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Research Paper

The Effect of Computer Network Simulators on Students' Motivation and Learning

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ABSTRACT

The purpose of this study is to explore students' attitude, motivation and learning in introductory networking courses where a simulator was utilized for doing practice on the content. Basic qualitative research method was utilized to seek answers to the research question. Data was collected by individual interviews, conducted to 12 undergraduate and 5 graduate students. The interview data was transcribed and analyzed trough content analysis to find out the themes and categories. Analysis of data culminated five main themes with categories. Two of the five themes were related to student attitudes; (1) *goal setting* theme with information age qualities, professional development and problem solving skills categories, (2) *learner internal factors*, with curiosity and interest categories. Other two themes were related to student motivation; (3) *Self-confidence*, with visuality and manuals categories and (4) *locus of control*, with chance to practice and trial and error categories. The last theme was related to learning; (5) *deep understanding* with providing concreteness, learning by applying and visuality categories.

Keywords: *simulation, network simulators, motivation, attitude, learning, computer networks*

INTRODUCTION

With the increasing use of computer technology especially since the last decade, the use of computer-based instruction methods has become more common. In today's information society, where people use information in any area possible from economy as consumers to education as learners or instructors, the tools providing information have also become incredibly important. Computer-based instructional methods which provide quick and easy, time and cost efficient ways of teaching and learning have become important in education. Technology can be used in many different ways to support learning. Simulations as a technology tool to support the learning enable students to model real world situations in virtual environments. Simulations are defined as "analogies of a real world situation" (Prensky, 2001, p. 128). According to De Jong and van Joolingen (1998) a computer simulation is "a program that contains a model of a system, natural or artificial, equipment or a process."

Research on teaching and learning of computer networks is an essential part of the information and instructional technology field. The use of simulators is very common in teaching of computer networks because they provide flexibility and availability. Because of the detailed and abstract concepts and protocols in computer networking content, it is a challenging area for instructors to teach. Students are expected to acquire both conceptual and procedural knowledge to be able to manage real computer networks scenarios (Ruiz-Martinez, Pereniguez-Garcia, Marin-Lopez, Ruiz-Martinez, & Skarmeta-Gomez, 2013). Creating procedural knowledge and skills and creating a semantic link to abstract concept of the course is challenging for teachers and learners. To deal with this challenge students need to do practice in laboratory environment. However, real computer networks laboratory environments are expensive to build. Virtual laboratories, on the other hand, are alternatives to real laboratories that can help students to master practical skills they need to acquire in the absence of real laboratories. Virtual laboratories can help making crucial educational applications available to students (Kumar, Pakala, Ragade, & Wong, 1998; Shin, Yoon, Park & Lee, 2000; Jeschke, Richter, & Zorn, 2010). Virtual laboratories help students' to relate the theoretical and conceptual information in the course content to the procedural and practical knowledge by simulating the real laboratory environment (Woodfield, 2005). Graven, Hassen and Mackinnon (2009) made a study related with the routing topic in computer network course. The purpose was to show the viability of using a specifically designed computer game to integrate abstract learning materials as a part of blended learning environment. The result of the study showed that students learned as much in specifically designed simulation platform as from a traditional lecture and lab

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setting. Moreover, the platform also increased the students' motivation.

Specialized network laboratories are important for the computer network courses. According to Alnoukari, Shafaamry and Aytouni (2013) teaching concepts, protocols, design and applications of computer network at colleges and universities are problematic without having specialized laboratories. However, real network laboratories are very expensive and they are not proper for the various network topologies. Also real laboratory platforms can be used only a small number of students due to physical limitations (Alnoukari, Shafaamry and Aytouni, 2013). At this point, computer network simulation provides solutions. Network simulators provide many advantages. For example, they are fast and inexpensive when compared to the real devices. Computer network simulators can help students to build virtual networks and concentrate on procedures. Network simulation could be used for teaching important networking topics such as IP addressing, static and dynamic routing like RIP and OSPF (Baumgartner, Braun, Kurt & Weyland, 2003). While setting up a network environment including multiple networked computers, routers and data links, network simulators are relatively fast and inexpensive in terms of cost and time (Potemans, Theunis, Rodiers, Van den Broeck, Ley, Van Lil, & Van de Capelle, 2002).

In computer networking courses, which include many abstract topic and protocols, motivating students is an important issues. According to Zheng (2015, p. 30), computer networks concepts and protocols are very abstract and can be boring for students. An interactive learning experience, which gives students the opportunity to control their own learning and a chance to have hands-on experiences with subject matter, is supportive of high-level student learning as well as mastery of practical skills. In terms of computer network courses, this interactive learning experience could be provided via simulators (Urhahne & Harms, 2006). Motivation is often thought as a necessary processor for the learning (Gottfried, 1985). Literature supports the idea that motivated students spend more time and effort in learning and they are more persistent so as to complete challenging tasks (Stipek, 1993).

Motivation might not mean much unless it lasts for a long time, as long as the learning period if possible. One of them is ARCS Model of Motivational Design, which ensures the continuity of the motivation to learn. According to ARCS Model, instructional materials should be configured with some strategies like (A) Attention, (R) Relevance, (C) Confidence and (S) Satisfaction (Keller, 1983; Keller & Kopp, 1987). Petranek et al. (1992) stated that games and simulations excited students and increased their motivation to learn. Akkağıt and Tekin (2012) conducted a study to see the effect of the simulation-based education on the secondary school students' achievement in the course of basic electronics and measurement. The study was conducted with 30 tenth-grade students form Palu Vocational and Technical Education Center. The result of the study shows that simulation based education increases students' achievement level, students' level of understanding and motivation. According to the results of the research of Kranjc (2011), simulation program attracted the interest and attention of the students. In their study, Garard et al. (1998) with the 90 undergraduate students enrolled in speech communication courses at Midwestern University found that there were significant differences in students' motivation according to types of instruction received. The research showed that students who study with the game and simulation activities during the lesson are more interested and motivated.

Positive attitude towards the course is also important since attitude affects the students' success. Hendricks (1997) stated that motivation and attitude is the key point for the achievement of the students. Zimmerman, Bandura, and Martinez-Pons (1992) also observed in their study a positive significant correlation between students' attitude and academic achievement. Eagly and Chaiken (1993, p. 1) state that attitude is "a psychological tendency" which is revealed through the evaluation of certain cases "with some degree of favor or disfavor"

According to Anderson (1994), five components of attitude are emotion, goal, direction, strength and consistency. There are many model related with the attitude. ABC model is one of the most useful attitude models (Eagly & Chaiken, 1998). According to the model, attitude has three elements, which are affective, behavior, and cognition. According to affective component, an individual's attitude towards an object cannot be determined only by identifying his/her beliefs about something. A person's feeling and emotions play an important role on attitude. According to Agarwal & Malhotra (2005), feeling, emotions and attitude are combined so as to propose an integrated model of attitude. Behavior is another component of attitude. According to Wicker (1969), behavioral tendency of an individual consists of actions and observable responses that are the result of attitude object. Behavioral intension is related with the people's goals and intentions to act in a specific way. Goal is one of these components of attitude. Goal setting provide a positive contribution to the development of positive attitude (Bennett as cited in Demir, 2002).

The purpose of this study is to investigate the students' attitude, motivation and learning towards course content in introductory computer networking courses. In doing so, three research questions were guiding the study:

1. What was the students' attitude towards the computer networks course content?
2. How did using the computer networks simulation program affect students' motivation in the computer network course?
3. What were students' perceptions about the effect of using a computer networks simulation program to learning the course content?

METHOD

Research Design

For this exploratory research, a qualitative research design with basic qualitative research method was preferred to get insight to participants' attitude towards the course content and thoughts, values and beliefs about the effects of computer networks simulation programs on their motivation and learning. Qualitative method in exploratory research has some advantages. First, participants have the opportunity to answer open-ended questions with their own words instead of choosing them from fixed responses as most quantitative methods do. Secondly, qualitative method gives chance to the researcher to probe initial participants' responses by asking how or why (Mack et al., 2005, p4). According to the Merriam (2009), the characteristics of basic qualitative research are as follows:

1. How participants commend their experiences,
2. How participants build their worlds,
3. How participants assign meanings to their experiences

Qualitative research design is employed to explore different aspects of experiences of students on phenomena. This study aimed to investigate students' attitudes and opinions about the effect of simulation program on their motivation and learning towards the computer network course.

Participants of the Study

The participants of this study were 17 students who took introductory computer networks courses at the 2014-2015 fall semesters at a public university. All participants experienced the simulator and the virtual laboratory activities for 8 weeks. Convenience sampling was used in the study. Like in most qualitative studies, generalizing the findings and conclusions drawn from the result of the study have to be done with great care to avoid any over generalizations.

The voluntary participants were interviewed individually and they were informed about the study the class meetings, presentation, lecturing and demonstrations were used as the instructional method by the teachers. In the hands-on laboratory activities, before starting the interview. During the interview, participants explained their opinions and perceptions about how the simulation program they used effect their attitude, motivation and learning in the course. The participants' characteristics are provided in Table 1.

Table 1 Characteristics of Participants

	Age	Gender	University	Grade
1	21	M	Undergraduate student	1
2	18	M	Undergraduate student	2
3	18	M	Undergraduate student	English Preparation
4	23	M	Undergraduate student	4
5	23	M	Undergraduate student	4
6	24	M	Undergraduate student	4
7	22	F	Undergraduate student	2
8	22	F	Undergraduate student	1
9	21	F	Undergraduate student	4
10	24	M	Undergraduate student	2
11	32	F	Graduate student	M.Sc.
12	25	M	Graduate student	M.Sc.
13	29	M	Graduate student	M.Sc.
14	23	F	Undergraduate student	3
15	24	M	Undergraduate student	3
16	26	M	Graduate student	M.Sc.
17	37	F	Graduate student	M.Sc.

Context and Procedures

During the study, the data was collected from two introductory network courses with very similar content utilizing computer simulators to support students learning. The main goal of the courses was to present information about entry-level computer networks topics like OSI Reference Model, TCP/IP Model, data communication, network devices, and routing. The courses consisted of class meetings and laboratory activities. The courses had an online platform for presenting the course reading materials to students. In

students experienced real network devices. The classes were held in a computer laboratory with computers having Internet connections. After demonstration of

procedural knowledge such as configuring devices for specific protocols, students were asked to use the computer networks simulation programs to actually apply the procedures. The purpose of the simulation program was to provide an environment for practicing immediately after demonstration of the procedure.

The Computer Network Simulator

The computer network simulator was creating a virtual networking environment to simulate device configuration and functions like assigning hostnames, IP address, subnet mask, gateway, DNS, switching, and routing protocols. Students could configure devices by using the graphical user interface in the virtual space provided. In addition, they could observe the protocol interaction and encapsulation process. The students could see simulated data packets and observe the functions in layers of OSI and TCP/IP models. The main screen of a simulator is provided in Figure 1.

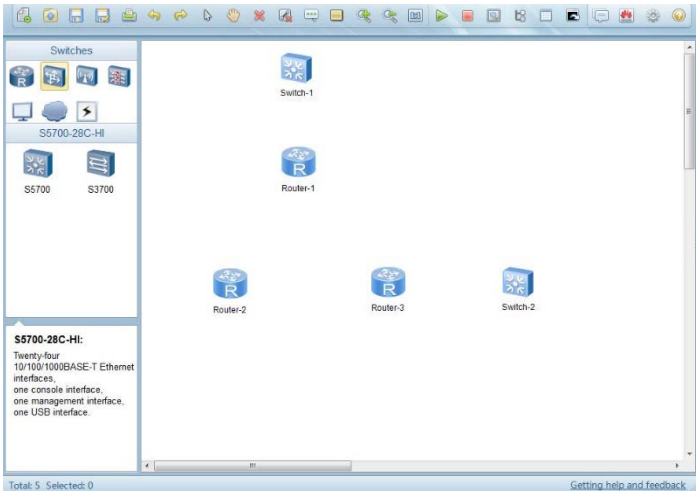

Figure 1. Simulation program main screen

The components and features of the simulator programs are explained below:

Workspace: The virtual workspace allowed students to create logical network topologies. In addition, physical workspace provided students a graphical physical dimension of logical network.

Networking Devices: Various networking devices like routers, switches, connections, end devices, hubs, and servers were simulated so that students could create different networking scenarios.

Connections: **V**arious cable types such as console cable, copper straight-through cable, crossover cable, and serial cables could be used to connect the virtual networking devices to each other.

Command Line Interface (CLI): Created a text based user interface where students could type different commands to configure the virtual devices.

Graphical User Interface (GUI): Enabled users to easily drag and drop the network devices in the virtual environment to create networking topologies.

Protocols: The simulator supports various TCP/IP and routing protocols that could be started for execution on the virtual devices.

Modular Devices: Virtual devices with modular physical interfaces enabled users to plug in interface cards like in a real device.

Tutorials: Simulation programs included many step-by-step tutorials so that students could familiarize with device and protocol features.

Help: Included many notes and tips to support the students understanding.

Activity Wizard: Allowed students to control their own learning by using guided activities.

Lab Grading Function: Provided students with grading and feedback information on how well they performed in the simulator activities.

Interview Protocol

Semi-structured interviews were carried out to determine the students' attitude towards the course content and perceptions on the effect of the simulator on their motivation and learning. The advantage of semi-structured interviews was that the researcher could ask further question so that participants could give further detailed answers.

The interview protocol consisted of 11 open-ended questions based on three subscales, i.e. attitude, motivation and learning. The first three questions were related with the attitude of the students toward the course content. The next four questions were about the effect of simulation program on students' motivation. The last four questions were about the effect of simulation program on students' learning. The protocol was checked and revised by a field expert on computer networks and an expert in instructional technology field for validity. According to the feedback of the experts, revision on the interview questions were made. After a three stage iterative feedback process (revision-corrections), interview questions were finalized.

Data Collection and Analysis

From 35 students taking the introductory courses, 17 students participated to the interviews voluntarily. The interview place was the class where the courses were held. Interviews were made individually and were recorded with the consent of the participant. Before the interview, participants were informed about the purpose

and approximate duration of the interview which was around 15 to 20 minutes. The interviews were recorded and transcribed.

Content analysis was used and data was investigated and described in a systematic way. During the data analysis, the themes and categories were found to drive meaningful results. The reliability of the analysis was established through repeated audit trails. According to Lincoln and Guba (1985) audit trial is one of the important elements that establish the credibility of qualitative studies. For inter-coder validity, two different researchers conducted the generation of themes and categories independently. After they located their themes and categories independently, the results were compared. Cohen's Kappa statistics was utilized to examine inter-coder reliability. The results of the inter-coder reliability on this study showed that kappa was equal to 0.72 which showed that there was a substantial agreement between two coders. According to Landis and Koch (1977), kappa values between 0.61 and 0.80 are substantial. In qualitative paradigm, transferability or applicability is an essential criterion for the quality of research study (Lincoln & Guba, 1985). In this study, detailed description of data was provided in order to establish transferability. All of the interviews were transcribed and turned into written format. The quotations used by the researcher were directly taken from transcribed data without any manipulation. This allows other researchers to transfer and generalize the results of this study to the other context and settings.

RESULTS

Results on Attitude of Students

The answers of the participants showing their attitude towards the computer network topics were collected under two themes, "goal setting" and "learner internal factors". Tables 2 summarize the themes and categories related with attitude of students' towards course content.

Table 2. Attitude themes and categories

Themes	Categories	Total *f* (N=17)
Goal Setting	Information Age Qualities	5
	Professional Development	12
	Problem Solving Skills	5
Learner Internal Factors	Curiosity	9
	Interest	11

Goal setting was the first theme found in the attitudes of the interviewed students. It is related to the process of deciding what someone wants to accomplish and devise a plan to achieve the result he/she desires. Students stated that personal development in a field like computer networks is very important for them because of their career goal. Some of the keywords related to this theme were information age, career, and solving computer and internet related problems which were further grouped into categories.

Information age qualities was the first category driven under the to the goal setting theme. Some of the participants mentioned that they took the course because "we are living in the information age". They thought that information technologies are widespread and almost all of the professions have some form of connection to it. A typical quotation from the interviews in this category is provided below:

"Since we live in this system, we should have information about computer networks. There is a growing system. We must learn computer networks not to be a small fish in the computer age."

The second category found was *professional development*. Considering that development of skill is largely relied on its practice, the simulations in network course allowed students to facilitate development of profession-related skills and improvement of knowledge related to network topics. This was clearly indicated by following participant:

"I am …. Engineering student and I know we will be experts in IT. Technology and IT will reach a higher importance level in the coming years and it will be very important for the companies. So I want to get expertized in computer networks."

The third category under the Goal setting theme was found to be "*problem solving skills*". Some of the participants mentioned that they took this course because they use computers and internet and they think they could improve their knowledge and skills to solve problems they will encounter while using them. A participants' answer on this is given below:

"Everyone should have some knowledge about computer networks since all people are computer users. When we have a simple problem related with connection, we should be able to handle it."

Learner Internal Factors was the second emerging theme related to students' attitudes towards the course. It was related to the reactions that people create inside themselves. Curiosity, attention and interest are some of these reactions. This theme had two categories, i.e.

"*curiosity about the content*" and "*interest*". The first category was generated based on the students' statements indicating their curiosity in the computer networking topics. The latter category defined was "*interest*" according to answers of participants. They used the term *interest* directly several times in their answers.

"*Curiosity about the content*" is a category affecting students' attitude towards computer networks course content. Some of the participants mentioned that they took this course because they want to know how computer networks work. A participant's answer is given below:

"I take this course because I want to learn how computer networks work and how this technology develops. When I started to get interested in computers, I saw that there are many different things in computer networks. For this reason, I need to learn computer networks."

The last category related with attitude is "*interest*". Many of the participants mentioned that they are interested in computer networking topics. A typical answer was:

"I noticed that computer networks interests me as I continued to the lecture. For this reason, I will continue to learn more advanced topics related with computer networks."

Results on Motivation

Students were asked about how the simulation program affected their motivation towards the computer network course. The answers of the participants could be categorized under two themes, "self-confidence" and "locus of control". Table 3 shows themes and categories for motivation.

Table 3. Motivation themes and categories

Themes	**Categories**	**Total *f* (N=17)**
Self-confidence	Visuality	7
	Manuals	10
Locus of Control	Chance to Practice	11
	Trial and Errors	7

The **self-confidence** theme was built on participants statements that simulation program provided them the feeling of "I can do it" since it included visuals of all network devices, and manuals showing them how they could perform the procedure. The theme had two categories, and "*Visuality*" was the first repeatedly stated category. Visuals of network devices in the simulation program motived students. Most of the participants in this study mentioned that simulation program provide them with good visuals.

The second category that motivated students were the "*manuals*" provided by simulation programs. Many of the participants mentioned that the simulation program was very useful since it provided manuals to perform a laboratory activity without needing the help of someone else. They did not encounter major problems while using the simulator because of those manuals. One of the participants stated that:

"During the lab session, we had manuals about the simulation. I did not have any problems while I was using simulation program because of the manuals."

The second theme was **locus of control**, which is related to individuals' control over events effecting them such as success, or failure. It is defined as the perceptions of students on the results of their behaviors. A person who has locus of control would hardly say something like "I failed because the task was hard" but instead he or she would take responsibility by asking questions such as "what was the cause for this result" and "how can I prevent that from happening again next time". This theme had two categories, which were "*chance to practice*" and "*trial and errors*". Participants thought that simulation programs helped them to make practice and try an activity many times until they could master it. Students' took control over their own failure and success.

"*Chance to practice*" was one of the category affecting students' motivation towards the course. Most of the participants mentioned that the simulator gave them a chance to practice for the procedural content. They thought that after face-to-face instruction, making practice on that week's topic was very beneficial. A typical comment of a participant was:

"I want to take another course where simulations are used because simulation program gave me a chance to practice."

The last category related to motivation was "*trial and error*". Most of the participants mentioned that simulation program provide them opportunity to make mistakes and error through their learning. Using the simulation program, they could try a procedure many times until they could accomplish the task. They stated that this was motivating, a participants' comment was:

"In simulation environment, I made a lot of errors. I tried many times a laboratory activity. After making an error, I found the correct way and I learned how devices work using the simulation platform."

Results on Learning

Students were asked about how the simulation program affected their learning the course content. The answers of the participants were categorized under a single theme named as "*deep understanding*" with three categories. Table 4 shows the theme and categories related to students' perceptions on learning the course content.

Table 4. Learning theme and categories

Theme	Categories	Total *f* (N=15)
Deep Understanding	Provide Concreteness	11
	Learning by Doing	12
	Visuality	7

The categories under the **deep understanding** theme were constructed according to participants' comments during the interviews. The first category "*provide concreteness*" was found out from participants' statements like "abstract" and "invisible". Second category was "*learning by applying*", based on answers of participants mentioning about practice and writing. The last theme that could be highlighted in the interview data was "*visuality*", driven from statements on visuals and images. After categories were defined, these three categories were grouped into one umbrella theme.

"*Provide concreteness"* was the first category found since students were mentioning that there were many abstract topics in the course content. Students thought and said that using the simulation program, they could learn abstract topics easier. One of the participants' answers is given below:

"*Simulation program helped me to understand concrete topics. Theoretical knowledge became more concrete. If I had not used the simulation, I might have not understand the abstract topics."*

"*Learning by doing*" was another category, specifically important for procedural knowledge. The participants said that simulation program helped them to learn by applying. A participant's comment was:

"*We learned some of the protocols theoretically. However, I wonder what about these protocols, why we use it. In simulation program, I applied these protocols in the routers and switches and I see protocols more closely."*

The last category in this part is the *"visuality"*. Some of the participants thought that visuals in the simulator, they learned the course content better. Two comments of the of the participants related to this category were:

"Simulation program helped me to learn the topics easier. I think that visual memory is very important during learning and simulation served for this. So with simulation program, network topics can take place for longer time in one's mind. I think it was very useful."
"There are many visual examples in the simulation program. These visuals helped me to understand the content better."

DISCUSSION AND CONCLUSION

The results of the study are discussed in alignment with the theories and models used as theoretical framework in designing and carrying out the research. The respective models were, ABC Model of attitude, ARCS Model of Motivation and Learning as presented in Table 5. The categories that came up in participants answers aligned with the components of theses theoretical frameworks. While interpreting the results it should be kept in mind that these categories are not mutually exclusive as it would be important in quantitative research, especially having inferential analysis. On the contrary, we would expect that they are closely related.

Table 5. Alignment of to the results of study with theoretical frameworks

Model	Components of Model	Categories of Study
ABC Model	Affective	Curiosity
		Interest
	Behavioral	Information Age
		Qualities
		Personal Development
		Problem Solving Skills
ARCS Model	Attention	Visual Support
	Relevance	Manuals
	Confidence	Trial and Error
	Natural Consequences	Chance to Practice
Learning	Experimenting	Provide Concreteness
	Allowing Trials without Fear of Failing	Learning by Applying
		Visual Support

The results of this study indicate that student participants attitudes towards computer networks content was related to the career path they would like to follow in future, their interest to computer networks, the information age where computers and Internet is a part of daily life, the need to solve computer and Internet related problems, and curiosity. Curiosity encourages students to participate to the course activities and lead to positive attitudes towards the content.

A dictionary definition of motivation is "to provide with, or affect as, a motive or motives; incite or impel" (Webster's unabridged dictionary, 2001, p. 1254). Researchers in the field of education have recognized the importance of motivation on learning long time ago. The results of the study are in harmony with literature on the importance of motivation on learning since participants think that simulation program increase their motivation for the computer network course and this, as a result, increase their learning. Participants thought that simulation positively affects their motivation in computer network course because

- Simulation program provided visuals,
- There were many manuals available to use as a guide by the students,
- It provided a chance to do practice,
- Simulation program gave the chance for trial and errors.

Building a real-life networking laboratory requires space, time and resources. Moreover, working algorithms of network systems cannot be observed even in a real-life laboratory. For example, a real-life laboratory cannot provide information on how some specific protocols operate since these protocols are abstract. Participants of this study, nonetheless, were aware of the fact that simulations could overcome this problem. Participants considered the ability of simulations to provide practices to them to be one of the most important aspects of simulations since these practices open the way to them to master network skills. An important upside of simulations, according to the participants of this study, is that simulations bestow them the opportunity to try to learn with whichever scenario they desire. This would be hard in real-life situations because of cost and other realities. An institution of learning cannot provide real machines or devices to students to explore because of the possibility of spoilage. As participants of this study make clear, simulations can remove this problem with their spoilage-free nature. Participants say that they can have many trials and errors with simulations, which, in turn, can increase their learning. Hence, this study reveals that participants believe that simulations increase their motivation on computer network course. According to Shneiderman (1993), creation, exploration and discovery are the key factors for the student motivation. Sylwester (1995) claimed that engagement is critical for motivation of the students. Since participants in this study think that simulation provides them the opportunity of trial and error, they may be more engaged to network class and as a result have more motivation on it. To add, simulation program have advantages in terms of time, security cost, and motivation in addition its nature to protect students from dangerous, difficult, and impossible experiments (Tekdal, 2002).

This study reveals that computer simulations help students to visualize the network concepts and procedures. The feature of simulation program on providing visual experiences to learners is very innovative and helpful in a way that it gives a chance to students to observe underlying processes, which is not possible in other methods. Therefore, simulation program increases high-level learning of students. Similarly, Bell (2008) say that simulations propose students empirical control to observe, explore, recreate, and receive immediate feedback about real objects, phenomena, and processes.

The results of the study revealed that simulation program helps participants to learn computer network topics. In this sense, participants claimed that simulation program has a positive effect on their learning of computer network course. Participants provided three reasons for this:

- The simulator helped them to learn abstract topics better than conventional ways.
- Simulator gave them a chance to learn by applying.
- Simulator provided them visuals.

One of the biggest challenges stated by the participants of this study on learning computer network courses was the abstract nature of the course content in computer networking courses. The simulation program gave them a chance to study these abstract concepts and procedures in a visual and concrete environment. Many of the participants in the study thought that simulation helped them to do practice. With the simulation program, they learned procedures by applying what they had covered in the class lectures.

This study reveals that computer simulations help students to visualize the network concepts and procedures. The ability of simulation programs for providing visual experiences to learners is very innovative and helpful since it gives a chance to students to observe the underlying processes, which would not be possible in real laboratories.

The current study revealed positive opinions on simulation programs in the computer networking courses, however further research is need that could find causal-comparative results on the relation of the three factors and their effect when using simulation programs in teaching abstract concepts. The findings of the current research is bounded with the participants comments and the context of the study, which can provide valuable information for educational researchers and instructional designers working on similar technology enhanced learning environments.

REFERENCES

Agarwal, J., & Malhotra, N. K. (2005). An integrated model of attitude and affect: Theoretical foundation and an empirical investigation. *Journal of Business research*, *58*(4), 483-493.

Akkağıt, Ş. F., & Tekin, A. (2012). Simülasyon Tabanlı Öğrenmenin Ortaöğretim Öğrencilerinin Temel Elektronik ve Ölçme Dersindeki Başarılarına Etkisi. *Ege Eğitim Dergisi*, *13*(2).

Alnoukari, M., Shafaamry, M. & Aytouni, K. (2013). Simulation for Computer Sciences Education. *Communications of the ACS*, *6*(1), 1-19.

Anderson, L.W. (1994). Attitude measures. In T. Husen (ed.). The *International Encyclopedia of Education.* (2nd ed.), 1.Oxford: Pergamon.

Baumgartner, F., Braun, T., Kurt, E., & Weyland, A. (2003). Virtual routers: a tool for networking research and education. *ACM SIGCOMM Computer Communication Review*, *33*(3), 127-135.

De Jong, T., & Van Joolingen, W. R. (1998). Scientific discovery learning with computer simulations of conceptual domains. *Review of educational research*, *68*(2), 179-201.

Demir, D. (2002). *The Effects of Student Awareness of Goals on Success in and Attitudes Towards a Reading Course at Gaziosmanpaşa University* (Doctoral dissertation, Institute of Economics and Social Sciences, Bilkent Univ.).

Eagly, A. H., & Chaiken, S. (1993). *The psychology of attitudes*. Harcourt Brace Jovanovich College Publishers.

Eagly, A.H. & Chaiken, S., 1998. Attitude structure and function.

Garard, D. L., Lippert, L., Hunt, S. K., & Paynton, S. T. (1998). Alternatives to traditional instruction: Using games and simulations to increase student learning and motivation. *Communication Research Reports*, *15*(1), 36-44.

Gottfried, A. E. (1985). Academic intrinsic motivation in elementary and junior high school students. *Journal of Educational Psychology, 77*(6), 631-645.

Graven, O., Hansen, H., & MacKinnon, L. (2009). A computer game modelling routing in computer networks as abstract learning material in a blended learning environment. *International Journal of Emerging Technologies in Learning (iJET)*,*4*(2009), 18-22.

Hendricks, A.B. (1997). *Predicting student success with the Learning and Study Strategies Inventory (LASSI).* Unpublished Master's thesis. Iowa State University, Ames, IA.

Jeschke, S., Richter, T., & Zorn, E. (2010). Virtual labs in mathematics and natural sciences. International Conference on Technology Supported Learning & Training: Online Educa Berlin.

Keller, J. M., & Kopp, T. W. (1987). An application of the ARCS model of motivational design. In C.M. Reigeluth (Ed.), Instructional theories in actions: Lessons illustrating selected theories and models (pp. 289-320). Hillsdale, NJ: Lawrence Erlbaum.

Keller, J. M. (1983). Motivational design of instruction. *Instructional design theories and models: An overview of their current status*, *1*, 383-434.

Klopfer, E. (2008). *Augmented learning: Research and design of mobile educational games.* Cambridge, MA: MIT Press.

Kranjc, T. (2011). Simulations as a complement and a motivation element in the teaching of physics. *Metodički obzori*, *6*(12), 175-187.

Kumar, A., Pakala, R., Ragade, R. K., & Wong, J. P. (1998, November). The virtual learning environment system. In *Frontiers in Education Conference, 1998. FIE'98. 28th Annual* (Vol. 2, pp. 711-716). IEEE.

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *biometrics*, *33*, 159-174.

Lepper, M. R., Corpus, J. H., & Iyengar, S. S. (2005). Intrinsic and extrinsic motivational orientations in the classroom: age differences and academic correlates. *Journal of educational psychology*, *97*(2), 184-196.

Lincoln, Y. S. & Guba, E. G. (1985). *Naturalistic inquiry.* Thousand Oaks, Calif.: Sage.

Mack, N., Woodsong, C., MacQueen, K. M., Guest, G., & Namey, E. (2005). Qualitative research methods: a data collectors field guide.

Merriam, S. (2009). *Qualitative research: A guide to design and implamentation.* San Francisco, CA: Jossey-Bass.

Petranek, C.F.,Corey, S.,& Black,R.(1992).Three levels of learning in simulations: Participating, debriefing, and journals writing. *Simulation & Gaming*, *23*(2),174-185.

Potemans, J., Theunis, J., Rodiers, B., Van den Broeck, B., Leys, P., Van Lil, E., & Van de Capelle, A. (2002). Simulation of a Campus Backbone Network, a case-study. *education*, *5*(6), 7.

Prensky, M. (2001). *Digital game-based learning*. New York: McGraw Hill

Ruiz-Martinez, A., Pereniguez-Garcia, F., Marin-Lopez, R., Ruiz-Martinez, P. M., & Skarmeta-Gomez, A. F. (2013). Teaching Advanced Concepts in Computer Networks: VNUML-UM Virtualization Tool. *Learning Technologies, IEEE Transactions on*, *6*(1), 85-96.

Shin, D., Yoon, E.S., Park, S.J., & Lee, E.S. (2000). Web-based interactive virtual laboratory system for unit operations and process systems engineering education. *Computers and Chemical Engineering*, *24(2)*, 1381–1385.

Shneiderman, B. (1993, June) Education by engagement and construction: Experiences in the AT&T teaching theater. Keynote for ED-MEDIA meeting, Orlando, FL.

Stipek, D. (1993). Motivation to learn: From theory to practice. Needham Heights, MA: Allyn & Bacon.

Sylwester, R. (1995). A celebration of neurons. Alexandria, VA: ACSD Books

Tekdal, M. (2002). Etkilesimli fizik simulasyonlarinin gelistirilmesi ve etkin kullanilmasi, V. Ulusal Fen Bilimleri Ve Matematik Egitimi Kongresi, ODTÜ, Ankara, Turkey

Urhahne, D., Harms, M. G. (2006). Instruktionale Unterstützung beim Lernen mit

Computersimulationen. *Unterrichtswissenschaft, 34*(4), 358–377.

Webster's unabridged dictionary (4th ed.). (2001). New York: Random House.

Woodfield, B. (2005). Virtual chemlab getting started. *Pearson Education website. Retrieved May*, *25*, 2005.

Zheng, D. (2015) *Future Communication, Information and Computer Science.* CRC Press.

Zimmerman, B.J., Bandura, A. & Martinez-Pons, M. (1992). Self-motivation for academic attainment: The role of self-efficacy beliefs and personal goal setting. *American Educational Research Journal, 29*(3), 663-676.

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