Role of Feedbacks in Simulation-Based Learning

Usman Ghani

Abstract—Feedback is a vital element for improving student learning in a simulation-based training 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.

Keywords—Simulation, feedback, training, hands-on, labs.

I. INTRODUCTION

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 [1]. 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.

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

Dr. Usman Ghani, Senior Professor is with the Network and Communication Management in the College of Engineering and Information Science at DeVry University, Addison, Illinois.

Professor Ghani's area of specialization is 'Network Infrastructure and Security (e-mail: ghani@devry.edu).

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

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

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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. the result of his study showed that KCR was superior on identical questions. Reference [12] in contrast to Morrison et al., however, answer-until-correct (AUC) feedback was equivalent to knowledge-of-correct-response (KCR) and was significantly more effective than no feedback.

Clariana examined the differences in the use of KCR and AUC feedback for low ability learners [14]. 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]". According to [8], 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 ('AUC outperforming KCR cannot be verified, at least in the area of self-regulation, reported by Agina [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 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 [22], 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 [23]:
1. Knowledge-of-Response (KOR), which simply indicates that the learner's response is correct or incorrect.
2. Answer-Until-Correct (AUC), it requires learners 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 "The importance of feedback in promoting learning is inarguable [15]. 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 [24]-[6]. 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 [25]". Consequently, research must be conducted to empirically attempt to determine the most appropriate ways to use technology to administer feedback in computer learning environments,

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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 I. 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 Fig. 1.

TABLE I
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)

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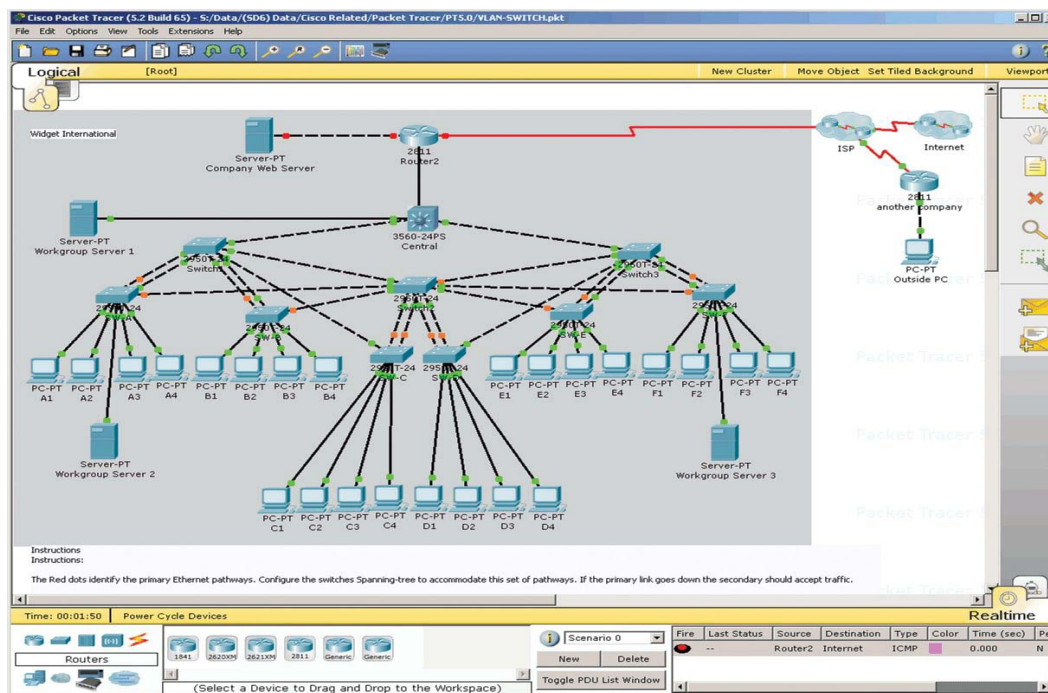International Journal of Educational and Pedagogical Sciences
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Fig. 1 Packet-Tracer Screen Shot

VI. DATA ANALYSIS

A. Quantitative Findings

1. 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 II shows participants' demographic characteristics.

TABLE II
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 III 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 did not enjoy working in groups

TABLE III
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 Fig. 2, the

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outliers were moved one standard deviation closer to the mean.
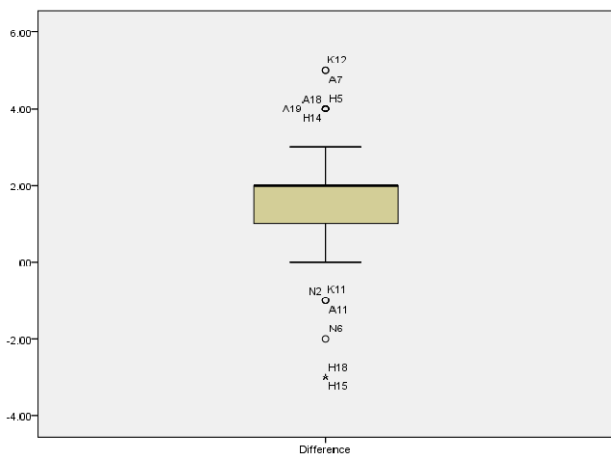

Fig. 2 Boxplot Displaying Outliers

For determining the reliability, Cronbach's alpha was calculated for all the four groups' pre and posttest scores as shown in Table IV. Both tests were comprised of seven questions. The effect size $\eta2$ (partial eta) was calculated to validate the association between the sampled data test scores.

TABLE IV
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 [27].' Table V summarizes the results of ANOVA analysis.

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 VI shows the results of Kruskal-Wallis test for all four groups.

TABLE V
GENERAL LINEAR MODEL REPEATED MEASURES ANALYSIS (ANOVA)

TESTS OF INTERACTION EFFECTS ON NFB AND AUC GROUPS

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
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		

TABLE VI
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 in Table VII, statistically there is no significant difference: (U = 130, p =.053>.0125).

TABLE VII
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:

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

TABLE VIII
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 IX, statistically there is no significant difference: ($U = 152$, $p = .186 > .0125$).

TABLE IX
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 in Table X, statistically there is no significant difference: ($U = 169.5$, $p = .390 > .0125$).

TABLE X
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 in Table XI, statistically there is significant difference: ($U = 76.5$ $p = .001 < .0125$).

TABLE XI
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

VI. FINDINGS

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 [26]. 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 [26]."

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

VII. IMPLICATIONS FOR PRACTICE: RECOMMENDATIONS

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.

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- 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.

VIII. 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. 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.

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