



## **THE ROLE OF COMPUTER GAMES IN THE LEARNING OF PROGRAMMING AMONG TERTIARY STUDENTS IN GHANA**

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### **ABSTRACT**

Computer Games may be an innovative and fun way to improve learning among students. For first year computer programming students, an introductory course in programming is challenging as there is difficulty in grasping the fundamental concepts in the course. This paper investigates how computer games can improve first year students' learning of programming in the University of Education, Winneba. The study sought to investigate the type of computer game and game elements that will improve understanding of programming concepts. It also aimed at developing of a conceptual game model for programming skills development. A case study was conducted with questionnaires administered to 123 first year programming students on their gaming behaviour. A conceptual strategic game model is proposed for learning programming. The results show that strategic games have the key elements that can help learners understand programming. Programming students are encouraged to play more strategic games and should be included as part of the curricula for learning programming.

**Keywords:** *Programming, strategic, game, cognitive, learning*

### **INTRODUCTION**

As a way of improving learning, researchers have started paying attention to computer games (Gee, 2005; Oblinger, 2006). Recent studies support computer games as educational resource to promote learning among students (Annetta, Minogue, Holmes, & Cheng, 2009; Vogel, Vogel, Cannon-Bowers, Bowers, Muse, & Wright, 2006).

A computer program is a collection of instructions written by a programmer and executed on a computer. Though software development encompasses the process from concept to executable program, this research is limited to only writing code (programming). A good programmer has a good mental model of his programming environment which is similar to the design of computer game architecture.

A good computer game player needs to be endowed with high-level cognitive abilities such as general strategic thinking and abstract reasoning (Morris and Shin, 1997). This revives some of



the hope that was initially raised for computer game playing as a key to human-level Artificial Intelligence (Shannon, 1950; Schaeffer & Van den Herik, 2002).

### ***Purpose of Study***

The purpose of this research is to investigate a comparatively untouched area of research into computer games; the type of computer game and game elements that will improve understanding of programming concepts. The outcome is the development of a conceptual game model for programming skills development.

### **Problem Statement**

Introductory courses in computer programming are challenging for first year university students offering Information Technology or Computer Science (Miliszewska & Tan, 2007; Lahtinen, Ala-Mutka, & Järvinen, 2005; Jenkins, 2002). The case is no different for First Year ICT (Information and Communication Technology) students of the University of Education, Winneba taking the introductory C++ programming course. The students find it difficult to grasp basic concepts in programming and this has affected their performance in the course over the years. Programming involves logical reasoning and problem-solving skills (Miliszewska & Tan, 2007) and Jenkins (2002) indicates that programming is difficult to learn based on two cognitive factors; learning style and motivation.

Hence, this research seeks to establish that the difficulty of learning programming for first year students will be improved if learners are encouraged to play computer games and also if computer games are integrated into the programming curriculum.

### **THEORETICAL FRAMEWORK OF COMPUTER GAMES IN EDUCATION**

In educational technology, the current support for research in the field of learning and development has grown appreciably. Computer games can be the new paradigm in learning. It can aid in learning process in almost any discipline (Annetta, Minogue, Holmes & Cheng, 2009). Computer games can be an appropriate way to improve learning as they are user-centered; and so they can be challenging and engaging, enforce co-operation, and help in the development of problem-solving skills (Gros, 2007).

Research has emphasized the use of computer games for learning and instructional purposes; referring to such games as serious games, game-based learning or educational games (Wouters, Nimwegen, van Oostendorp & van der Spek, 2013; Annetta et al., 2009; Greitzer, Kuchar, & Huston, 2007).

Gredler (1996) concluded that “computer technology is contributing to renewed interest in games and simulations” (p.521), and that games and simulations can provide an environment for the creation of new knowledge.

Computer games may contribute to learning, and Gee (2008) states that learning theory and game design when considered together may enhance each other. Also, educational games provide the opportunity for learners to apply subject matter knowledge in a new context (Gredler, 2004).

Notwithstanding this, Wouters et al. (2013) concluded that “specific instructional or contextual features, such as supplementing with other instructional methods and working in groups increase the effect of serious games” (p.14).



Researchers have suggested that further work on educational games should be focused on many areas such as how serious games can be designed (Wouters et al., 2013). Game-playing in various classroom contexts are different because researchers are convinced that such environments would include differing cultures and grades that will enhance learning (Henderson, Klemes & Eshet, 2000). The review of various literature establishes that games used for educational purposes can enhance learning. However, the type of game design that can facilitate learning by improving on a learner's cognitive reasoning and consequently impacting on academic performance is not evident.

### ***Game Categories***

Computer games are programs that enable a player to interact with a virtual game environment for entertainment and fun. According to Ludens (1955), computer games provide a source of enthusiasm to the player and a feeling of goal-approach and tension accompanies the actions for enjoyment, diversion and amusement. Based on extensive literature, game genres are re-categorized into four types: First Person Shooter, Racing and Sports, Third Person Views and Strategic Games.

#### *First Person Shooters*

The FPS (First Person Shooter) is a more specific video game sub-genre where the player controls a character or a vehicle to shoot at adversaries (Elias, 2009). A First Person Shooter defines a perspective in relation to normal shooters. A player in FPS interacts with a virtual environment and observes all the action from the player's eye. According to Laramee (2002), many contemporary games are designed such that the player, depending on a situation or personal preferences can choose a perspective. Games such as Call of Duty, 4 dead and Half-life 2 follow the First Person perspective and the player experiences an action through the eyes of a protagonist.

#### *Third Person Views*

The TPS (Third person shooter) games are based on camera effect when the player is seen from a distance. Third person views are mainly based on camera effects such as bloom, camera shake, degrees of freedom, depth of field, field view and lens flare (Epic Games, 2012; Muir, 2004; Weisstein, 2007; Atkins, 2004). In third person games there is less immersion of character in the virtual environment (Denisova and Cairns, 2015). Games such as Assassin's Creed, MDK and Star Wars are typical examples of TPS games and enable the player to control the character from afar.

#### *Racing and Sports Games*

Racing and Sports Games are based on Augmented Reality (AR) where virtual objects are overlaid on the real world and real objects are tracked and used to control virtual ones (Oda, Lister, White, & Feiner, 2008). Racing and Sports games are simulator games with much excitement and the need to achieve a goal. It does not involve much planning but a behind-the-wheel feeling of the player. Games such as Motor-storm, Need for speed, FIFA and MotoGP are typical examples of Racing and Sports Games.



### *Strategic Games*

Strategic Games or Real-Time Strategy Games (RTS) offer fundamental Artificial Intelligence (AI) research problems and differ from the other game genres (Buro, 2003). Most Strategic games are serious games (Von der Lippe et al., 1999) that impart knowledge or skill to gamers (Zyda, 2005). Specific key elements of strategic games include: resource management, decision making under uncertainty, logical reasoning, and collaboration, opponent modeling and learning and, adversarial real-time planning (Buro, 2003).

Playing Strategic games is challenging due to game variants and involves a lot of reasoning with endless application in programming algorithm and training of military personnel (Herz and Macedonia, 2002).

### *Strategic Games and Programming*

Strategic games emphasize skillful thinking and planning to achieve victory. A player must plan a series of actions against one or more opponents, and the reduction of enemy forces is usually a goal (Rollings and Adams, 2003). In most strategic games, there are elements of warfare to varying degrees, and they feature a combination of tactical and strategic considerations (Walker, 2002). Novice-programming environments have been built to allow students forget syntax and at the same time experiment with programming. Examples include StarLogo, The Next Generation, Scratch, Alice2, and Cleogo. A video game that is built on a programming language similar to C++ helps gamers to learn programming and at the same time enjoy all the fun of games (Muratet, et al., 2009) and Robocode, a Java programming game is designed to help gamers learn Java programming (Muratet, et al., 2011).

### *Existing Game Models*

Game models for learning have been proposed by several researchers. Garris, Ahlers and Driskell (2002) discuss the need to design an instructional program that has certain features of games that can trigger a cycle of gamer reactions such as interest or judgment, behavior, and system feedback. This gaming activity will result in the achievement of specific learning outcomes.

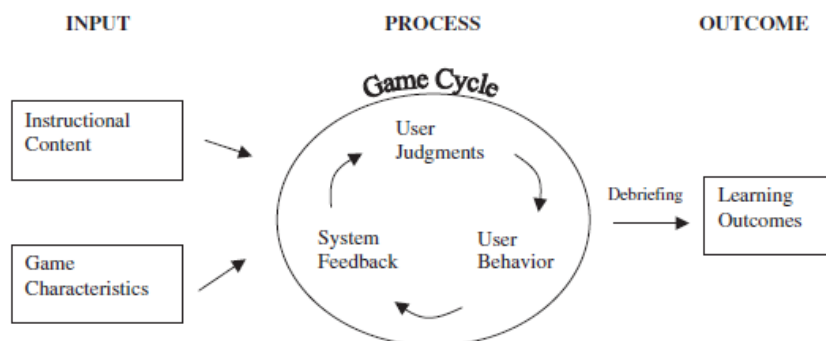


Figure 1: Input-Process-Outcome Game Model (Garris et al., 2002)



Another model proposed by Bulander (2010) on the effects of serious games on learning argues that the input stage of a game includes gamer goals or objectives; and that the learning outcome will be effective depending on the kind of gamer.

In another proposed framework, nine (9) major components: capability, instructional content, intended learning outcomes, game attributes, learning activity, game mechanics, games genre, reflection, game achievement are combined in a structural class diagram to model learning through the use of serious games (Yusoff, Crowder, Gilbert, & Wills, 2009). The researchers' framework is a basis for effective game design for designers and teaching professionals.

In this research, an input-process-output game model showing the relationship between the elements in algorithmic programming and strategic games is presented.

## **RESEARCH METHODOLOGY**

A case study was conducted in the University of Education, Winneba on first year students taking the introduction to programming course in the 2015/2016 academic year at the department of ICT (Information and Communication Technology) Education. A population of 174 first year students in the department of ICT Education was used for the study. 123 students were selected from the population using convenience sampling technique. This sampling technique was used because one of the authors of this study was the Instructor for the programming course. The first-year programming students were chosen because it is at this level that students are introduced to programming for the first time and hence build their fundamental concepts in programming. The majority of the respondents were males (90.24%) and females (8.13%) were the minority because the ICT programme generally has more male students enrolled than female students. The range of the respondents' ages was 18-24 years. Quantitative data was collected through questionnaires. The questionnaire consisted of both open-ended and closed-ended questions.

## **RESULTS**

Research results were summarized from departmental assessments on the programming performance of first year students over three academic years and also from questionnaires on the gaming behaviour of first year students studying the introduction to programming course.

### ***Programming Performance***

From figure 2 below, programming assessments for students in the Department of ICT Education shows an average performance in programming over the last three (3) years; first semester, 2012/2013; first semester, 2013/2014 and second semester, 2014/2015 academic years respectively. These statistics established the fact that programming performance of first year students in the previous three academic years prior to this study was not encouraging.

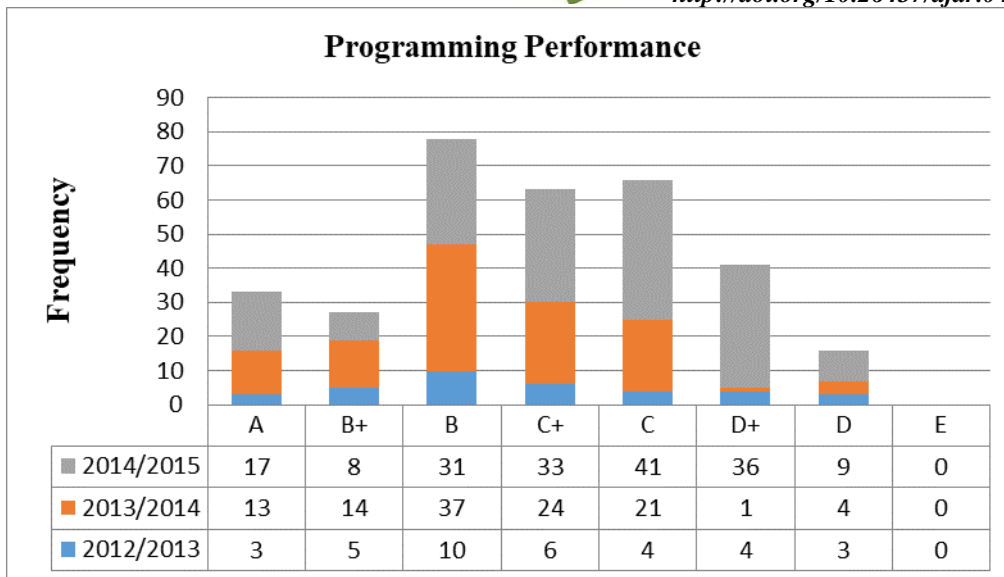


Figure 2: Performance of students over three semesters

### **Game Categories**

Computer Games played by first year students of the 2015/2016 academic year were categorized into Strategic games, First person shooters, Third person views, Racing and Sports games.

Table 1: Category of games played by students

<b>GAME CATEGORY</b>	<b>GAME EXAMPLES</b>	<b>FREQUENCY</b>
Strategic games	3D Snippers, Age of Empire, Zuma Revenge, Chicken Invaders, Killer Bean, Euro Track Simulator 2, Bejeweled, Solitaire ,Games, Temple Run, Jardinians	40
First person shooters	Alien Shooter, Call of Duty, Amazing Spiderman, Far Cry	6
Third person views	Assasin's Creed, Resident Evil, God of War, Mortal Kombat, Prince of Persia, Total Overdose, Super Mario	8
Racing and Sport games	Car Racing, Deadly Race, GTA (Grand Theft Auto), Need for Speed, Road Rash, Motor Racing, Blur FIFA, PES (Pro Evolution Soccer) / Winning Eleven, Real Football, WWE	69

Table 1 illustrates the various game categories and the frequency with which students play these games. Racing and sport games got the highest with a frequency of 69, followed by strategic game with a frequency of 40, with third person views and first person shooter games recording frequencies of 8 and 6 respectively.

### **Gaming Behaviour of First Year 2015/2016 academic year students**

Students' responded that the main reason for playing computer games was because it is a form of entertainment representing 27 responses. Other major reasons were because gaming helps them reduce stress, exercise their brains creatively and challenges them. A minority of 5 responses indicated that students saw gaming as a way to interact with friends.

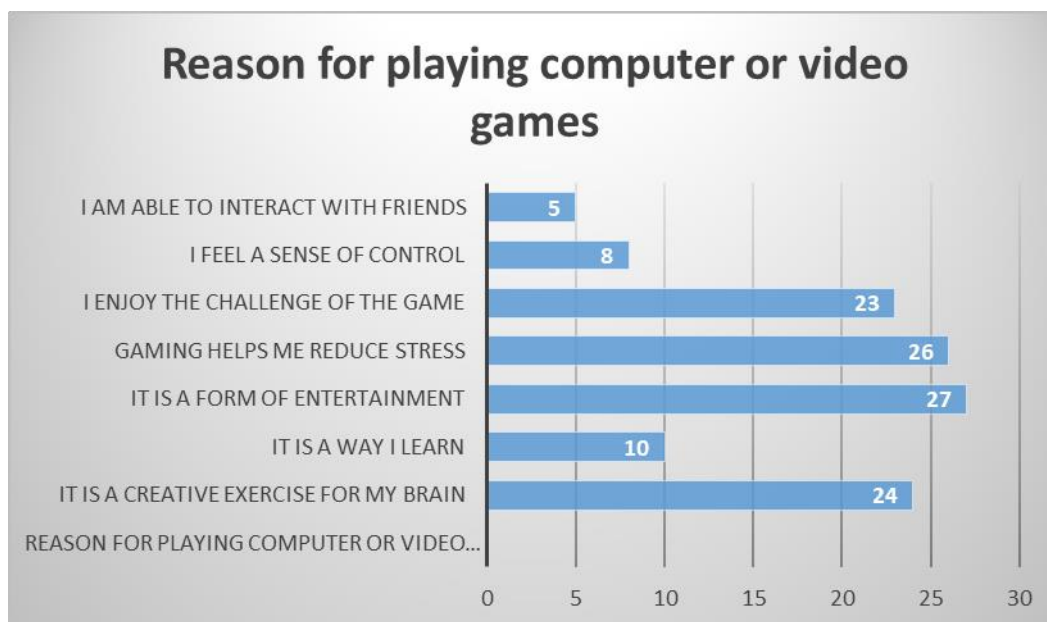


Figure 3: Students' reasons for playing games

The age range of the majority of the respondents when they started playing computer games was from 11 to 15 years. A significant number of respondents representing 69.9 % indicated they have been playing computer games for more than 5 years.

## DISCUSSION

### *Conceptual Strategic Game Model*

The Conceptual Strategic Game Model for Learning Programming is adopted from the Input-Process-Outcome Game Model by Garris et al. (2002) but emphasizes on strategic game elements and algorithmic programming elements which will help learners understand fundamental programming concepts.

A typical programming project can be divided broadly into two categories: Problem Solving Phase and Implementation Phase. The Strategic Game Model critically considers the problem solving phase of computer programming where algorithm design is important before implementation. A programmer's understanding of algorithm design is the most intelligent and logical phase of any given programming task. Five key elements of strategic games which the researchers found to be relevant in programming are classified into the three stages of algorithmic design: Input, Process, Outcome or Output and a player in any strategic game is exposed to these elements.

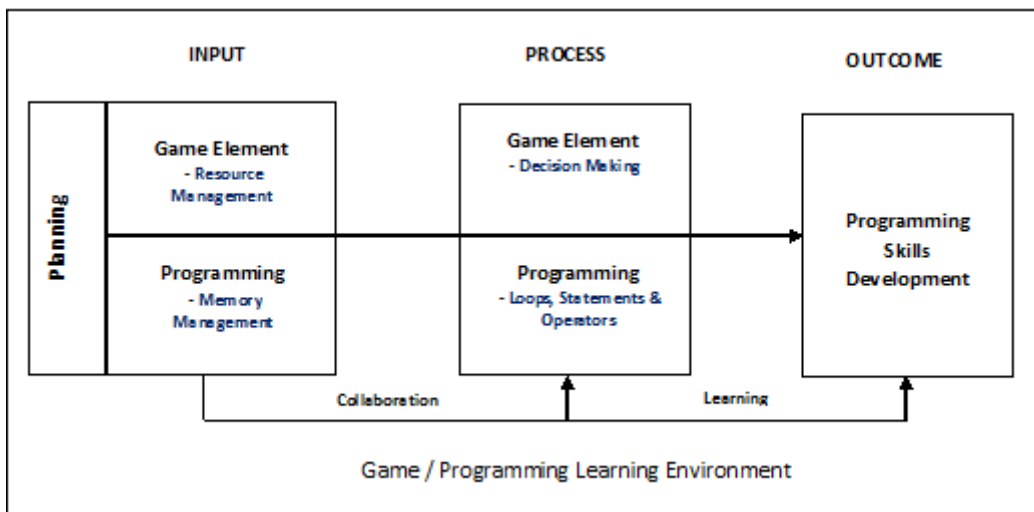


Figure 4: Conceptual Strategic Game Model for Learning Programming

### *Planning*

Planning in programming is part of the learning environment where learners develop an informal narrative specification of the system. Feasibility studies, requirement analysis and specification are important phases of any software development life cycle. This specification into source code component is seen in strategic games where a player plans ahead of adversaries in a smart, dynamic and hostile game environment.

### *Resource Management*

Resource Management in Strategic games is an input phase where a player gathers limited resources to build up defense and attack forces. In programming, memory management is a core component of software development. The choice of data types and variable usage is important in the input stage of programming.

### *Decision Making*

Decision making in game elements is about intelligence gathering where user judgment and system feedback serves as the core engine for game agents in directing activities towards achieving a goal. Ability to understand and implement a system feedback is important for a game agent in making a decision. Decision making in programming is the functional phase where a bad decision from the programmer affects the output. Programmers spend most time on the processing phase in making the best decisions to affect the output.

### *Collaboration and Learning*

Collaboration and Learning are continuous processes in the Programming Learning Environment. Most times, programmers normally work in groups. This form of collaborated project happens throughout the programming phase and is similar to the pattern of strategic game playing where game players join forces and coordinate actions effectively to overcome an adversary.





Recursive programming helps programmers to better understand syntax and semantics and application of functions in various contexts once the fundamental concepts are grasped.

### *Programming Skills Development*

The outcome of playing a strategic game is the acquisition of programming skills or knowledge by the gamer after having achieved the game goal. This achievement can be coupled to the learning outcome; which in the case of a strategic game, the learner is now equipped with programming skills without having to write code. These skills are fundamental in any programming environment, and the learner will be able to program in any language if need be.

### **CONCLUSION AND FUTURE WORK**

In this paper, we reviewed the types of games available and selected strategic games as having effect on cognitive skills development of the learner. We identified resource management, decision making under uncertainty, logical reasoning, and collaboration as elements in strategic games that can be linked to any programming paradigm. The key elements in programming involves algorithms, flowcharts and logical reasoning sequence which we compared to skillful thinking and planning to achieve victory in a strategic game. The result of this comparison is the development of a proposed Conceptual Strategic Game Model that are in three phases; Input, Process and Output.

In the model, we compared the input phase of Strategic Game Element, Resource Management to Memory Management in programming where variables are declared. For the process, decision making in strategic games was compared to understanding loops structure, statement and operators in programming. The outcome of this comparison and linkage is the improvement on the programming skills of the learner. The focus of this research primarily is to establish a link between strategic games and programming skills development of the game player by developing a conceptual model. Learners will be encouraged based on the model to play more strategic games to improve their logical reasoning skills in programming.

As a next phase to this research, future work will be focused on designing a strategic game for programming students to experiment the effect of strategic games on their programming performance.

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