The effectiveness of conceptual change texts in reducing pre-service physics teachers’ misconceptions in photoelectric effect

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Abstract. There are many misconceptions on the concept of photoelectric effect so it is important to reduce these misconceptions using conceptual change texts. In this study, the effectiveness of conceptual change texts on reducing pre-service physics teachers’ misconceptions of photoelectric effect will be explained. The conceptual change texts (CCT) are enriched by using animation, simulation video, and data from photoelectric effect experiments in modern physics laboratories. Two texts were tried out on two groups, one experimental group (n=31) and one control group (n=31). Experimental group were given CCT, whereas the control group was given text of modern physics book. Data will be collected by four-tier test and questionnaire. The result of this study will compare two texts in reducing pre-service physics teachers’ misconceptions of photoelectric effect.

1. Introduction
Understanding concept of physics is very important for pre-service physics teacher to be professional teachers who will educate students in understanding phenomena of nature in daily activities. Conceptual understanding influenced by pre-service physics teachers’ unique conception of physics concept. Misconceptions occur if pre-service physics teacher’s conception different from the scientific conception. Therefore, identification misconception and assessment of pre-service physics teachers’ misconception becomes important to be implemented in physics learning [1].

There are some reasons of misconceptions are as followed: Teachers and, environment of students, students’ insufficient prior knowledge and their misperception about concepts, teaching concepts with traditional methods and the fact that concepts used in everyday language are different in scientific language [2].

Based on the literature study it is known that there are many misconceptions in modern physics, especially on the concept of photoelectric effect so it is important to reduce the misconception on that concept [3-6]. Preliminary study results have shown that 84% pre-service physics teacher’s misconception on the concept of photoelectric effect. In addition, results of interviews with students are known that students still have difficulty in understanding the concept of photoelectric effect because they don’t interpret experimental experience in the laboratory. Another difficulty is that the language of
textbook from modern physics are not easy to understanding because that textbook only translating from foreign language. Results of other interviews with lecturers also known that there is no specific learning tool used to reduce misconceptions and that learning is not focused on the reduction misconceptions because students give presentations in groups then the discussion and concluded by the lecturers at the end of the learning.

Conceptual Change Text on Photoelectric Effect Concept (CCTPEC) can be used to reduce misconceptions on the concept of photoelectric effect by applying the Conceptual Change Model (CCM). CCTPEC is designed to identify misconceptions, refute these misconceptions and introduce a scientific conception to explain problems. Students are asked to answer about a particular situation in CCTPEC then misconceptions will be presented scientifically.

Based on the results of research on Conceptual Change Text, it is known that CCT is more effective than traditional instruction in reducing misconceptions and this strategy is more advantageous especially in large class sizes [7]. Other research has been done that CCT can help students reduce misconceptions about sound and make learners more meaningful [8]. CCT can be used in large classes in practical terms [9]. Studies suggest that CCTs are more effective in increased understanding of the nature of science by 60% by applying CCM. Another found that Computer-Assisted Instruction with CCT (CAI + CCT) was more effective in reducing misconceptions compared with traditional learning on radioactivity subjects [10]. CCT can be used to improve students' conceptual understanding and to reduce misconceptions on the topic of kinematics [11]. The results of Ozmen and Akbar's research suggest that CCT is useful for improving conceptual understanding and reducing conception alternatives to the equilibrium concept [12].

CCTPEC present many problems, simulation video, animation and experimental data so that it will attract students' attention and enrich students' understanding so that the process of changing conception will be more focused on text and video. Moreover, the concept of the photoelectric effect is chosen because CCT for the concept of photoelectric effect does not yet exist so researchers are challenged to develop CCT for the photoelectric effect as an effort that can be done to reduce misconceptions.

2. Method

This research uses mixed-methods with explanatory design. In this design, researchers do quantitative methods first and then use qualitative methods to follow up and improve quantitative findings. Two types of data were analyzed separately, with the results of qualitative analysis used by researchers to expand the results of quantitative research.

The subjects for the study consisted of 62 students (31 and 31 students) from two intact classes of a state university in Bandung. The students in both classes had similar educational and socio-economic backgrounds. One class (N=31) was assigned as experimental group (EG) and the other (N=31) was assigned as control group (CG). Experimental group were given CCTPEC, whereas the control group was give text of modern physics book but both groups applying same CCM.

The FTTEC (Four-Tier Test on Photoelectric Effect Concept) including 12 four-tier multiple choice items and questionnaire was used to find out the students' responses to CCT that have been validated by experts, were used in the study to collect data. The questionnaire was measured to represent descriptive analysis and any statistical differences between groups. The test items was analyzed using five criteria to categorize the pre-service physics teachers’ responses [13].

3. Results and discussion

Table 1 shows the results percentage pre-service physics teachers’ misconceptions which is reduced in photoelectric effect. Results show that both groups can reduce misconceptions but with different categories. CCTPEC more effective than modern physics textbooks in reducing misconceptions with high category because CCTPEC easy to understand and readable explanations. In addition, the simulation video and animation presented a microscopic video of the photoelectric effect.
In control group, textbook of modern physics used is considered still poorly understood by pre-service physics teacher because it is not focused in reducing misconceptions so that students are still misconceptions. It shown that textbook of modern physics not effective in reducing misconceptions.

Table 1. Percentage pre-service physics teachers’ misconceptions which is reduced in photoelectric effect.

| Pre-Service Physics Teachers’ Misconceptions (M)                                                                 | Control Group | Experimental Group |
|-----------------------------------------------------------------------------------------------------------------|---------------|-------------------|
| M1: Any irradiation on the metal surface will cause the photoelectrons ejected so as to produce an electric current. | 64 Medium     | 87 High            |
| M2: The photoelectron current still flows in the circuit because there is an electrical voltage even though the photon energy is smaller than the metal work function. | 67 Medium     | 79 High            |
| M3: All metals that have metal work functions will happen photoelectric effect when if irradiated with certain photon energy. | 68 Medium     | 90 High            |
| M4: Photoelectron velocity ejected from the metal surface is proportional to the wavelength of light used to irradiate the metal. | 53 Medium     | 79 High            |
| M5: The photoelectron kinetic energy does not depend on the frequencies of light that irradiate the metal.       | 57 Medium     | 86 High            |
| M6: The photoelectron kinetic energy is inversely proportional to the frequency of light in the same type of metal. | 60 Medium     | 94 High            |
| M7: The photoelectron kinetic energy is inversely proportional to the photon energy.                             | 64 Medium     | 78 High            |
| M8: The intensity of light increases then energy of photons is also increases.                                   | 46 Medium     | 93 High            |
| M9: The number of photoelectrons ejected from the metal surface does not depend on light intensity.             | 53 Medium     | 93 High            |
| M10: The intensity of light has no effect on the photoelectron current.                                          | 46 Medium     | 91 High            |
| M11: Stopping potential depends on the intensity of light used to irradiate the metal.                           | 57 Medium     | 86 High            |
| M12: Stopping potential is not affected by the magnitude of the photoelectron kinetic energy.                    | 46 Medium     | 93 High            |

Both groups tested data normality and homogeneity test then ANOVA to see average difference between two texts. ANOVA results show that F calculation result is 101.69 and F tabel is 1.60 at 5% level there was a significant difference between the two texts. It shows that CCTPEC is better than
modern physics textbooks in reducing pre-service physics teachers’ misconceptions for the concept of photoelectric effect. The results of these studies showed that teaching with conceptual change texts increases the pre-service physics teachers’ conceptual understanding about science concepts and reducing their misconceptions [14]. The results of this study are consistent with studies in the literature.

Students responded better to CCTPEC compared to modern physics textbooks. Students feel interesting reading CCTPEC and more motivated in learning. It shows that 100% of pre-service physics teachers strongly agreed with the statement expressed positive and there are no pre-service physics teachers who gave a statement to agree to a negative statement on student attitude scale sheet. Modern physics books present text only and don’t give a microscopic appearance in the photoelectric effect.

4. Conclusion
CCTPEC more effective than modern physics textbooks in reducing pre-service physics teachers’ misconceptions of photoelectric effect. CCTPEC enriched by using animation, simulation video, and data from photoelectric effect experiments in modern physics laboratories easy to understand and readable explanations.

Acknowledgments
The authors appreciate the support of the physics education majors UIN Sunan Gunung Djati Bandung and the support of the lecturers concerned in this research.

References
[1] Taslidere E 2016 “Development and use of a three-tier diagnostic test to assess high school students’ misconceptions about the photoelectric effect,” Research in Science & Technological Education p 1-23
[2] Yumuşak A, Ismail M and Mehmet S 2015 “Effects of Computer-Assisted Instruction with Conceptual Change Texts on Removing the Misconceptions of Radioactivity,” Journal for the Education of Gifted Young Scientists 3 (2) p 23-50
[3] Asikainen, Pekka E and Hirvonen 2009 “A study of pre- and inservice physics teachers’ understanding of photoelectric phenomenon as part of the development of a research-based quantum physics course,” American Journal of Physics 77 p 658-666
[4] Leone C J and Oberem 2004 “Toward understanding student Conceptions of the Photoelectric Effect,” AIP Conf Proc 720 p 85–88
[5] McKagan S B W, Handley, Perkins K K and Wieman C E 2009 “A Research-Based Curriculum for Teaching the Photoelectric Effect,” American Journal of Physics 77 (1) p 87–94
[6] Wuttiprom S, Sharma M D, Johnston I D, Chitaree R and Soankwan C 2009 “Development and use of a Conceptual survey in Introductory Quantum Physics,” International Journal of Science Education 31 (5) p 631–654
[7] Durmus and Sule 2010 “Effects of Conceptual Change Texts and Laboratory Experiments on Fourth Grade Students’ Understanding of Matter and Change Concepts,” Journal Science Education and Technology 19 p 498–504
[8] Özkam G 2013 “The use of conceptual change texts as class material in the teaching of “sound” in physics,” Asia-Pacific Forum on Science Learning and Teaching 14 (1) p 1-23
[9] Çepni S and Emine C 2015 “The effectiveness of conceptual change texts and concept clipboards in learning the nature of science,” Research in Science & Technological Education p 1-26
[10] Yumuşak A, Ismail M and Mehmet S 2015 “Effects of Computer-Assisted Instruction with Conceptual Change Texts on Removing the Misconceptions of Radioactivity,” Journal for the Education of Gifted Young Scientists 3 (2) p 23-50
[11] Syuhendri 2016 “Developing of Conceptual Change Texts (Ccts) Based on Conceptual Change Model to Increase Students’ Conceptual Understanding and Remediate Misconceptions in Kinematics,” Proceedings The 2nd Sriwijaya University Learning and Education International Conference p 1191-1205
[12] Özmen and Akbar 2017 “Effect of simulations enhanced with conceptual change texts on university students’ understanding of chemical equilibrium,” *Journal of the Serbian Chemical Society* **82** (0) p 1–16

[13] Samsudin A, Nur F A and Nugraha M G 2017 “Developing energy and momentum conceptual survey (EMCS) with four-tier diagnostic test items,” *AIP Conference Proceeding* p 1-6

[14] Arslan H O, Cigdemoglu C and Moseley C 2012 “A three-tier diagnostic test to assess pre-service teachers’ misconceptions about global warming, greenhouse effect, ozone layer depletion, and acid rain,” *International Journal of Science Education* **34** (11) p 1667-1686