Conceptual progression of K-10 student on the free-falling objects acceleration concept as an effect of E-CDCCText

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Abstract. The purpose of this study was to obtain the impact of using Electronic Conceptual Development Conceptual Change Text (E-CDCCText) related to the concept of acceleration of free-falling objects on K-10 students. E-CDCCText consists of seven parts. The third part is a conceptual development text. The fourth, fifth, and sixth parts are conceptual change text added with cognitive conflict and scientific explanation. The method used is pre-experiment with one group of three test designs. Research subjects were 32 K-10 students whose average age is 14-15 years old, consisting of 20 female and 12 male students in Yogyakarta. The research subjects were selected by random sampling techniques for the class. Data is collected based on parallel conception tests in the four-tier test format on the free-falling objects acceleration concept. These results indicate that E-CDCCText has high effectiveness in remediating misconceptions. In general, the use of E-CDCCText has been effective in facilitating the conceptual progression of students in the type of well progression (75%). The use of E-CDCCText does not cause gender bias between female and male students. E-CDCCText has been effective in facilitating the conceptual progression of female and male students in the type of well progression (75%). E-CDCCText can effectively use in conceptual development and conceptual changes activities on the free-falling objects acceleration concept.

1. Introduction
Students who entering the class to take learning activities have various conceptions [1], [2]. Some students do not have an initial conception, some students have a scientific conception, and some students experience misconceptions [2]. Learning activities are needed that can facilitate the entire diversity of students’ conceptions. Learning activities should facilitate the formation of scientific conceptions for students who do not have the initial conception. Furthermore, learning activities must also facilitate students to eliminate the misconceptions they have, and turn them into scientific conceptions. Students’ misconceptions must be eliminated so that learning goals are achieved. Misconceptions are obstacles in the learning process because misconceptions are resistant to new scientific ideas, so students can reject the scientific ideas that they will received [3], [4]. Misconceptions in students must be eliminated. Therefore, the teacher must choose the optimal model, approach, and strategy in learning activities.

According to the theory of constructivism, students can build concepts through the process of assimilation and accommodation [5]. This conception can develop simultaneously through the process of assimilation and accommodation [6]. The process of assimilation occurs when students do not have
an initial conception or have a conception that is not yet intact. The internalization of conceptions in the minds of students occurs through the process of concept development [2]. However, the process of assimilation is difficult for students who experience misconceptions. Misconceptions of students must collapse first, so students can accept the new scientific conceptions they receive. One strategy used is through a cognitive conflict strategy. Cognitive conflict strategies are applied in the conceptual change model (CCM) [1], [7]. Cognitive conflict strategy is done by confronting students' conceptions with real situations or phenomena that are contrary to the students' conceptions. These conflicting concepts cause a disequilibrium of conceptions or conceptual conflicts [8]. The situation caused the accommodation process. Internalization of conceptions that occur in the minds of students whose misconceptions are carried out through the process of changing the conception [2].

The process of conceptual development and conceptual change can be achieved through the merging of the conceptual development approach (CDA) and the conceptual change approach (CCA) [2]. A conceptual development approach is an approach that can be used for conception construction [2], [9]. Meanwhile, the conceptual change approach is an approach that is often used for conception reconstruction [2].

Text mode is often used in learning activities aimed at remediating misconceptions. The text that has been developed by several researchers to change misconceptions is called Conceptual Change Text (CCText) [3]. However, CCText only facilitates students who are misconceptions, even though students have various conceptions when entering class [1], [2]. Therefore, CCText performance will be maximized if the conceptual development text is added because the construction and reconstruction process can occur simultaneously [6]. One technique for eliminating misconceptions is done using computer-assisted learning materials [10]. Learning using computers can be supported by a variety of media such as pictures and videos [1]. The electronic text of conceptual development and conceptual change which have been developed in this research were named as Electronic Conceptual Development Conceptual Change Text (E-CDCCText).

Conceptual progression describes a sequential series of how students' conception changes in a better state as an effect of E-CDCCText. Conceptual progression can be used to describe a change of conception from the initial, process, and final states of E-CDCCText activity. Therefore, conceptual progression for teachers is useful for assessing the meaningfulness of the teaching and learning process applied, determining further action on the tendency of the development of student conceptions, and monitoring the progress of student conception during learning activities. There are four types of conceptual progression, are consistent with scientific conception, well progression, no progression, and degradation [11].

In this research, the development and testing of E-CDCCText have been carried out. E-CDCCText is designed by combining CDA and CCA in a Conceptual Change Model (CCM) that is introduced by Stepans [7] based on misconceptions that exist in students. One such misconception is related to the concept of acceleration of free-falling between two objects that have the same size, but their masses are different and dropped from the same height simultaneously [12], [13]. In such cases, many teachers report that many students state that objects with greater mass will touch the ground faster than objects with a smaller mass [14]. This research was conducted to describe the results of the development and implementation of E-CDCCText in facilitating the development and change of conceptions that occur in students related to the concept of acceleration of free-falling objects. This article reports on the process and results obtained from the research activities that have been carried out.

2. Methods

This research method is pre-experimental by one group with three tests design. The research subject was given three parallel conception tests during the E-CDCCText activity as described in Table 1.
Table 1. Research design

| Subject test | Conception test 1 | Conceptual development activities using E-CDCCText | Conception test 2 | Conceptual change activities using E-CDCCText | Conception test 3 |
|--------------|-------------------|------------------------------------------|-------------------|------------------------------------------|-------------------|
| E            | O                 | X                                        | O                 | X                                        | O                 |

Table 1 shows the research design used, in which E is an experimental group, O is a conception test related to the concept of acceleration of free-falling objects, and X is an activity of conception development and conception change using E-CDCCText that were done in three lesson hours (135 minutes). Research subjects were 32 K-10 students whose average age is 14-15 years old, consisting of 20 female and 12 male students in Yogyakarta. The research subjects were selected by random sampling techniques for the class.

The condition of the students’ conception is known based on the results of the conception test in the four-tier test format related to the concept of acceleration of free-falling objects during the students doing activities in the text part I (text of introductory and identification of the students’ initial conception), text part III (text to re-identify the state of conception), and text part VII (text to identify the state of the final conception). The state of the conception of students is categorized according to Gurel [4]. A sample of conception test used in this research is shown in Figure 1.

Tier 1
You are an astronaut assigned to carry out a space expedition to the moon. On the expedition, you are required to do a simple experiment by dropping two balls of the same height simultaneously. The two balls have the same diameter, but the masses of the two balls are different. You realize that there is no air on the moon. Before the experiment, you put forward a hypothesis about the ball when it reaches the moon surface. In your opinion, what is the hypothesis that you can propose before conducting the experiment?
A. The smaller ball whose mass will reach the surface of the moon after the ball whose mass is bigger.
B. Both balls touch the surface of the moon simultaneously.

Tier 2
Are you sure about your answer in the Tier 1 section?
A. Sure
B. Not sure

Tier 3
The explanation that matches the answer you chose in Tier 1 is:
A. The acceleration of falling of both balls depends on the mass of both balls, when both balls are dropped simultaneously, smaller balls of mass will arrive at the surface of the moon after the ball with greater mass.
B. The acceleration of falling of both balls does not depend on the mass of the two balls, therefore both balls will touch the surface of the moon simultaneously after both balls are dropped simultaneously.
C. Write your explanation according to the answer you chose in Tier 1 if you have other explanations other than the answer choices available …………………

Tier 4
Are you sure about your answer in the Tier 3 section?
A. Sure
B. Not sure

Figure 1. A sample of conception test related to the concept of acceleration of free-falling objects

Conceptual progression of students during the E-CDCCText activity is categorized in several types according to the students' conception state as in Table 2 [11].
Table 2. The types of conceptual progression

| Types of conceptual progression | The pattern of changing conception state |
|--------------------------------|----------------------------------------|
|                               | Pre-conceptions | Change to | Process | Change to | Post-conceptions |
| Consistent with scientific conceptions (CSC) | SC | → | SC | → | SC |
| Well Progression (WP) | M | → | SC | → | SC |
| | M | → | M | → | SC |
| | M | → | NC | → | SC |
| | NC | → | SC | → | SC |
| | NC | → | M | → | SC |
| | NC | → | NC | → | SC |
| No progression (NP) | NC | → | NC | → | NC |
| | M | → | M | → | M |
| Degradation (D) | SC | → | M | → | M |
| | SC | → | NC | → | M |
| | SC | → | NC | → | NC |
| | SC | → | SC | → | M |
| | SC | → | SC | → | NC |

*SC = Scientific Conception, M = Misconception, NC = No Conception

In the text part I, the students’ initial conception is diagnosed. This section presents an image of phenomena associated with the concept of acceleration of free-falling objects. Students are asked to express their conceptions, explanations, and level of confidence in the images presented. Text part II of E-CDCCText is part of conceptual development. Students are asked to observe videos and read texts related to the concept of acceleration of free-falling objects. In part III, the conception of students that has been formed is re-diagnosed. This section presents an image of phenomena associated with the concept of acceleration of free-falling objects. In part IV, a confrontation of conception is raised through pictures and videos. Students are asked to compare their previous conceptions with the real phenomena shown in pictures and videos. In part V of the E-CDCCText, a scientific explanation is presented related to the concept of acceleration of free-falling objects through text representations, mathematical equations, and videos. Interactively students are asked to study the scientific explanation of E-CDCCText until the process of accommodation of new scientific conceptions can occur. Part VI, E-CDCCText provides confirmation regarding scientific conceptions that have been accommodated by students, after the students do E-CDCCText activities. In part VII of the E-CDCCText, the students’ final conception is diagnosed. A sample of E-CDCCText is shown in Figure 2.
3. Result and Discussion

The state of students' conception is known based on the E-CDCCText activities that have been carried out in the text part I, text part III, and text part VII. The state of the conception of female students regarding the concept of acceleration of free-falling objects is shown in Table 3.

| State of the female students' conception | Student codes |
|----------------------------------------|--------------|
| Pre-conception | Process | Post-conception |
| SC          | SC       | SC              | S08, S12, S14 |
| M           | SC       | SC              | S25, S27, S29 |
| M           | M        | SC              | S02, S03, S05, S07, S13, S16, S19, S23, S30, S31 |
| NC          | SC       | SC              | S20, S32 |
| M           | M        | M               | S06 |
| NC          | NC       | NC              | S09 |

Table 3 shows the state of female student conception related to the concept of acceleration of free-falling objects. Meanwhile, the state of male student conception is shown in Table 4.

| State of the male students' conception | Student codes |
|---------------------------------------|--------------|
| Pre-conception | Process | Post-conception |
| M          | SC     | SC              | S10, S15, S21 |
| M          | M      | SC              | S11, S18, S22, S24, S26, S28 |
| NC         | NC     | NC              | S01, S04, S17 |
Based on Table 3 and Table 4, the state of the students’ conceptions is known based on the conception tests on E-CDCCText activities part I, part III, and part VII. Furthermore, it can be made a map of students’ conceptual progression during the E-CDCCText activity as shown in Figure 3.

Based on Figure 3, it appears that almost all of students (75%) achieve conceptual progression in the type of well progression. The decrease in the number of students who are misconceptions (△M), both female (F) and male (M) students are included in the high category. Thus, 85% of students who experience misconceptions related to the concept of acceleration of free-falling objects have been remediated through E-CDCCText activities. The results show that the E-CDCCText has facilitated students to achieve the conceptual progression is well progression (75%). There was no student whose conception degraded. In general, both female and male students have achieved rapid conception progress to scientific conception after E-CDCCText activity. There is no significant difference in the final conceptions achieved by female and male students. This shows that there is no gender bias. E-CDCCText has high effectiveness in facilitating the remediation of students' misconceptions related to the concept of acceleration of free-falling objects. Good conceptual progression in K-10 students during the E-CDCCText activity shows the success of conceptual development text in part II of the E-CDCCText in construct students' conceptions. The situation also shows the success of cognitive conflict strategies in part IV of the E-CDCCText in making cognitive conflict situations in the students' minds through text, images, and videos, thereby eliminating students' beliefs about the wrong conceptions they have and also construct students' beliefs in new scientific conceptions. Good conceptual progression is also supported by the success of scientific explanations in section V of the E-CDCCText in adding and strengthening new scientific conceptions formed by students. Thus, E-CDCCText is suitable for use in learning activities that are oriented to the conceptual development and conceptual changes for both female and male students. These results are in line with the results of research obtained by several previous researchers, including there is no gender bias in merging CDA and CCA to facilitating students’ conceptual progression [2], the use of visual multimedia has successfully facilitated the decrease in the
number of students’ misconception [1], [15], and the use of visual multimedia supported CCText has effectiveness in facilitating students’ learning progression [11], [16].

4. Conclusion
Based on the research data, it can be concluded that the E-CDCCText activity has high effectiveness in facilitating the conception formation and remediating misconception of both female and male students related to the concept of acceleration of free-falling objects. E-CDCCText has been effective in facilitating conceptual progression students in the type of well progression. This shows the importance of the role of E-CDCCText in facilitating the diversity of students’ conceptions. There is no gender bias in E-CDCCText. Therefore, E-CDCCText can effectively use in conceptual development and conceptual changes activities related to the concept of free-falling objects. However, it was necessary to make improvements in some parts of E-CDCCText, so that it has better potential to facilitate student’s conceptual progression. Furthermore, E-CDCCText can be developed in other physics concepts.

5. References
[1] Hermita N, Suhandi A, Syaodih E, Samsudin A, Marhadi H, Sapriadiel S, Zaenudin Z, Rochman C, Mansur M and Wibowo F C 2018 Level conceptual change pre-service elementary teachers on electric current conceptions through visual multimedia supported conceptual change in *Journal of Physics: Conference Series* p.1013
[2] Basori H, Suhandi H, Kaniaiawati I and Rusdiana D 2020 Concept progression of high school students related to the concept of parallel electric circuits as the effect of applying CCROI integrated with T-ZPD strategy *J. Phys. Conf. Ser.* p. 1521.
[3] Hynd C R 2001 Refutational texts and the change process *Int. J. Educ. Res.*
[4] Gurel D K Eryilmaz A and McDermott L C 2015 A review and comparison of diagnostic instruments to identify students’ misconceptions in science *Eurasia J. Math. Sci. Technol. Educ.*
[5] Cakir M 2008 Constructivist approaches to learning in science and their implication for science pedagogy: A literature review *Int. J. Environ. Sci. Educ.*
[6] Posner Strike G J, Ilervson K A and Gertzog W A 1982 Accomodation of a Scientific Conception: Toward a Theory of Conceptual Change *J. Sci. Educ* 66, 2 p. 211–227.
[7] Stepans S 2011 *Targeting Students’ Science Misconceptions: Using the Conceptual Change Model* MN.
[8] Piaget J 1977 *Psychology and Epistemology* (New York: The Viking Press)
[9] Koponen J T and Huttunen L 2013 Concept Development in Learning Physics: The Case of Electric Current and Voltage Revisited *Sci. Educ.*
[10] Çepni S Taş E and Köse S 2006 The effects of computer-assisted material on students’ cognitive levels, misconceptions and attitudes towards science *Comput. Educ.*
[11] Hermita N, Kurnianan O, Noviana E, Malik A, Rochman C and Suhandi A 2019 Investigating concept progression of prospective primary school teachers in indonesian *Int. J. Sci. Technol. Res.*
[12] Poutot G and Blandin B 2015 Exploration of Students’ Misconceptions in Mechanics using the FCI *Am. J. Educ. Res.*
[13] Azita Seyed Fadaei and César Mora 2015 An Investigation About Misconceptions in Force and Motion in High School *US-China Educ. Rev. A.*
[14] Crogman H Peters R and Trebeau-Crogman M 2018 Probing Students Misconceptions results from Concept Inventory and Their Understanding in Science Learning *European Journal of Physics Education*. 9, 1 p. 23-44
[15] Hermita N et al. 2018 Constructing VMMSCCText for Re-conceptualizing Students’ Conception Constructing VMMSCCText for Re-conceptualizing Students’ Conception *J. Appl. Environ. Biol. Sci.*, 8, 3 p. 102–110.
[16] Suhandi A, Hermita N, Samsudin A, Maftuh B and Coştu B 2017 Effectiveness of visual multimedia supported conceptual change texts on overcoming students’ misconception about boiling concept *Turkish Online J. Educ. Technol.* 16 p.1012-1022