Methodology

Introduction

This chapter outlines the approach that will be employed to design the gamified software (GeoTrigs) and to explain the proposed evaluation process of this study. It also highlights the data collection instruments as well as how the data collected will be evaluated.

Implementation

In order to determine the impact of Gamification on students' motivation to practice Geometry and Trigonometry, a gamified software will be developed. This application will consist of three main parts; a content feature which contains a lesson on Translation, a manipulation feature which allows the students to plot images of points to perform translation and an evaluation feature which contains two levels of questions for students to answer, upon which they would receive points, view a leaderboard as well as view the length of time they took to complete the level.

Prototype Design

A web application will be employed in a classroom environment: GeoTrigs. A web application was chosen over a desktop application for the students to be able to access it outside of the classroom.

Motivational Design Model

The ARCS model will be used for analysing of the motivational categories. The goal of this model is helping educators and learners to learn and have satisfying lives (Keller, 2000). Moreover, the ARCS model is both a motivational and instructional model. This model integrates motivation into instruction, with four categories of Attention, Relevance, Confidence & Satisfaction (Keller, 1987). Hamzah et. al (2014) defined the categories as follows:

- **Attention** is referring to the response of learners to perceive instructional stimuli given by instruction.
- **Relevance** is about helping learners connect their prior learning experience to the instructions provided.
- **Confidence** refers to emphasize the importance of building positive expectations for the performance of their students in the learning task.

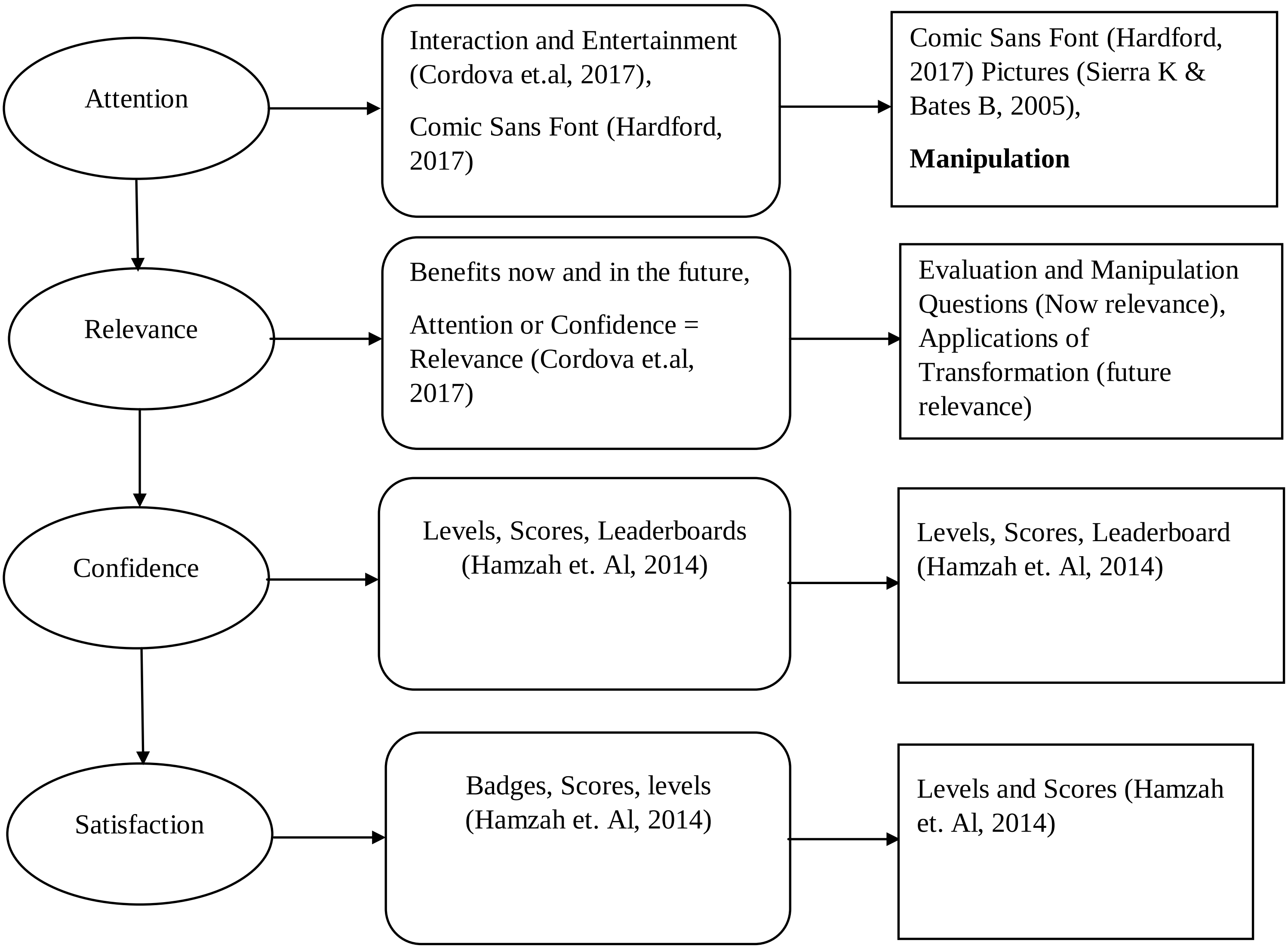
- **Satisfaction** will be achieved at the end of the learning process, where learners are allowed to practice new knowledge or skills acquired.

Karoulis & Demetriadis (2005) proposed that Keller's ARCS model should become the standard by which games increase learning motivation. In fact, several studies have utilized this model to design and evaluate motivational tools for enhancing learning among people (House, 2003; Chang & Lehman, 2002; Song & Keller, 2001 studies as cited in Córdova et. al, 2017) and it has also been tested in gamification contexts (Klein, 1992). Therefore, the ARCS model is acceptable as a suitable way of investigating motivational issues in gamification contexts (Córdova et. al, 2017).

Hamzah et. al (2014) proposed an enhanced ARCS model for gamification of learning called ARCS+G model. They incorporated elements of gamification as a way of incorporating gamification with the ARCS model which was based on the game dynamics such as reward, status, competition, achievement, self-expression, and altruism. However, not all of the gamification elements were utilized in the model. The table showing Hamzah et. al (2014) proposed model in matrix format is as follows:

Model/Technique	**Arcs Categories**			
	Attention	**Relevance**	**Confidence**	**Satisfaction**
ARCS	-Perceptual Arousal -Inquiry Arousal -Variability	-Goal Orientation -Motive Matching -Familiarity	-Learning Requirements -Success Opportunities -Personal Responsibility	-Intrinsic Reinforcement -Extrinsic Rewards -Equity
Gamification	-	-	-Reward -Status -Competition	-Achievement -Self-expression -Altruism

Based on the ARCS + G model, the following conceptual model was developed for the prototype.



Attention

Córdova et. al, (2017) argued that the interactive and entertaining nature of educational video games will draw students' attention to learning activities using educational video games designed to develop their competencies. Therefore, the researchers employed pictures as an entertainment feature (Sierra K & Bates B, 2005) for the students. Comic sans font proposed by Hardford (2017) was also employed as a way of capturing the students' attention. For the interactive element of attention, the manipulation feature of the gamified software was employed. The researchers' intention was to implement a gamified software prototype that remained both interacting and entertaining to its users. One that grabbed the students' attention and kept it throughout engagement in order that their motivation and engagement with the software is increased and thus, increase their competency with its content. More so, leading back to what gamification is all about.

Relevance

Once the students' attention is grasped or their confidence is achieved, relevance comes into play (Córdova et. al, 2017). Relevance with attention will be obtained from the students believing that because the gamified software prototype captured their attention, all its contents will be applicable to their learning process. Confidence based relevance, on the other hand, will be obtained from the students believing that because they used the gamified software prototype successfully, all its contents are relevant to their learning process (Córdova et. al, 2017). Cordova et. al (2017) also indicated that relevance can be obtained by showing students' the benefits of the lesson to them, both now and in the future. Therefore, the researches employed the evaluation and manipulation questions as the present benefits and the applications of transformation aspect of the software as the future relevance to the students. Finally, the researchers believe that the students' engagement with software will be increased and thus, their knowledge of game contents will be improved.

Confidence

Confidence –or expectancy for success– might influence learners' persistence and accomplishment (Keller, 1987). Córdova et. al, (2017) suggested that because fear of failure is important for students, believing that they can succeed when using online educational video games to develop their competencies will show a positive attitude towards the use of online educational video games to develop their competencies. Furthermore, Hamzah et. Al, (2014) argued that through gamification, confidence can be achieved with reward, status and competition.

For evaluating the students in this study, the prototype consisted of reward, status and competition as a way of motivating them in the confidence perspective. Reward in the form of points, were given with the intent of causing the students behaviour towards the learning activity to occur again. Points are used as the basic scoring schema in a game to indicate progress and when using them learners can claim rewards to advance in learning applications (Hamzah et. al, 2014).

Status, on the other hand, are conditions to show status or recognition has been achieved (Hamzah et. al, 2014). For the prototype, it was in the form of levels. This is because Hamzah et. al (2014) suggested that levels are used for signifying completion of intermediate goals in the learning process. They also stated that levels provide feedback to the learners regarding their progress with the use of learning applications.

Competition, unlike status and reward, enables people to challenge not only each other but also themselves to get the high score at some activity (Hamzah et. al, 2014). For the prototype, it was in the form of leaderboards. The leader-boards bring pride to the learner during the use of learning applications and show the leading scorers of same (Hamzah et. al, 2014). Thus, the researcher's purpose for utilizing them.

Satisfaction

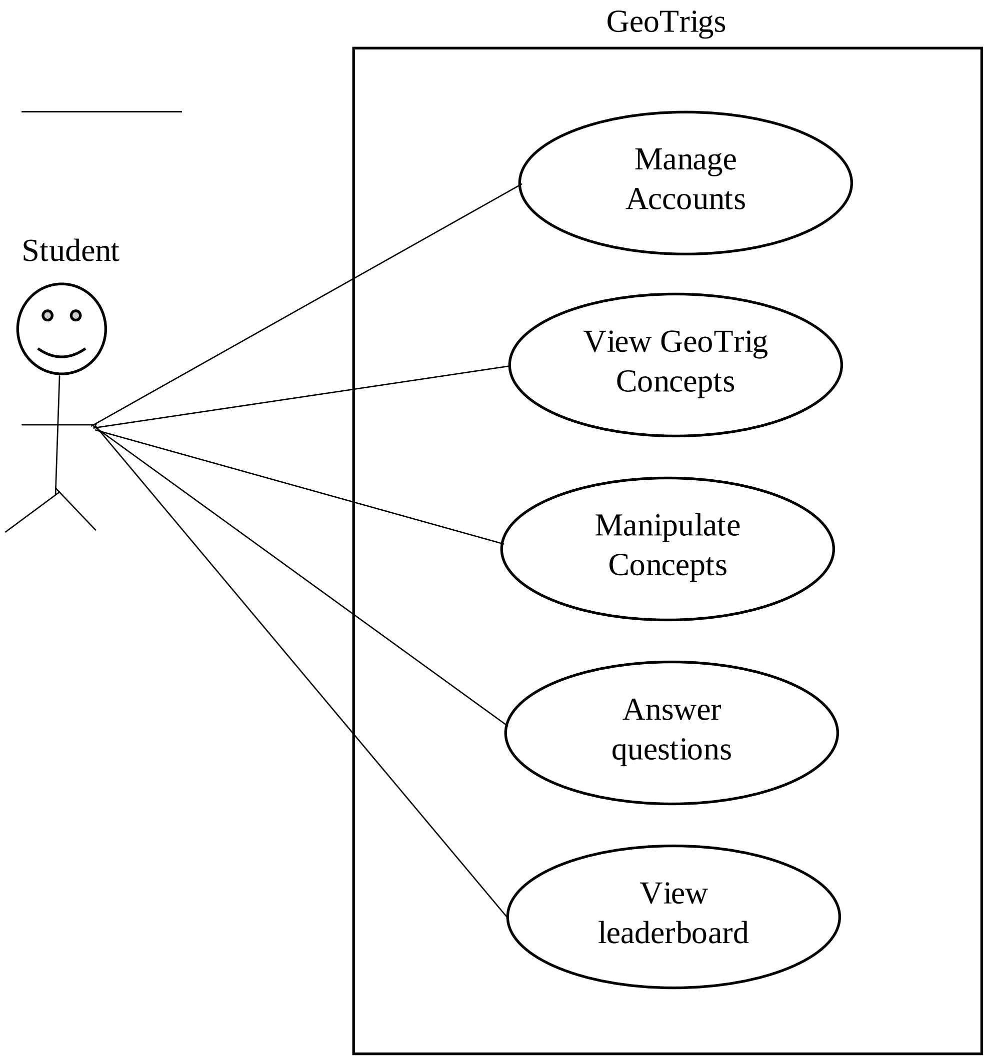
For students' satisfaction to be achieved, achievement, in the form of levels and scores were employed in the prototype. Levels were utilized to challenge the students and make them feel satisfied after accomplishing them, whereas scores were a form of reward.

Database Design

According to ANSI (American National Standards Institute), Structured Query Language (SQL) is the standard language for relational database management systems. Therefore, for data storage in the gamified software prototype, the Relational Database Management System (RDMS) will be used. RDMS was proposed since it is the most common database system used today and is preferred over other databases like Flat File Based Database Management Systems, Network Database Management Systems and NoSQL Database Management Systems due to its ability to easily link and manipulate data through the use of its built in querying system (Peters, 2014).

ER- Diagram

Use Cases



Use cases description

Manage Accounts

This use case allows the students to create a user account before they can work the evaluation or manipulation questions.

View GeoTrig concepts

This use case allows the students to view the lessons provided in the concept part of the application.

Manipulate concepts

This use case provides the opportunity to answer questions whose answer reflected a plotted image on the Cartesian plane provided.

Answer questions

This use case allows the students to answer the two levels of evaluation questions, upon which they received points for correctly answered ones. At the end of the level they viewed a leaderboard where they can compare their score with others.

View leaderboard

This use case allows the students to view the leaderboard for both levels without having to answer the evaluation questions first.

Evaluation

Introduction

This aspect of the methodology focuses on the description of the sample and population that will be used to carry out the testing in this study. It also highlights what data collection mechanism will be employed, how the data collected will be analyzed. The evaluation methodology also includes what decision criteria will be employed in order to realize the significance of the data collected and if there is any limitation of using any of the methods mentioned.

Population

The target population of this study will consist of Grade 10 students from the La Bonne Intention (LBI) Secondary School. This level of students was considered since they are the closest to writing the CSEC Mathematics examination and as a result are required to master all the topics in the CSEC Mathematics syllabus of which Geometry and Trigonometry is an area.

Sample

Webster (1985) defines a sample as “a finite part of a statistical population whose properties are studied to gain information about the whole.” There are generally two types of sampling techniques: probability and nonprobability sampling. This study will employ the probability sampling.

The sample of this study will consist of two groups. One group containing thirteen (13) students and the other group comprising of nineteen (19) students. Both groups will be selected using the non-probability sampling approach which is also known as convenience sampling.

One of the groups will be called the control group, and will be taught the concepts of Translation using the traditional teaching approach. These concepts will reflect the CSEC Mathematics syllabus for the particular topic. The lesson will be delivered by the Mathematics teacher to the control group.

The other group called the experimental group will utilize the gamified software prototype to be developed by the researchers. This prototype will comprise of a teaching aspect, a manipulation aspect and an evaluation aspect. The students will be encouraged to go through the teaching aspect in order to learn the concepts of the topic. However, like the traditional approach, all the concepts provided in the software will reflect the CSEC Mathematics syllabus for the area of Geometry and Trigonometry. After they go through the concepts, they will then proceed to answer the manipulation questions for translations on the Cartesian plane provided after which they will answer the questions contained in the evaluation aspect of the software. These questions will all be taken from CSEC- A Complete Course (Volume 1).

Data Collection Instruments

Two types of instruments will be utilized for data collection in this study. For gathering quantitative data, paper and pencil tests will be employed, whereas for collecting qualitative data, questionnaires will be utilized. The instruments are as follows:

Tests

Paper and pencil tests will be developed by the researchers and given to the students to determine their performance. These questions will be objective type questions geared towards testing the students' knowledge, understanding and application of Translation.

Two forms of tests will be utilized: a pretest and a posttest. The questions contained in the pretest will be identical to that of the posttest. The reason for this is that the researcher needs to find out whether or not there is change in performance by the students as a result of the teaching methods.

The aim of the pretest is to determine whether the students have any previous knowledge in the area of Translation. The posttest, on the other hand, which will be administered the very next day is aimed at determining the effectiveness of the teaching methods.

Performance Evaluation

In order to determine whether the gamified software prototype yields better results over the traditional teaching method, the posttest scores of the control and the experimental groups will be utilized. The data gathered will be analyzed using the T-test technique. This technique is proposed since it is suitable for a situation where one wants to assess whether two groups performed significantly different from each other.

The decision criteria is based on a critical value of 0.05. If the p-value obtained from the software corresponded to 0.05 or showed a lower value, this indicates that there was a significant difference in performance between the two groups. However, in order for the researchers to determine which teaching technique yielded better results, the means of the post test of both groups will be assessed. The group that scored the higher mean is the one that yields the better result.

Questionnaires

As mentioned previously, questionnaires will be utilized in this study as a method of collecting qualitative data. This is proposed since a questionnaire offers an inexpensive means of data collection and also it can reach a wider population compared to other methods.

In order to measure the students' overall motivation attained from the gamified software prototype, a questionnaire in the form of the **Instructional Materials Motivational Survey (IMMS)** will be employed in this study. This survey was proposed by Keller (2010) as a data collection tool to test the effectiveness of the ARCS motivational model strategies in different context. For this study, it is in the context of gamification in education where the gamified elements were incorporated with the ARCS categories. Keller (2010) also stated that the IMMS measures students' motivation towards different instructional materials. The IMMS originally consists of a 36-item survey and has four categories (attention, relevance, confidence, and satisfaction) which were all included in the gamified software prototype of this study. However, the items from this survey were modified to suit the prototype developed in this study. The responses from this survey follows a Likert-type scale (Keller, 2010) which ranged from 1 (Not True) to 5 (Very True) (Not, Slightly, Moderately, Mostly and Very True).

Motivation Evaluation

The maximum score attainable for each of the ARCS categories in the IMMS questionnaire will first be obtained by computing the product of the amount of participants in the evaluation, the total items in the questionnaire relating the specific category, and the maximum sum for each item in the questionnaire (since a Likert-type scale with five choices were used, this value was 5); **(maximum sum = N participants * total items for category * 5).** Based on the results of the IMMS survey, the sum obtained for each category will be computed and compared against the maximum sum. The maximum mean attainable as well as the mean obtained for each category will also computed.

Further, the results will be used to display each ARCS factor as a percentage. These percentages are based on how many students indicated that the gamified software captured their attention, of how many relevance showed and also how many of them gains confidence and satisfaction at the end of the study. A score of over 50% for a category indicates that more than half of the participants were motivated for that category. Also, all of the categories need to be present for a participant to be motivated (Keller, 2000).

In order to measure the student's overall experience attained from the gamified software prototype, the **User Experience Questionnaire** will be employed. The user experience questionnaire, according to Santoso et. al (2016), contains six scales with 26 items in total:

1) **Attractiveness**: General impression towards the product. Do users like or dislike the product? This scale is a pure valence dimension. Items: annoying / enjoyable, good / bad, unlikable / pleasing, unpleasant / pleasant, attractive / unattractive, friendly / unfriendly.

2) **Efficiency**: Is it possible to use the product fast and efficiently? Does the user interface look organize? Items: fast / slow, inefficient / efficient, impractical / practical, organized / cluttered.

3) **Perspicuity**: Is it easy to understand how to use the product? Is it easy to get familiar with the product? Items: not understandable / understandable, easy to learn / difficult to learn, complicated / easy, clear / confusing.

4) **Dependability**: Does the user feel in control of the interaction? Is the interaction with the product secure and predictable? Items: unpredictable / predictable, obstructive / supportive, secure / not secure, meets expectations / does not meet expectations.

5) **Stimulation**: Is it interesting and exciting to use the product? Does the user feel motivated to further use the product? Items: valuable / inferior, boring / exciting, not interesting / interesting, motivating / demotivating.

6) **Novelty**: Is the design of the product innovative and creative? Does the product grab the attention of users? Items: creative / dull, inventive / conventional, usual / leading edge, conservative / innovative.

The items are scaled from -3 to +3. -3 represents the most negative answer, 0 a neutral answer, and +3 the most positive answer. Scale values above +1 indicate a positive impression of the users concerning this scale, values below -1 a negative impression. Due to well-known answer effects, like the avoidance of extremes, observed scales means are generally in the range of -2 to +2. More extreme values are rarely observed, so a value near +2 represents a very positive, near optimal, impression of participants (Schrep, 2015). Example of an item is:

attractive o o o o o o o unattractive

User Experience Evaluation

The data form the UEQ will be analyzed using the UEQ Data Analysis Tool developed by Dr. Martin Schrepp. The evaluation of the data is based on the means of the scales. A mean value between -0.8 and 0.8 represents a neutral evaluation of the corresponding scale while a mean value greater than 0.8 represents a positive evaluation of the scale and a mean value less than -0.8 represents a negative evaluation of the corresponding scale.

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