Effect of physics module based on activity and conceptual change text on students’ conception of static electricity

K Suma*, I W Sadia, and N M Pujani
Ganesha University of Education, Singaraja, Bali, Indonesia

*Corresponding author: sumaketut@gmail.com

Abstract. The objective of this study is to investigate the effect of physics module based on activity and conceptual change text on students’ conception of static electricity. This study is a pre-experimental involving sixty 12-grade public senior high school students. The data on students’ conception were collected by Three Tier Static Electricity which has a reliability index of 0.61. The students’ conceptions were categorized into scientific knowledge, misconception, lack of knowledge, and error. The effectiveness of the module was measured from the significant difference in the mean level of students’ scientific knowledge, misconception, lack of knowledge, and error. The difference in mean was analyzed by t-test. The results showed that there is a significant difference between the mean level of students’ scientific knowledge, misconception, lack of knowledge, and error between pre-test and post-test. The physics module based on activity and conceptual change text is effective to improve the level of students’ scientific knowledge and reduce the level of students’ misconception, lack of knowledge, and error.

1. Introduction

Research shows that students enter physics classes, not with an empty brain. They have brought the initial conception gained from experience and previous physics lessons. Some students’ initial conceptions are in accordance with scientific concepts but some are contradictory. Students’ conceptions that are contrary to scientific concepts are labeled as: preconception [1, 2], children science [3, 4], misconception [5], naïve conception [6], and alternative conceptions [7]. This paper will use the term misconception for students' non-scientific conception. Misconceptions are resistant to change, very strong and difficult to be changed by traditional teaching [8]. The misconception is the most significant factor that contributes negatively to student academic success [9, 10].

Students’ misconceptions about physics can come from various sources such as students’ personal experience, content knowledge and language used by the teacher in the classroom, textbooks, reference books, teachers, cultural beliefs, and learning practices [11-13]. In physics learning, textbooks are essential components. Most physics textbooks are designed with text format in the form of expository text. In relation to students' conceptual change, it turns out that textbooks with expository texts are not the best texts as a means of conceptual change. Referring to the weaknesses of expository textbooks, the researchers developed text based on conceptual change. There are two types of text formats based on the conceptual change model proposed by Posner, Strike, Hewson, & Gertzog [14] namely conceptual change text and refutation text. In addition, the conceptual change texts that were developed were not packaged in a module/textbook that presented the whole teaching material in
a particular science field. Therefore, it is necessary to modify the conceptual change text by adding testing activities to students' ideas.

2. Theoretical Framework

2.1. Conceptual Change and Conceptual Change Text

According to constructivism, learning occurs when the learner actively constructs his knowledge, so that there is a conceptual change into a concept that is more detailed, complete, and in accordance with scientific concepts. According to Posner, Strike, [14] the concept change process consists of two stages. The first stage is called assimilation, where students use the concepts they already have to deal with new phenomena. The second stage is accommodation, where students change their concept which is no longer compatible with the new phenomenon they face. In order for accommodation to occur there are several conditions were needed: (1) there must be dissatisfaction with existing concepts, (2) the new concept must be understandable, rational, and can solve new problems or phenomena; (3) the new concept must be reasonable, can solve problems and answer previous problems, and be consistent with theories or knowledge that already existed before; (4) The new concept must be effective for the development of new research and discoveries.

The conceptual change text presents a scenario, forecasting questions made based on the scenario, describes misconceptions about the scenario and then provides a scientific explanation for the scenario. The text of conceptual change is an effective strategy for improving students' understanding reducing misconceptions [15-23]. Conceptual change text and refutation text as developed by [17, 23-25], not accompanied by students' concept testing activities through hands-on experiences. Therefore, Cetingül and Geban [22] suggest that the conceptual change text as a conceptual change strategy needs to be enriched with demonstration activities, laboratories, computer assistance, concept maps, and other activities. This is because active learning and teaching involve students learning more deeply and more intensively than traditional teaching [26]. Active learning methods have a positive impact on the quality of the learning process and student achievement motivation [27]. Referring to Cetingül and Gebans’ suggestion [22] an activity-based physics module and conceptual change text were developed.

2.2 Activity Based Physics Module and Conceptual Change Text

Physics module based on activity and conceptual change text in this study is modified from the conceptual change text structure developed by Ozkan and Selcuk [28]. The modification is done by adding one more part of the structure, namely the activity of testing students' ideas, after the third part (the scientific explanation section of the concept) so that the structure of the module becomes as follows. The first part contains questions to identify misconceptions experienced by students. The second part contains exposure to general misconceptions and answers that are scientifically incorrect. The third part contains activities for testing students' ideas/misconceptions stated in the first section. These activities can be in the form of experiments, demonstrations, simulations, student worksheets, and others. The fourth part contains a scientific explanation of the concepts asked in the first section. The fifth part contains statements or opinions of students about the differences between the misconceptions he experienced, the results of the test of ideas and scientific explanations obtained from reading the text in the third part and testing his ideas in the fourth part. The sixth part is the section to check the acquisition of student knowledge and drawing conclusions by the teacher. With the physics module based on activity and conceptual change text, students' knowledge is reconstructed in two ways, namely scientific explanation of direct experience.

2.3 Scientific Knowledge, Misconception, Lack of Knowledge, and Error

Using Three Tier Test, students' conceptions can be categorized into four categories namely specific knowledge, misconception, lack of knowledge, and errors. Scientific knowledge refers to the correct student response with the right reasoning and is accompanied by confidence in the response. Misconception refers to responses that are wrong and or right, explanations that are not scientific but
accompanied by confidence in the response. Lack of knowledge refers to the concept of right or wrong, right or wrong explanation, and is accompanied by uncertainty. Meanwhile, an error refers to the wrong concept, non-scientific explanation, and not sure. This categorization shows that when students incorrectly answer questions, they do not automatically experience misconceptions, but can be lack of knowledge or errors.

3. Method

3.1 Research Design

This study is a pre-experimental study with one group pre-test post-test design: O X O. A research subjects are the 12th-grade students of Senior High Schools totaling 65 students. They were given treatment in the form of teaching facilitated by physics module based on activity and conceptual change texts. The pre-test was given to the students to reveal the variety of their initial conceptions of static electricity. After eight times of teaching, they were given a post-test to reveal the changes in their conceptions of static electricity due to the treatment they received.

3.2 Instrument

The instrument used to reveal the various conceptions is the Three Tier Static Electricity Test (TTSET). This test is a multiple choice with three tiers. The first tier, in the form of ordinary multiple choice that asks students to choose one answer about a concept. The second tier, in a multiple choice form that provides a choice of scientific explanations of the answer in the first tier. The third tier is a multiple choice that asks students' confidence in the first and second tier answers. Based on variations in student responses to this TTSET, students' conceptions were categorized into four categories such as Table 1.

| Tier I | Tier II | Tier II | Conception category   |
|--------|---------|---------|-----------------------|
| True   | True    | Sure    | Scientific Knowledge (SK) |
| True   | True    | Not Sure | Lack of Knowledge (LK) |
| True   | False   | Not Sure | Lack of Knowledge (LK) |
| False  | True    | Not Sure | Lack of Knowledge (LK) |
| False  | False   | Not Sure | Lack of Knowledge (LK) |
| True   | False   | Sure    | Misconception (M)     |
| Not True | Not True | Sure    | Misconception (M)     |

3.3 Data Analysis

To describe the level of students' conception of static electricity, data were analyzed with descriptive techniques. The level of knowledge of students in each category is stated as

\[
\text{level of knowledge category} = \frac{\text{total score for each category}}{\text{number of test items}} \times 100
\]

Furthermore, the students' conception level is stated in the very high, high, medium, low, and very low qualification by using the criteria as shown in table 2. To test the different levels of student conception in each category between pre-test and post-test, the data were analyzed by a paired sample t-test at a significance level of 0.05.
Table 2. Criteria for qualification level students’ conception

| Conception Level | Qualification   |
|------------------|----------------|
| 85-100           | Very high      |
| 70-84            | High           |
| 55-69            | Medium         |
| 45-54            | Low            |
| <45              | Very low       |

4. Results and Discussion

Table 3 is a comparison of mean level of students’ conception about static electricity concepts between pre-test and post-test.

Table 3. The comparison of mean level of students’ conception

| Students’ Conception | N  | Mean  | SD  |
|----------------------|----|-------|-----|
| SK-pre               | 65 | 13.29 | 8.03|
| SK-post              | 65 | 75.20 | 16.60|
| M-pre                | 65 | 37.66 | 12.76|
| M-post               | 65 | 13.60 | 9.82 |
| LK-pre               | 65 | 35.51 | 13.59|
| LK-post              | 65 | 4.80  | 8.67 |
| E-pre                | 65 | 13.48 | 9.02 |
| E-post               | 65 | 6.34  | 6.24 |

Table 3 shows that the scientific knowledge level of students on the concepts of static electricity on before teaching (pre-test) is at a very low level and after teaching (post-test) is in the high category. There is an increase in the scientific knowledge level of 465% (almost five times). Misconceptions, lack of knowledge, and errors before and after each teaching are in the very low category. Even so, there was a decrease in the mean level of misconception about 65%, lack of knowledge about 86%, and an error of about 53%. It appears that the physics module based on activity and conceptual change text effectively increases the level of scientific knowledge and decreases the level of misconception, lack of knowledge, and student errors on static electricity concepts.

Table 4 shows a summary of the t-test results of the difference mean level of students’ conception between the pre-test and post-test.

Table 4. Summary of t-test results of the difference mean level of students’ conception

| Paired Differences | Mean  | SD    | t     | df  | Sig (p) |
|--------------------|-------|-------|-------|-----|---------|
| Pair 1 SKpost-SKpre| 61.91 | 19.57 | 25.50 | 64  | .000    |
| Pair 2 Mpost-Mpre  | -24.06| 16.47 | -11.78| 64  | .000    |
| Pair 3 LKpost-LKpre| -30.71| 16.93 | -14.62| 64  | .000    |
| Pair 4 Epost-Epre  | -7.14 | 11.46 | -5.02 | 64  | .000    |

From table 4 it appears that: t values for students' scientific knowledge differences between pots-tests and pretest are t = 25.50, p <0.05; t value for different levels of misconception is t = -11.777, p <0.05; t value for the difference in lack of knowledge level is t = -14.625; and the value for error level is t = -5.024, p <0.05. In other words, there are significant differences in students’ scientific knowledge,
misconception, lack of knowledge, and error levels between the pre-test and post-test. The scientific knowledge level rose significantly from the pretest to the posttest, while the level of misconception, lack of knowledge, and errors dropped significantly.

Physics module based on activity and conceptual change texts are one of the text-based conceptual change strategies. Thus the findings above support the claim that conceptual change strategy is one of the most effective ways to increase students' scientific knowledge. Conceptually the effectiveness of the module can be explained as follows. In this module, students are asked to express their ideas about static electricity before teaching. Their ideas are then compared to the non-scientific ideas found in the various literature. To test students' ideas, they are given the opportunity to read texts that contain scientific explanations of the concepts of static electricity. In addition, students are given the opportunity to test their ideas through activities such as conducting experiments, demonstrations, and working on non-experimental student worksheets. Through these activities, students reconstruct their prior knowledge through direct experience. Through reading and direct experience, students will feel that their non-scientific ideas are contrary to scientific concepts that are read and obtained from direct experience. Thus there is an awareness of students to change their conceptions.

The results of this study support the findings of other studies that report the effectiveness of learning facilitated by a conceptual change text to the achievement of students' conceptual understanding such as [19,20, 22, 23, 28, 31]. For example, Akpinar & Tan [29] states that the conceptual change text is more effective than traditional text in building conceptual schemes about relativity. Aydin [25] found that conceptual change text is more effective than traditional methods for teaching eliminating misconceptions of students about geometric optics. Ozkan and Selcuk [28] states that the conceptual change text is sound learning material that is very useful for lifelong learning. McKenna [30] states that conceptual change text is the best application of conceptual change models and can be used in every field of science. Cetin, Ertepinar, & Geban [19] concluded that the influence of text-based teaching conceptual change is better than traditional learning on students' understanding of ecological concepts. Ozkan and Selcuk [31] concluded that understanding experimental buoyancy style concepts are higher than that of the traditional instruction group.

5. Conclusion and Suggestion
Physics module based on activity and conceptual change texts is an effective tool to increase the level of scientific knowledge and reduce the level of misconception, lack knowledge and errors on the static electricity concepts. Therefore, the physics teachers at the school are encouraged to apply this module in teaching static electricity. This study has limitations in the research design, that is one group pre-test post-test without involving the control group. For this reason, subsequent researchers are advised to compare the physics module based on activity conceptual change texts with traditional teaching materials.

References
[1] Kelley P 2012 Sci. Scope. 35 12
[2] Turgut U, Gürbüz F and Turgut G. 2011 Procedia Soc. Behav. Sci. 15 1965
[3] Bell, B.F. 1993. Children’s Science, Constructivism, and Learning in Science (Victoria: Deakin University)
[4] Osborne R, Freyberg P, Bell B, Tasker R, Cosgrove M and Schollum B 1985 Learning in Science. The Implication of Children’s Sience (London: Heinemann)
[5] Elliot K and Pillman K 2016 Teach. Sci. 62 36
[6] Alwan A2011 Int. Conf. on Education and Educational Psychology (ICEEPSY 2010)
[7] Chhabra M and Baveja B 2012 Procedia Soc. Behav. Sci. 55 1069
[8] Tippet CD 2010 Int. J. Sci. Math. Educ. 8 951
[9] Blas TM, Seidel L and Fernandez A S 2010 Eur. J. Eng. Educ. 35 597
[10] Ozkan G and Selcuk G S 2012 J. Educ. Instr. Stud. World. 2 2146
[11] Kaltakci D and Eryilmaz A 2010. In G. Çakmakçı & M. F. Taşar (Eds.), Contemporary Science
Education Research: Learning and Assessment (Ankara, Turkey: Pegem Akademi)

[12] Gurel DK and Eryilmaz A 2013 Hacettepe Univ. J. Educ. 28 234
[13] Zajkov O, Zajkova SG, and Mitrevski B 2017 Int. J. Sci. Math. Educ. 15 837
[14] Posner G J, Strike K A, Hewson PW & Gertzog WA 1982 Sci. Educ. 66 211
[15] Yuruk N and Eroglu P 2016 J. Balt. Sci. Educ. 15 693
[16] Yalcin U 2014 Conceptual Change Text Oriented Instruction in Teaching Solution Concept (Unpublish Thesis. Middle East Technical University)

[17] Gurefe N, Yarar SH, Pazarbasi BN, Es H 2014 Int. J. Educ. Stud. Math. 1 58
[18] Sendur O and Toprak M 2013 Chem. Educ. Res. Pract. 14 431
[19] Cetin G, Ertepinar H and Geban O 2015 Educ. Res. Rev. 10 259
[20] Suma K 2016 Jurnal Pendidikan Indonesia. 5 749
[21] Broughton SH, Sinatra GM and Reynold RE 2010 The Nature of the Refutation Text Effect: an Investigation of Attention Allocation (UtahStae University. Mrril Leazier Library)

[22] Cetingul I and Geban O 2011 Hacettepe Univ. J. Educ. 41 112
[23] Aydin S 2012 J. Educ. Res. Behav. Sci. 1 001
[24] Parie Perdana G, Suma K, and Pujani NM 2017 SHS Web of Conference. 42 1
[25] Subratha I.N and Suma, K. 2015 Pengembangan Teks-Teks Sangkalan (Refutation Text) Untuk Meremidi Miskonsepsi Siswa SMA Tentang Mekanika (Bali, Indonesia: Laporan Penelitian Hibah Bersaing Tahun III) (Unpublished)

[26] Meltzer D E and Thornton R K 2012 Am. J. Phys. 80 478
[27] Soltanzadeh L, Hashemi S R N and Shahi S 2013 Arch. Appl. Sci. Res. 5 127
[28] Ozkan G and Selcuk G S 2013 Asia Pasific Forum Sci. Learn. Teach 14
[29] Akpinar M and Tan M 2011 West. Anatolia J. Educ. Sci. 139
[30] McKenna D M 2014 Using Conceptual Change Texts to Address Misconceptions in the Middle School Science Classroom (New York, US: The College at Brockport, State University of New York) (Unpublished)

[31] Ozkan G and Selcuk G S 2015 Univers. J. Educ. Res 3 981