. Result and Discussion

The study was conducted in three stages. This article reports the research activities for some activities in stages 1 and 2 for kinematics topics.Based on the analysis of the Basic Competence and Competency Standards produced some changes in the Basic Competence and Competency Standards that must be mastered by students for Newtonian mechanics materials in the Physics 1 course. The new Competency and Competency Standards also emphasis on conceptual understandings besides mastery of knowledge/decrease equations. Number of Competency Standards also changed from 5 to 7. The new Basic Competencies are 1) Mastering the basic knowledge about relationships of physics with others knowledge and the development of physics and physical science structure, quantities and units, dimensional formula, vector operations in depth, comprehensively and correctly and be able to apply them to solve simple physics problems and to study the higher physics concepts, 2) Mastering the general equation of motion of point particles and its application in a one-dimensional motion in depth, comprehensively and correctly and be able to apply it to solve simple physics problems and to study the higher physics concepts, 3) Mastering the general equation of motion of a point particle and its application in two-and three-dimensional motion in depth, comprehensively and correctly and be able to apply it to solve simple physics problems and to study the higher physics concepts, 4) Students master the basic concepts of dynamics in depth, comprehensive, and correct and be able to apply to solve simple physics problems and to study the higher physics concepts, 5) Students are able to apply the basic concepts of dynamics in depth, comprehensively, and right to solve various more complex physics cases and be able to develop it to study the higher physics concept, 6) Mastering the basic concepts of work and energy in depth, comprehensively and correctly and be able to apply it to solve simple physics problems and to study the higher physics concepts, and 7) Mastering basic concepts of linear momentum and collisions in depth, comprehensively and correctly and be able to apply them to solve simple physics problems and be able to develop it to study the higher physics concepts.

The indicators havebeen also change in the quantity from 24 items to 61 items and a change of quality from emphasis on equation mastery into conceptual mastery. As an example for Kinematics II: Motion in Two and Three Dimensions, the indicators are: 1) Describe and apply the equations of position, displacement, velocity and acceleration in two-and three-dimensional motion; 2) Formulate and apply the equations of projectile motion; 3) Explain that on the projectile motion, the horizontal and vertical motions are independent; 4) Create and interpret graphs of position, velocity, and acceleration as a function of time for projectile motion; 5) Analyze various cases of projectile motions; 6) Explain that the equations of projectile motion meets the parabolic equation; 7) Describe and derive the equations of uniform circular motion and changed uniform circular motion; 8) Distinguish radial acceleration and tangential acceleration; and 9) Describe and apply the equation for the relative motion.

Based on the analysis of the concepts obtained key concepts that must be mastered by students on Kinematics topic, namely terms of reference, position, displacement, distance traveled, time needed, average velocity, average speed, instantaneous velocity, speed, average acceleration, instantaneous acceleration, rectilinear uniform motion, uniformly accelerated motion, free fall motion, projectile motion, and relative velocity.

Furthermore, based on the study of literature from previous studies e.g. by Schoon (1995), Hestenes&Halloun (1995), Bayraktar (2009), and a preliminary study by researcher using the instrument of Indonesian version of the Force Concept Inventory (FCI)e.g.inSyuhendri&Mayanti (2013), Syuhendri, Jaafar, and Yahya (2014a), Syuhendri (2014), Syuhendri, Jaafar, and Yahya (2014b) can be recapitulated the various forms of misconceptions that commonly held by students in kinematics. The misconceptions can be seen in Table 5.1 below.

Table4.1 Recap of misconceptions on kinematics

No	Dimension	Kinds of misconceptions
	Kinematics	
1		Position and velocity are considered equal
2		Velocity and acceleration are considered
3		Velocity is not as vector quantity
4		Ego-centered reference frame
5		Heavier objects fall faster
6		Grafity increase as object falls
7		Acceleration differs along the trajectory of a projectile motion
8		An object thrown vertically upward from alinier moving object will land behind the moving object.
9		The bullet will not hit the target if the target falls when the bullet was fired.

Misconceptions found above constitute the basis for the development of Conceptual Changes Text (CCT) for Kinematics materials.

At the development of design stagewas done drafting/prototype the CCT of kinematics. The prototype was developed for the Kinematics 1: Motion in one dimension, Kinematics II: Motion in two and three dimensions. The format of the CCT is:

- Case
- Question
- The empty space for answers and reasons
- Kinds of misconceptions
- Explanation of the right concepts

Draft 1 of CCT of Kinematics was developed based on the format above. Furthermore, based on self evaluation, researcher carried out improvements to the Draft 1. Improvements regarding content, language, and lay out. The results of revision are cited as Draft 2. The example of Draft 2 of CCT can be seen as below:

The configuration of like that texts are believed successful inincreasing theconceptual understanding toward thecorrect concept. The reasons are firstly, CCTwas credible sources of information for the students. The CCT informed various alternative conceptions that some may be equal tothe students' views orin linewith their thinking. Statements of alternative conceptions that are in the CCT remind learners that their ideas are wrong. Then the argument of scientific explanation given that guarantee why the replacement concepts are correct and explain the consequences that occur if the concept is not as described make students aware that these are indeed the new correct concepts. This helped students to see the difference between alternative conceptions and scientific concepts. Secondly, the CCT are powerful tool forl argeclass sizes. Lecturer will not beable to touch more deeply every problem that exists in the mind of every student if the number of students is large and the time is limited.

The successful of CCT have been reported for examples by Özmen (2007), Palmer (2003), Hynd, Mcwhorter, Phares, and Suttles (1994), Baser and Geban (2007), and Tekkaya (2003). Palmer (2003) found that conceptual change text instruction are effective increase students' understanding of photosynthesis, human circulatory system, and ecological roles. Meanwhile, Tekkaya (2003) investigated the effectiveness of combining conceptual change texts and concept mapping strategies on students' understandings of diffusion and osmosis and reported there was a statistically significant difference between experimental and control groups after treatment. In addition, Özmen (2007) also demonstrated that conceptual change texts based instruction was more successful in remediating students' alternative conceptions about chemical equilibrium than traditional instruction.

Yürük (2007) argued that CCTs can be used effectively in both large and small classrooms to facilitate conceptual change. In addition, CCTs do not demand additional and expensive materials to be used in the instructional environment. However, Syuhendri (2010) recommended to use the CCTs for large classes that are often encountered in Indonesia with the number of students of 35 to 50 or more to cover the limitations of the interaction among teacher and students.Teachers and textbook writers can easily incorporate CCTs into the science texts or teachers can use them in a worksheet format or as supplement classroom instruction materials. Unlike to the other instructional strategies, CCTs are flexible, they can be read by the students anytime and anywhere when needed. Although the implementation of the CCTs instruction needs the intensive teacher-student interaction (Balci et al., 2006), it supports flexibility in learning process.

5. Conclusion and Remark

Based on the description above, it can be concluded that it has been successfully carried out analysis of competencies, essential materials, and the dominant misconceptions experienced by students on the kinematics materials. Then, it was obtained the revision of basic competencies and competency standards for Physics 1 course qualitatively and quantitatively. Qualitatively, it was given the emphasis on mastery of concepts in addition to mastery of content knowledge and derivation of equations. In quantitatively, it do change the number of competence standards from 5 to 7. Furthermore, it has found 9 kinds of common misconceptionsin kinematics. These misconceptionsare the basis for the development of CCT.

The CCT for Kinematics topics has started to be developed with the format: case, question, answer and reasons, kinds of misconception, and explanation of right concepts. The CCT finally can be used to improve conceptual understanding and remediation of misconceptions on the kinematics.

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