Effectiveness of Scaffolding in Simulated IT Training and Education

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ABSTRACT

The continuing growth on the technological front has been challenging all of us with the new ways to convey information. From the early days of radio to the new age of the Internet, the underlying purpose remains the same. The key components to the success of every new instructional or communication technology are the dissemination of information, its timeliness, and its effectiveness. It is no secret that today's Internet and associated technologies are encouraging evolutionary learning techniques both in academia and the corporate world. From a corporation website to a college online system, new ways are being implemented daily to formulate information and enhance delivery mechanisms to improve effectiveness. The Internet, with its distributive architecture, has provided the power to combine a series of discrete, unlinked, and unmeasured activities into an enterprise-wide process of continuous learning that directly links business goals and individual outcomes (McCrea, Gay, & Bacon, 2000). Our economic, social, and technological forces today are pushing all of us to become more productive in every walk of life, and learning is no exception.

Timely and an appropriate feedback is a critical element for improving student learning and simulation-based training is no exception, as it guides and refines learning through scaffolding. A number of studies in literature have shown that students' learning is enhanced when feedback is provided with personalized tutoring that offers specific guidance and adapts feedback to the learner in a one-to-one environment. Thus, emulating these adaptive aspects of human tutoring in simulation provides an effective methodology to train individuals.

This paper presents the results of a study that investigated the effectiveness of automating different types of feedback techniques such as Knowledge-of-Correct-Response (KCR) and Answer-Until-Correct (AUC) in software simulation for learning basic information technology concepts. For the purpose of comparison, techniques like simulation with zero or no-feedback (NFB) and traditional hands-on (HON) learning environments are also examined.

The paper presents the summary of findings based on quantitative analyses which reveal that the simulation based instructional strategies are at least as effective as hands-on teaching methodologies for the purpose of learning of IT concepts. The paper also compares the results of the study with the earlier studies and recommends strategies for using feedback mechanism to improve students' learning in designing and simulation-based IT training.

I. Introduction

The continuing growth on the technological front has been challenging all of us with the new ways to convey information. From the early days of radio to the new age of the Internet, the underlying purpose remains the same. The key components to the success of every new instructional or communication technology are the dissemination of information, its timeliness, and its effectiveness. It is no secret that today's Internet and associated technologies are encouraging evolutionary learning techniques both in academia and the corporate world. From a corporation website to a college online system, new ways are being implemented daily to formulate information and enhance delivery mechanisms to improve effectiveness. Our economic, social, and technological forces today are pushing all of us to become more productive in every walk of life, and learning is no exception. One of the learning tools that have become more prevalent in the field of instructional technology is simulation. The focus of this paper is to understand software simulation and its role in technology-based curricula, especially in the area of information technology (IT) training such as computer networking and infrastructure.

Historically, simulation has been most identified with aviation, but recently it has become well known in other fields such as games, technology and healthcare. Today, simulations are available to support instructions in many areas of schooling including science and technology. Generally speaking, it is less expensive to develop a simulation than to provide real experience, and this is particularly true with complex devices such as flight simulators (Srinivasan et al., 2006). Incorporating and implementing state-of-the-art technological tools and equipment demands a considerable investment of time and financial resources. In the case of many training institutions where funds are usually very limited, keeping curricula and lab resources current with respect to the fast rate of change of technological advances poses a real challenge. Therefore engineering and engineering technology communities all over the world can address some of the challenges by using simulation and virtual experiments (Agrawal, & Cherner, 2009). In addition to the cost saving, simulations for technical training offer a number of other advantages, which includes the following:

- Allowing users to modify system parameters and observe the outcomes without the possibility of harming "real" expensive equipment.
- Learning trouble-shooting by fixing or replacing faulty equipment without any additional cost.
- Encouraging users to take "bold" steps in the process of discovering and understanding any technical details.
- Upholding users' interest through multimedia especially if presenting 'dry concepts'.

The educational institutions are continuously being challenged to offer flexible learning platforms. According to Bell, Kanar, and Kozlowski, "A number of emerging challenges, such as economic pressure, globalization, work-life issues, have combined to create a business environment that demands innovative flexible training solutions."[2] From distance education to online learning and from portable gears to simulations, are all parts of the same effort, i.e., to establish flexible learning environment. Today, most undergraduate technical education and/or training such as electronic circuit analysis, microcomputers circuits, information technology management, etc. are being offered in a traditional hands-on lab environment, but recent advances in technology have positioned simulations as a powerful tool for creating more realistic learning platforms. [3]Therefore, the challenge of completing required hands-on activities in science and engineering curricula can be realistically achieved through the use of simulations. According to Bell et al., "One of the major benefits of online/offline simulation is its flexibility, as simulations can offer learning opportunities that can take place almost anytime anywhere without the additional cost of traditional lab equipment and instructors."[2] According to Sancristobal, Castro, Martin, and Tawkif when the real instruments are very expensive, it is a good solution to use simulation programs. The use of simulation not only reinforces the possibility of flexible learning,[4] it may also prove to be a very good business model, as stated by Gillet, Ngoc and Rekik "The motivation for flexible education at the level of academic institutions is mainly a question of competitiveness in attracting students and in positioning as centers of excellence".[5]

A student working in a traditional lab environment also has the disadvantage of being frustrated in terms of his/her classmates' interference and the noise intensity, which can potentially prohibit students from immersing completely. Simulations, on the other hand, have the ability to create customized micro or synthetic worlds that capture trainees' attention and absorb them fully, [6] and such immersion can enhance learners' feeling of presence, or the perception of actually being in a particular environment.[7] Such real-world settings can in turn contribute to prompting psychological processes that are responsible for improving performance characteristics. [6]

II. Importance of simulation and feedback

One of the possible performance characteristics simulations can improve is one's ability for critical thinking. According to Zantow, Knowlton, and Sharp (2005), "The learning environment created by simulations helps developing an understanding of the relationships among different components, integrating information with existing knowledge, and making decisions" (p. 452). Making decisions requires problem-solving skills, and problem-solving practices promote cognitive processes. According to Gokhale (1996), "Simulations help develop higher-order thinking strategies and improve student cognitive abilities employed in the service of recall, problem-solving, and creativity" (p. 44). Leger et al. (2011) reported that simulations involve interaction that allows learners to test problem-solving strategies, experience the consequences of their actions, and adjust their decisions in a safe environment.

Games and social simulations are often used for training and teaching in management science, economics, psychology, sociology, intercultural communication, political science, and military strategy because through simulations students can sharpen their observational skills, decision-making skills, and critical thinking (Howard-Jones & Demetriou, 2009). Risk taking is another area where simulation outshines traditional lab models. The attractiveness of uncertainty has been well established by psychological experimentation that has shown moderate risk taking heightens motivation (Howard-Jones & Demetriou, 2009). But for the purpose of minimizing potential risks, hands-on experiments performed in traditional labs are usually very controlled and structured. Experimenting with expensive equipment and/or hazardous material in labs, therefore, usually prohibits certain students from being very imaginative and bold in terms of carrying out uncertain procedures.

One of the key attributes of any guided-discovery learning is scaffolding, which will be the primarily focus of the study. The term scaffolding was introduced to psychology by Wood, Bruner, and Ross (1976). In that first incarnation, scaffolding was used to describe the support given by a more expert individual in one-on-one tutorial interactions. Most recently, it has been used by researchers in the learning sciences when discussing features and functions of learning artifacts, especially those of educational software (Sherin, Reiser, & Edelson, 2004). Scaffolding enables the learner to achieve goals or accomplish processes normally out of reach (Jackson, Krajcik, & Soloway, 1998). One of the scaffolding techniques is supportive scaffolding. In this type of scaffolding, a learner is guided in terms of what to consider, how to create associations between ideas, and how these associations form a supportive scaffolding structure (Hannafin, 1999; Linton, 2000). According to Cagiltay (2006), supportive scaffolding can be accomplished by several methods and mechanisms, such as coaching comments, providing feedback, and provoking reflection.

The use of feedback is a critically important attribute in computer-based instruction (CBI) such as multimedia simulations, as it promotes learning by providing students with information about their responses.[8] Especially when it comes to novice learners, research has demonstrated that novices do not learn as well when they are placed in unguided training environments .[9] Novices need to be given some degree of guidance when learning new information, especially those involving complex tasks. The content of the feedback should help the novice develop accurate knowledge structures and build schema in order to better learn the information and eventually become an expert. [10] Therefore, feedbacks, being an essential part of a guided discovery-based learning platform such as simulation, deserve serious attention by the instructional designers.

Even though the effects of multiple types and forms of feedback have been investigated in a large variety of instructional contexts, some of the widely used feedback types in a multimedia learning environment are:

1. Knowledge-of-response (KOR), which indicates that the learner's response is correct or incorrect.
2. Knowledge-of-correct-response (KCR), which identifies the correct response.
3. Elaborative feedback, a complex form of feedback that explains, monitors, and directs, such as answer-until-correct (AUC).

A meta-analysis done by Azevedo and Bernard suggests that the achievement outcomes generally are greater for students receiving CBI that utilizes feedback than for comparison groups with no feedback. The study, however, does not provide insight into the specific type of feedback that is most effective.[11]

Morrison, Ross, Gopalakrishnan, and Casey , on the other hand, found that knowledge-of-correct response (KCR) and delayed feedback (providing feedback at the end of the testing session) within computer-based instruction (CBI) produced greater learning than answer-until-correct (AUC) or no feedback for lower level questions (declarative knowledge).[12] For higher level questions (application or transformation knowledge), however, there were no learning differences in response to the various forms of feedback.

Clariana also examined the effects of various forms of feedback.[13] Similar to Morrison et al.[12] the result of his study showed that KCR was superior on identical questions. In contrast to Morrison et al.[12], however, answer-until-correct (AUC) feedback was equivalent to knowledge-of-correct-response (KCR) and was significantly more effective than no feedback.

Clariana [14] examined the differences in the use of KCR and AUC feedback for low ability learners. The results of this study indicated that low ability students benefit more from KCR than AUC feedback, as they do not have the prerequisite knowledge to effectively reexamine and evaluate the options available during AUC feedback.

According to Moreno "The importance of feedback in promoting learning is inarguable. Previous research indicates that different types of feedback have different influences on performance".[15] Several studies have shown KCR to be superior to KOR, and KOR to be superior to no feedback, but this hierarchy of immediate feedback types is not so well established [8] (AUC outperforming KCR cannot be verified, at least in the area of self-regulation, reported by Agina et al.[16] However, Kalyuga argues that presenting the proper forms of guidance and feedback are critical at different stages in the learning process, because this can directly affect how well a person can process information and whether or not effective learning will take place.[17]

III. Theoretical Framework

The multimedia-guided discovery-based learning platform chosen for this study is called Packet-Tracer developed by Cisco Systems. Packet Tracer can be configured to provide learners with corrective feedback in the form of AUC (answer-until-correct) or KCR (knowledge-of-correct-response). It provides AUC and KCR feedbacks in the form of graphics (animation). Graphic or pictorial feedback may be more accommodating and effective in accompanying instructional material that is highly visualized (Lin and Dwyer, 2010), but additional research is needed to verify the learning outcomes. As the research focuses on students with no prior knowledge of the subject matter, a guided discovery-based multimedia environment is an ideal platform for novice learners because it minimizes extraneous cognitive load. According to Moreno (2004), "When students lack significant prior knowledge, the demands that arise from processing the new information without guidance can be overwhelming and leave students with insufficient capacity for building mental representation of the system to be learned" (p. 110).

The present study focused on students with no prior knowledge of the subject matter, guided discovery-based multimedia environment is an ideal platform for novice learners because it minimizes extraneous cognitive load. One of the key attributes of any guided-discovery learning is scaffolding, which will be the primarily focus of the study. The term scaffolding was introduced to psychology by Wood, Bruner, and Ross.[18] In that first incarnation; scaffolding was used to describe the support given by a more expert individual in one-on-one tutorial interactions. Most recently, it has been used by researchers in the learning sciences when discussing features and functions of learning artifacts, especially those of educational software.[19] Scaffolding enables the learner to achieve goals or accomplish processes normally out of reach.[20] One of the scaffolding techniques is supportive scaffolding. In this type of scaffolding, a learner is guided in terms of what to consider, how to create associations between ideas, and how these associations form a supportive scaffolding structure. [21, 22] According to Cagiltay[23] supportive scaffolding can be accomplished by several methods and mechanisms, such as coaching comments, providing feedback, and provoking reflection. Packet-Tracer provides scaffolding in the form of corrective feedback. According to Jaehnig and Miller the types of corrective feedbacks commonly used are:[24]

1. Knowledge-of-Response (KOR), which simply indicates that the learner's response is correct or incorrect.
2. Answer-Until-Correct (AUC), it requires learner's to remain on the same test item until the correct answer is selected.
3. Knowledge-of-correct-response (KCR), which identifies the correct response i.e. it directs the student to the correct response

According to Moreno[15] "The importance of feedback in promoting learning is inarguable. Previous research indicates that different types of feedback have different influences on performance." Several studies have shown KCR to be superior to KOR, and KOR to be superior to no feedback, but this hierarchy of immediate feedback types is not so well established.[8] According to Jaehnig and Miller, "Overall AUC feedback appears to be highly effective but further study is warranted."[24] On the other hand, a recent study done by Agina, Kommers, and Steehouder couldn't validate the superiority of AUC over KCR.[16]

IV. Problem statement

Feedback has the potential to significantly improve learning and performance outcomes; however, there is a continuing discussion about how and when to deliver feedback.[25,26 & 27] Narciss notes that "modern information technologies increase the range of feedback strategies that can be implemented in computer-based learning environments; however, the design and implementation of feedback strategies are very complex tasks that are often based more on intuition than on psychologically sound design principles".[28] Consequently, research must be conducted to empirically attempt to determine the most appropriate ways to use technology to administer feedback in computer learning environments, which may not always align with strategies that are thought to be intuitive.

According to Moreno, "The importance of feedback in promoting learning is inarguable but additional research is needed to determine the effects of structured guidance on other educational areas, methods, and student populations."[15] One way to better understand the effect of simulated activities on students' learning is to expand the research to uncommon educational areas such learning technical concepts related to information technology (IT). Even though for several decades researchers have explored the use of simulation to augment the laboratory experiences in the areas of surgery, physics, chemistry, biology, math, and dental education, there is no significant study that measures the effect of students' learning of IT matters using simulation software such as Packet-Tracer. Therefore, conducting research, for finding the effects of simulated lab activities on students' learning of Local Area Network (LAN) design and/or troubleshooting concepts, will be a significant step in enhancing the instructional strategies and design in the field of instructional technology. Following are the research questions:

1. Do pure discovery-based (no feedback) simulated labs improve students' declarative knowledge?" The premise of this research is that the simulated experiments are better than the hands-on laboratory exercise when it comes to understanding basic IT concepts. Therefore, the hypothesis is: The use of simulated experiments in the teaching of IT concepts in CCNA program with no feedback (pure discovery learning environment) will

produce improved declarative knowledge (as reflected in the differences between pretest and posttest scores) more than the hands-on activities.

2. Do KCR (knowledge-of-correct-response) feedback feature of simulated labs in CCNA program improve students' declarative knowledge in the learning of basic IT concepts? Therefore the hypothesis is: The use of KCR-enabled simulated experiments in the teaching of basic IT concepts in CCNA program will produce improved declarative knowledge (as reflected in the differences between pretest and posttest) more than the hands-on activities.

3. Do AUC (answer-until-correct) feedback feature of simulated labs in CCNA program improve students' declarative knowledge in the learning of basic IT concepts?" Therefore the hypothesis is: The use of AUC-enabled simulated experiments in the teaching of basic IT concepts in CCNA program will produce improved declarative knowledge (as reflected in the differences between pretest and posttest scores) more than the hands-on activities.

4. Do KCR (knowledge-of-correct-response) feedback feature of simulated labs in CCNA program improve students' declarative knowledge in the learning of basic IT concepts as compared to no-feedback (pure discovery) based simulation?" Therefore the hypothesis is: The use of KCR-enabled simulated experiments in the teaching of basic IT concepts in CCNA program will produce improved declarative knowledge (as reflected in the differences between pretest and posttest scores) more than the no-feedback simulated environment.

5. Do AUC (answer-until-correct) feedback feature of simulated labs in CCNA program improve students' declarative knowledge in the learning of basic IT concepts as compared to no-feedback (pure discovery) based simulation?" Therefore the hypothesis is: The use of AUC-enabled simulated experiments in the teaching of basic IT concepts in CCNA program will produce improved declarative knowledge (as reflected in the differences between pretest and posttest scores) more than the no-feedback simulated environment."

V. Description of Study

The sample for the study comprised of 80 students enrolled in four sections of Cisco Routing Fundamentals (NETW205) course offered during the winter session of 2012, at DeVry University, Addison, Illinois 60101. DeVry University is a Cisco Network Academy (CNA) where Cisco Certified Network Associate (CCNA) training is regularly offered throughout the year. NETW205 is one of the required courses to complete training for CCNA certification. All 80 participants involved in the study were enrolled to complete their CCNA certification. Classes were randomly selected and assigned to one of the four groups: simulation- lab with AUC (AUC), simulation lab with KCR (KCR), simulation lab with no feedback (NFB), and traditional hands-on lab (HON) group. Even though all four groups were given the same lab work to complete, the AUC group was required to complete the lab using the simulation software with

AUC feedback, the KCR group was required to complete the lab using simulation with KCR feedback, and the NFB group was required to complete the lab using simulation with no feedback. The hands-on HON group was asked to complete the same experiment using physical equipment in the traditional hands-on lab environment; irrespective of the class size and the level of students' prior technical knowledge, section assignments are illustrated in Table 1. Assigning a class arbitrarily to one of these groups avoided any biasing as far as student selection and lab assignments were concerned. Computer network simulation software known as 'Packet-Trace' from Cisco Systems was used to conduct the study. Packet-Tracer's screen shot is illustrated in Figure 1.

Table 1: Control and Treatment Groups (20 Students Each)

Class	Group Assignment
Morning Session	Traditional Hands-on Group (HON)
Afternoon Session	Simulation with KCR Group (KCR)
Evening Session	Simulation with AUC Group (AUC)
Weekend Session	Simulation with no-feedback Group (NFB)

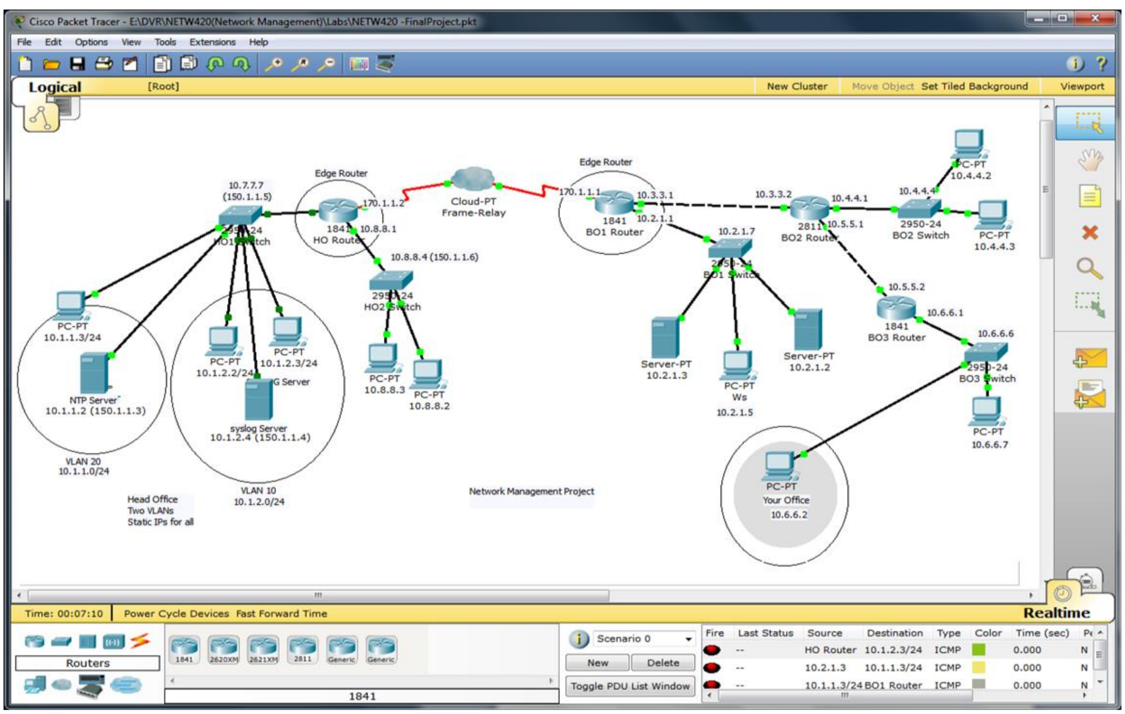

Figure: 1: Packet-Tracer Screen Shot

Packet-Tracer essentially offers three guided discovery learning environments with varying degree of technical details, known as topology, simulation, and real-time. One may switch between these modes by clicking on the topology, simulation, and real-time tabs.

In topology mode, one can build a network by choosing, connecting, and configuring devices. In terms of filtering and forwarding packets, the network is not "intelligent" at this point because network convergence hasn't occurred. One may inspect physical connectivity in this mode, but some Interconnect Operating System (IOS) diagnostic commands will not work; hence, this learning environment was not be used for the study.

In simulation mode, one may run and diagnose the network one step at a time by sending packets in the desired sequence and viewing network parameters at each hop. Certain commands, like PING and TRACEROUTE, are not suited for this step-by-step approach, as one single ping operation involves many packets being sent back and forth in the network and would take a long time. Therefore, this learning environment was also not suitable for this study.

In real-time mode, one can issue troubleshooting commands such as PING and receive a timely response. From the Cisco IOS and PC command line interfaces, the user may also issue extended PING and TRACEROUTE commands as well. All experiments by the three treatment groups were completed in this environment, as it offered experience analogous to working with the real equipment.

Packet-Tracer's feedback options can be customized using the Preferences tab as shown in Figure 2.

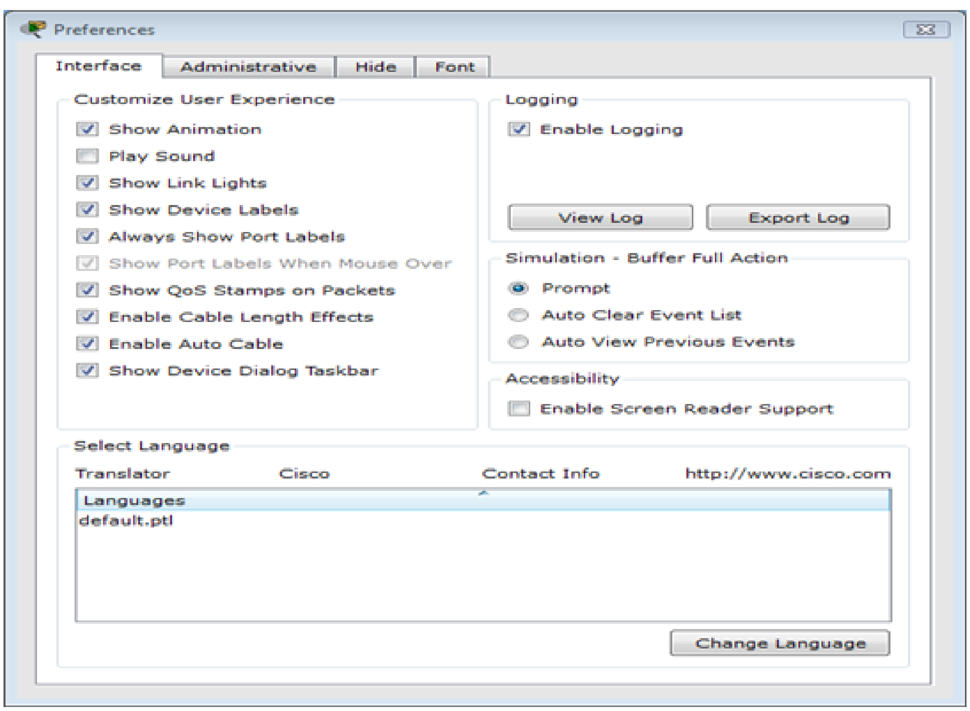

Figure: 2. Packet-Tracer Preference Tab

From the list in Figure 2, the following options were used to modify and study the effect of different feedback types (treatments) on students' learning:

•Knowledge-of-correct Response (KCR): Enabling "Show Animation" displayed the result of a selection, i.e., right or wrong, same as KCR feedback.

•Answer-until-correct (AUC): The "Enable Auto Cable" option, when unchecked, allowed learners to keep selecting a cable from the list until the right one is chosen, same as AUC feedback.

•No Feedback: For no feedback, "Show Animation," "Show Link Lights," and "Enable Auto Cable" options were all unchecked.

VI. Data Analysis

Quantitative Findings

Participants

The sample size consisted of 80 participants; 71 (88.75%) were male and 9 (11.25%) were female. They all agreed voluntarily to be a part of the research. All 80 participants were randomly but equally assigned to the following four groups i.e. 20 members per group.

1. Hands-On (HON) Group
2. No-Feedback (NFB) Group
3. Knowledge-of-Correct-Response (KCR) Feedback Group
4. Answer-Until-Correct (AUC) Feedback Group

All participants were between the ages of 18 and 35 years, 22.75 years being the average, with AUC group demonstrating the largest standard deviation (SD = 5.59). Table 2 shows participants' demographic characteristics.

Table 2: Participants' Demographic Characteristics

Group	Male	Female	Age (Mean)	Age (SD)	Total
HON	19	1	23.5	3.59	20
NFB	18	2	22.0	3.48	20
KCR	16	4	23.0	4.29	20
AUC	18	2	22.5	**5.59**	20
Total	71	9	22.75	4.27	80

Table 3 shows participants' average prior technical experience and lab preference in terms of both hands-on and Packet-Tracer (simulation). After running the test of homogeneity, one outlier was identified and removed from the KCR computation. It is important to note the following key points:

- AUC group had the least prior technical experience
- NFB group was most comfortable working with the simulation software
- HON group preferred the most working with the physical equipment though they didn't enjoy working in groups

Table 3: Survey Summary

Group	Like Working in Groups	Experience with Packet-Tracer	Like Hands-On Labs	Have Networking Experience
Hands-On (HON)	**3.50**	2.60	**2.15**	3.40
No-Feedback (NFB)	3.15	**3.05**	2.55	3.60
Knowledge-of-Correct-Response (KCR)	2.90	2.60	2.21	3.15
Answer-Until-Correct (AUC)	3.35	2.80	2.35	**3.80**
1.Strongly Agree 2.Agree 3.Neutral 4.Disgree 5.Strongly Disagree				

The data were analyzed using statistical package known as Statistical Package for the Social Sciences (SPSS). The data analysis technique used was the analysis of variance (ANOVA), which is commonly used to determine the influence of the independent variable on the dependent variable. Using ANOVA, the average score of the two groups (control and one of the treatments) was calculated, means were compared, and standard deviations were examined for the purpose of drawing any meaningful conclusions.

In the case of ANOVA, some small violations may have little practical effect on the analysis, while other violations may render the result uselessly incorrect or un-interpretable. Therefore for cross validation, two nonparametric tests, Kruskall-Wallis and Mann-Whitney U, have been conducted as well. To reduce data skewness as illustrated in in Figure 2, the outliers were moved one standard deviation closer to the mean.

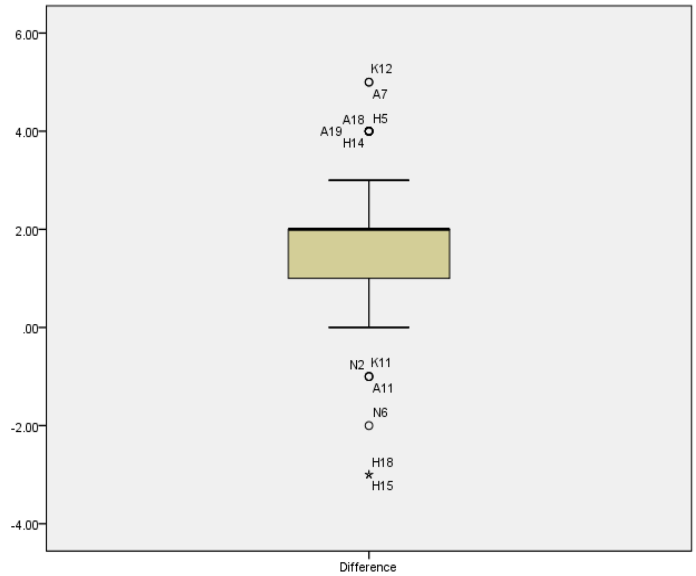

Figure 2: Boxplot Displaying Outliers

In order to test the assumption of normality, the difference between pretest and posttest scores have been analyzed for all four groups. Table 11 shows descriptive statistics and the results of the Shapiro-Wilk test for all 80 participants. It is evident that the dataset did not pass the normality test. The dataset showed a highly negative skewness of -.341.

Table 11 : Results of Descriptive Statistics

				Shapiro-Wilk		
	n	M	SD	Statistic	Df	sig
Difference	80	1.537	1.591	.950	80	.003

Validity refers to the appropriateness, meaningfulness, correctness, and usefulness of the inferences a researcher makes, and validation is the process of collecting and analyzing evidence to support such inferences. Normally, there are three types of evidence a researcher can discover:

1. Content validity. Content-related evidence of validity refers to the content and format of the instrument. In this study, the format was the lab environment and the content was interconnecting Cisco devices. To maintain the validity, the lab was developed by the professional trainers, and the result was evaluated by the content experts in the field of Local Area Network (LAN) infrastructure. All professionals involved were certified by Cisco Systems as Cisco Certified Associate Instructors (CCAI).

2. Criterion validity. Criterion-related evidence of validity refers to the relationship between scores obtained using the instrument and scores obtained using one or more other instruments or measures (often called a criterion). As Packet-Tracer was the only simulation software available

on the market to learn Cisco business class devices, it was not possible to verify the criterion-related validity at this time.

3. Construct validity. Construct-related evidence of validity refers to the nature of the psychological construct or characteristic being measured by the instrument. In this study, test results were used to validate the students' learning in the area of cabling system necessary to interconnect Cisco devices.

For determining the reliability, Cronbach's alpha was calculated for all the four groups' pre and posttest scores as shown in Table 4. Both tests were comprised of seven questions. The effect size η^2 (partial eta) was calculated to validate the association between the sampled data test scores.

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Table 4: Cronbach's Alpha

Test	N	Number of Items	Alpha
Pretest	80	7	.601
Posttest	80	7	.270

The value of Cronbach's alpha is moderately low for pretest and low for posttest. In most cases it is recommended that the alpha should be higher than 0.7, but according to Schmitt 'There is no sacred level of acceptable or unacceptable level of alpha, in some cases low level alpha may still be quite useful.'[29] Low data reliability resulted here may be due to the length of the test i.e. only 7 questions. As reported by Tavakol & Dennick 'low value of alpha could be due to a low number of questions, poor interrelatedness between items or heterogeneous construct. A longer test increases the reliability of a test regardless of whether the test is homogeneous or not.' [30] Table 5 summarizes the results of ANOVA analysis.

Table 5: General Linear Model Repeated Measures Analysis (ANOVA)

Source		Type III Sum of Squares	Df	Mean Square	F	Sig.
Tests of interaction effects on NFB and AUC groups						
Lab	Greenhouse-Geisser	54.450	1	54.450	65.169	.000
Lab*Group	Greenhouse-Geisser	12.80	1	12.80	15.320	.000
Error(Lab)	Greenhouse-Geisser	31.750	38	.836		
Tests of interaction effects on NFB and KCR groups						
Lab	Greenhouse-Geisser	23.113	1	23.113	30.952	.000
Lab*Group	Greenhouse-Geisser	1.013	1	1.013	1.356	.251
Error(Lab)	Greenhouse-Geisser	28.375	38	.747		

Tests of interaction effects on HON and AUC groups						
Lab	Greenhouse-Geisser	80.00	1	80.00	52.459	.000
Lab*Group	Greenhouse-Geisser	4.050	1	4.050	2.656	.111
Error(Lab)	Greenhouse-Geisser	57.950	38	1.525		
Tests of interaction effects on HON and KCR groups						
Lab	Greenhouse-Geisser	40.613	1	40.163	28.278	.000
Lab*Group	Greenhouse-Geisser	.313	1	.313	.218	.644
Error(Lab)	Greenhouse-Geisser	54.575	38	1.436		
Tests of Interaction effects on HON and NFB group						
Lab	Greenhouse-Geisser	28.80	1	28.80	22.449	.000
Lab*Group	Greenhouse-Geisser	2.450	1	2.450	1.910	.175
Error(Lab)	Greenhouse-Geisser	48.750	38	1.283		

Since the data collected for the one-way analysis of variance (ANOVA) violated the assumption of normality, it became essential to a conduct nonparametric analysis as well for any trustworthy comparison and/or conclusion. Kruskal-Wallis test is the nonparametric test equivalent to the one-way ANOVA to allow the comparison of more than two independent groups. Table 6 shows the results of Kruskal-Wallis test for all four groups.

Table 6: Kruskal-Wallis Test Result

Group	N	Rank		HON-NFB
HON	20	43.75	Chi-Square	13.034
NFB	20	29.30	Df	3
KCR	20	35.30	Asymp. Sig.	.005
AUC	20	53.65		

There exists a statistically significant difference between the groups' mean scores (H (4) = 13.034, $p = .005 < .05$), with a mean rank of 43.75 for HON, 29.30 for NFB, 35.30 for KCR and 53.65 for AUC group. One of the shortcomings of the Kruskal-Wallis test is that, it is an omnibus test statistic and thus, it cannot indicate which specific groups were significantly different from each other; it only indicates that at least two groups were different. Therefore, in order to further analyze the data, Mann-Whitney test between the groups was conducted:

Mann-Whitney test between HON and NFB Groups:

Result of Mann-Whitney U test is shown below Table 7, statistically there is no significant difference: (U = 130, p =.053>.0125).

Table7: Mann-Whitney U Test Result for HON and NFB Groups

Group	N	Mean Rank	Sum of Ranks		
HON	20	24.00	480.00	Mann-Whitney	130.00
NFB	20	17.99	340.00	Wilcox W	340.00
Total	40			Z	-1.937
				Asymp. Sig.	.053
				Exact Sig.	.060

Mann-Whitney test between HON and KCR Groups:

Result of Mann-Whitney U test is shown below Table 8, statistically there is no significant difference: (U = 157, p =.235>.0125).

Table 8: Mann-Whitney U Test Result for HON and KCR Groups

Group	N	Mean Rank	Sum of Ranks		
HON	20	22.65	453.00	Mann-Whitney	157.00
KCR	20	18.35	367.00	Wilcox W	367.00
Total	40			Z	-1.188
				Asymp. Sig.	.235
				Exact Sig.	.253

Mann-Whitney test between HON and AUC Groups:

Results of Mann-Whitney U test are illustrated in Table 9, statistically there is no significant difference: (U = 152, p =.186>.0125).

Table 9: Mann-Whitney U Test Result for HON and AUC Groups

Group	N	Mean Rank	Sum of Ranks		
HON	20	18.10	362.00	Mann-Whitney	152.00
AUC	20	22.90	458.00	Wilcox W	362.00
Total	40			Z	-1.324
				Asymp. Sig.	.186
				Exact Sig.	.201

Mann-Whitney test between NFB and KCR Groups:

Result of Mann-Whitney U test is shown below Table 10, statistically there is no significant difference: (U = 169.5, p =.390>.0125).

Table 10: Mann-Whitney U Test Result for NFB and KCR Groups

Group	N	Mean Rank	Sum of Ranks		
NFB	20	18.98	379.00	Mann-Whitney	169.00
KCR	20	22.03	440.00	Wilcox W	379.00
Total	40			Z	-.860
				Asymp. Sig.	.390
				Exact Sig.	.414

Mann-Whitney test between NFB and AUC Groups:
Result of Mann-Whitney U test is shown below Table 11, statistically there is significant difference: (U = 76.5 p =.001<.0125).

Table 11: Mann-Whitney U Test Result for NFB and AUC Groups

Group	N	Mean Rank	Sum of Ranks		
NFB	20	14.33	286.50	Mann-Whitney	76.50
AUC	20	26.68	533.50	Wilcox W	286.50
Total	40			Z	-3.440
				Asymp. Sig.	.001
				Exact Sig.	.001

VII. Findings

This research was designed to analyze the potential impact of the use of various computer simulation feedback types on students' declarative knowledge in learning information technology concepts while preparing for the Cisco CCNA certification exam. As we know laboratory exercises play a key role in the education of future scientists and engineers, yet there exists disagreement among science and engineering educators about the effectiveness and types of technology-enabled laboratory exercises to be used.[31] The present study was designed to address this concern. The first three hypotheses involved a comparison of the hands-on experiment and simulation labs with or without any feedback type such as KCR and AUC. It is interesting to note that the study showed no advantage for simulated labs under any feedback condition over hands-on experiments. The finding was similar to the observation made by Corter et al. "There was no significant difference in lab test scores when experimenting with either simulation or hands-on physical equipment." [31]

The following is a summary of findings after running repeated measures analysis of variance (ANOVA) followed by Kruskal-Wallis and Mann-Whitney U tests for cross validation:

- Simulated labs with no-feedback statistically do not produce better results than the hands-on physical activities when it comes to improving declarative knowledge in the learning of basic IT concepts.
- Simulated labs with KCR feedback statistically do not produce better results than the hands-on physical activities when it comes to improving declarative knowledge in the learning of basic IT concepts.
- Simulated labs with AUC feedback statistically do not produce better results than the hands-on physical activities when it comes to improving declarative knowledge in the learning of basic IT concepts.
- Simulated labs with KCR feedback statistically do not produce better results than the simulated labs with no feedback when it comes to improving declarative knowledge in the learning of basic IT concepts.
- Simulated labs with AUC feedback statistically do produce better results than the simulated labs with no-feedback when it comes to improving declarative knowledge in the learning of basic IT concepts

VIII. Implications for Practice: Recommendations

Laboratories play a key role in the education of future scientists and engineers, yet there is disagreement among science and engineering educators about whether and which types of technology-enabled labs should be used (Corter et al. 2007). This study was designed precisely to address this dispute.

The findings of the current study suggest that in order to enhance student learning, the instructional designers should consider the following recommendations for incorporating simulation and feedback in the design of curricula:

- The use of simulation is at least as effective as hands-on labs in the learning of basic information technology concepts; therefore, when and where appropriate, traditional hands-on laboratories can be replaced with the simulated labs.
- Simulation with AUC feedback proved to be more effective than traditional hands-on labs; using such methodology will not only improve students' learning but will also offer a low-cost and a flexible training platform.
- Even though AUC is a preferable type of feedback compared to KCR, it is more complex and therefore expensive to develop.
- Instructional designers are often interested in efficiency. It might be expected that the additional steps necessary for AUC would require more study time.
- Simulation-based teaching methodology offers a cost reduction by replacing expensive physical lab equipment such as routers, switches, and firewalls. By incorporating simulation-based laboratory experiments in place of physical laboratories, institutions can save a tremendous amount of expenditure.
- Simulations offer flexibility in terms of anywhere, anytime learning. Being able to access the software online can benefit both onsite and offsite students equally.

- Students' knowledge of simulation programs is one of the major factors for enhancing their learning experiences. Necessary software training should be provided before it is used as a learning platform.
- Simulation based labs offer a safe working environment for learners. In a traditional lab, a typical station has high voltage connections and outlets to run IT equipment such as routers and switches, potentially creating a hazardous environment. Simulation, on the other hand, has no such threats.

Before making any solid recommendation in the favor of simulated labs, further research is needed due to the following concerns: first, most science and engineering educators believe that the hands-on experience of the science laboratory is a necessary supplement (Schwartz & Dunkin, 2000); second, student cognitive style can affect their preferences for educational media (Corter et al., 2007); third, it is clear that students learn not only from equipment, but from interactions with peers and teachers (Ma & Nickerson, 2006); and fourth, excessive exposure to simulation will result in a disconnection between real and virtual worlds (Magin & Kanapathipillai, 2000). Until we have concrete answers to these questions, recommendations to replace traditional hands-on with simulated labs in the learning of IT concepts cannot be crystallized.

IX. Conclusion

The paper presented the results of a quantitative study designed to explore the impact of the use of computer simulation's feedbacks such as knowledge-of-correct-response (KCR) and answer-until-correct (AUC) on students' declarative knowledge in the area of information technology, i.e., computer networking and infrastructure.

The findings based on quantitative analyses verified that the simulation-based instructional strategies are at least as effective as hands-on teaching methodologies for the purpose of learning of IT concepts. These findings were consistent with the studies reported in the literature. On the other hand, the study failed to validate the superiority of simulation over hands-on labs; therefore, further research is needed.

The results of previous studies, suggesting that AUC might be an optimum form of simulation feedback, have been verified. But on the other hand, the effectiveness of the KCR feedback could not be validated by the present study.

The paper provided insights on the effectiveness of different types of scaffolding & feedback mechanisms used in a simulated environment. The paper also provided recommendations for instructional designers to devise effective learning platforms.

Consistent with the literature such as reported by Corter et al. (2007), "Simulated labs can be at least as effective as traditional hands-on labs in teaching specific course concepts" (p. 36), the findings did verify the studies; however, the question whether the simulated labs with or without any feedback is superior to hands-on labs needs further investigation.

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