Archimedes law simulation for physics instructional media

D D Bhakti¹,*, A Ismail², I Nasrulloh³, P Sidiq¹ and Y Nugraha¹

¹ Department of Information System, Institut Pendidikan Indonesia, Jl. Pahlawan No.32, Garut, Indonesia
² Department of Physics Education, Institut Pendidikan Indonesia, Jl. Pahlawan No.32, Garut, Indonesia
³ Department of Information Technology Education, Institut Pendidikan Indonesia, Jl. Pahlawan No.32, Garut, Indonesia

*demmy@institutpendidikan.ac.id

Abstract. Students find physics difficult, because they have to contend with different representations such as experiments, formulas and calculations, graphs, and conceptual explanation at the same time [1]. As far as we know that physics experiments which conducted in well-equipped laboratories, improve student’s science process skills. It is hard to imagine learning to do science, or learning about science, without doing laboratory or fieldwork. But many schools in various part of the world have very poor or no laboratories, so the teachers have to use their own equipment and replace the students experimental work with simple demonstration experiments. The purpose of this study was to create physics learning media for Archimedes law using simulation to cover the lack of the availability of laboratories and physics practicum tools. Rapid prototyping lifecycle model was used as a design of study. CSUQ is used to test usability of the simulation. To test the functional aspect, this study used black box testing the result of questionnaire was 88.4% with very decent criteria. Based on the development steps and test results, it can be concluded that developing a simulation requires full collaboration between IT experts and physics.

1. Introduction

Student finds physics difficult, because they have to contend with different representations such as experiments, formulas and calculations, graphs, and conceptual explanation at the same time [1]. As far as we know that physics experiments which conducted in well-equipped laboratories, improve student’s science process skill [2]. It is hard to imagine learning to do science, or learning about science without doing laboratory or fieldwork [3]. But many schools in various part of the world have very poor or no laboratories at all, so the teachers have to use their own equipment and replace the student experimental work with simple demonstration experiments [4].

The use of technology is growing very rapidly among the community not only in the field of business but also in the field of education where the use of technology is very helpful for all those who need it. Educational institutions make various kinds of needs and complement the needs of users of technology utilization in the field education includes the creation of learning media, searching for material about online learning using smartphones, seeking information related to the world of education.

Simulation is one of the world developments in technology that can be used in the field of education to help the learning process and the delivery of learning material between teachers and students.
practical learning, simulations can be used for cover the lack of the availability of laboratories and practicum tools, in this case especially physics practicum learning. The experimental results prove that computer simulations play an important role in studying aspects related to physical phenomena that occur [5]. Computer simulation can also function as an effective tool to improve the ability of students to make hypotheses, interpret graphics, and predict abilities [6].

The purpose of this study was to create physics learning media for Archimedes law using simulation to cover the lack of the availability of laboratories and physics practicum tools, so that it can help teachers and students in implementing physics learning.

2. Methods
Rapid prototyping lifecycle model are used as the methodology to develop Archimedes law simulation. A rapid prototype is a working model that is functionally equivalent to a subset of the product. A rapid prototype for a target product that is to determine the concentration of an enzyme in a solution might perform the calculation and display the answer, but without doing any validation or reasonableness checking of the input data. Rapid prototyping lifecycle model consisting of 6 different step, namely: rapid prototype, analysis, design, implementation, post-delivery maintenance, and retirement.

Figure 1. Rapid prototyping lifecycle model.

A major strength of the rapid-prototyping model is that the development of the product is essentially linear, proceeding from the rapid prototype to the delivered product; the feedback loops of the waterfall model are less likely to be needed in the rapid-prototyping model. There are a number of reasons for this. First, the members of the development team use the rapid prototype to construct the specification document. Because the working rapid prototype has been validated through interaction with the client, it is reasonable to expect that the resulting specification document will be correct. Second, consider the design. Even though the rapid prototype has (quite rightly) been hurriedly assembled, the design team can gain insight from it—at worst it will be of the “how not to do it” variety. Again, the feedback loops of the waterfall model are less likely to be needed here.

Implementation comes next. In the waterfall model, implementation of the design sometimes leads to design faults coming to light. In the rapid-prototyping model, the fact that a preliminary working version of the software product has already been built tends to lessen the need to repair the design during or after implementation. The prototype has given some insights to the design team, even though it may reflect only partial functionality of the complete target product. Once the product has been accepted by the client and installed, post-delivery maintenance begins. Depending on the specific maintenance task that has to be performed, the cycle is re-entered either at the requirements, analysis, design, or implementation phase.
An essential aspect of a rapid prototype is embodied in the word *rapid*. The developers should endeavour to construct the rapid prototype as rapidly as possible to speed up the software development process. After all, the sole use of the rapid prototype is to determine what the client’s real needs are; once this has been determined, the rapid prototype implementation is discarded but the lessons learned are retained and used in subsequent development phases. For this reason, the internal structure of the rapid prototype is not relevant. What is important is that the prototype be built rapidly and modified rapidly to reflect the client’s needs. Therefore, speed is of the essence.

**3. Result and discussion**

The development of the Archimedes law simulation for physics instructional media using the rapid prototyping lifecycle model consisting of 5 different step, namely: rapid prototype, analysis, design, implementation, and post-delivery maintenance.

**3.1. Rapid prototype step**

Rapid prototype step is to build the Archimedes law simulation prototype and let the client and future users in this case the physics teacher interact and experiment with the prototype. The programming language used to build Archimedes law simulation prototypes is a java programming language. Once the physics teacher is satisfied that the rapid prototype indeed does most of what is required, then post-delivery maintenance step begins.

![Figure 2. Archimedes law simulation.](image)

**3.2. Analysis step**

The analysis step is done by finding problems in the prototype based on data obtained from the information gathering interviews, questionnaires and research results directly that has been validated through interaction with the client.

**3.2.1. Analysis of functional needs.** The main function of this simulation is to simulate the first law of Archimedes law in in physics learning that reads “An object which is dipped partially or wholly into a
liquid will experience an upward force whose magnitude is equal to the weight of the liquid transferred by the object”.

Functional requirements includes things that can be presented by the system which is to display simulation of object conditions on liquid objects based on object weight, object width, object length, object height, type of liquid, and volume of liquid.

3.2.2. Analysis of software requirements. The Archimedes law simulation will be created with java programming language.

3.2.3. Analysis of hardware requirements. Analysis of hardware requirements is done to determine the hardware needed to make the simulation. The minimum hardware used includes using the Windows 8.1 Pro 64-bit operating system with 4 GB RAM.

3.3. Design step
The design the Archimedes law simulation, we use a couple diagram in Unified Modelling Language (UML) such as activity diagrams and sequence diagrams. Other than that, the design of the user interface is used to plan a simulation display that is more user friendly.

![Activity diagram of Archimedes law simulation.](image)

3.4. Post-delivery maintenance step
Testing the functional aspects of the Archimedes law simulation use black box testing with 15 scenarios test case for each and every aspect in simulation. The scenarios used consist of scenarios to see the simulation display of the condition of an object on a liquid based on the object's weight, object's width, object length, object height, type of fluid, and volume of fluid entered with different data. The functional aspects of the simulation fulfil the results as expected, evidenced by black box tests with various scenario with the conclusion of each scenario “running”.

Data collection strategies were carried out on 30 students, and 5 teacher. After giving questionnaires using the questionnaire of the Computer System Usability Questionnaire (CSUQ) developed by IBM for standard usability measurement software [7]. The results obtained are the number of questions and the total number of scores, as shown in the table 1.
Table 1. The results of CSUQ.

| Question item                                                      | Total score |
|------------------------------------------------------------------|-------------|
| Overall, I am satisfied with the ease of this system.            | 85          |
| How to use this system is very simple.                           | 94          |
| I can complete the task effectively when using this system.     | 87          |
| I can quickly complete the task using this system.              | 87          |
| I can complete the task efficiently when using this system.     | 87          |
| I feel comfortable using this system.                            | 92          |
| This system is very easy to learn.                               | 94          |
| I am sure to be more productive when using this system.         | 85          |
| If an error occurs, this system provides a notification message about steps to be taken to resolve the problem. | 97          |
| Whenever I make a mistake, I can go back and recover quickly    | 83          |
| The information provided by this system is very clear.          | 94          |
| Easy to find information needed.                                | 95          |

The results of the calculation of the total score in table 1 are the results of calculating the total score of each questionnaire statement item from each respondent, both prospective physics teacher and students. Based on the results of the calculation of the questionnaire on 35 respondent, the percentage of respondent 88.4% with very decent criteria was obtained.

4. Conclusion
Based on the description of the results of the analysis carried out during the development of the Archimedes law simulation for physics instructional media, the following conclusions can be drawn:
- The functional aspects of the simulation fulfil the results as expected, evidenced by black box tests with various scenario with the conclusion of each scenario “running”.
- The results of usability testing with percentage 87.6% thus entered the criteria of “very descent”.
- To develop the Archimedes Law Simulation requires full collaboration between IT experts and physics to guarantee the best results.

Acknowledgments
The researchers would like to extend gratitude to Dr. Nizar Alam Hamdani as The Rector of Indonesia Institute of Education for all the support and motivation given to the researchers.

References
[1] Angel C, Guttersrud O, Henriksen E and Isnes A 2004 Physics: Frightful but fun. Pupils and teacher Views of physics and physics teaching A Journal in Science Education
[2] Hirca N 2012 The influence of Hands on Physics Experiments on Scientific Process Skill According to Prospective Teacher Experiences European J of Physics Education
[3] Trumper R 2003 The Physics Laboratory – A Historical Overview and Future Perspectives (Kluwer Academia Publishers)
[4] Ozvoldova M, Spilakova P and Tkas L 2014 Archimedes Principle-Internet Accessible Remote Experiment
[5] Ingerman A, Linder C, Marshal D and Booth S 2007 Learning and the Variation in Focus among physics students when using a computer simulation NorDiNa
[6] Sahin S 2006 Computer Simulations In Science Education: Implications for distance Education

Turkish Online Journal of Distance Education

[7] Lewis J R 1993 IBM "Computer Usability Satisfaction Questionnaires" Psychometric Evaluation and Instructions for Use