Evaluating and Developing Physics Teaching Material with *Algodoo* in Virtual Environment: Archimedes' Principle

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Abstract

This study examines pre-service physics teachers' perception on computer-based learning (CBL) experiences through a virtual physics program. An *Algodoo* program and smart board was used in this study in order to realize the virtual environment. We took one specific physics topic for the 10th grade according to the physics curriculum in Turkey. Archimedes` principle is one of the most important and fundamental concepts needed in the study of fluid mechanics. We decided to design a simple virtual simulation in *Algodoo* in order to explain the Archimedes' principle easier and enjoyable. A smart board was used in order to make virtual demonstration in front the students without any real experiment. There were 37 participants in this study who are studying pedagogical proficiency at Kırıkkale University, Faculty of Education in Turkey. A case study method was used and the data was collected by the researchers. The questionnaire consists of 28 items and 2 open-ended questions that had been developed by Akbulut, Akdeniz and Dinçer (2008). The questionnaire was used to find out the teachers` perceptions toward *Algodoo* for explaining the Archimedes' principles. The result of this research recommends that using the simulation program in physics teaching has a positive impact and can improve the students' understanding.

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Introduction

In a time when technologies are increasingly using for educational reason occurring across states, nations and even internationally, for example, the Turkish national physics curriculum of secondary education on interactive whiteboard and tablet to enhance better education, the interrogation of these data is not necessarily occurring at a level adequate to inform strategic directions of governments and local schools. More often, such data are used to provide metrics for school and system performance, and is often presented in a highly emotive fashion and viewed as threatening (Turkish Ministry of Education, 2013). In this paper, we interrogate how technology impacts the teachers' opinion on teaching physics in the class.

The primary purpose of science education is to teach the science concepts meaningfully and make students become aware of how these concepts can be used in their daily lives (Çepni, Taş and Köse, 2006). Throughout this learning process, imagination and visualizations are an ever more essential component of this learning process. Introducing technology into the learning processes can contribute to the advantage of a vast quantity of visual material to make learning more efficient and more engaging (Kommers, 2002). Computer-based cognitive tools are designed to support learning, provide problem solving and encourage human thinking. So, the features of effective cognitive tools are shaped by our nations of learning and pedagogy. Various pieces of software may be considered as cognitive tools with

varying potential to meet the requirements discussed (Orhun, 2002). Simulations, supported by software programs are computer-based cognitive tools. The most emphasized and explored field in analysis of the physics educational research on the computer-based learning is related to the application of simulation (Bayrak, Kanlı and İngeç, 2007; Jaakkola and Nurmi, 2008; Çelik, Özbek and Kartal, 2013). In the physics area, there are so many abstract concepts and principles so that it is important to generate some simulations with the kinds of computer program for the physical activities and experiments. Researchers have found that using computer simulations in instructional contexts may afford students with opportunities to promote their understanding of unobservable or specific phenomenas and principles that can be seen in daily life in science learning (De Jong, Martin, Zamarro, Esquembre, Swaak, and van Joolingen, 1999; Khan, 2002).

Nowadays, physics teaching activities are permeated by didactical proposals involving variety personal computers using more and more elaborate software in order to facilitate student' knowledge construction (Araujo, Veit and Moreira, 2008). The use of spreadsheets and simulations in particular would be considered activities associated with higher order thinking skills, beneficial to the study of science (Khan, 2011). Computer-based cognitive tools provide some of products that can be used for educational purposes. For example: interactive whiteboard with related instruments can be used for teaching physics, it also takes part the continuous development for enhancing the quality of education (Geban and Demircioğlu, 1996). According to Crook, Sharma and Wilson (2014), computer tools have significant effects on learning. Specifically in the study on the use of laptop, it would appear that the more substantial effect size for laptops in physics is due to new pedagogies capitalizing on the affordances of the 1:1 laptop environment for student-centered, personalized learning, particularly in the use of simulations and spreadsheets. Within the 1:1 computer tools physics classes, it would appear that there were greater opportunities for students to experience phenomena and perform experiments individually through simulations, represent and analyze data through spreadsheets, and collaborate and co-construct knowledge through wikis (Ruth and Houghton, 2009).We must also consider that the physics teachers may have had greater readiness and stronger belief systems around using computer tools such as the laptops with their students (Campbell, Zuwallack, Longhurst, Shelton, and Wolf, 2014; Howard, Chan, and Caputi, 2015).

Similarly when examined in the literature, the simulation can be seen that a lot of benefits in the learning environment. Technology-based teaching environment accommodates simulation so that students can use it for calculating data, sorting data, recording intended layout, testing the hypothesis, changing the variables, observing the results and visualizing the process of the information. The simulation accommodates students' initiative so that they can control or operate by their own without teachers. It also helps the students in providing tips and access more information. Increasing the students' motivation enables them to have the opportunity to learn everything by their own (Edelson, Gordin and Pea, 1999; Tao and Gunstone, 1999; Şen, 2001; Rutten, van der Veen and van Joolingen, 2015). In addition to the implementations suggested by the above researchers, simulation can be used to evaluate the problem-solving competency in the science and technology curriculum. These are (a) it simulates a well-defined and clearly constrained problem to be solved, which can be mathematically treated, (b) it suggests that an optimal solution "positively" exists, (c) it simulates manipulation errors, (d) it allows for trial-and-error, iterations, and interactions with the "reality" of the simulation, (e) it employs a variety of representations (images, animations, graphs, numerical data) that are helpful in understanding the underlying concepts, relations and processes (f) it isolates and manipulates parameters and therefore help students

to develop an understanding of the relationships between physical concepts, variables and phenomena, (g) it investigates phenomena that would not be possible to experience in a classroom or laboratory (Potvin, Dumont, Boucher-Genesse and Riopel, 2012; Esquembr 2002). In contrast, the use of computer-based cognitive tools for teaching some controversies is also available. Ongoing debate topics generality, proper level, transparency, directness of manipulation, adaptability, mutual intelligibility, ınternalization and heterogeneity as noteworthy (Orhun, 2002).

The new modified physics program had been prepared to improve students' scientific process skills, develop a framework of students' analytical and critical thinking skills, realize the physics concepts in their daily activity, and build a suitable correlation between science, technology, society and environment. The application of information technology, like smart board, can be used for performing a simulation or practicing an educational activity on virtual laboratory. It becomes an important issue in educational activities (Turkish Ministry of Education, 2013). On the other hand, the studies about the use of technology on achieving the goals of education in recent years were reported to be integrated with appropriate pedagogical approaches and they must be used together (Chai, Koh, Tsai and Tan, 2011). Therefore, the simulation can be used as a teaching material and it also takes part of the pedagogical evaluation.

There are some prepared and developed software that can be applied for simulation-assisted instruction, such as: *Interactive physics*, *Crocodile physics*, *Phet* and *Algodoo*. All of the programs have different properties and uniqueness. The specification of *Algodoo* is that it provides dynamic simulation using water and it can't be found in other physics simulation programs. *Algodoo* provides fluid dynamic simulation in which gravitational acceleration automatically works. So it can be used to explain the phenomena of Archimedes' principle virtually. We decided to use and develop the physics material program with *Algodoo* in order to prepare an alternative physics course in virtual environment. This study tried to develop a physics course program with Algodoo in virtual environment. Researchers focused on designing Archimedes' principles with *Algodoo* program that provides some useful simulations. This study also explored the pre-service physics teachers' perceptions towards Algodoo for explaining the Archimedes' principles.

Methodology

Research Model

The overall research methodology was comprised of two effective assessments, including quantitative and qualitative research methods. For that reason, case study method was used in this research (Cohen and Manion, 1994). Since few contemporary physics education programs had been effectively implemented in schools in Turkey, the present study focused on pre-service teachers' learning performances to upgrade their competence via integrated simulations in physics teaching. In this research we used *Algodoo* program as integrated animations of physics instruments. All of the followed-up questionnaires had assessed pre-service physics teachers' performances in the *Algodoo*-based instruction toward Archimedes' principles.

Population and Sampling

Assessments of statistical samples for surveys were taken from 37 pre-service physics teachers in Kırıkkale, Turkey. The participants take some pedagogical courses and practical teaching in Education Faculty of Kırıkkale University. They were enrolled in a course entitled "the Archimedes' principles with *Algodoo* simulation". This was a required course for pre-service physics teachers and taught by a bilingual Turkish and English instructor.

Data collection instrument and procedure

Gathered data were analyzed by quantitative and qualitative methods. Quantitative data sources included a questionnaire that used semantic differentials of a likert scale. Akbulut, Akdeniz and Dinçer (2008) had developed a questionnaire and used it to test teachers' perception on computer-based learning in 5 likert scale. The developed questionnaire consists of 4 major factors with 28 questions. Twenty eight questions were completed and returned by participants. The questionnaire that evaluates computer assisted teaching material was used to collect the pre-service physics teachers' perception on simulation-based teaching instruction. The first part which was made up of four factors, such as: instructional relevance, convenience of the program, convenience of instruction and program and formal conformity. The first factor consists of 14 questions, the second factor 4, and the third factor 5 and the fourth factor 5. We used SPSS 17.0 to find out the statistical calculation.

In the second part, two open-ended questions reflecting the advantages and disadvantages were conducted as qualitative data sources to find out and explore the participants' opinions about virtual physics teaching through *Algodoo*. The participants could write freely about their opinions toward virtual physics teaching. The data obtained from the interviews was analyzed by using the content analysis method. Data that are got from participants' answers to open-ended questions are separately coded by two independent researchers and these codes are gathered together within the frame of specific concepts. In the next step the frequency of these codes are given in table format for the aim of visualizing the study and providing easiness for the readers.

Materials

In this study we developed a physics material through *Algodoo* in virtual environment. We decided to take one physics course in accordance with the standard curriculum of Turkey. In this point we used the 10^{th} grade course program in accordance with the instruction of the Turkish Ministry of Education. We agreed to take the physics topic of Archimedes' principles. The Archimedes' principle was explained to the pre-service teachers from the basic concept. We tried not to use formula in the beginning of learning. The virtual simulation through *Algodoo* (*phun*) was conducted to visualize how the Archimedes' principle works in the fluid without real experiment in laboratory (Fig. 1.).

We decided to choose the *Algodoo* program because it was so easy to operate, suitable for physics simulation and provide water simulation that are not available in other simulation programs. The simulation program used is an attractive software that can be used to help the students' understanding on learning some of physical experiments. The users can build their own virtual experiment by exploring some playful physical simulations, building cartoony manner of inventions and designing interactive experiments so that it encourages students' motivation on physics learning. Students improve their own creativity and ability while

having fun so *Algodoo* was designed in playfull and cartoony manner as educational games. In addition to this, *Algodoo* provides dynamical simulations that help the teachers' performance when they were explaining the Archimedes experiment to the students in the class. It was believed that physics instruction in simulation program would stimulate more interactions between students and instructors and it is suitable for the students' learning competence (http://www.algodoo.com/).

The simulation program provides a simulation of fluid dynamic so it can be applied to show the Archimedes' principle in virtual environment. Some of the tools in the simulation program used can be changed automatically by the users. For example: the material's density can be changed just by controlling a bottom so that we can get any desired value of material's density. It's so easy to operate simulation program used from the zero until we get any desired Archimedes experiment. First the users found a blank background with some tools above. A reference point can be prepared by clicking the surface block in the toolbars. This reference point usually was assumed as an Earth surface. The users can draw their own any solid materials such as solid balls, stone, metal and wood. If you have 3 solid objects, please make it into 3 different densities. And users can also draw their own bucket by clicking the paint in the toolbars. It was very important to check the gravitational acceleration on the gravity in options menu. If the gravitational acceleration was active all the objects will be falling down. The water can be provided by clicking the liquid bottom to change the prepared solid object into liquid one by one.

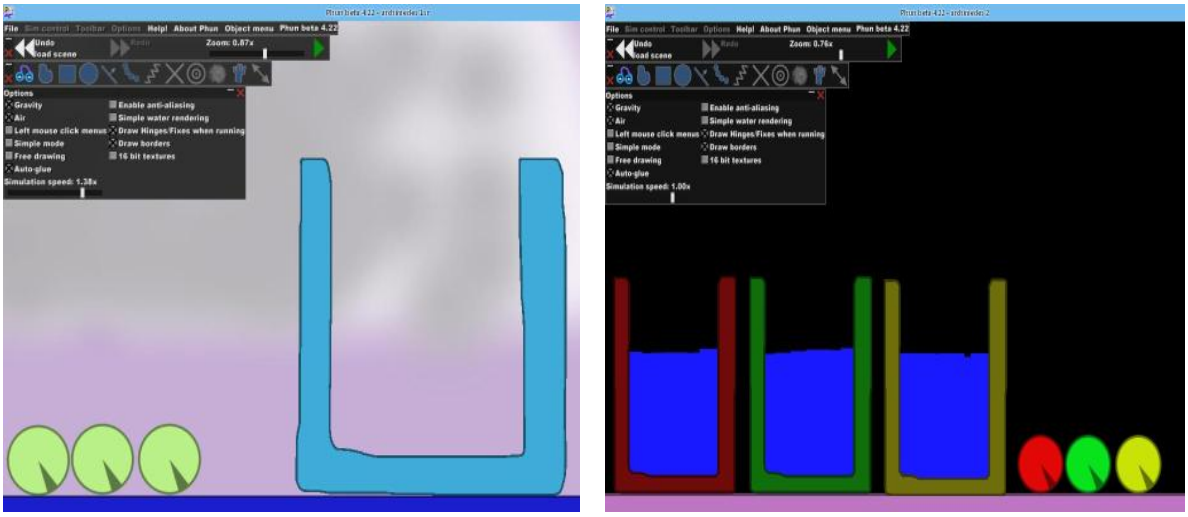

Figure 1. Example of simulation program output in topic of Archimedes' principles.

Results and Discussion

We have identified a number of characteristics that make a formal conformity, many of which are what make the simulation program being formal conformity. These include (i) using color and graphic, (ii) using appropriate visualization, (iii) display intensity, (iv) available to read the display and (v) using a screen space. Item (ii) is the best developed being a factor of formal conformity. For the convenience of the program, we identified some of characteristics, such as: (i) clear of error, (ii) working properly, (iii) faultless display to the students' input and (iv) the speed of operation. Item (iv) is the highest output as a part of the convenience of the program. Convenience of instruction and program have some features: (i) the lenght of working time, (ii) compliance between the course's objectives and outcomes,

(iii) providing complete subject, (iv) using flexibility and upgradeability software and (v) constructivism activity. Item (ii) and (iii) is the best developed through convenience of instruction and program. The same method was used to identify some features in instructional relevance factor. The compositions of instructional relevance are given in Table 1.

Table 1. Table pre-service physics teachers' perceptions about simulation based teaching material

	Instructional relevance	N	Mean	St.Dev.		
Q1	Accuracy and topicality of information	37	4,00	0,707		
Q2	Compatibility of content and activities	37	4,06	0,674		
Q3	Evident and understandable instructions	37	3,73	0,902		
Q4	Feedback properties	37	3,76	0,796		
Q5	Compliance between individual and collaborative learning	37	4,00	0,745		
Q6	Content of comprehensible level	37	4,05	0,848		
Q7	Active participation and interactive accommodation	37	4,05	1,104		
Q8	Encouraging creativity and developing the logical thinking	37	4,41	0,644	Total $\bar{x}$ =	Total SD=
Q9	Appropriate content of partition and logical sequence of presentation	37	3,89	0,699	3,98	0,803
Q10	Remarkable	37	4,54	0,650		
Q11	Increasing the motivation	37	3,97	0,866		
Q12	Easy to operate	37	3,65	0,949		
Q13	Understanding the content level	37	3,81	0,811		
Q14	Compatibility of students' characteristics and growth	37	3,86	0,855		
Convenience of the program						
Q15	Clear of errors	37	3,43	0,765		
Q16	Working properly	37	3,57	0,603	Total $\bar{x}$ =	Total SD=
Q17	Faultless display to the students' input	37	3,58	0,692	3,59	0,726
Q18	The speed of operation	37	3,81	0,845		
Convenience of instruction and program						
Q19	The length of working time	37	3,57	0,689		
Q20	Compliance between the course's objectives and outcomes	37	4,03	0,763		
Q21	Providing complete subject	37	4,03	0,833	Total $\bar{x}$ =	Total SD=
Q22	Using flexibility and upgradeability software	37	3,84	0,688	3,89	0,751
Q23	Constructivism activity	37	4,00	0,782		
Formal conformity						
Q24	Using color and graphic	37	4,16	0,727		
Q25	Using appropriate visualization	37	4,24	0,723	Total $\bar{x}$ =	Total SD=
Q26	Display intensity	37	3,92	0,924	4,06	0,835
Q27	Available to read the display	37	3,81	0,938		
Q28	Using the screen space	37	4,16	0,866		

Table 1 showed some mean values from all factors: instructional relevance ($\bar{x}$ = 3.98), convenience of program (3.59), convenience of instruction and program ($\bar{x}$ = 3.89) and formal conformity ($\bar{x}$ = 4.06). Each factor has mean value more than $\bar{x}$ = 3.43. It indicates that simulation program used is good enough as a virtual program for teaching the Archimedes' principles. There are 3 items that have mean value more than $\bar{x}$ = 4.23, show specific reason why simulation program used has high influence for teaching physics. The result is that remarkable and encouraging creativity and developing the logical thinking both are highest factor as a part of the instructional relevance. Considering to the positive response given by participants in this study, deemed appropriate and supporting meaningful learning of this simulation program is remarkable. Akbulut, Akdeniz and Dinçer (2008) have benefited from the material evaluation questionnaire to analyzing computer-aided teaching material by their developed. Researchers due to overall average score on 4 categories relating to the

questionnaire, stated that the material be suitable. So the presented simulation can be modified appropriately to the scientific literature. When a simulation based learning conducted in science education was explored, it will be seen that the most popular topic was the use of simulation (Jimoyiannis and Komis, 2001; Wieman, Adams and Perkins, 2008; Jaakkola and Nurmi, 2008; Jaakkola, Nurmi and Veermans, 2011; Rutten, van der Veen and van Joolingen, 2015). By developing integrated program in *Algodoo*, the teachers can easily and freely change the configuration of the program to get desired display of virtual simulation and provide an alternative way on explaining some specific phenomenas appropriately with the physical laws.

The qualitative data was prepared by giving two open-ended questions to the participants. The participants can freely write their own opinion on the simulation program used for teaching Archimedes experiment. The open-ended questions were explored to collect the teachers' opinion on what makes the simulation useful (being advantage) to help on explaining the Archimedes experiment and also the disadvantage of it. From all the coming reasons in open-ended questions, researchers classified the coming reasons into eight highest items for each advantages and disadvantages column (Table 2).

Table 2. Table pre-service physics teachers' opinion about the simulation program for teaching physics

Advantages		Frequency	Percent (%)
1.	Increasing the students' understanding toward physics	18	29
2.	Providing good visualization	17	28
3.	Easy to operate	7	11
4.	Enhance the students' creativity	5	8
5	Making physics easier	5	8
6.	Represent the physical phenomena in visual program	5	8
7.	Entertaining	3	5
8	Good for fluid simulation	2	3
Total		62	100
Disadvantages		Frequency	Percent (%)
1.	Problem with foreign language	9	26
2.	Can't represent the overall of physical phenomena	6	18
3.	Preparation time	6	18
4.	Lack of properties and tools	5	14
5.	The water density can't be changed	4	12
6.	Unavailable for mathematical calculation	2	6
7.	Lack of computer literacy	1	3
8.	Operating program	1	3
Total		34	100

From the qualitative result, researchers found some of the advantages on using the simulation program for explaining Archimedes experiment according to the science teachers (Figure 2), such as: increasing the students' understanding toward physics, providing good visualization, easily to operate, enhance the students' creativity, making physics easier, representing the physical phenomena in visual program, entertaining and good for fluid simulation. However, regarding the pre-service teachers' opinion on the advantages of the simulation for explaining Archimedes experiment, even though the percentage of each item was small to medium, the two highest items (increasing the students' understanding toward physics and providing good visualization) took totally more than 50%.

The participants wrote their opinion on the disadvantages of using *Algodoo* for teaching Archimedes' principle (Figure 3). Than all the written opinion were classified into eight items, such as: problem with foreign language, can't represent the overall of physical phenomena, preparation time, lack of properties and tools, the water density can't be changed, unavailable for mathematical calculation, lack of computer literacy and operating program. We found that problem with foreign language took 26% and each other reasons took below 20%. So it means that the language was the main problem of using the simulation in Archimedes' principle. Since the research took place in Turkey, it was normal because the Turkish students didn't use English as their formal language and they always use their Turkish language in their class and daily activities.

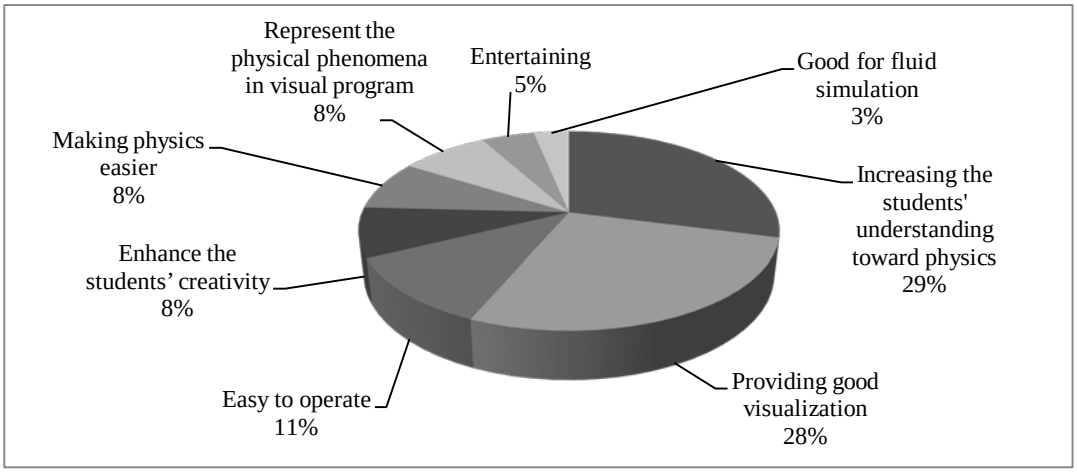

Figure 2. The Advantages of Using the simulation program for Teaching Physics

We found that the advantages of this program according to the participants are that it can help students to increase their understanding toward physics and also it gives a good visualization. However, some problems with the simulations reduce or are minimized the impact of such software. These are "Problems with foreign language", "Can't represent the overall of physical phenomena", "Preparation time" and "Lack of properties and tools" that are more dominant than others. In the literature, the problems encountered in simulations of supported applications include similar elements (Diagram 2.). According to Bingimlas (2009), with the integration of computer technology into learning environments successes and obstacles encountered in classifying studies "lack of access", " resistance to change", "lack of time", "lack of training", and "lack of technical support" indicates problems.

In the findings we found some of physics teachers' opinion on the advantages of using the simulation program for teaching Archimedes' principle, such as increasing the students' understanding toward physics, providing good visualization, easy to operate, enhance the students' creativity, making physics easier and represent the physical phenomena in visual program. It indicates that the physics teachers agree that lecturing by the simulation program used is good enough as an alternative way for explaining Archimedes' principle. So, we believe that there is considerable additional pedagogical advantage to be gained by the integration of the various computer based learning tools and concepts available, particularly by integrating "teaching curriculum" and "virtual" laboratory activities (Podolefsky, Perkins and Adams, 2010; Sarı and Güven, 2013; Tatlı and Ayas, 2010).

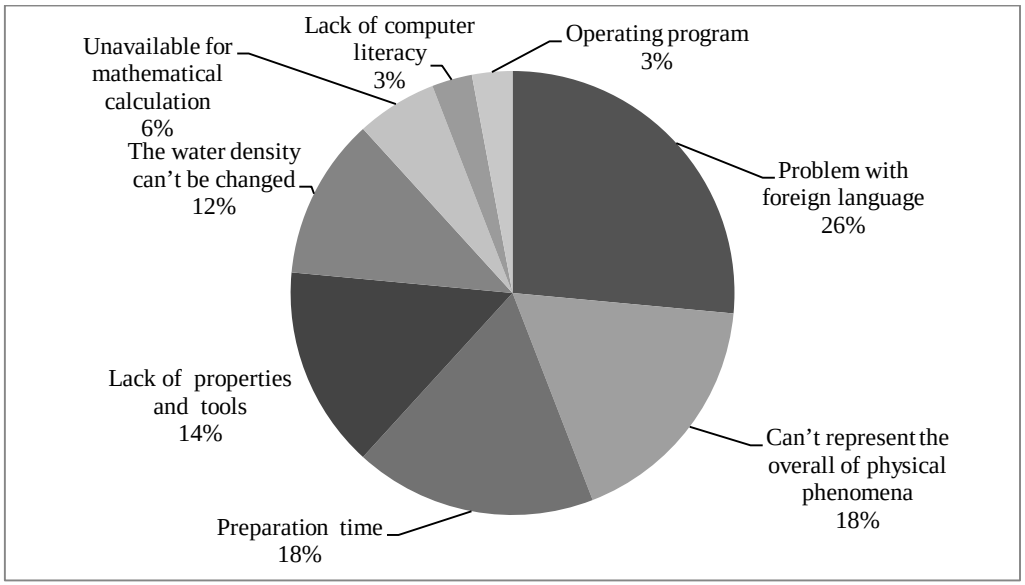

Figure 3. The Disadvantages of Using the simulation program for Teaching Physics

Conclusion

The quantitative method was explored on what makes *Algodoo* suitable for helping teachers on explaining physical phenomena. We identified four criteria in order to review the teachers' opinion toward the simulation program when it was being used for helping students on understanding the Archimedes' principle, such as: instructional relevance, convenience of the program, convenience of instruction and program, and formal conformity. Results indicated that most pre-service teachers were highly interested in using the simulation for helping them when they were explaining Archimedes' principle in class. The teachers thought that the simulation program has a positive expectation on all criteria including instructional relevance, convenience of the program, convenience of instruction and program, and formal conformities, while it was used to help students on understanding the Archimedes' principle. There was no significant problem related to the instructional relevance, program relevance, instructional-program relevance and formal relevance. In summary, considering pre-service physics teachers' the positive attitude towards the simulation prepared in this study, deemed appropriate and supporting meaningful learning of the simulation program is remarkable.

This study also shows that the advantages of this program according to the participants are that it can help students to increase their understanding toward physics and also it gives a good visualization. However, some problems with the simulations reduce or are minimized the impact of such software. These are problem of foreign language, incapability to represent the overall of physical phenomena, preparation time, lack of properties and tools, water density can't be changed, unavailable for mathematical calculation, lack of computer literacy and operating program. All of these reasons were coming on the weakness of using simulation program. But only problem of foreign language took the highest percentage and it's become important point because can be a suggestion to *Algodoo's* developers to make it into Turkish language.

Recommendation

The computer program can be used to enhance the students' motivation toward physics (Şen, 2001). Computer program sometimes provides an alternative solution for solving unobserved phenomena. *Algodoo* is one program that can be operated in various physical phenomena. It provides fluid simulation so it can be utilized for explaining the Archimedes' principle to the students. By giving attractively demonstration and virtual visualization, it can increase the students' motivation and gain a better understanding toward physics. To gain a better educational service, the teachers and students should improve their English language skills because almost the computer program is operated in English instructional language. And simulation programs should develop their program in order to provide a better and more complete physical simulation.

References

Akbulut, Ö. E., Akdeniz, A. R., & Dinçer, G. T. (2008). Bilgisayar destekli biröğretim materyalinin tasarlanması ve değerlendirilmesi. *Proceeding of the 8th International Conference of Technology for Education*, (pp. 974-978, Eskişehir: University of Anadolu.

Araujo, I. S., Veit, E. A., & Moreira, M. A. (2008). Physics students' performance using computational modeling activities to improve kinematics graphs interpretation. *Computers and Education, 50*(4), 1128-1140, doi:10.1016/j.compedu.2006.11.004.

Bayrak, B., Kanlı, U. & İngeç, Ş.K. (2007). To compare the effects of computer-based learning and the laboratory-based learning on students' achievement regarding electric circuits. *The Turkish Online Journal of Educational Technology*. *6*(1), 15-24.

Bingimlas, K. A. (2009). Barriers to the successful integration of ICT in teaching and learning environments: a review of the literature. *Eurasia Journal of Mathematics, Science and Technology*. *5*(3), 235-245.

Campbell, T., Zuwallack, R., Longhurst, M., Shelton, B. E., & Wolf, P. G. (2014). An examination of the changes in science teaching orientations and technology-enhanced tools for student learning in the context of professional development. *International Journal of Science Education*, *36*(11), 1815–1848. doi:10.1080/09500693.2013.879622

Chai, C. S., Koh, J. H. L., Tsai, C. C., & Tan, L. L. W. (2011). Modeling primary school preservice teachers' technological pedagogical content knowledge (tpack) for meaningful learning with information and communication technology. *Computers and Education, 57*(1), 1184-1193. doi:10.1016/j.compedu.2011.01.007

Cohen, L., & Manion, L. (1994). *Research Methods in Education.* Newyork: Rutledge.

Crook, S. J., Sharma, M. D., & Wilson, R. (2014). An evaluation of the impact of 1:1 laptops on student attainment in senior high school sciences. *International Journal of Science Education, 37*(2), 272-293. doi: 10.1080/09500693.2014.982229.

Çelik, H., Özbek, G., & Kartal, T. (2013).The effect of computer-aided 7E instruction model on students' scıentıfic process skılls. *Mediterranean Journal of Educational Research, 14a*, 926-932.

Çepni, S., Taş, E., & Köse, S. (2006). The effects of computer-assisted material on students cognitive levels, misconceptions and attitudes towards science. *Computers and Education, 46*, 192–205. doi:10.1016/j.compedu.2004.07.008

De Jong, T., Martin, E., Zamarro, J. M., Esquembre, F., Swaak, J., & van Joolingen,. (1999). The integration of computer simulation and learning support: an example from the physics domain of collision. *Journal of Research in Science Teaching, 36*(5), 597-615.

Edelson, D.C.,Gordın, D.N. & Pea, R.D. (1999). Addressing the Challenges of Inquiry-Based Learning Through Technology and Curriculum Design. *Journal of the Learning Sciences*, 8: 391–450.

Esquembre, F. (2002). Computers in physics education. *Computer physics communications, 147*(1), 13-18. doi:10.1016/S0010-4655(02)00197-2

Geban, Ö. & Demircioğlu, H. (1996).Fen Bilgisi Öğretimind eBilgisayar Destekli Öğretim ve Geleneksel Problem Çözme Etkinliklerinin Ders Başarısı Bakımından Karşılaştırılması. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*. 12, 183-185.

Howard, S. K., Chan, A., & Caputi, P. (2015). More than beliefs: subject areas and teachers' integration of laptops in secondary teaching. *British Journal of Educational Technology*, 46(2),360-369. doi:10.1111/bjet.12139

Jimoyiannis, A. & Komis, V. (2001). Computer simulations in physics teaching and learning: a case study on students' understanding of trajectory motion. *Computers & education, 36*(2), 183-204.

Jaakkola, T., & Nurmi, S. (2008). Fostering elementary school students' understanding of simple electricity by combining simulation and laboratory activities. *Journal of Computer Assisted Learning*, 24(4), 271-283. doi: 10.1111/j.1365-2729.2007.00259.

Jaakkola, T., Nurmi, S., & Veermans, K. (2011). A comparison of students' conceptual understanding of electric circuits in simulation only and simulation-laboratory contexts. *Journal of Research in Science Teaching, 48*(1), 71-93. doi:10.1002/tea.20386

Khan, S. (2002). *Teaching chemistry using guided discovery and an interactive computer tool*. Unpublished doctoral dissertation (pp. 1-337). Amherest: University of Massachusetts.

Khan, S. (2011). New pedagogies on teaching science with computer simulations. *Journal of Science Education and Technology*, 20(3), 215–232. doi:10.1007/s10956-010-9247-2

Kommers, P. (2002). "Playing for cognitive growth: learning the unknown" a research agenda for the didactic Integration of Virtual Reality. E. Orhun, P. A.E. Commers (Eds.). *Information and Communication Technologies in education: A focus on cognitice tools* (pp.157-174). Cog-Tech Network, Ege University, Turkey.

Orhun, E. (2002). Design of computer-based cognitive tools. E. Orhun, P. A.E. Commers (Eds.). *Information and Communication Technologies in Education: A focus on Cognitice Tools.* (pp.157-174). Cog-Tech Network, Ege University, Turkey.

Podolefsky, N. S., Perkins, K. K., & Adams, W. K. (2010). Factors promoting engaged exploration with computer simulations. *Physıcal Revıew Specıal Topıcs–Physics Educatıon Research, 6*(2), 020117. Retrieved 2015, May 11 from http://dx.doi.org/10.1103/PhysRevSTPER.6.020117

Potvin, P., Dumont, J. G., Boucher-Genesse, F., & Riopel, M. (2012). The effects of a competency-based reform on the development of problem-solving competency in science and technology using a computer simulation and on general attitudes toward science and technology. *International Journal of Innovation in Science and Mathematics Education (formerly CAL-laborate International)*, 20(4).

Ruth, A., & Houghton, L. (2009). The wiki way of learning. *Australian Journal of Educational Technology*, 25(2), 135–152.

Rutten, N., van der Veen, J. T., & van Joolingen, W. R. (2015). Inquiry-Based Whole-Class Teaching with Computer Simulations in Physics. *International journal of science education*, (ahead-of-print), 1-21. doi: 10.1080/09500693.2015.1029033

Sarı, U., & Güven, G. B. (2013). Etkileşimli Tahta Destekli Sorgulamaya Dayalı Fizik Öğretiminin Başarı ve Motivasyona Etkisi ve Öğretmen Adaylarının Öğretime Yönelik Görüşleri, *Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi (EFMED)*, 7(2), 110-143.

Şen, A. İ. (2001). Fizik Öğretiminde Bilgisayar Destekli Yeni Yaklaşımlar. *G.Ü. Gazi Eğitim Fakültesi Dergisi, 21*(3): 61-71.

Tao, P. K. &Gunstone, R. F. (1999).The Process of Conceptual Change in Force and Motion during Computer-Supported Physics Instruction. *Journal of Research in Science Teaching*, 36(7), 859–882.

Tatlı, Z., & Ayas, A. (2010). Virtual laboratory applications in chemistry education. *Procedia Social and Behavioral Sciences, 9, 938–942.*

Turkish Ministry of Education. (2013). Fizik öğretim programı, Talim ve Terbiye Kurulu Başkanlığı. Ankara, Turkey

Wieman, C. E., Adams, W. K., & Perkins, K.K. (2008). PhET: Simulations that enhance learning. *Science*, *322*, 682-683.