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The Development of Newtonian Mechanics Conceptual Change Texts to Overcome Students' Misconceptions

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ABSTRACT

The research aimed to develop a valid and practical Conceptual Change Texts (CCT) of Newtonian mechanics materials. The method used was educational research and development. The data were collected using questionnaires and expert validation sheets, as well as questionnaires and interviews with students. The design of the CCT was developed based on the conceptual change theory using the following format: situation, questions, space for answers and reasons, misconception forms, and correct concept explanations. There have been 21 developed units of the CCT distributed in four chapters, i.e. Basic Laws, Applications of the Basic Laws, Work and Energy, and Impulse and Momentum. The results of the data analysis revealed that the CCT had content, conformity with needs, language, presentation, and graphic feasibility levels of 70%, 40%, 80%, 90%, 87%, respectively to mean that the teaching materials were very valid. Based on the practicality test, the teaching materials were very practical, i.e. 87%. In other words, the Newtonian mechanics CCT was easy to read and understand and could be used to change misconceptions. Educators can use these supplement teaching materials in the Basic Physics courses in college and in mechanics topics in a high school.

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1. INTRODUCTION

Newtonian mechanics is one of the most important materials in physics. Almost all of the physics materials depend on Newtonian mechanics concepts. For example, the understanding of electromagnetism, thermodynamics, optics, and wave depends on the concepts of speed, velocity, acceleration, force, work and energy given in the Newtonian mechanics course. Moreover, Newtonian mechanics is also knowledge to understanding physics world that engages in real daily activities. Therefore this material is usually taught early in physics lessons.

Unfortunately, there are many misconceptions encountered by students in the Newtonian mechanics materials. For examples, Low and Wilson [1] reported that most students thought that the normal force and weight were a pair of action-reaction forces instead of the gravitational force of the Earth on the object and the gravitational force of the object on the Earth. Similarly, Zhou et al. [2] found students from all grades had trouble understanding the gravity interaction and distinguishing between balance force and interaction force. Duman et al. [3] found university students had weak understanding and ran into many misconceptions of rolling, rotational motion, and torque. Liu and Fang [4] also revealed misconceptions on their subject of force and acceleration. Ishimoto et al. [5] found students dominantly thought force proportional to velocity rather than proportional to acceleration. Poutot and Blandin [6] reported that students had misconceptions such as 1) force needs in the direction of object moving, 2) motion and mass of an object influencing its path in free fall motion, and 3) not able to distinguish acceleration, velocity, and position from each other. Syuhendri [7] also found that 86.67% respondents still hold Aristotelian conception that the heavier objects fall faster and have a strong impetus concept that "force" is necessary to keep an object moving. Furthermore, Syuhendri [8] revealed seven common misconceptions on active forces based on taxonomy of misconceptions probed by Force Concept Inventory, i.e. 1) only active objects exert forces, 2) the motion of an object representatives of active forces acting on the object, 3) no motion means no force, 4) velocity is proportional to applied force, 5) acceleration of an object implies increasing force acting on the object, 6) force causes acceleration to reach terminal velocity, and 7) active force wears out; and two misconceptions on actionreaction pairs, i.e. 1) greater mass exerts greater force, and 2) most active object produces greater force. Abundant misconceptions are found in the Newtonian mechanics materials because the concepts are directly engaged in everyday human life.

This condition is clearly unfavorable for the learning process. Ausubel [9] states that meaningful learning only occurs when the learners can integrate the new information to what she or he has already known. Therefore, the misconceptions must be overcome. The problem is that it is not easy to remediate the misconceptions. Based on my teaching experience, learners still use the old concepts that are misconceiving after they are taught the correct concepts. Thus, misconceptions are difficult to change by the traditional learning [10-13]. Therefore, special learning approach is needed to remove them. Posner et al. [14] propose a general model of conceptual change learning. They state there are four conditions that must be met in order to conceptual change take place, i.e. dissatisfaction, intelligible, plausible, and fruitful. Furthermore, they also put forward five features of conceptual ecology in selection the replacing concept, i.e. anomaly, analogy and metaphor, epistemological commitment, metaphysical belief and concept, and other knowledge. In accordance with this general model, Nussbaun & Novick [15] suggest a special instructional sequence for conceptual change, i.e. 1) a teacher should attempt to make misconceptions invisible to learners, and then, 2) the teacher exposes that such conceptions are incompatible or unable to solve the problem so that the learner becomes dissatisfied with the conceptions.

There are many strategies and methods of learning that fulfill the Posner et al's requirements that can be used to change students' conceptions such as POE (Predict-Observe-Explain), POEA (Predict-Observe-Explain-Apply), learning cycle, concept map, Conceptual Change Texts (CCT), analogy, and bridging analogy, concept substitution, refutational texts, constructive teaching, and Continuous Computer Assisted Activation (CCAA). Each strategy has its own advantages and disadvantages. There is no appropriate teaching strategy for all conditions. A strategy by using the CCT is suitable for condition in Indonesia where there are many students in a class so that it is difficult for a teacher to interact with every student to dispel every misconception. The power of the CCT is that it can be read repeatedly anytime and anywhere by learners. The use of CCT is believed to help students overcome their misconceptions and increase their conceptual understanding from non-scientific concepts to scientific concepts.

Various studies on chemistry education have proven that using CCT is an effective way to improve students' conceptual understandings. For example, Ültay et al. [16], in a quasi experimental study to see the effect of CCT in the REAC strategy, found that CCT was slightly effective in dispelling students' misconceptions in solution chemistry materials. Then, Ozkan and Selcuk [17] have also conducted a study on the topic of pressure and buoyancy in chemistry. They who involved three groups in their quasi experimental research, i.e. group 1 using CCT, group 2 using real life context-based learning, and the last group as a control group using traditional learning approach, found that the CCT group had conceptual understanding scores significantly higher than those groups of the context-based learning and the traditional learning approach. In addition, Yumuşak et al. [18] also proved that CCT and CCT with CAI (Computer-Assisted Instruction) were more successful in dispelling misconceptions than traditional teaching methods on the subject of radioactivity. Moreover, Özmen and Naseriazar [19] revealed that learning with computer simulations enriched with conceptual change texts was more effective to help students to construct chemical equilibrium concepts in their mind and overcome their misconceptions. In brief, CCT that was firstly developed by Wang and Andre [20] has become the most important tool to overcome learners' misconceptions [18] in chemistry materials.

It seems that the use of CCT to improve students' conceptual understanding and overcome their misconceptions has been successful for chemistry materials. However, it has still few been implemented for physics materials and it has not been developed in Indonesian language yet. Therefore, it could also be developed for physics materials. Furthermore, it is also necessary to develop CCT in Bahasa Indonesia for users in the Indonesian language. Moreover, the development of CCT for Newtonian mechanics materials are important in order to solve problem that is many minconceptions was found for that materials held by students in the previous study. So, increasing the mastery of the conceptual understandings of Newtoian mechanics needs to be done. Hence, this research developed Newtonian mechanic Conceptual Change Texts (NW CCT) teaching materials with the statements of the problems of how to develop a design of CCT for Newtonian mechanics material, and how to develop a valid and practical NM CCT teaching materials.

2. RESEARCH METHOD

The research used educational research and development (R&D) method. Educational research and development method is a process of developing a product in the field of education. The study was conducted in three stages, i.e 1) preliminary study, 2) design development, and 3) evaluation.

In the preliminary stage, the study focused on the analyzing of competence, essential materials, and misconceptions experienced by students in Newtonian mechanics. The data of these students' misconceptions are the basis for developing relevant CCT. Design of CCT was developed based on Posner et al's [14] theory about conceptual change interpreted in terms of format and prototype of the NM CCT. The evaluation process used in the development stage followed Tessmer's[21] formative evaluation such as in Figure 1.

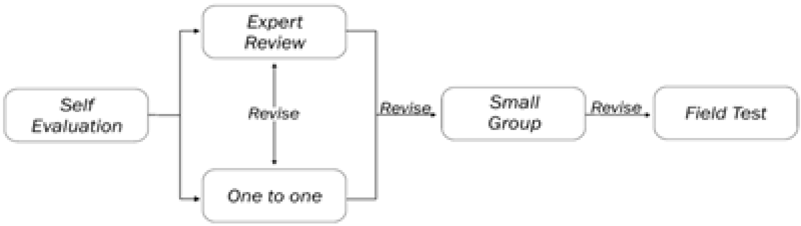

Figure 1. Formative evaluation according to Tessmer [21]

The research was conducted in Mathematics and Science Education Department, Faculty of Teacher Training and Education, Universitas Sriwijaya in 2017. The research subjects were students taking Basic Physics course. The instruments used were Experts'Validation Sheet and Questionnaires, and Students' Feedback Questionnaire and interviews. The expert validation sheets and questionnaires were instruments given to experts in order to validate the developed CCT. Based on the analysis of this sheet, some suggestions and recommendations were given by the experts to improve the CCT. The students' feedback questionnaire provided some information about the practicality of the CCT. The practicality means how easy the CCT is to read and to understand by students and whether the CCT is easy to use as its objective to change misconceptions.

The experts' validation questionnaire was in the Likert scale comprising 35 items with four choices, namely very good (score 4), good (score 3), not good (score 2), and very bad (score 1). The experts' validation questionnaire was divided into 5 aspects: content feasibility, conformity with needs, language feasibility, presentation feasibility, and graphic feasibility. This Instrument was divided into two major parts, namely part A consisting of content feasibility, conformity with needs, language feasibility, and part B consisting of presentation and graphic feasibility. Part A was used to assess each of the CCT made while Part B was used to validate the CCT as a whole. Table 1 figures out the distribution of experts' validation instruments.

Table 1. The Distribution of Experts' Validation Questionnaire

No	Aspects	Number of Items	Instrument Part	Items
1	Content Feasibility	5	Part A	1 to 5
2	Coformity with needs	14	Part A	6 to 19
3	Langguage Feasibility	6	Part A	20 to 25
4	Presentation Feasibility	6	Part B	1 to 6
5	Graphic Feasibility	4	Part B	7 to 10

The Students' Feedback Questionnaire consisted of 29 items using the Likert scale with 5 choices, i.e. strongly agree (score 5), agree (score 4), less agree (score 3), disagree (score 2), and strongly disagree (score 1). This questionnaire revealed the practicality of teaching materials being used by students in order to increase the understanding of the concepts from the non-scientific concepts to the scientific concepts and/or from misconceptions to the correct concepts.

The data were analyzed qualitatively and quantitatively. The quantitative analysis of the experts' validation and student feedback questionnaires in terms of descriptive statistics to get the mean and percentage were used to find out the validity and practicality of the CCT. The qualitative analysis was conducted based on the experts' and students' comments and interview results.

3. RESULTS AND ANALYSIS

The results of this research are design, validity, and practicality of the Newtonian mechanics Conceptual Change Texts (NM CCT). The design was based on the theory of conceptual change. The validity was done by experts to give the judgment and recommendation about the content feasibility, the conformity with the needs, the language feasibility, the presentation feasibility, and the graphic feasibility of the texts. The practicality was found out to see the readability and understandability of the texts by users and the ability of the texts to change misconceptions.

3.1. Units and Design of the Newtonian Mechanics Conceptual Change Texts

The development of NM CCT refers to form of misconceptions experienced commonly by students in Newtonian mechanics materials. The first thing to do with overcoming misconceptions was to identify them [18]. So, based on the preliminary study, there were 31 kinds of the misconceptions held by the students in Newtonian mechanics area distributed in the domains of kinematics, impetus, active forces, action-reaction pairs, influence sequences, and other forces that influence motion in sub topics of kinematics, Newton first law, Newton second law, Newton third law, superposition principles, and kinds of forces [7], [8], [22]. Based on these misconceptions, there have been developed 21 units of NM CCT as shown in Table 2.

Table 2. The Units of CCT for each Sub Topic of Newtonian Mechanics Materials

Sub Topics	Unit of CCT	
Basic Laws	1.1	Free Fall Motion
	1.2.1	Interaction between Two DifferentMass Objects
	1.2.2	Force Excerted by Two Different Velocity and Mass Objects
	1.2.3	An Object Pushs other Object that has Different Mass
	1.3	Force on Stationary Object
	1.4	Force on Moving Object
	1.5.1	Force on Moving Lift
	1.5.2	Force on a Stationary Box on the Floor
Application of The Basic Laws	2.1.1	Trajectory of an Object after the String Breaks
	2.1.2	Force on the Swing
	2.1.3	Force on a Circular Motion Object
Work and Energy	3.1	Work Done to Move an Object with Constant Velocity
	3.2	Work Done by an Object to Rotate around the Earth
	3.3	Velocity of Different Weight Objects to Slide
	3.4	Work Done to Hold the Wall
	3.5	Sliding on DifferentSlides
Impuls and Momentum	4.1	Change of Object Trajectory after Getting a Force
	4.2	An Object Thrown Upward
	4.3	The Bouncing Marbles
	4.4	Falling Objects after Passing the Highest Point
	4.5	Uniform Linear Motion Objects after Getting a Hit

The NM CCT consisted of four chapters, i.e. Basic Laws, Application of the Basic Laws, Work and Energy, as well as Impuls and Momentum. The order of the material of each chapter was based on the hierarchical of the mechanics materials and corresponded to the order of the topic in the Basic Physics course. The Applications of the Basic Laws was given after the students understood the Basic Laws well. Work and Energy materials were based on the Basic Laws of mechanics, while Impuls and Momentum depend on the mastery of the Basic Laws materials as well as Work and Energy. There were eight, three, five and five units of the CCT for the chapters of Basic Laws, Application of the Basic Laws, Work and Energy, as well as Impuls and Momentum, respectively. The number of the units of the CCT for each chapter corresponded to the common misconceptions in the chapter. Especially, for the Basic Laws chapter there were five sub-chapters, namely free fall motion, interaction forces between two objects, force on stationary object, force on moving object, and force on the object with constant speed. In these five sub-chapters, there were eight units of CCT as shown in Table 1. Chapter 1 has the most units of CCT compared to other chapters as there were also many misconceptions that need to be overcome.

The Basic Laws chapter is started with Free Fall Motion CCT. This CCT was placed at the beginning of the chapter because the misconception about speed of falling object was experienced dominantly by the students. They thought that heavy objects would always fall faster than the light ones. The studies by Hestenes et al. [23], Luangrath et al. [24] and Syuhendri [13] found out that students had misconceptions about free fall motion that heavier objects fell faster. Putting the dominant misconception at the beginning of the chapter would make the learners interested to the teaching materials. The interviews with the students revealed that they were interested in this CTT because of at the beginning they had gotten something different from what they understood. Another common misconception was the interaction between two different mass objects. The students thought that objects with bigger mass would give greater attraction force to smaller object compared to the force of smaller object to the larger one. The CCT for this case was placed in the second order of the basic law topics.

The Applications of The Basic Laws chapter began with CCT “Trajectory of an Object after the String Breaks”. This CCT related to the case of circular motion, in which many students also experienced misconception related to the force acting on a circular moving object. From the analysis of misconceptions, the students considered that centrifugal force was a defined force rather than a term used for force that had a direction away from the center of a circle. The existence of the centrifugal force away from the center of the circle lead the students to think that the object would come out of the circle if the string that bound it broke instead of moving forward in the direction of the tangent of its velocity just before the string broke. The students’ conception that an object would be thrown out was also reinforced by their experiences of riding in a car when the car turned to the left as if they were pushed to the right. This CCT was placed at the beginning of the chapter to draw the students’ attention to read the texts further. For chapters 3 and 4, because the misconception level was relatively the same, the teachers could make the order of the CCT based on the sequence of the material conveyed. In conclusion, these 21 units of the NM CCT included all the dominant misconceptions in the Newtonian mechanics materials. The developed CCT is sufficient enough for teachers to improve conceptual understanding and overcome misconceptions in Newtonian mechanics materials. However, there is an opportunity for teachers to add the CCT if necessary. The design of the NM CCT was based on Posner et al’s [14] conceptual change theory. Based on the analysis of the Posner et al’s [13] theory, steps of the development of the CCT are shown in Figure 2. The design of each unit of the CCT is described in Figure 3.

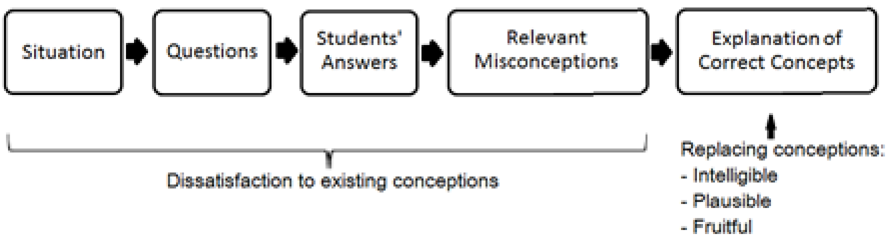

Figure 2. Steps of development of the CCT

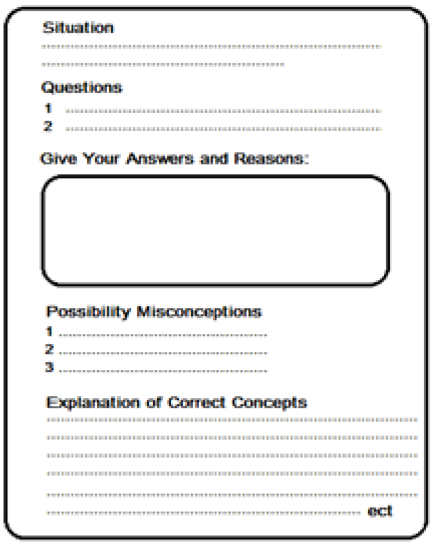

Figure 3. Design of the Developed CCT

The situation provides the context of the questions. It makes clear on what circumstances the questions are given. This clarifies the questions so that students can give the answer clearly based on their conceptual understandings. For example, in CCT 1.1 it is given the situation of "Two different heavy stones, stone **A** is much heavier than stone **B**, dropped from the same height. Think about the time they take to arrive on the ground". Providing the situation at the beginning of CCT was also done by Ültay et al. [16] in order to activate students' prior knowledge. Then the question is given based on this situation, e.g. for situation 1.1 the questions are: 1) Which stone arrives first on the ground? 2) Does the weight of the object influence the speed of the object to fall? and 3) Does the weight of the object influence the time they take to fall? After that, the students answer the questions and give their reasons in the provided spaces. In this CCT, the answers given by the students are also followed by the reasons. Disclosure of the reasons is important to see if a person holds misconception or not. Giving the wrong answer is not necessarily means that a person is experiencing misconceptions. Therefore, the reasons determine the students' way of thinking. It leads to the decision whether the students hold misconceptions or not. Then, some forms of misconceptions that are often experienced by students related to the case are given. Giving the situation up to the examples of misconceptions aims to generate students' dissatisfaction with their prior knowledge of the conceptions, which is in line with the first requirement of Posner et al's [14] theory. Finally, the CCT is followed by the explanations of the correct concepts. The scientific conceptions can replace the misconceptions if they are intelligible, plausible and fruitful by the learners[13]. Therefore, the correct concept explanations are made in such a way that the explanations are easy to understand, give rise to new beliefs, and are more powerful than the previous conceptions.

Self-evaluation and one to one evaluation were conducted as soon as Draft of NM CCT was formed. The self evaluation was conducted several times and followed by the revisions to the Draft. The revisions were made to the physics contents which were in the explanation of the correct concepts, the language aspect such as word selection, phrase and sentence writing, as well as the existing figures and graphics. Then, teaching materials were also given to some students to read. Those were carried out to get input from the students about the readability and understandability of the teaching materials, whether the teaching materials were easily readable and well understood. The students' inputs were also used to revise the CCT being developed. Based on the process, finally a better Draft of the CCT was obtained and it was ready to be tested for its validation and practicality.

3.2. The Validity of the Newtonian Mechanics Conceptual Change Texts

To validate the NM CCT, a modification instrument from the Formative Evaluation Instrument for teaching materials by Ministry of National Education (MoNE) of Indonesia [24] was created. The main difference between the MoNE's teaching materials instrument and the instrument used in this research is the existence of the items to validate the aspects related to the objective of the CCT. On one hand, the MoNE's instrument is to validate the teaching materials written by authors. On the other hand, the instrument required in this study was to validate teaching materials developed based on certain characteristics. Because the teaching materials were developed based on a certain characteristic, then in the same way this instrument had to have this certain characteristic. The characteristic in this study was the teaching materials based on the conceptual change theory in order to overcome misconceptions and to improve conceptual understanding from non-scientific conceptions to scientific conceptions. Therefore, an instrument was developed in order to be able to validate the teaching materials based on the conceptual change theory, called conformity with the aspect needs. There were 14 items related to this aspect. The modifications were made for content feasibility, language feasibility, presentation feasibility, and graphic feasibility. As a result, there were 5, 6, 6, and 4 items for content feasibility, language feasibility, presentation feasibility, and graphic feasibility respectively. The validation was conducted by two validators who were experts in physics and physics education. The result of the analysis of the validation is provided in Table 3 as follows.

The validation process was done for each of 21 units of the NM CCT. The rates shown in the Table 3 are the average rate from validator 1 and validator 2. In Table 3, all NM CCT units are very valid with the percentages of validity above 90%, except for CCT 4.1 with a validation rate of 87.5%. However, it is still in the very valid category. In CCT 4.1, it was given the situation: *"An object moves in a uniform linear motion over a flat path without friction, also ignore air friction. Suddenly, at point **B** the object gets a constant force that continues working on the object as shown in the picture"*, and the question is: *"DRAW the trajectory of the object starting from the point **B**. Give your REASONS"*. Based on the validator comment, this CCT does not clearly put the point **B**. By revising the picture, then the CCT 4.1 finally became very valid. The interesting thing is that both validators gave the maximum rates for the content feasibility aspect except for CCT 4.1. Based on the comment from validator, the problem of the CCT 4.1 was that it contained an unclear question. After the question was revised, the CCT 4.1 had high validity. Based on Table 3, the content feasibility has the highest validation rate, i.e. 3.98 and followed by language feasibility 3.93, and finally the conformity with the needs 3.90. Although the validation relating to the suitability of the CCT with conceptual change theory has the lowest rate, it is still in a very valid category. In conclusion, all CCT units are very valid for the content, conformity with the needs, and language aspects. The average rate for all of these aspects is 98.5%.

Table 3. The Results of Validity of EachUnit of Newtonian Mechanics Conceptual Change Texts

No	CCTs	Content Feasibility	Conformity with the Needs	Language Feasibility	M	M(%)	Category
1	1.1	4.00	3.95	4.00	3.98	99.6	Valid
2	1.2.1	4.00	4.00	3.90	3.97	99.2	Valid
3	1.2.2	4.00	3.85	4.00	3.95	98.8	Valid
4	1.2.3	4.00	3.85	3.90	3.92	97.9	Valid
5	1.3	4.00	3.95	4.00	3.98	99.6	Valid
6	1.4	4.00	3.90	4.00	3.97	99.2	Valid
7	1.5.1	4.00	4.00	4.00	4.00	100.0	Valid
8	1.5.2	4.00	4.00	4.00	4.00	100.0	Valid
9	2.1.1	4.00	3,90	4.00	3.97	99.2	Valid
10	2.1.2	4.00	3,50	3.50	3.67	91.7	Valid
11	2.1.3	4.00	3,90	4.00	3.97	99.2	Valid
12	3.1	4.00	4.00	4.00	4.00	100.0	Valid
13	3.2	4.00	4.00	4.00	4.00	100.0	Valid
14	3.3	4.00	4.00	4.00	4.00	100.0	Valid
15	3.4	4.00	3,90	4.00	3.97	99.2	Valid
16	3.5	4.00	3,95	4.00	3.98	99.6	Valid
17	4.1	3.50	3,50	3.50	3.50	87.5	Valid
18	4.2	4.00	4.00	4.00	4.00	100.0	Valid
19	4.3	4.00	3.85	3.90	3.92	97.9	Valid
20	4.4	4.00	4.00	4.00	4.00	100.0	Valid
21	4.5	4.00	4.00	3.90	3.97	99.2	Valid
	M	3.98	3.90	3.93	3.94	98.5	Valid

Validation for the presentation and graphic aspects was applied to the CCT as a whole textbook. The validation results for these two aspects are shown in Table 4. The results also show that CCT book is also very valid for presentation and graphic aspects. Table 3 and Table 4 conclude that the NM CCT teaching materials have high validation rates for all aspects.

Table 4. The Result of Validity of Presentation and Graphic Feasibility of NM CCT

Validator	Presentation Feasibility	Graphic Feasibility	Mean	%	Category
1	3.8	3.8			
2	4	4			
Mean	3.9	3.9	3.9	97.5	Valid

3.3. Practicallity of the Newtonian Mechanics Conceptual Change Texts

The practicality of this teaching materials was examined in small group trials. The NM CCT was given to 44 students to read and do assignments. Yürük and Eroğlu [11] propose that checking whether the developed text can be understood by students or not can be done by asking them to read it. Then they are asked to give the feedback through a questionnaire. Furthermore, interviews were conducted by taking sample consisting of 5 students. Based on the responses given by the students it seems that most students strongly agree and agree to each statement in the questionnaire. Table 5 shows the result of the questionnaire analysis for the practicality of the NM CCT.

Table 5. Practicality of Newtonian Mechancs Conceptual Change Texts

Readability	Understan-ability	Ability to Change Conceptions	N	Mean	%	Category
0.85	0.86	0.91	44	0.87	87	Practical

Table 5 shows that practicality levels of NM CCT are 0.85, 0.86. and 0.91 for readability, understandability, and ability to change misconceptions respectively. The total practicality level is 87%. Based on the analysis of the students' responses n the questionnaire, NM CCT is categorized practical. In other words, the NM CCT teaching materials are easy to read and understand by the students. Readability of teaching materials depends on whether the teaching material communicative or not and the familiarity of the user to the vocabulary used. This is influenced by text format, reader ability, vocabulary used, text structure and syntax. Accordingly, Devetak and Vogrinc [26] state that the quality of teaching materials depends on the word, sentence, and overall text used. Therefore, the students need to figure out if there are complex texts or not meaningful texts in the teaching materials [11]. The complex texts and not meaningful texts must be revised. The analysis of the student responses shows that the whole texts can be read and understood very well.

Interviews with the learners revealed that the NM CCT teaching materials were interesting to them and help them obtain the correct concepts. The teaching materials have been exposed to them that the concepts they had previously were wrong. The explanations of the correct concepts given in the teaching materials make them aware of the true concepts. Next, there are some excerpts from interviews about how students'responses to the developed NW CCT.

Student X :	*"the teaching materials is good Sir... we have already had concepts from senior and junior high school, but now [we] just know they are wrong [concepts] and [we] can get the right explanation now".*
Student Y:	*"I am more interested to read it ... [it is] easy to understand ... I can read ... [it] changes my previous concepts for example I think the heavy [object] faster fell, but it is not in this book".*

Students' interest in this kind of materials is further expressed by the student's expectation such as:

Student Z :	*: ". ... I hope [this teaching materials were] also made for other materials such as for fluids and so on... and so [it] can be marketed so that [it] can be read by other children".*

Overall, the difference between the CCT developed in this study and other CCT is that this NM CCT provides a circumstance for students to discuss and to come up with ideas about the given questions. The learners not only answered the questions but also gave reasons. There are two advantages of the reasons given by the students. First, it ascertains whether the students had truly misconception or they just could not answer the questions correctly. Not all wrong answers are categorized as misconceptions [12], but they may be caused by lack of knowledge, negligence, unlucky factors, or mis-choosing [27], [28]. Second, the reasons given can be used by a teacher to figure out what kind of way of thinking the students have so that the teacher can determine the way of teaching and learning to overcome the misconceptions. The importance of students' way of thinking relevant to the classical Ausubel's [9] dictum that the most influence factor in learning is what students already know. This second reason paves the way for the teacher to use the CCT in the beginning of the lesson to explore the students' mind and at the end of the lesson to check whether students already have the correct idea or not yet.

Furthermore, the superiority of this NM CCT is that the students not only passively read the existing misconceptions but also actively expose their conceptions. They are intellectually active and can eventually lead to cognitive conflict in their minds. The cognitive conflict that is created by asking students what will happen in a situation is the first kind of the cognitive conflict [29]. It is also what makes NM CCT attractive to the students because they see the real mistakes in their mind and get clear explanations of the correct conceptions. This way, the correct concept explanations become more memorable for them. This design differs slightly from the CCT developed by Yumuşak et al. [18]. They developed CCT comprise firstly determining the concepts of the conceptual change texts and followed by questions, common misconceptions, reasons for the misconceptions made by writer, detailed information why the misconceptions are incorrect, and scientific information about the misconceptions. They do not ask the students to express the reasons for the given answers. On the other hand, Yürük and Eroğlu [11] in general exposed the example of their CTT consisting of questions or questions and asking the reason that is followed by written scientific explanations.

4. CONCLUSION

Based on the previous results and discussions, in conclusion a set of CCT has been produced for Newtonian mechanical materials which can be used to enhance conceptual understandings and remediate misconceptions. The design of this teaching material is developed based on a conceptual change theory that explains how old concepts that are strongly embedded in the students' mind can be replaced with the new concepts. There are 21 units of NM CCT that cover the entire materials of Newtonian mechanics distributed in four chapters, namely Basic Laws, Application of the Basic Laws, Work and Energy, and Impuls and Momentum. Based on the validation process the NM CCT was very valid with an average rate of 98%. This means that the NM CCT teaching material has high feasibility, in terms of content, conformity with needs, language, presentation, and graphic feasibilities. Practicality trials also found that the teaching material can be used by students with the practical level of 87%. This means the teaching material is easy to read and understand, and can change the misconceptions to the scientific concepts.

The prospect from this research is that the NM CCT can be used by teachers in Basic Physics courses at higher educations, and mechanics materials in secondary schools, both as a reading source and worksheets which aim to improve conceptual understandings and overcome misconceptions. Moreover, this research can be used as a model for developing CCT materials for other topics. Misconceptions and low conceptual mastery in sciences are fundamental problems that have long been faced in science education in Indonesia. Therefore, it needs a serious attention from education experts to cope with this problems. Learning innovations need to be done to solve these problems such as by producing certain types of texts and developing teaching strategies. Last but not least, further research is needed to find out the effectiveness or potential effect of the use of these teaching materials in improving conceptual understandings and reducing the misconceptions.

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