

Turnitin Harjono Lampiran C3

by Ahmad Harjono

Submission date: 28-Nov-2020 10:37AM (UTC+0700)

Submission ID: 1458465476

File name: Turnitin Lampiran C3.pdf (1.14M)

Word count: 4590

Character count: 24857

An Interactive e-Book for Physics to Improve Students' Conceptual Mastery

<https://doi.org/10.3991/ijet.v15i05.10967>

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Abstract—Rotational dynamics is one of topic in physics for high school students that require visualization of its concepts. This research developed an interactive e-book for physics learning with its features consisting of multimedia content such as audio, video, animation, and simple problem-solving activities. This e-book has been validated and recommended by a team of experts. This trial aims to determine the effectiveness of e-book by students in mastering concepts, using a quasi-experiment. The sample was chosen using purposive sampling technique at senior high school with 42 students. Data were collected using multiple choice questions. The increase of student concept mastery is determined based on the N-gain score of pretest and posttest data. The results show that the average student response to e-book is 81% in the very good criterion. The N-gain scores for the equilibrium concepts of A and B classes are 0.79 and 0.70 in the high criteria, while, the concept of rotational dynamics are 0.66 and 0.66 respectively and in the medium criterion. The increase of conceptual mastery occurs in every cognitive domain (remembering, understanding, applying, analyzing, evaluating, and creating). In conclusion, the e-book has been effective in enhancing the mastery of student concepts.

Keywords—Interactive e-book, rotational dynamics, conceptual mastery

1 Introduction

The e-book is a digital version of the traditional printed book read on a personal or desktop computers, laptops, smartphones, tablets, or e-book readers [1]. Therefore, the Indonesian government, through the Ministry of Education and Culture, has provided e-books for schools which are accessible online in PDF format (Portable Display Format).

E-book PDFs are designed like a printed book and cause significant eye effect [2], such as dry eyes, ocular discomfort, headache, and other visual symptoms [3]. Users

tend to read quickly to obtain main points. However, this is not optimally utilized because limited learning message is acquired, and the concept is not fully conveyed.

Lately, e-books have been designed with more interactive features such as audio, video, slideshows, and image galleries [4]. In addition, there are multimedia which links manually users [5]. There are also variables in the interactive e-book diagrams, symbols, signs, shapes, and tools which supports thinking skills [6].

Concepts are defined as abstractions of various events, objects, phenomena, and facts comprising of special attributes. Generalization helps to classify and organize knowledge and experience [7]. The concept marks on an object which helps students to understand and directly visualize the abstract models through a real laboratory [8]. Similarly, the virtual labs are an alternative to physics experiments and help visualize abstract concepts such as 'Rotational Dynamics [9]. Previous research has shown that the level of 'conceptual mastery' of students on the subject of Rotational Dynamics is low. There is a fundamental error [10] and high misconception [11]. This problem is solved by developing teaching materials such as e-books with variety of benefits such as improving motivation for beginner readers [12], enhancing children's understanding and literacy [13] and enabling parents and teachers to provide an efficient and enjoyable learning experience [14].

This type of media also provides an opportunity to develop conceptual mastery in any physics matters. Hermansyah et al. [15] stated that virtual labs could improve students' understanding of heat concept. Gunawan et al. [16] also found that interactive simulation could improve students' conceptual understanding universally in physics learning. Both e-book and virtual lab are computer-based media, which helps students increase their conceptual mastery, of physics and other courses. The teaching material that has been developed is an interactive e-book on physics learning. Its content is 'Rotational Dynamics' which has been designed using Adobe Flash Professional CS5 with Action Script 3.0. Furthermore, the integration of multimedia makes it more interactive. In high school, 'Rotational Dynamics' is parallel to the 'Equilibrium of rigid bodies' competence. Therefore, the developed e-book has two basic concepts, namely equilibrium and rotational dynamics.

2 Method

This study is a quasi-experiment with the design of 'one group pre and post-test' as shown in Table 1. It comprises of a total of 42 high school students grouped into two experimental groups, namely A and B.

Table 1. Reseach Design

Groups	Pre-test	Independent Variables	Post-test
Experiment	O1	X1	O2

Each group is given a pre-test through 24 items of multiple choice questions which consists of 12 items on the concept of 'Equilibrium of rigid bodies,' and the 'Rotational Dynamics.' Furthermore, students are given treatment by applying an interactive e-

book of physics as the main teaching material. The learning process is conducted for four sessions with each allocated a 90 minutes timeframe. In early learning, teachers prepared an 'e-book interactive physics' on computers for 2-3 students, therefore, making it possible for learning to take place as facilitators. The final stage is a post-test containing the same question as to the pre-test.

The data obtained were quantitative and analyzed by the normalized gain test (N-Gain). This aims to determine the improvement of conceptual mastery in both classes. The N-gain equation is:

$$N - gain = \frac{\text{Post test} - \text{Pre test}}{\text{Maximum Score} - \text{Pre test}} \quad (1)$$

Table 2. Interpretation of N-gain Score

N-gain	Criteria
$N - gain > 0.70$	High
$0.70 \geq N - gain \geq 0.30$	Medium
$N - gain < 0.30$	Low

Each score is interpreted to be a low, medium, and high criterion (Table 2). The test result score is converted to a total value of 100 on a scale to obtain the average value of each experimental class. The analysis was performed on every major concept and cognitive domain, according to Bloom's taxonomy [17]. The domains include remembering (C1), understanding (C2), applying (C3), analyzing (C4), evaluating (C5), and creating (C6).

3 Result

Physical interactive e-book profiles as teaching materials to enhance students' conceptual mastery are shown in Table 3. This product has been validated by a team of experts comprising of materials, media, and practitioners (physics teachers). The results show that the interactive e-book design is 'Feasible' to be used as teaching material in physics learning.

Table 3. Profile of E-book Interaktif for Physics

No.	Type of Design	Result
1	The Name of the Product	E-book interactive for physics
2	Extension	.exe
3	Material content	Equilibrium rigid body and Rotational dynamic
4	Media content	Video, animation, and audio
5	Leaming activities	Finding facts, making temporary allegations, looking for learning information, making problem answers, Exercises.

Each group is given a pre-test through 24 items of multiple choice questions. The question consists of 12 items of concept 'Equilibrium of rigid bodies,' and the other is on 'Rotational Dynamics.' Furthermore, students are given treatment by applying an

interactive e-book of physics as the main teaching material in Rotational Dynamics. The learning process is conducted for four sessions with a 90 minutes timeframe for each. In early learning, teachers prepared an 'e-book interactive physics' on computers for 2-3 students, thereby making students learn independently with teachers as facilitators. The final stage is a post-test containing the same question as to the pre-test.

Table 4. N-Gain Score The Concept of Equilibrium and Rotational Dynamics

Materials	Test	Average Score	
		Group A (N=26)	Groups B (N=16)
Equilibrium	Pre-test	22.12	20.83
	Post-test	83.33	75.93
	N-gain	0.79	0.70
Rotational Dynamics	Pre-test	30.13	3.090
	Post-test	76.19	75.93
	N-gain	0.66	0.66

Table 4 shows the N-gain scores of groups A and B. Group A's score with a sample size of 26 students on the concept of equilibrium of a rigid body' is 0.79. According to Table 3, this score is 'high- criterion,' and the concept of Rotational Dynamics material is 0.66 (medium criterion). Meanwhile, group B with a sample size of 16 students, and N-gain scores for the concept of equilibrium and Rotational Dynamics are 0.70 (high criterion) and 0.66 (medium criterion).

N-gain scores of each cognitive domain are shown in Table 5. The mean scores of each cognitive domain have increased based on pre-test and post-test. Group A is highly criteria for domains C1, C2, C3, and C5. However, medium criteria are obtained in C4 and C6. Furthermore, group B is in the highly criteria on C1 and C2 domains while C3, C4, C5, and C6 are medium criteria

Table 5. N-Gain Score for Cognitive Domains

Group	Test	Average Score					
		C1	C2	C3	C4	C5	C6
Group A	Pretest	41.03	36.54	3.73	7.69	2.56	0.00
	Posttest	87.18	85.90	79.33	70.51	83.33	46.15
	N-gain	0.78	0.78	0.79	0.68	0.83	0.46
Group B	Pretest	14.58	20.83	27.34	22.92	47.92	25.00
	Posttest	85.42	85.42	68.75	66.67	77.08	75.00
	N-gain	0.83	0.82	0.57	0.57	0.56	0.67

4 Discussion

The results of the analysis indicate that the interactive e-book is effective to improve the mastery of Rotational Dynamics by students in two schools. These results are in line with previous research by Darlen et al. [18] and Cahyanti et al. [19], which shows that the integration of multimedia in e-books is effective in enhancing students' conceptual understanding.

The process requires many factors which must support it such as creativity which sometimes appear after or before mastering the concepts. In general, computer-based media such as e-books have proven to be able to support these capabilities. Research conducted by Adawiyah et al. [20] showed that e-books were able to improve students' creative thinking skills. This is also similar to the research conducted by Gunawan et al. [21], which concluded that the use of virtual lab media improves student creativity. Creativity is defined as the result of good understanding of the concepts with the ability to provide computer-based media and increase in students' understanding and support of good physics concepts.

Learning activities in this study were conducted in groups, which allow interaction between students. Tsang [22] revealed that interaction between students triggers the exchange of information, complement, and create active learning. Group learning increases students' positive activities, while, the active students tend to score high. Flexibility and freedom to explore capabilities independently improve their learning abilities [23].

The learning outcomes of groups A and B are concept mastery data, comprising of pre-test data (before treatment) and post-test (after treatment) which are multiple choice tests. Researchers made use of multiple-choice tests to facilitate scores and assessment. Simkin & Kuechler [24] stated that multiple-choice tests are the most popular test because they are easy to assess, practical, and is a basis for analyzing students' understanding of learning.

The average score of the two schools on the pre-test is low because it has not reached the minimum standard of learning completeness of 75. This is due to the administration of the pre-test before learning. However, the average score of students in the cognitive domain is high (C1, C2, and C3) owing to the higher level of difficulty and cognitive domains. This case corresponds to the average score in group A, which states that the higher the cognitive domain, the lower the score.

Different results occurred in group B. Based on Table 5, the average score of each cognitive domain approached the same result because the ranged values were small. The difference between the domains is not dominant from C1 to C6 and greater in C5. This needs to be questioned, as there is inconsistency with the material that has been described in group A. Based on the instrument used (multiple choice), the student's chance to guess the correct answer is pretty much on the subject that the student has never learned before. One of the weaknesses of multiple choice questions is the numerous opportunities to guess the right answers.

Post-test results of the concept of equilibrium and Rotational Dynamics in both groups have increased based on pretest. Therefore, the average score of the two schools is declared complete. This increase is due to the learning treatment provided. Learning to use interactive e-book media provides students with an opportunity to learn independently (student-centered). These results are in line with Efe et al. [25], which revealed that learning through animation increases their confidence because visual effects enhances affective, cognitive, and understanding a. The post-test average score on equilibrium is higher than the concept of Rotational Dynamics. This is due to the high level of cognitive domain question in the concept of Rotational Dy-

namics, which is correctly answered by some students. Finally, the average score is lower than the equilibrium concept.

The N-gain equation determines the improvement of concept mastery based on pre-test and post-test. It is performed to determine the mean value of each concept in the 'Rotational Dynamics of each cognitive domain. The results show that the N-gain for equilibrium concept in group A is close to B score. The second group score is interpreted in high criterion, which means that the improvement of mastery of the concept before and after treatment with physics interactive e-book is 'high'.

The N-gain score for the concept of Rotational Dynamics in Group A is closer to B. This value includes medium criterion, which means that increasing the mastery of the concept in both schools is in the medium category. Comparison of each concept of Rotational Dynamics shows that group A is always higher than B. As a result, the average pre-test in group A is always smaller than B, and in the mean post-test the two schools approach each other. Therefore, group A rises higher than group B.

Table 5 shows the difference between the pre-test and post-test scores of both groups. The N-gain value for the cognitive domain of C1 in group A is smaller than in B. However, this value is highly criteria. This means that the increase in the C1 domain of both groups is high which is due to the learning experience of students with an interactive e-book. The e-book presents an explanation of a concept with a short and simple language to enable students to easily remember its definition through the explanation presented. Learners using interactive electronic books have a more active and relaxed attitude because they propose solutions to computers independently [26].

Each student has a high criterion on domain C2. This result is the impact of using e-book equipped with the elaboration of concepts and examples to strengthen students' understanding. Small discussion groups in the learning activities which takes place, is able to overcome misunderstandings of students. The uses of features in computers such as PowerPoint helps students understand Physical phenomena, thereby, helping them to understand Physics [27].

The N-gain scores on the C3 domains of groups A and B are distinctly different from the range of values, with the first having a high criterion and the second a medium criterion. The average pre-test scores of each group differed significantly where group A was 3.73, and group B 27.34. While the post-test average scores of both groups were 79.33 and 68.75, respectively, average difference of pre-test and the post-test for group A is higher than that of B (group B obtains a very large average pretest value) therefore, the N-gain will be different. Similarly, in domain C5, group A increases with 'high criterion' and B with medium. This situation is caused by multiple choice patterns giving students a great chance to guess the correct answer during pre-test.

The N-gain for C4 domains in groups A and B was 0.68 and 0.57, respectively by medium criterion. Therefore, both schools experienced the same improvement for C4 domains. Although the criteria are the same based on the average score, group A is higher than B. Similarly group B is caused by the high average pre-test value therefore, the post-test increase the medium.

The domain C6 is almost similar to the C4, the difference is that the C6 of group B is higher than A where the N-gain score for group B is 0.67 and 0.46 for A. In this

domain, the average score of group A is zero (0) because most students' answers are wrong. The test items on this domain are the most difficult, as evidenced by the difference in average pre-test and post-test in group A which are categorized as medium. Likewise, with group B, the average score of pre-test and post-test is in the high category. Therefore, the N-gain score is in the medium criterion.

The application of an interactive eBook is effective to increase the mastery of the concept of Equilibrium rigid body and Rotational Dynamics. The mix of audiovisual content such as animation, video, images, and text make it easier for students to understand the concept. Learning using physics e-books helps students understand abstract concepts. Hermansyah et al. [28] found that the use of interactive multimedia improves creative thinking skills and the mastery of student concepts.

The application of interactive e-books as the main 'teaching materials' in learning activities affects the mastery of student concepts. An interactive e-book maximizes direct learning. Collaboration between direct learning and computer-based media such as e-books has proven to support students. Research conducted by Sumtsova et al. [29] stated that without doubt, collaborative learning is an active method of teaching and is very effective as it combines all the recent trends and developments in the field of mastering. Bi & Shi [30] stated that computer-assisted teaching is recognized by both teachers and students and effectively improve teaching effects. Based on this, the application of e-book and direct learning has proven to be empirically and theoretically capable of supporting learning. With good learning, this leads to an increase in understanding the concept of students.

The future of the e-book is quite promising. Research by Abuloum et al. [31] stated that students have a positive response to the use of digital books, although they have not matched the level of readability of printed books. Low e-book usage is due to the use of devices not comfortable to the human eye. A computer screen or tablet is not good when used continuously over a long period. This is one of the biggest weaknesses of e-book. However, it will continue to grow both in quality and technologically. In the future, the e-book is expected to overcome its shortcomings with the application of a screen that is more comfortable for the eyes, such as a screen with a blue light filter.

5 Conclusion

The interactive e-book contains videos, animation, audio, and simple problem solving activities in everyday life, effective for improving students' concept and mastery. The results show improvement with 'high criteria' on equilibrium and 'medium criteria' on Rotational Dynamics. Increased mastery of concepts also occurs in each domain of knowledge (cognitive domain). The cognitive enhancement criteria of groups A and B are 'high' in C1 and C2, and 'medium' for C4 and C5 domains. Different criteria were found in the two domains, where group A contained C3 and C5 domains which received high improvement criteria, and B was medium criteria.

6 Acknowledgement

The authors are grateful to all those who helped in the development of e-books, research processes, data collection, and improvements to this article, especially those at the research center for physics and technology education, University of Mataram.

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Article submitted 2019-06-01. Resubmitted 2019-10-23. Final acceptance 2019-11-01. Final version published as submitted by the authors.

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