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IMPACT OF THE USE OF SIMULATION PACKAGES ON STUDENTS' LEARNING

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ABSTRACT

The purpose of this research is to identify the effect of simulations in the enhancing of learning. Expressed in the rate of acquisition of what is given during lessons, in the amount of possible information and knowledge that can be offered in one class and new ideas that these technologies urge students for further creativity.

The Software Packet Tracer has been experimented as a simulation tool in the Faculty of Electrical and Computer Engineering in the University of Pristina. The results which are obtained from this experimentation highlight the positive effect that the use of simulations in teaching and learning process have in terms of improving the efficiency of learning. The results also show that the use of simulations motivates students to learn, making them more cooperative and developing their skills for critical approach.

Keywords: Simulations, Information Technology, Packet Tracer, Teaching, Learning

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1. INTRODUCTION

In recent decades, many reforms to improve art and techniques of teaching and learning have been made [1]. The traditional model of teaching, despite some positive aspects of teaching and learning process, was incapable to face the challenges and demands the technological development brought, notably the Information Technology [2].

The rapid development of Information Technology has contributed to the rapid change of the way of dealing with research and development of science and engineering.

Nowadays, the application of various processes requires the practical incorporation of IT, while the education in engineering fields and its quality in relation to development trends and requirements is and should be a priority of every country. Therefore, a focus, a great and well planned work is required in order to increase the quality of the teaching process in

engineering fields, in order to prepare the engineers of the future to be able to face many innovation demands in this field.

In this context, the integration of Information Technology and its new teaching methods should be inevitable for the entire education system, in particular for engineering fields. It has the potential to significantly improve teaching and learning by using simulation packages while studying the course. The integration of these simulation tools and software packages brings excellent results to the knowledge level. The use of IT tools is, undoubtedly, fundamental for engineering education and professional engineering practice. Simulation tools play an important role in comprehending the theory, in analysing complex systems, in solving problems in the real world. They help to design projects, increase the interest for technical profession, enable a flexible study and motivate students to learn.

2. PURPOSE AND OBJECTIVES OF THE STUDY

Information Technology is imperative of time used to improve the way we live and work, therefore it should also be used to enhance the learning and the way of learning.

Therefore, referring to this fact, the overall purpose of this research is to explore the impact of information technology in enhancing the teaching. To understand and interpret this impact, the focus was put on the following case study: the impact of the use of the Packet Tracer simulator in the function of enhancing the students' learning in the course Computer Network in FECE.

Given the fact that graduates in the field of IT engineering need to be able to program, visualize, simulate systems with dynamic behaviour, etc., during their studies, they should be offered not only with relevant theoretical content but also with the content in practical form, through the IT tools and the new teaching methods offered thanks to it.

Studying complex technological processes using modelling and simulation as knowledge transfer techniques are of great importance in engineering fields [3]. Visual learning through simulation is necessary to enable the increase of learning in science and engineering [4]. It is a method through which ideas, concepts, data and other information are related to images and animations, while the course is graphically presented. It uses methods that help students to open their minds and think graphically. The connection between the graphics and the type of information increases the learning and provides the opportunity to apply what is learned [5].

Therefore, this research was conducted taking into account the importance of using simulation to improve teaching and learning in the engineering fields and referring to the fact that as part of the teaching program at FECE. Up to the point of this current study no research on the impact of the use of the Packet Tracer simulator has been conducted. In this paper, a study was conducted to understand and analyse the role of Software Packet Tracer use for the course 'Computer Network' in undergraduate studies at FECE will be presented. The key objective of this research was to demonstrate the effectiveness of the simulation package in improving the students' learning.

3. SIMULATION SOFTWARE - PACKET TRACER

To enable the integration of theory and practice to make it more concrete for students, it is very important to use a simulation tool in the teaching and learning process [6]. Software packages such as: MATLAB, EMU8086, ELECTRONIK WORKBENCH and PACKET TRACER have been used to develop and harmonize the hypothetical concepts of various fields explained in class within the engineering programs and to bring virtual labs to classrooms.

A computer simulation is a learning tool used to provide students with a realistic experience. It can serve as a technique for increasing learning [7], increasing the interest and awareness of the students for the topic being discussed [8].

Simulations also provide new ways of using new computer technologies that offer a variety of strategies to design realistic, authentic learning environments where students at the same time engage and experience a sense of satisfaction [9]. Also, simulations can be used to remove the risks of real life learning experiences, while allowing the user to gain needed perspective. Computer simulations are not intended to be a substitute for hands-on classroom experience; rather, they provide specific skill-building lessons to teacher candidates [10]. The use of simulators in various fields is shown to be fruitful for learning. In a study conducted with medical students, results showed that medical students improved their self-confidence, knowledge, and skills for intubation, arterial line placement, lumbar puncture and central line placement through use of a simulation [11].

Simulations give students the opportunity to practice a problem learned in theory through a particular task, issue, or problem. In situations when the problem occurs, students work together to think about a possible solution and prove that it works or fits in with the criteria for solving that problem. Thus, besides being able to benefit from the group work, students at the same time get prepared for the group work and get socialized. Thanks to the application of the theory into practice [12], the students learn how to think critically in a complex situation [13].

Software Packet Tracer- Cisco Packet Tracer is powerful network simulation software that enables students to experiment with network topology design, configuration and testing of computer network performance [14]. It also enables the teachers to demonstrate the connection between the theory and the practice. Packet Tracer offers simulation, visualization, evaluation and facilitates the teaching and learning of complex technology concepts.

Computer Network is a course taught in bachelor studies, Computer and Telecommunication course at the Faculty of Electrical and Computer Engineering, at the University of Prishtina. This course includes a wide range of Computer Networking principles, including TCP/IP structure, control terminals, hubs, switches, routers, computer networking design models, network topologies, types of Computer Networking, forms of communication with packages and circuits, etc. It is a great challenge for students to understand the content of the theory and to understand how computers are connected to communicate with one another within the framework of the Computer Networking Systems. Several activities can be performed in the lab, such as configuration of a router or creation of a simple topology and students can acquire the content quite good. But, when it comes to more complex topologies, with the absence of sufficient hardware tools for a large number of students and limited time to stay in the lab, this does not provide the opportunity to all students to gain full knowledge of such topologies. This will, by all means, affect the overall learning of the practical part of this course. In this case, the Packet Tracer will help both students and teachers to increase learning and improve teaching. It offers virtual environments and demonstration opportunities, visualization and evaluation to many users [15].

4. LEVELS OF STUDENTS' LEARNING

Students learn in many ways: by observing and listening, reflecting and acting, reasoning logically and intuitively, memorizing and visualizing, etc [16]. Although there are different divergences regarding the styles and levels of learning for the students of engineering, their learning ways can be classified as inductive line, but in some cases there are elements of the deductive line [16]. This paper will investigate the impact of simulation on different levels of learning according to Bloom's categorization [17]. Bloom's taxonomy for cognitive learning

consists of six levels organized hierarchically. From the bottom to the top, the six types of learning are as follow:

***Knowledge*:** the ability of recalling the information acquired during the learning process. It includes activities such as designation, description and identification.

***Comprehension**:* the ability of the student to learn the meaning of a topic, problem or a certain situation. It includes activities such as quoting, explaining, giving examples, summarizing, generalizing, etc.

***Application**:* the ability of the student to use or apply known information in new situations. It includes activities such as applying, building, forecasting, solving, etc.

***Analysis**:* the ability of the student to divide information into components, to better understand the issues, to draw and make conclusions. The analysis includes activities such as analysing, comparing, opposing, differentiating, etc.

***Synthesis**:* the ability of the student to bring together different aspects of a course in order to understand the whole issue as a great picture. It includes activities such as formulating, integrating, negotiating, etc.

***Evaluation**:* the ability of a student to make a judgment about the value of concepts and ideas based on personal values or thoughts.

5. RESEARCH QUESTION, HYPOTHESIS AND METHODOLOGY OF THE PAPER

In order to capture the impact of the use of Information Technology in improving learning in engineering fields, we will try to answer the following question:

What is the impact of Software Packet Tracer in improving learning in computer network course?

Answer which would affirm or deny the raised hypothesis that:

The use of the Software Packet Tracer would enhance students' learning and their creative skills in the fields of engineering.

In order to assess the impact of simulation in students' learning, respectively to respond to the research question and to affirm or deny the raised hypothesis, students had to fill out a survey (see Table 1). The survey was composed of three sections. In the first section, students had to write answers on three knowledge questions in get the opinions of the students about what they have learned during the simulation. The second section of the survey had 18 Likert questions, about what the students learned while using the Packet Tracer Simulator and their attitudes on the simulator in general. The respondents answered these questions using a 5-point scale ranging from Strongly agree (5) to Strongly disagree (1). Items on the scale were named: "**Strongly agree", "Agree", "Neutral", "Disagree" and "Strongly disagree".** Eleven out of these eighteen questions were related to the learning categories mentioned above (see Table no. 2). While the third part of the survey included demographic questions, and also questions about the role of the simulation played in their learning, gender, age, course attendance and experience with previous simulations.

Measurable objectives such as performance simulation are shown to be poor learning meters. According to [18] earning is an internal intellectual process and what is learned and how it is learned is unique for each individual". To create an instrument capable of understanding what has been actually learned is easier to say than do, because students should be motivated to express what they have learned.

As in any other survey, there is a threat of bias, as the data are usually gathered at the same time and in the same context, using a single source or a single methods collection [19].

To eliminate bias, the survey for gathering the data for this study was prepared by taking into account MacKenzie & Podsakoff's recommendations [20], where anonymity is a protected element, no information for identification is required and the evaluation of students for this course is not affected. Therefore, the time and the anonymity of the study have minimized the possibility of prejudice. In order to accurately respond to the questions of the research study for confirming the basic hypothesis, the comparison of the results achieved in the intermediate evaluation of the students who attended the course where the lesson was developed with the simulator, with the results of the students of the previous year, who we considered as a control group. The control group students attended this course without using the Packet Tracer simulator.

Sample - Out of 60 students enrolled in this course, 47 (78.33%) of them participated in this study, their average age was 19.43 years old (std=0.830), 66% were male and 98% of them took this course for the first time (see Table 1)

Table 1 Demographic features

	Frequency	**Percentage**
Gender:		
Female	16	34%
Male	31	66%
Age:		
19	16	34%
20	21	45%
21	8	17%
22	2	4%
Attendance:		
For the first time	46	98%
Repeated	1	2%
Have you ever used a Simulator?		
Yes	25	53%
No	2	47%

6. ANALYSIS AND INTERPRETATION OF DATA

The 11 questions related to learning, used in this analysis, were organized based on the categories of learning, learning styles and techniques in engineering education. They are summarised under Table 2, where the average rate for these 11 questions were used to determine the effect of the simulation on the learning outcomes. The neutral point is 3. Results rated above 3 indicate the negative effect while the results below 3 indicate the positive effect of the simulation use. The average of these 11 questions is about 1.72 to 2.28, which indicate that most students had a positive opinion on the impact of simulation on their learning. Students did not ignore the questions or did not give same answers to all questions.

Table 2 Results related to the learning category.

Questions	Learning category	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Average
Simulation enables the application of what has been learned in theory.	Application[1]	16	25	6	0	0	1.79
		34%	53%	13%	0%	0%	
Simulation enables to make judgements on selecting various topologies.	Analysis[1]	9	21	17	0	0	2.17
		19%	45%	36%	0%	0%	
Simulation helps me to comprehend that I have learned a lot about computer network.	Analysis[1]	20	16	10	1	0	1.83
		43%	34%	21%	2%	0%	
Simulation allowed me to apply the concepts and ideas discussed during lectures in the classroom.	Application[1]	19	18	10	0	0	1.81
		40.4%	38.6 %	21%	0%	0%	
The simulator helped me to critically approach various computer network problems	Synthesis[1]	11	23	13	0	0	2.04
		23.4%	49%	27.6%	0%	0%	
Simulation made me face the compromises among different perspectives for selecting a network design.	How to learn the lesson[2]	11	20	10	5	1	2.26
		23.4%	43%	21%	10.60 %	2%	
I felt comfortable using the simulator.	Human[2] dimension	16	17	14	0	0	1.96
		34%	36%	30%	0%	0%	
The simulator helped me make the right comparison between my selection and the selection of others	How to learn the lesson[2]	10	16	19	2	0	2.28
		21%	34%	41%	4%	0%	
Simulator increased my learning in the computer network course	Assessment[1]	15	27	4	1	0	1.81
		32%	58%	8%	2%	0%	
After using simulator, I think I will be more professionally	Assessment[1]	8	28	9	2	0	2.11
		17%	60%	19%	4%	0%	

prepared for working with computer networks							
I think the experiences gained in the simulation will be useful in the future	Assessment[1]	17	27	2	1	0	1.72
		36%	58%	4 %	2%	0%	

Note: 1. Bloom, 2. Fink, n=47.

The question about how the simulation enabled students to apply what they learned in theory, clearly matches the category for application of Bloom's Taxonomy (Bloom, 1956).

Eighty-seven percept of students have indicated that simulation has actually helped them to apply the concepts learned in theory into "real situations". On the other hand, the same conclusion is drawn from the answers given by the students related to the first question of the survey. One student indicated that: "The simulation practically helps to understand the purpose of tasks or problems set forth in theory. Simulation brings theory into practice; it has a coherent influence on solving the problem and we can benefit a lot from this" (Student 119522).

Another student stated that "in the absence of realistic tools, simulation helps a lot in our education as an engineer, especially when we need to understand abstract concepts" (Student 125431). In his response, a student said that "simulation has made the course more attractive, simpler and more practical since we can see how the data is actually transmitted in the network in a simpler way" (Student 135900).

Questions in the survey, specifically focused on simulation as a tool helping students to gain skills, had an average rating of approximately 2.4, indicating that, on average, students agreed that simulation helped them think about the problems of Computer Network. In his response, Student 123267 said that "by designing and managing networks through simulation, I have gained the perception for difficulties and challenges that we face during this process. But, I believe that the simulation will help me a lot in my work in the future".

Another student indicated that "simulation enabled me to more seriously approach different issues and select topology" (Student 321471).

Responses given by the students again showed the importance of using simulation in relation to traditional teaching where the teacher transmits his or her knowledge to the students by using the board. This kind of learning is passive for students because they passively and uncritically accept the information, while simulation obligates the students to draw conclusions and to compare different views. In addition, they are the main actors in debates related to the issues and information presented, while the professor has the role of a mentor. This form enables students to think critically. This was also noted in the responses received from the survey where on questions related to the impact of the simulator to participate in the debates in order to draw conclusions, to critically compare and analyse certain issues, over 75% of the students agreed or completely agreed that the simulator had helped them to make their own judgments, comparing to those of others, and in the end undertake a decision in critical way. On the question related to how they felt while using the simulator, 70% of them responded that they completely agree or agree they felt good, while 30% of them were neutral. With regard to the questions of the evaluation, about how the simulator helped them to come up with arguments and judgments about certain issues and how the simulator helped them to increase their learning for Computer Networks and Computer Network Testing, over 80% of students agreed or completely agreed to the positive impact of the simulator. The simulator helps students to easier understand the concepts of the

course by creating visual environment of learning. On the question of whether the simulations were effective for you, the followings answers were received: Simulations were very effective because they gave me a realistic picture of what I had chosen as a possible solution to the problem (Student 213431), while the Student 134235 indicated that the simulation showed its effectiveness by enriching his knowledge in Computer Network design in terms of creativity. Another student indicated that the simulation was necessary to apply in order to have effective learning of Computer Network problems and that thank to the use of Packet Tracer simulator he understood in detail how to properly approach and come up with a concrete answer for transmitting packages in network (student 432132). From these and other answers in the survey, they were able to analyse various solutions for each problem related to the course and this contributed in increasing the learning of the course in general.

That simulation contributes to the increase of learning show the conclusions drawn by comparing the results of the intermediate evaluation of the students who attended the course where the lesson was developed with the simulator, with the results of the answers given by the students of the previous year who we consider as a control group. Control group students attended this course without using the Packet Tracer simulator. After the students answered the questions of the questionnaire the intermediate evaluation was done by the teacher. In order to make a comparison of these results, we divided the students of the two groups according to the grade point average and matched the results of the students with the same grade point average. More attention was paid to the students with grade point average lower than 9, as it is known that those with grade point average over 9, from both groups, are very good or excellent students.

Table 3 Comparison of the intermediate test for both groups

Results of the control group students				**Results of the interviewed students**			
Grade point average	**No. of students**		**Results expressed in points (max. 100)**	**Grade point average**	**No. of students**		**Results expressed in points (max. 100)**
Over 8-9	6	Student1	75	Over 8-9	6	Student1	80
		Student2	80			Student2	79
		Student3	71			Student3	85
		Student4	74			Student4	90
		Student5	85			Student5	85
		Student6	70			Student6	75
The average points:			75.83	The average points:			82.33
Over 7 – 8	8	Student1	65	Over 7 – 8	8	Student1	70
		Student2	71			Student2	68
		Student3	60			Student3	75
		Student4	75			Student4	75
		Student5	60			Student5	78
		Student6	63			Student6	65
		Student7	68			Student7	65
		Student8	70			Student8	70
The average points:			66.5	The average points:			70.75
Over 6 – 7	10	Student1	53	Over 6 – 7	10	Student1	65
		Student2	59			Student2	70
		Student3	50			Student3	60

		Student4	51			Student4	78
		Student5	62			Student5	56
		Student6	65			Student6	75
		Student7	50			Student7	65
		Student8	55			Student8	60
		Student9	57			Student9	59
		Student10	50			Student10	70
The average points:			55.2	The average points:			65.8

As can be seen, the average points of the interviewed students for all three categorizations, according to the grade point average, are higher than those of the control group students. The effect of using simulation on student achievements is noted more at those with grade point average over 6 to 7, with a difference of 10.6 points from those of the control group. In total, the average points of students interviewed is 7.11 points higher than of the student of the control group.

The difference in the quality of students' learning of both groups is clearly seen in matching their opinions related to the expectations they have for the final grade in this course. 57% of the interviewed students stated that they would reach the maximum grade 10; while 28% - grade 9; 12% - grade 8 and only by 1 student of each group were for grades 7, 6 and 5. While, for the students of the control group who did not use the simulator in the lesson or the learning, such high results were not expected.

These differences are inevitable, as learning with the use of the simulator has many advantages. These simulator benefits are communicated by the students themselves in their answers presented above.

7. CONCLUSION

Use of simulation in the course Computer Networks plays an important role in providing students with opportunities to address different issues with regard to better design choice and network topologies, as well as network testing opportunities.

Solutions of such problems require analysis, judgment, planning and the incorporation of information learned in theory. The entire process provides students with a critical approach and discussion of possible solutions in order to reach the best possible solution. This enables students to think critically, creatively, and gives them the opportunity to bring innovations within the context of the field discussed.

However, the use of simulation is not the only element for enhancing students' learning, as the use of simulation should be accompanied by a range of other activities that involve the teaching process without leaving aside the theoretical aspect. The simulation without the theoretical part would be a practice without theoretical basis, and the simulation without theory would be virtually unrealisable. However, with a proper approach and preparation of the simulation structuring and theoretical lessons, the desired students' learning can be achieved.

Therefore, the data obtained from the survey showed the students' feedback on the use of the Packet Tracer simulator, which according to the students was very helpful in understanding theoretical concepts and principles, giving them many opportunities for practical application of their theoretical knowledge, and creativity as far as designing the network is concerned, and testing of that creativity from a functional point of view.

While testing creativity, discussions about that selection take place, encouraging fully constructive debates with very fruitful conclusions which have been tested for their practical operation through simulation. However, in this regard, the task and role of the teacher should not be abstracted in the orientation of the discussions in order that they do not take any zigzag course from the ideas and opinions expressed by the students.

The role and the approach of the teachers are also two important components, as the teacher shapes and realises the structural form of the interconnection of theory and practical simulation.

However, the inalienable role of simulation for the realization of theory in practice should not be minimized, a process of great importance for students' learning since during visual demonstration the students increase the amount of memorized information, even though not the sole purpose, it has its own positive side, as students learn how to apply the things they have in their minds in real life. Therefore, referring to the positive aspects of the impact of using the simulation, in this case the simulation carried out with the Packet Tracer software in the context of teaching the course Computer Network, we can issue a general recommendation that would be dedicated to the teaching of all courses within all programs in FECE. Application of the respective software packages with the nature of the course content for enhancing student' learning and increasing the efficiency of teaching in general, should be priority for all teachers.

Thus, the integration of Information Technology and new teaching methods, such as the use of the simulation offered by this technology, should be the main objective for successful teaching.

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