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# Assessment of the effectiveness of learning theories using gamified android app in teaching C programming

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**Abstract.** New knowledge of learners can be easily attained by applying different strategies in the classroom instructions. In the pedagogical domain, learning theories had been enforced and embedded to all instructional materials especially on gamification. Gamification is a concept of game-based approach in the teaching and learning process by offering challenges, tasks, rewards, badges and assessment. An android-based application called C-Rocks had been used in this study which comprises three learning theories: constructivism, behaviourism and instructivism. A pre-test was conducted to the fifty first year IT students who learned C programming in a traditional way of teaching to determine their prior knowledge. After that, the C-rocks was used by the students to facilitate the learning of C programming. A post-test was conducted to determine the post-knowledge gained after using the android app. The students were clustered using the k-means clustering algorithm of educational data mining to good, medium, and poor standard students. It was found out that most students excelled in variable topic while they performed least in the control statement topic. A T-test was also utilized and showed that the result of pre-test and post-test is highly significant with a t-value of 7.236 and a probability of 0.000. With the result established, the C-android app containing three learning theories is an effective Gamified tool in learning C programming as students can achieve greater learning.

*Keywords* – Learning theory, gamification, programming,

## 1. Introduction

Learning process requires of acquiring and modifying knowledge, strategies, skills, attitudes, beliefs and behaviours. Learners can gain variety of forms of knowledge such as cognitive, linguistic, motor, and social skills [1]. Learner's experience with the interaction to the environment or discovering scenarios of the world provides huge factor to the development change of human performance. This learning concepts covers the attributes commonly associated with behaviourism, instructivism, and constructivism [2]. Behaviourism is a learning process based on objectively observable changes in behaviour. The learning begins when a cue or stimulus from the environment is presented and the learner reacts to the stimulus with some type of response [3]. Learning through instructivism is the controlled display of text or graphical instructions for the user to follow [4]. Constructivism promotes active



assimilation and accommodation of new information to existing cognitive structures. A discovery by learners [5].

With the increased availability of mobile devices, educational games have the potential to become a major tool for learning. One of the emerging fields is using gamification in education which is more fun and facilitates information keeping. Gamification means the use of game thinking, game elements, game techniques, game methodologies, and game framework in a non-game context in order to motivate users, solve problems, increase user experience, and encourage good desired behaviours [6]. Gamification increases level of engagement and motivation in classrooms which are directly needed by students [7]. There was a study that used gamification in teaching C programming language to evaluate learning effectiveness and engagement. The study was conducted using the mixed-method sequential explanatory protocol. A gamification framework is prepared to enable students to ask questions and learn subjects related to C programming language using basic elements of game mechanics. The results show that most students continued working even after earning the maximum amount of grade points to collect all the badges and to keep learning. The author mentioned that gamification is successful and engagement is a valuable indicator of students' academic achievements [8].

Teaching programming requires a systematic approach that involves a combination of activities like planning, designing, testing and debugging [9]. To learn on how to develop, student needs to understand the syntax of programming language. Programming is a technical course when if not properly handled, students will find frustrated and tend to be unmotivated due to its nature of complexity [10]. But with the aid of gamified application, learning programming is becoming more fun and engaging. There is the incorporation of different learning theories to make learning more comprehensive [11].

C rocks is an android app that provides C programming instructions, simulations, and tutorials of syntax, semantics and assessment. The gamified android application is incorporated with several pedagogical approaches to ensure the student's learning can be easily grasp on the idea of basic C programming [9]. The C-rocks android application comprises of several learning styles which aims to arouse the learning process of students. The gamified application is embedded with constructivism, behaviourism and instructivism learning styles. Constructivism is applied in the android apps by influencing the design and world appearance of the game. Drawing the theories of constructivism, the game offers challenges and tasks for each level which provides opportunities to the user to explore and make decisions about their learning and the content they want to find out. On the other hand, behaviourism was integrated by using cue or stimulus on which the user can react to the stimulus with some type of response. Learning through instructivism was applied by displaying text or graphical instructions for the user to follow. This approach is necessary for the progress of the student, especially as the game will be used by students with only simple programming knowledge being taught to them. However C Rocks does not contain all the knowledge about C programming, a feedback feature is given to encourage the user to look at other sources to further their knowledge.

With the learning theories integrated in C Rocks, the researchers prompted to conduct a study that assessed its effectiveness on the learning process of the students. The researchers administered a pre-test to assess first the prior knowledge of students who learned C programming in the traditional way of teaching in the first three topics namely, keywords, variables and conditional statements. Eventually, the C-Rocks android app was utilized by the students as a game learning tool in learning C programming. The students were engaged in exploring and discovering on how to operate and traversing every level of the app. After using the app, the researchers conducted a post-test to assess the gained knowledge using the gamified learning tool. Clustering method of educational data mining using k-means algorithm was applied to group the students to good, medium and poor classification of students. And, T test was used to determine the significant difference of pre-test and post-test.

## 2. Conceptual Framework

The overall process in evaluating the student's concepts in C programming using Android Gamified Application comprises with several steps with series of activities. Pre-test was used to determine the pre-knowledge of learner regarding C programming concepts on the three topics which are keywords, variables and conditional statement. A paper and pen assessment was conducted and it was performed by fifty first year IT students for thirty questions items in the three selected C programming topics.

To test if the learning theories applied in the development of C Rocks android app is debunk or not, the system logs were gathered. After using the C-Rocks game based learning, post-test was administered to evaluate the level of improvement on C programming skills on the three topics namely keywords, variables, and conditional statements. After which a T-Test instrument was used to determine the significant difference of pre-test result and post-test result. T-test outcome was the basis of evaluation on programming skills of first year IT students from its pre-knowledge in C programming to post-knowledge using C-rocks android app (see Figure 1.)

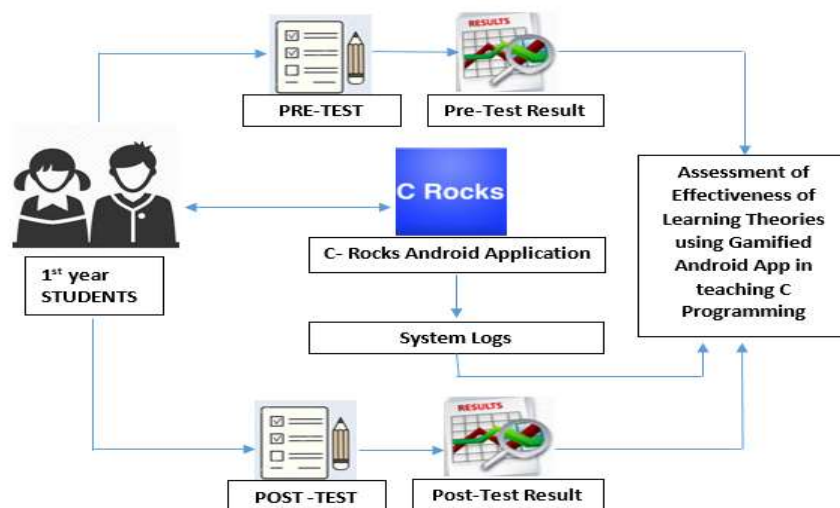


Figure 1. Conceptual Framework of the study

## 3. Methodology

### 3.1 Research Design

The study used the descriptive type of research wherein the researchers conducted a pre-test to test the prior knowledge of the BSIT students who learned C programming in traditional way of teaching. Post-test was administered after C-Rocks was introduced and used by the students to learn C programming. This is to assess the effectiveness of learning theories integrated in the android application. Likewise, progress reports logs were also gathered to determine the learning progress of students using the application.

### 3.2 Sources of Data

The fifty first year students enrolled in Bachelor of Science in Information Technology in the Abra State Institute of Sciences and Technology served as the sources of data in the study. C programming is an introductory programming course for BSIT program that must be enrolled in the second semester and for this, first year IT students were selected as respondents or learner to this research. On the other hand, the progress report logs of students in using the C Rocks android application were also recorded.

### 3.3 Data Instrumentation

For objective 1, a pre-test was conducted to test the pre-knowledge of students in C programming skills in the three topics namely the keywords, variable, and conditional statements. The test was composed of 30 items covering the three topics. Post-test was also administered to determine their post knowledge after letting the students used the C-Rocks application on their learning process.

The pre-assessment and post-assessment content comprises of three major topics namely keywords, variables and control statement. Each topic contains ten questions with a total of thirty items. Questions in the first topic emphasizes on keywords as an introductory part on learning C programming. It includes C language keywords such as void, int, printf, scanf, etc. After the introductory part is variable which contains int, char, float, etc. The third topic is control statement which contains if and if else statement.

For objective 2, a gamified android app called C-Rocks was utilized by the first year IT students to facilitate the learning process of students in C programming for three topics: keywords, variables, and conditional statements. The game-based android apps was developed through the incorporation of different learning theories such as behaviourism, instructivism and constructivism to make the application as a tool in learning C programming. The progress report logs were recorded such as how many attempts the students answered the teacher question and end level questions and the knowledge score the students acquired while playing the android app.

For objective 3, the results of pre-test and post-test were evaluated using T-test to determine the significant difference of knowledge level of students on their programming skills before and after using the Gamified android app.

### 3.4 Data Analysis

The clustering method of educational data mining applied in this study was the k-means algorithm. This algorithm was used to choose the best cluster center to be the centroid. It is one of the simplest unsupervised learning algorithms used for clustering. Initially the students are all in one group then the researchers segmented the students into three groups based on their rating for each topic in the post-test. The clustered groups were labeled as good, medium and poor standard students. Through this, it is easy to determine the topic that need improvement and the group of learners that need extra effort in the teaching process. In addition, the progress reports logs were analyzed using frequency count and mean. On the other hand, T-test using two tailed was used to determine the significant difference of pre-test and post-test results and the level of significant used was 0.01.

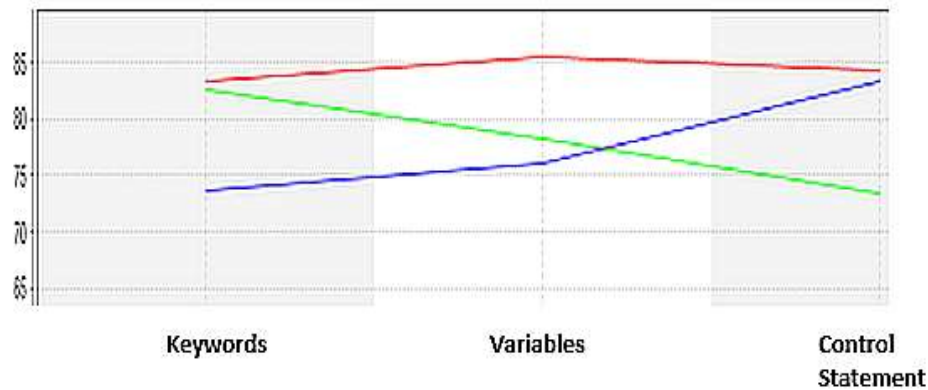
## 4. Results and Discussion

This context shows the result and discussion of the study. The 30 items exam that was given to the first year BSIT students was focused on the three topics of C programming such as keywords, variables and control statements. In the pre-test and post-test assessment, it was found out that post-test is higher with an average of 77.33 compared to the 70.08 average of the pre-test. The result implies that the students gained more knowledge after using the C- Rocks android application in learning C programming.

Furthermore, it can be inferred in figure 2 the k-means clustering centroid plot which describes the performance of the students during the assessment of their knowledge in C programming. The students were clustered into three based on their performance and categorized as poor standard students, medium standard learners, and good standard learners. Therefore students belong to Cluster 1 (green line) had mediate scores and they excelled more in keywords but they got a very low performance in control statement. This group is called medium standard students. Students who belong to cluster 2 (red line) had the best performance in all topics. Students belong to this group are called good standard students. On the other hand, students belong to cluster 0 (blue line) got the lowest score on the first two topics keywords and variables but they excelled in control statement. Students belong to this group can be labelled as poor standard students. The result implies that most of the students did not excel in the control statement topic this may be due of having complex syntax compared to the two topics. Furthermore,

most students excelled in the variable topic this may be due of greater understanding about variables since they are already using Python which variables have almost same function and scope in C programming.

0 1 2



**Figure 2.** K - means Clustering Centroid Plot

Table 1 shows the average result of progress report logs of students in using C- Rocks application. In the Teacher Question (TQ), it can be inferred that students has lesser attempts in answering the teacher question in 2<sup>nd</sup> try with a general average of 1.43 compared to the average of 1<sup>st</sup> try which is 1.94. In the End Level Question (ELQ), it also shows that on the second try the student has lesser attempts with a general average of 1.34 compared to 1.84 general average of 1<sup>st</sup> try. Furthermore, the table shows that students has higher knowledge score on their second try in Knowledge Gained (KG) with a general average of 8.67 compared to 7.03 general average of 1<sup>st</sup> try. The result implies that students learned more and the learning theories constructivist, behaviourist and instructivist are effective as students' attempts of answering questions decreased, the knowledge score increased.

**Table 1.** Progress Report Logs

Level	T Q (1st try)	TQ (2 <sup>nd</sup> try)	ELQ (1 <sup>st</sup> try)	ELQ (2 <sup>nd</sup> try)	KG (1 <sup>st</sup> try)	KG (2 <sup>nd</sup> try)
1	1.84	1.3	1.76	1.24	7.64	9.42
2	1.94	1.46	1.78	1.32	6.88	8.32
3	2.04	1.54	1.98	1.48	6.58	8.28
Gen. Avg	1.94	1.43	1.84	1.34	7.03	8.67

However, in the T-test result of pre-test and post-test, the derived T-test value was 7.236 with a probability of 0.000 therefore the null hypothesis is rejected and it is highly significant. The result implies that the learning theories applied in the development of C-Rocks android app has a great impact to students learning because they learned more when they used the app as their learning tool in learning C programming.

## 5. Conclusion

The intervention of C-rocks android app improves the knowledge of students in C programming as the t-test result revealed that it has significant difference. Likewise, on the progress report logs it attest that as the students used the android apps they are learning more as their attempts in answering teacher

question and end level questions is decreasing while knowledge score is increasing. Therefore, the incorporation of learning theories such as behaviourism, constructivism and instructivism in the C-Rocks android application as tool in learning C-programming is effective as students can achieve greater learning.

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