Effects of Differences in Electronic Course Design on University Students' Programming Skills

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Summary
This study touched on the effect of the different electronic course designs on the programming skills of university students. The researcher used the experimental research design of a quasi-experimental of two experimental groups to achieve the objectives of the study. The first group underwent an electronic course designed in the holistic pattern, and the second group was taught a course in a sequential pattern. This experimental design was intended to measure the impact of these two learning modes on the learners' cognitive and performance achievement of programming skills. An achievement test and observational form were the data collection tools. Data were analyzed statistically using Pearson correlation, Mann Whitney Test, and Alpha Cronbach. The findings revealed statistically- significant differences between the mean scores of the students of the first and second experimental groups in favor of the former concerning the observational form and the latter in the cognitive test. Based on the findings, some recommendations are suggested. Due to their effectiveness in the educational process, expanding using the e-courses at universities is vital. The university teachers are highly recommended to design e-courses and provide technical and material support to the e-courses user to fulfill their design purpose.
Key words:
Effects of Differences, Electronic Course Design, Students' Programming Skills

1. Introduction

Electronic learning (e-learning), which is a modern learning mode, integrates technology into the educational process so as to enrich the learning environment. It employs interactive tools that facilitate interaction between learners themselves as well as learners and the teacher. The capabilities enabled by such e-learning environments provide them with numerous solutions that arise in the traditional educational process.

Prior research highlighted the effectiveness of electronic courses in developing knowledge, skills, and positive attitudes towards computers and programming. For instance, [1] studied the effectiveness of an electronic course in developing programming skills in the programming language dubbed Visual Basic Net for educational technology students. This study is in line with [2], who confirmed the effectiveness of an electronic course in developing programming skills and attitudes towards programming among third-year middle school students.

Research Question1:
What are the programming skills deemed necessary for the students at Umm Al-Qura University ?
Research Question2:
What are the effects of the different models of electronic course design (holistic & sequential) on:
a. Cognitive aspects related to Python-based programming skills.
b. Performance aspects related to Python-based programming skills.

Programming skills

It is essential to think seriously about how to provide our children with programming skills in the early stages of education so that they will be able to build and develop their societies in the future. Digital technology is now one of the crucial means that help in this development. For this reason, some countries (e.g., Estonia) have included teaching programming in the primary stage starting in 2012. Similarly, the United States has a great interest in teaching programming skills in public education. Major technology companies such as Google and Microsoft have established the International Hour of Code organization (Code.org) to support learning to code early. The organizes an "Hour of Code" event around the world [3].

Programming Stages:

There are steps that the learner must follow in order to master programming skills. [4] summarized them in the following steps:

- An overview of the cognitive aspects of the skill, along with a theoretical explanation of how to perform it.
- Application of the skill in front of the student. The student' role is to observe each step of the skill performance.
- A student is given the opportunity to apply the skill according to what was learned in the previous steps.
- A learner repeats the training process until he or she masters the skill.

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- Observing and evaluating the learner's performance and addressing his/her weaknesses according to the evaluation results.

[2] revealed the effectiveness of an e-course in developing some programming skills in the Visual Basic.net language among third-year middle school students. The study used a quasi-experimental research design in which two groups were assembled: a control group and an experimental group. The control group comprised 30 students vs. 30 students in the experimental group. The researcher used an achievement test to measure the cognitive aspects of Visual Basic.net and an observational guide to measuring the performance skills of programming in Visual Basic.net. The study concluded that the electronic course was influential in developing programming skills in Visual Basic.net.

The importance of skill assessment criteria stems from their connection to learners' mastery of the target skill, recognizing learners' weaknesses and treating them, as well as developing the strengths. Noticeably, some researchers have genuine interests in evaluating performance skills. For instance, [5] delineated some of these criteria:

- **Estimation:** This criterion is concerned with the learner's ability to use the appropriate units of measurement.
- **Interpretation:** This criterion measures the learner's ability to provide a logical explanation for the performance steps he or she takes for each skill.
- **Level of performance:** The learner's performance of the skill according to the sequence of its required steps leads to correct performance of the skill.
- **Conclusion:** The learners' knowledge of the consequences of the performance steps is a criterion for judging the extent to which they master the required skill.

Characteristics of Programming Skills:

According to [4], the following features characterize programming skills:

- A skill consists of knowledge and is an integral part of it.
- A skill consists of a set of small and partial performances and operations, simple operations, or consistent and straightforward responses.
- The skill performance of learners is developable through training and practice. Training should be following a practical methodology that enhances correct performances and treats erroneous performances of the skill until the learner reaches an advanced level of mastery.
- Skills consist of a mixture of mental processes such as thinking skills, problem-solving skills, other cognitive functions, and social skills that require social interactions and skills for interaction with the family and school environment.

[1] identified the effectiveness of an e-course in teaching programming in Visual Basic language in developing higher-order thinking skills and attitudes towards programming. The sample of the study was nominated from the fourth-year students of the Computer Teacher Preparation Division in the Department of Technology Education at the Faculty of Education at Minya University. The course included basic skills in programming using Visual Basic.net language (version 2008). The two study tools had an achievement test that measured higher-order thinking skills from Bloom's modified classification and a measure of attitude towards programming. The study disclosed that the course was influential in developing programming skills as well as attitudes towards it among the experimental group.

[4] aimed to explore the effectiveness of electronic content programmed in a computer program in a private teaching style to develop the skills of solving programming problems among students of the Computer Teacher Preparation Department at the Faculty of Education at Mansoura University. They studied programming skills in Visual Basic. The results showed that the experimental group outperformed the control group in the observation form's achievement test.

As discussed above, some of the previous studies on e-courses confirmed the effectiveness of the e-course on developing programming skills and the associated cognitive achievement. Some differences exist, though: [2] study was conducted on students from the third preparatory stage, while [1] and [4] studies recruited students from higher education institutions. The researcher extracted the effectiveness of e-courses in developing performance skills in programming and the cognitive aspects associated with them at all educational levels from previous studies. The researcher benefited from the earlier studies in designing the electronic course and how to formulate the skill in it and present it to students and evaluate it.

2. Hypotheses

1. There are no statistically significant differences between the mean scores of the students of the first experimental group and the students of the second experimental group in the posttest of the cognitive achievement test that relates to programming skills. The former group underwent the design of sequential electronic courses while the latter had holistic electronic courses.
2. There are no statistically significant differences between the mean scores of (a) the students of the first experimental group and the students of the second experimental group in the posttest of the practical performance of programming skills. The former group experienced the sequential electronic pattern while the latter practiced the holistic electronic design.

3. Method

The researchers adopted the experimental research design of a quasi-experimental for two experimental groups. The first group had an electronic course designed in the holistic module and the second group in the sequential pattern. This was intentional in order to measure the impact of these two learning modes on the learners' cognitive and performance achievement of programming skills.

The internal validity was ascertained by the following table of specifications. The topics related to programming skills the educational units approved were checked, and the objectives were distributed according to their levels: remembering, understanding, application and analysis that correspond to the topics, and the number of test items that measure those goals and their relative weights. Table 1 shows the specifications of the cognitive achievement test for programming skills in Python:

Table 1. *Specifications of the Achievement Test*

Topics	Remember		Comprehension		Application		Analysis		Total objective	%
	objective	Q	objective	Q	objective	Q	objective	Q		
Unit 1	1	1	-	-	3	3	-	-	4	19%
Unit 2	-	-	1	1	3	3	1	1	5	24%
Unit 3	1	1	2	2	8	8	1	1	4	19%
Total	2	2	3	3	14	14	2	2	21	-
%	9.5 %	9.5 %	14.3%	14.3 %	66. 7%	66.7%	9.5 %	9.5 %	-	100 %

Population of the Study

The research population consists of all students of the joint first year at Umm Al-Qura University, whose number is 1522 students registered in the second semester of the academic year 1440-1441 (Hijri Calendar).

Instruments

a. Achievement test

An achievement test was prepared to measure the cognitive aspects germane to programming required skills that fit in with Bloom's levels of behavioral goals: remembering, understanding, application, synthesis, and analysis, with a focus on the higher levels. The test was written as 21 multiple-choice items: remembering (2 items), understanding (3 items), application (14 items), and analysis (2 items).

Validity of the test:

Validity of the test means that the test measures what it was designed for. The validity of the test at hand was attained in two ways:

A: Face validity

The test was assessed by some experts. Some necessary changes were made. In its final form, it has 21 items of the multiple choice type.

A: Internal validity

Reliability of the test

The test reliability was checked by running the test-retest statistical procedure. The value of Cronbach's Alpha was 0.85, which means the test is adequately reliable.

B. Observation

An observational protocol was prepared of 32 items to keep a closer look at the practical performance of the participants regarding their Python-based programming skills. The observational agenda were prepared in accordance with the programming skills course description and the required skills that the students have to master.

Validity of the observation

The observational form was approved by some arbitrators who assure its clarity and accuracy in measuring students' skill level. They recommended that the quantitative assessment level should be modified to be of three levels as follows:

Table 2. *Quantitative Estimation of Performance Levels*

Performance level	Little	Moderate	Much
Quantitative average	1	2	3

Internal validity

The internal consistency of the form was verified by applying it to an exploratory sample of students from outside the research sample, and calculating correlation coefficients for each item in the card with the total score of the field as follows:

Table 3. *Internal Consistency of the Observational Form*

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No.	Correlation	Sig.
1	.654**	0.01
2	.526**	0.01
3	.611**	0.01
4	.555**	0.01
5	.554**	0.01
6	.542**	0.01
7	.357*	0.05
8	.456**	0.01
9	.445*	0.05
10	.396*	0.05
11	.452*	0.05
12	.597**	0.01
13	.716**	0.01
14	.685**	0.01
15	.617**	0.01
16	.386*	0.05
17	.581**	0.01
18	.557**	0.01
19	.541**	0.01
20	.486**	0.01
21	.541**	0.01
22	.486**	0.01
23	.542**	0.01

Reliability

Reliability measures the extent to which a test is able to give the same or close scores when applied more than once, and in the same circumstances [6]. The researcher calculated the reliability of the observation form using the method of test-re-test, and Cronbach's Alpha was 0.81, which means that the observation has a high degree of reliability. Similarly, the researcher calculated the form by using the method of agreement of the observers: The researcher and his colleague chose 15 students from the research community and outside the research sample and observed their performance in an achievement test.

The performance skills, after processing the scores, the percentage of the observers' agreement was calculated using Cooper's equation:

$$\text{Coeficient of agreement} = \frac{\text{number of times agreed}}{\text{number of times greed} + \text{number of times difference}} \times 100$$

The percentage of the observers' agreement reached (80%), which indicates that the observation card has high stability and is suitable for application.

Pre-test

A. Achievement test

To ensure that the two research groups are equal in the cognitive achievement test related to measuring the cognitive aspects of programming skills, the test was applied to the two groups of research, test correction, and score monitoring and analysis using the SPSS program, and the results were as follows:

Test	Sample	N	Rank means	Z	Sig.	Mann Whitney
Achievement Test	Experiment 1	15	17.59	1.017	0.309	94.500
	Experiment 2	15	14.30			

Z at 0.01 = 2.58
Z at 0.05 = 1.96

As Table 4 shows, the calculated "z" value (1.017) is less than the tabular "z" value at the level of significance (0.05), and this indicates that there are no statistically significant differences between the two research groups, and this means that the two research groups are equivalent. In the cognitive achievement test.

B. Performance observation

To ensure that the two research groups are equal in the practical performance note card related to measuring the performance aspects of programming skills, the researcher, in the second meeting of the first week of the experiment, distributed a paper copy of the test to the two research groups, correcting the test, monitoring scores and analyzing them using the (SPSS) program, and the results were as follows:

Table 5. T*he Two Research Groups in Observational Form*

Test	Sample	N	Rank means	Z	Sig.	Mann Whitney
Performance (Observation form)	Experiment 1	48#	48196#	315:8#	31:;7#	4471#33#
	Experiment 2	15	16.40			

As data in Table 5 indicate, the calculated "z" value (2.215) is less than the tabular "z" value at the level of significance (0.05), and this indicates that there are no statistically significant differences between the two research groups in the practical performance observation card, and this indicates that my two groups The search is equivalent.

4. Results and Discussion

Data were treated statistically using appropriate measures. The hypotheses were ascertained, and the results are outlined and discussed below.

Hypothesis 1: There are no statistically significant differences between the mean scores of the students of the first experimental group and students of the second experimental group in the post-application of the achievement test of programming skills.

To test this hypothesis, the researcher used Mann Whitney Test with independent samples that did not meet the conditions of the t-test, either because moderation was not achieved or the research community poorly represented the sample. To identify the significance of the differences between the mean values, the results are outlined Table 6.

As displayed in Table 6, the calculated "z" value (2.275) is greater than the tabular "z" value at the level of significance (0.05), and this indicates that there are statistically significant differences in favor of the second experimental group that was studied using an electronic course designed in the holistic style. This is because its ordinal average reached (19.10), greater than the average of the second group that studied using an electronic course designed in a sequential style. On this basis, the null hypothesis was rejected. The alternative hypothesis accepted, which states that "there are statistically significant differences between the average scores of the students of the first experimental group And the students of the second experimental group in the post-application of the cognitive achievement test related to programming skills in favor of the second experimental group that studied using the holistic style.

To determine the size of this effect, the researcher used the binary correlation coefficient for the ranks, as shown in Table 6. The value of the coefficient was (0.48), which is a medium effect. This indicates the effectiveness of the holistic style of the programming skills course in developing the students' cognitive achievement of the second experimental group. The researcher attributes this effect to the fact that the holistic style of cognitive skills provides information in an integrated manner, which helps students to understand and master the educational content.

Table 6. ***Students' Results of the Achievement Post-Test***

Test	Sample	N	Z	Sig.	Mann Whitney	Rank means	Coef.	Effect size
Cognitive test	Experiment 1	15	2.275	0.01	58.500	11. 90	0.48	Moderate
	Experiment 2	15				19.10		

Z at 0.01 = 2.58
Z at 0.05 = 1.96

Table 7. ***Students' Results of the Practical Performance Measurement***

Test	Sample	N	Z	Sig.	Mann Whitney	Rank means	Coef.	Effect size
Performance observation	Experiment 1	15	2.215	0.01	59.500	19. 03	0.394	Moderate
	Experiment 2	15				11.97		

Z at 0.01 = 2.58
Z at 0.05 = 1.96

Hypothesis 2: There are no statistically significant differences between the mean scores of the students of the first experimental group and students of the second experimental group in the post-application of the practical performance observation of programming skills.

To test this hypothesis, the researcher used Mann Whitney Test with independent samples that did not meet the conditions of the t-test, either because moderation was not achieved or the research community poorly represented the sample. To identify the significance of the differences between the mean values, the results are outlined Table 7.

Table 7 shows that the value of calculated Z (2.215) is greater than the tabular Z at the significance level of 0.05. This indicates statistically-significant differences in favor of the first experimental group that used an electronic course designed in the sequential model. Its ordinal mean is 19.03, which is greater than the mean of the second group that used an electronic course designed in a holistic manner. On this basis, the null hypothesis was rejected, and the alternative hypothesis is accepted. Statistically speaking, there was significant differences between the mean scores of the students of the first experimental group that studied sequential electronic courses and students of the second experimental group who had exposure to the holistic electronic courses. The significant difference was in the post-application in favor of the first experimental group that underwent the sequential pattern. To determine the size of this effect, the researcher used the binary correlation coefficient for the ranks (see Table 7), wherein the coefficient value is 0.394 - the medium of the effect, as outlined by [6]. This indicates the effectiveness of the sequential style of the programming skills course in developing the skill performance achievement of the students of the first experimental group. The researcher may attribute this effect to the sequential module that helps to present the skill in a sequential manner; and according to a chronological sequence that helps them master the skill within the allotted time.

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