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Using Interactive Course Modules to Improve Students' Understanding of Electric Circuits*

OMUR AKDEMIR
Department of Computer Education and Instructional Technology, Kdz. Eregli, Zonguldak, 67300, Turkey.
E-mail: omurakdemir@gmail.com

Offering safe, relatively inexpensive and reproducible teaching environment for exploring phenomena, interactive course modules are applications of special interest in education. Engineering and physics students usually have difficulty understating the topic of electrical circuits. There is limited evidence in the literature supporting the premise that utilizing interactive course modules improves student learning for the topic of electric circuits. Understanding the topic of electric circuits is important for high school students who plan to enter engineering programs at universities in Turkey since it is a topic covered at the university entrance exam conducted nationwide. Moreover the topic of electric circuits is taught in many engineering programs. This study explored the question that whether the achievement of students using interactive course module is different from the achievement of students taught with didactic teaching along with traditional teaching tools with fifty high school students. The pre-test/post-test with control group research design is used to investigate the research question. Findings revealed that utilizing interactive course modules to teach the topic of electric circuits is found to improve students learning better than teaching the same content with didactic teaching along with traditional teaching tools. Further research should be undertaken to compare the use of the simulations and real laboratory equipment.

Keywords: educational technology; interactive exercises; simulations; electric circuits

1. Introduction

Improvements in technology provide several alternatives for improving traditional education [1]. The information age requires the integration of computers in schools not for managerial tasks but also for improving teaching and learning [2]. The view that computers should be integrated in education has become widespread [3, 4]. Each year computers have become more and more widespread in schools [5]. The role that computers play in education is astonishing and critical in the rapidly changing world [6]. The rapid increase in the use of computers in education has changed nearly every aspect of teaching and learning. "Multiple media" including text, graphics, animation, video and sound are combined and used in computers [7]. Multimedia computer technology is used as a mean of teaching tool. Multimedia is incorporated into different subjects [8]. Receiving such a great tool teachers use multimedia computer technology to enhance their instruction with colorful visualizations and animation which are accompanied by the oral explanation [9]. [10] emphasized the importance of using vivid and accurate visuals in teaching. Simulations are smaller-scale programs that are devoted to the graphical visualization of a model of a system or a process [11]. Computer simulations have received a special interest in science and engineering education [12] since teachers are capable of manipulating variables and observing the process [13]. The need for studies investigating the effects of the simulations increases as the use of computer-based simulations in educational environments grows [14].

Traditionally, physics courses are taught using lectures with procedural knowledge followed by laboratory activities [7]. Although the laboratory process is often important for students to learn from their mistakes, a high degree of uncertainty is often found as a result of laboratory experiments and students sometimes are exposed to potentially hazardous situations in laboratory experiments [8]. Computer simulations, which offer safe, relatively inexpensive and reproducible environment [8], are an alternative to laboratory environment in courses when potentially hazardous situations in laboratory experiments are present. Basically, interactive simulations allow learners to change the input variables, to manipulate parameters, and to directly receive feedback on the changes [15].

Teachers and students often consider learning physics as a difficult pursuit [13]. It was reported that many students experience difficulties in solving applied problems [16]. It should also be remembered that solving problem is an important goal of secondary education [16]. Utilization of the computer simulations as an instructional tool was suggested to improve students' functional understanding in science courses [13]. Computer simulations are applications of special interest in teaching. The high number of sales demonstrates that teaching difficult concepts, computer simulations have

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become very popular in teaching topics in physics [15].

[17] conducted two studies to investigate the effects of using simulations in physics classes. Undergraduate students were the participants of the study. The first study compared the students' conceptual understandings during the peer instruction between traditional instruction and computer simulation developed to construct circuit. Conceptual understands of the students using simulation were higher than students in the traditional demonstrations. In a follow up study, the impact of the simulation's explicit visualization was compared. Students using simulation without the explicit current model favored the simulation more than the other group. The study also revealed that majority of students preferred the use of simulation over real laboratory environment.

[18] conducted two studies on computer simulations accessible from the PhET. In the first study, the effects of using the simulations and real equipment on students were compared. It was observed that students used the simulations just to answer the posed questions. Students reported that simulations were not very engaging. On the other hand it is also reported that real equipment often gives faulty results while simulations always produce accurate results. Different from the first study, the second study was designed to drive students' exploration with simulations by providing supporting materials having open-ended questions to support exploration. As a result of the change in the treatment used in the study, it was observed that participants dedicated significant time in the laboratory for exploration with simulations. It was concluded that simulations can be used besides the real laboratory equipment to support students' scientific exploration.

[19] investigated the effects of using simulations as a substitute for the real laboratory equipment in the direct current laboratory. Introductory physics course students' mastery of physics concepts and skills were compared for real environment and simulation. Results of the study revealed that conceptual survey scores of the students using simulations were better than the other students using the real laboratory equipment.

[20] pointed out that there are simulations available on the internet, many of which require users to subscribe for the access. On the other hand simulations on the PhET are available for everyone. Reporting the student observations on using the PhET simulations over the four years, [20] indicated that simulations are effective for students and also stimulate higher order thinking. It was also emphasized that students including reluctant learners are eagerly participate the course when simulations are used. It was reported that students learned while engaging with the simulations as if they had been playing games. Therefore students were enthusiastic about using the simulations in the class.

[21] conducted a study to compare the learning outcomes of the students engaging with blended instruction incorporating pedagogical principles derived from cognitive apprenticeship to the learning outcomes of the students using text-based materials and homework for learning. Results of the study revealed that students engaging in the blended instruction outperformed learning outcomes of the students using text-based materials and homework. Qualitative findings also revealed that students engaging in the blended instruction developed a positive attitude towards studying physics in a blended format.

[22] reported the lesson developed to engage students in the process of mathematical modelling. Simulations available at the PhET (Interactive Simulations Project at Colorado University) originally developed for physic courses were used. In a developed lesson, aligned with the Australian mathematics curriculum, students can work with simulations independently or simulations can be projected to whole students in the class. In all instances, teachers work as a facilitator. It was reported that students using the simulations in the lesson highly praise the new learning environment. It was also reported that using simulations affect students' test scores positively.

The effects of the utilizing simulations available on the PhET on achievement and attitudes of students were investigated by [23]. The quasi-experimental research design was used to conduct the study. Undergraduate students in the experimental group completed the course supported through simulations to explain the concepts on electricity and magnetic. The students in the control group completed the course taught through the traditional lecture. It was found that the course achievements of students using the simulations improved better than the students taught through the traditional lecture. However the attitudes of the students in two groups did not show differences.

[24] conducted a study to investigate the use of PhET simulations in Middle schools. Observations and interviews were conducted with four teachers to investigate the use of PhET simulations. Researchers found that PhET simulations are generally useable, engaging, and effective learning tools for Middle Schools students.

In a study comparing the effects of using simulation applets and traditional didactic, chalk-and-talk instruction on students' understanding of the gas and liquid pressure concepts, [25] found that students utilizing the simulation applets outperformed the students completing the course through the didactic instruction. Results also indicated that students generally found the animation applets interesting and helpful in their physics lessons.

In a study conducted to investigate the effectiveness of undergraduate course enhanced with technology, [1] found that digital communication course enhanced with computer simulations, web-based simulation tools and remote laboratory experiment improved the progress and satisfaction of the students.

[26] conducted a study to investigate the effects of a real-world engineering example integrated into a computer simulation learning module to improve student understanding in high school physics. Findings of the study revealed that students reported positive experiences with the developed computer simulation module.

Considering the general characteristics of new generation students, often called ''Nintendo generation, Z generation, digital native'', are expected to use interactive course modules more often than a traditional textbook to learn science concepts [7]. It is rational to think that in order to respond to the preferences of new generation students, teachers may consider the integration and the use of interactive course modules more often in their courses than traditional teaching tools. Also it was pointed out that engineering and physics students usually have difficulty understating the topic of electrical circuits [12]. For instance over 5 million students are registered in universities in Turkey including two year vocational schools and four year colleges in 2015 [27]. More than 4 million students study at four year colleges and almost 300 thousands of them are in engineering programs. Being an engineering student is challenging since every year two million high school graduates enter the compulsory university placement exam and then based on their preferences and their scores at the university placement exam, high school graduates enter a program at universities in Turkey. Thirty physics questions are asked to the students at the exam but the average correct answer is six [28]. There is a need to improve the scores of students. In an afford to improve students' knowledge for the topic of electric circuit, this study was designed to investigate the question that whether the achievement of students in courses where interactive course modules are integrated is different from the achievement of students in courses where didactic teaching method and traditional teaching tools are used to teach the topic of electric circuit. This study is designed to address the following research questions:

1. How does the use of course module enhanced with interactive computer simulations in the physics course affect students' achievement on the topic of electric circuit?
2. How does students' achievement on the topic of electric circuit change when the didactic teaching method and traditional teaching tools are used in the physic course?
3. Is there a difference between the gain scores of students utilizing course modules enhanced with interactive computer simulations and exercises in their physics course and the gain scores of students utilizing the didactic teaching method and traditional teaching tools in their physics course?

2. Method

2.1 Participants

The study was conducted in a high school located in the Black Sea region in the Spring semester. There are four grade levels, 9th, 10th 11th 12th, in high schools in Turkey. After 8 years primary education, students start 4 years secondary education. Primary and secondary education is compulsory for all students in Turkey. The participants of this study were 10th grade high school students who enrolled to the physics course. The age of the students ranges between 16 and 17 years old. Two sections of the physics course were taught to participants by the same instructor. 50 students participated in the study. The researcher randomly assigned one section of the course as the experiment and the other section of the course as the control group.

2.2 Research design

The pre-test post-test with control group quasi-experimental research design was used to conduct the study. The topic of electric circuits was taught to the experiment and control groups. Computer simulations obtained from the University of Colorado's PhET project were integrated in the developed instructional course module which was used for the experimental group. The open-source authoring application ExeLearning was used to construct the course module (Fig. 1). Students and the teacher, for example, were able to manipulate variables such as the electric voltage and resistance and were able to observe the changes happening in the electric current in the simulation. Fig. 2 demonstrates the simulation used in the study. The developed course module was presented to the students in the experimental group through the computer presentation and students' active participation was encouraged and asked in the class to use computer simulations and to complete interactive exercises in the course module. For instance after explaining serial circuit, students were asked to increase the value of the resistance and observe the changes

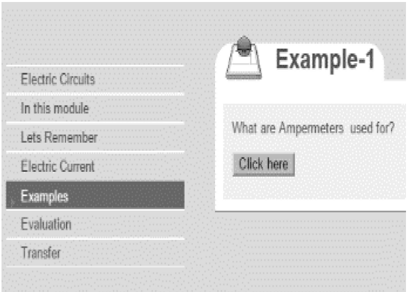

Fig. 1. A sample figure from the course module.

happing on the current. Besides simulations, course module had the course content and interactive exercises (Fig. 1). The students in the experimental group saw the course content and completed the interactive exercises (Fig. 2) in the module presented through the LCD projector.

On the other hand, the control group received instruction in a traditional manner. Didactic teaching method was used to teach the course to the control group. PowerPoint slides having figures and text were used to present the course content to students in the control group through the LCD projector. Students in the control group were also asked to complete course exercises found in the course book. For instance after explaining the serial circuit, students were asked to compute currents in the serial circuit for different values of the resistance. The multiple choice test about electric circuits was administered before and after the study to the experiment and the control group.

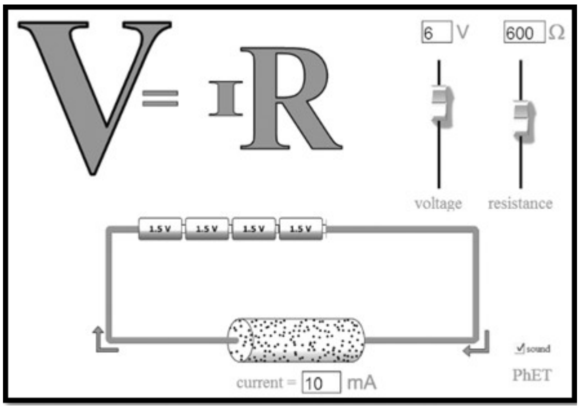

Fig. 2. A sample figure from the simulation.

2.3 Data collection instrument

The achievement of students on electrical circuits was measured through the multiple choice test. Initially the 40-item multiple question test was constructed for the topic of electric circuits. The experienced instructor reviewed the multiple-question test to ensure its content validity. The developed test was administered to 60 students who took the same course a year before the study to find the measure of internal consistency. After removing items whose Point Biserial values falling below 0.3, the measure of internal consistency of the electric circuits test was calculated. The internal consistency of the electric circuits test found 0.859. The final version of the achievement test had 25 items, each of which has five choices for each answer.

3. Analysis and results

Student learning for the topic of electric circuit was measured by the multiple-choice test. Participants were received four points for the each correct answer in the pre-test and the post-test. The same 25-question-multiple-choice test with 5 response choices was used before and after the study to collect data. Scores of students ranged from 0 to 100 in the multiple-choice test measuring students' learning for the topic of electric circuits. Descriptive statistics, independent and dependent t-tests were used to investigate the research questions.

The descriptive analysis of the pre-test result of participants is presented at the Table 1. When the pre-test results are reviewed, it is found that the mean score of the experimental group is 32.4 (SD=7.68) and the mean score of the control group is 27.5 (SD=6.86).

The descriptive statistics for the post-test scores of participant is presented at the Table 2. Findings in the Table 2 reveal that the mean score of the

Table 1. The descriptive analysis of pre-test results of participants

		N	Mean	Std. Deviation	Std. Error Mean
Experimental Group	1.00	25	32.4800	7.68722	1.53744
Control Group	2.00	25	27.5200	6.86246	1.37249

Table 2. The descriptive analysis of post-test results of participants

		N	Mean	Std. Deviation	Std. Error Mean
Experimental Group	1.00	25	59.6800	4.74974	0.94995
Control Group	2.00	25	43.2000	3.65148	0.73030

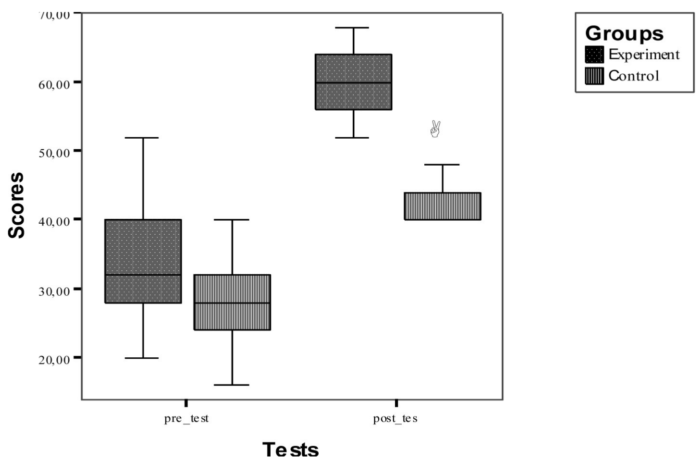

Fig. 3. Pre-test/post_test scores of the experimental and control groups.

experimental group is 59.6 (SD = 4.74) and the mean score of the control group is 43.2 (SD = 3.65).

Figures 3 and 4 present the findings of the pre-test, post-test and gain scores for the control and experimental group. As displayed in the Fig. 3, scores of the experimental group are higher than the control group throughout the study. The Fig. 3 also reveals that both groups' scores improved in the post-test as compared to the pre-test scores.

The first research question investigated the effects of the use of course module enhanced with interactive computer simulations and interactive exercises in the physics course on students' achievement for the topic of electric circuit. The result of the paired sample t-test revealed that post-test scores (M = 59.6) of the experimental group is statistically higher than the pre-test scores (M = 32.4) of the experimental group ($t_{(24)} = -13.08$; $p < 0.05$) (Table 3). The use of the course module enhanced with simulations and interactive exercises improved the achievement of the students at the end of the study. The participants in the experimental group were received the course module which was presented to the students through the computer presentations. During the course students' active participation was encouraged in the class to manipulate the variables in the computer simulations and to complete the exercises. The use of course module enhanced with computer simulations and interactive exercises improved the achievement of students in the physics course. This result supports the finding of [13]'s study on the effect of using simulation to teach physics course and [15]'s findings for the effectiveness of using simulations for learning concepts.

The second research question explored the effects of the instruction taught using the didactic teaching method and traditional teaching tools in the physics course on students' achievement for the topic of electric circuit. The result of the paired sample t-test revealed that the post-test scores (M = 43.2) of the control group is statistically higher than the pre-test scores (M = 27.5) of the control group ($t_{(24)} = -12.8$; $p < 0.05$) (Table 4). The achievement of students improved at the end of the study as compared to the beginning of the study. The control group was received the instruction taught through didactic teaching method. PowerPoint presentations were used during the course to present the course content. Students in the control group were also asked to complete course exercises found in the course book. This finding indicates that instruction taught using the didactic teaching method and traditional teaching tools for the control group also improved the achievement of students.

The last research question investigated the difference between the gain scores of students in the experiment and in the control group. The gain score for each student was calculated by subtracting the post-test results from the pre-test results.

Table 3. Pre-post test comparison of the experiment group

	Paired Differences							
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
				Lower	Upper			
Pre-Post Test	–27.2	10.4	2.1	–31.4	–22.9	–13.08	24	0.000

Table 4. Pre-post test comparison of the control group

	Paired Differences							
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
				Lower	Upper			
Pre-Post Test	–15.6	6.1	1.22	–18.19	–13.16	–12.8	24	0.000

Table 5. The comparison of the mean gain scores

Groups	N	Mean	Std. Deviation	df	t	p
Experimental group	25	27.2	10.39	38.7	4.78	0.0
Control group	25	15.68	6.1			

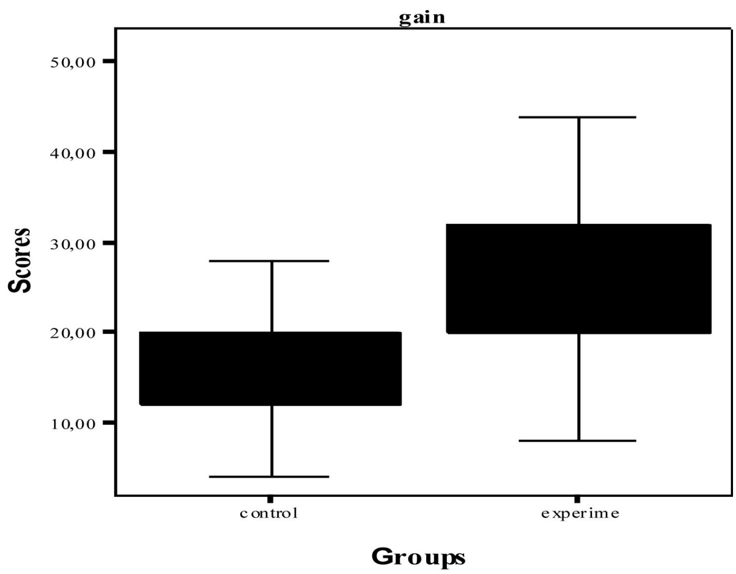

Fig. 4. The gain scores of the experimental and control groups.

Figure 4 presents the gain scores of the control and experimental group. As displayed in Fig. 4, the gain scores of the experimental group are higher than the control group in the study.

For the investigation of eventual differences, the independent samples t-test was used to explore changes between the gain scores of the control group and the experimental group. Results of the independent samples t-test revealed that there is a statistically significant difference between the gain score of the experimental group and the gain score of the control group ($t_{(38)} = 4.78$; $p < 0.05$) (Table 5). The gain score of the experimental group ($M = 27.2$) was higher than the gain score of the control group ($M = 15.68$). This finding indicates that integrating computer simulations and interactive exercises to the course modules to teach physics course for the topic of electric circuit improves students' achievement more than the course that was taught with the didactic teaching method and traditional teaching tools.

4. Discussion

The findings of this study suggest three important findings regarding the use of course modules enhanced with computer simulations and interactive exercises on the achievement of students for the topic of electric circuits. The first finding indicated that the use of course module enhanced with computer simulations and interactive exercises improved the achievement of students for the topic of electric circuits. The second result revealed that instruction taught using the didactic teaching method and traditional teaching tools for the control group also improved the achievement of students. The last finding pointed out that integrating computer simulation and interactive exercises to the course modules to teach the topic of electric circuit improves students' achievement more than the course taught using the didactic teaching method and traditional teaching tools.

[18] pointed out the fact that today's learners can access to a wide range of learning tools, from traditional textbooks to the internet to computer simulations. Properly designed computer simulations are useful tools to promote student learning for different contexts [1, 19, 26]. In this study, interactive simulations have made part of the course module to enhance students' knowledge and understanding for the topic of electric circuit. Interactive simulations that support scientific exploration provided students a tool to manipulate variables and observe the effects of the changes on the resistor, current and voltage. The course modules were designed based on the premise that representations embedded into the learning materials can play important roles in engaging students' learning. Visual cues found in the computer simulations have made concept visible for students. Simulations embedded into the course module have provided a conceptual access to concepts including resistor, voltage and current. Having been able to visualize the concepts that are otherwise not visible, students were able to comprehend the concepts better in simulations. [20] also reported that even reluctant learners participate in the learning activities enthusiastically when the instruction was designed with simulations which promote higher order thinking. Positive influence of using simulation on students' learning has also been reported in other studies [13, 15, 17, 19, 23]. Besides the course content, the course module had interactive exercises.

In a study investigating the effects of interactive exercises developed using the open source authoring tool on students' achievement in the Science and Technology course, [29] found that the use of interactive exercises embedded in the instruction improves the achievement of students more than the instruction having traditional exercises. Therefore the use of the interactive exercises on the course module might have a positive impact on the achievement of students as well. The designed course module having simulations and interactive exercises permitted students to interact with the course materials and increased the interaction between students and materials.

Even it does not improve student achievement as much as the instruction enhanced with simulations and interactive exercises, it is important to note that teaching the topic of electric circuit with the didactic teaching method and traditional teaching tools also improved students' achievement. Similarly, [9] reported that visualization generated by computers offers a visually intuitive and pedagogically sound medium. The control group utilized visuals in the presentations and in their course book throughout the study. Utilization of the visuals appears to improve student learning in the control group.

The findings in this study are consistent with findings of [17] study which found that conceptual understanding of the students using simulation were higher than students in the traditional demonstrations. [25] also found that students utilizing the simulation applets outperformed the students completing the course through the didactic instruction. [22] added that students using the simulations in the lesson do not only highly praise the new learning environment but also get higher test scores. Identically, while [23] found that the course achievements of students using the simulations improved better than the students taught through the traditional lecture. [23]'s finding revealed that the attitudes of the students in two groups did not show differences. This raises the question why? Further research needs to examine more closely the effects of simulation on the attitudes of the students. [24] reported that simulations available on the PhET are generally useable, engaging, and effective learning tools for Middle Schools students.

Several studies also investigated the effects of using simulations instead of real laboratory equipment [18] reached the conclusion that simulations which always produce accurate results can be used besides the real laboratory equipment to support students' scientific exploration since real equipment often give faulty results. Identically [19] found that conceptual survey scores of the students using simulations were better than students using the real laboratory equipment.

In this decade teachers are entering new territory with respect to technology implementation [30]. Stimulating experiments, simulations are very useful tool in engineering [31]. Simulation technologies are always evolving. This study demonstrated that the use of course modules enhanced with computer simulations and interactive exercises is useful to enhance the students' learning for the topic of electric circuits. It seems that as the use of course module having computer simulations and interactive exercises increases, students' functional understanding for the topic of electric circuits will be improved. [32] pointed out the importance of integrating the simulation-based engineering and science in the 21st century engineering education curricula. Improving the achievement of high school students by the use of simulations for the topic of electric circuits will have positive effects on the scores of students at the nationwide university placement exam in Turkey. As a result, among more two millions high school graduates entering the university placement exam in Turkey [28], students dreaming about entering engineering programs will find themselves within the 300 thousands engineering students [27].

5. Conclusion

In conclusion giving students an opportunity to change the input variables and observe the effects of the changes assists students to understand the topic of electric circuits better than utilizing didactic teaching method and traditional teaching tools. The implication of this study's finding in practice is that course modules enhanced with interactive simulations and interactive exercises should be preferred to improve the achievement of students for the topic of electric circuits. It should also be remembered that in the absence of the course modules enhanced with interactive simulations and interactive exercises, the didactic teaching method and traditional teaching tools including computer presentations and course books, should also be used to increase student learning to teach the topic of electric circuit. It was beyond the purpose of this study to compare the use of the simulations and real laboratory equipment. However it is recommended that further research should be undertaken to provide more results to elaborate the issue.

References

1. A. Kara, N. E. Cagiltay and Y. Dalveren, An enhanced course in digital communications, *International Journal of Engineering Education*, **30**(4), 2014, pp. 1048–1059.
2. R. M. Marra, An online course to help teachers "use technology to enhance learning": Successes and limitations, *Journal of Technology and Teacher Education*, **12**(3), 2004, pp. 411–429.
3. J. E. Davies, M. Szabo and C. Montgomerie, Assessing information and communication technology literacy of education undergraduates: instrument development, ED_MEDIA 2002 World Conference on Educational Multimedia, Hypermedia & Telecommunications, Denver, Colorado, 2002.
4. M. C. Linn, Technology and science education: starting points, research programs, and trends, *Journal of Science Education*, **25**(6), 2003, pp. 727–758.
5. M. E. Jennings, L. B. Holcomb, C. O. Lima and S. W. Brown, Teachers' perception of their classroom technological resources and the perceived feasibility of implementation of their Connecticut teacher technology competencies: level II proposals, Northeastern Educational Research Association Conference, Kerkonkson, New York, 2005.
6. B. Abbey, C. Tsai, S. S. J. Lin, and M. Tsai, Developing an internet attitude scale for high school students, *Computers & Education*, **37**, 2001, pp. 41–51.
7. J. P. Stoquert, F. Pezheux, Y. Herve, H. Marchal, R. Stuck and P. Siffert, VRBS: A virtual RBS simulation tool for ion beam analysis, *Nuclear Instruments and Methods in Physics Research*, B 136–138, 1998, pp. 1152–1156.
8. R. Allen, The Web: interactive and multimedia education, *Computer Networks and ISDN Systems*, **30** (1998), 1998, pp. 1717–1727.
9. D. J. Whitford, Teaching ocean wave forecasting using computer-generated visualization and animation Part 1: Sea forecasting, *Computers & Geosciences*, **28**, 2002, pp. 532–546.
10. T. Mzoughi, S. D. Herring, J. T. Foley, M. J. Morris and P. J. Gilbert, WebTOP: A 3D interactive system for teaching and learning optics, *Computers & Education*, **49**, 2007, pp. 110–129.
11. F. Esquembre, Computers in physics education, *Computer Physics Communications*, **147**, 2002, pp. 13–18.
12. E. G. Bakhoum, Experimental demonstration of a fundamental concept in electromagnetics, *International Journal of Engineering Education*, **25**(5), 2009, pp. 962–968.
13. A. Jimoyiannis and V. Komis, Computer simulations in physics teaching and learning: a case study on students' understanding of trajectory motion, *Computers & Education*, **36**, 2001, pp. 183–204.
14. D. A. Rehn, E. B. Moore, N. S. Podolefsky and N. D. Finkelstein, Tools for high-tech tool use: A framework and heuristics for using interactive simulations, *Journal of Teaching and Learning with Technology*, **2**(1), 2013, pp. 31–55.
15. A. Holzinger, M. D. Kickmeier-Rust, S. Wassertheurer and M. Hessinger, Learning performance with interactive simulations in medical education: Lessons learned from results of learning complex physiological models with theHAEMOdynamics SIMulator, *Computers & Education*, **52**, 2009, pp. 292–301.
16. H. J. Pol, E. G. Harskamp and C. J. M. Suhre, The effect of the timing of instructional support in a computer-supported problem-solving program for students in secondary physics education, *Computers in Human Behavior*, **24**, 2008, pp. 1156–1178.
17. C. J. Keller, N. D. Finkelstein, K. K. Perkins and S. J. Pollock, Assessing the effectiveness of a computer simulation in introductory undergraduate environments, *2006 Physics Education Research Conference*, **883**, 2006, pp. 121–124.
18. N. S. Podolefsky, K. K. Perkins and W. K. Adams, *Computer simulations to classrooms: tools for change*. Boulder: University of Colorado, 2009.
19. N. D. Finkelstein, W. K. Adams, C. J. Keller, P. B. Kohl, K. K. Perkins, N. S. Podolefsky and R. LeMaster, When learning about the real world is better done virtually: A study of substituting computer simulations for laboratory equipment, *Physical Review Special Topics-Physics Education Research*, **1**(1), 2005.
20. C. Sandoval, Computer simulations in physics, chemistry, earth science and biology, Teaching Science: *The Journal of the Australian Science Teachers Association*, **57**(2), 2011.
21. V. Chandra and J. J. Watters, Re-thinking physics teaching with web-based learning, *Computers & Education*, **58**(1), 2012, pp. 631–640.
22. A. Sokolowski and R. Rackley, Teaching harmonic motion in trigonometry: inductive inquiry supported by physics simulations, *Australian Senior Mathematics Journal*, **25**(1), 2011, pp. 45–53.
23. M. S. Alrsa'i and Y. Ahmed Aldhamit, The effect of computer simulation on al-Hussein Bin Talal university student's understanding of electricity and magnetism concepts and their attitudes toward physics learning, *International Journal of Educational Research and Technology*, **5**(1), 2014, pp. 54–60.
24. K. Perkins, E. Moore, N. Podolefsky, K. Lancaster, C. Denison, N. S. Rebello and C. Singh, Towards research-based strategies for using PhET simulations in middle school physical science classes. *AIP Conference Proceedings-American Institute of Physics*, **1413**(1), 2011, pp. 295–298.
25. E. Y. Y. Oh, D. F. Treagust, T. S. Koh, W. L. Phang, S. L. Ng, G. Sim and A. L. Chandrasegaran, Using visualisations in secondary school physics teaching and learning: evaluating the efficacy of an instructional program to facilitate understanding of gas and liquid pressure concepts, *Teaching Science*, **58**(4), 2012, pp. 34–42.
26. N. Fang, K. Nielson and S. Kawamura, Using computer simulations with a real-world engineering example to improve student learning of high school physics: A case study of k-12 engineering, *International Journal of Engineering Education*, **29**(1), 2013, pp. 170–180.
27. Council of Higher Education (CoHE), https://istatistik.yok.gov.tr/, Accessed 1 March 2015.
28. Student Selection and Placement Centre (ÖSYM), http://www.osym.gov.tr/, Accessed 1 March 2015.
29. Ö. Akdemir, K. Kunt and İ. Tekin, The effects of interactive

exercises on students' achievement: using the open source authoring application, *Procedia-Social and Behavioral Sciences*, **55**(2012), 2012, pp. 1009–1013.
30. V. Irvine and C. Montgomerie, A survey of current computer skill standards and implications for teacher education, ED_MEDIA 2001 World Conference on Educational Multimedia, Hypermedia & Telecommunications, Tampere, Finland, 2001.
31. J. D. Dominguez and J. A. D. Lopez, Learning to design experiments using computer simulations, *International Journal of Engineering Education*, **27**(4), 2011, pp. 693–702.
32. A. J. Magana, S. P. Brophy and G. M. Bodner, student views of engineering professors technological pedagogical content knowledge for integrating computational simulation tools in nanoscale science and engineering, *International Journal of Engineering Education*, **28**(5), 2012, pp. 1033–1045.

Omur Akdemir received a B.Sc. degree in Electronic and Computer Education from Gazi University (Ankara, Turkey). He received his M.Sc. and Ph.D. degrees in Instructional Design, Development and Evaluation Department from Syracuse University (New York, USA). He is an Associate Professor in the Department of Computer Education and Instructional Technology at Bülent Ecevit University (Zonguldak, Turkey). His research interests and consulting experience are online learning environments and ICT integration.