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Learning through Games: Essential Features of an Educational Game

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ABSTRACT

This study investigated the following research questions: (1) Do instructional games augment learning? (2) What is the impact of the challenge and fantasy features in instructional games on learning? For the purpose of this study, a game called “Humatan” was designed to teach human anatomy to high school students based on the Baltimore County Public Schools curriculum. Four different versions of the Humatan game were created:

- A game with only the challenge feature turned on
- A game with only the fantasy feature turned on
- A game with both the challenge and fantasy features turned on
- A game with challenge and fantasy turned off.

High school students from Baltimore County Public Schools (n=202) were randomly assigned to play one of the above four versions of the Humatan game after taking a pretest on human anatomy. After playing the game, they also took a posttest and a survey to obtain information related to their Grade Point Average (GPA), Socioeconomic Status (SES), game skillfulness, gender, and the ethnicity. Since there were no existing survey instruments available for measuring game skillfulness, the researcher created a new survey instrument which was validated by the Survey Research Laboratory in the University of Illinois at Chicago. All the four groups showed an improvement in learning, which suggests that instructional games augment learning. Students who played the game version with only the challenge feature turned on (n=48) scored a higher average gain score than the students who played other variations of the game. Analysis of variance showed a main effect of challenge on the gain score, $F(3, 198) = 4.71$, $p = .003$. Students who played with only the fantasy feature turned on (n=52) obtained the lowest

average gain score. This implies that the challenge feature significantly improved learning and the fantasy feature did not significantly improve learning. The GPA, SES, game skillfulness, gender, and the ethnicity of the students did not show any significant impact on learning.

LEARNING THROUGH GAMES:
ESSENTIAL FEATURES OF AN EDUCATIONAL GAME

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Chapter I: Introduction

This chapter introduces the problem statement and the purpose of the present research study. The expected research contribution is then discussed, and finally a definition of the key terms pertaining to the current study is presented.

The purpose of this research was twofold: The first purpose was to determine whether instructional games augment learning. Through an extensive review of literature, different game features were explored and two of the features, challenge and fantasy, were selected as being the most important. The second purpose was to study the impact of the challenge and fantasy features on learning through instructional games. With this aim in mind, an educational game called “Humatan” was created to teach the human skeletal system to high school students.

During data collection for the study at one of the schools, a student asked the researcher, “Did you create this game?” When the researcher nodded his head in an affirmative manner, the student further asked, “Do you have a game that would teach the muscular system as well? Next year we need to study the human muscular system. I would love to play a game like this…” This anecdote was a good indication that games do motivate students toward learning. In order to meet the new millennial student generation, it is imperative that instructional designers and teachers understand that technology is a lifestyle for students: A student sits in front of a computer to do a class assignment, and simultaneously turns on a webcam and internet chat application to chat with someone. In the meantime, the student downloads some music from the internet, simultaneously browsing for some research work, while also emailing a friend, and answering the cell phone. And not to forget the fact that the student also checks the status of a Massively Multiplayer Online Role-Playing Game (MMORPG) in which a very large number of

gamers play with one another within a virtual world. Thus instructional games could be a good tool to engage millennial students.

Problem Statement

Students' achievement in Science is on the decline in the United States. From among the 30 countries that form the Organization for Economic Co-operation and Development (OECD), United States ranks 21st in scientific literacy, with a score of 489, which falls below the average of 500 (OECD, 2007). The same OECD Program for International Student Assessment (PISA) report mentions that one quarter (24.4 percent) of fifteen-year-olds in the United States of America do not reach the baseline level of science achievement. The baseline level is the level at which students begin to demonstrate science competencies that enable them to use science and technology in life situations (OECD, 2007). The report further says that the United States has a comparatively large proportion of poor performers.

National Academies (2007) mentions "the critical lack of technically trained people in the United States can be traced directly to poor K–12 mathematics and science instruction" (p. 114). Further, it elaborates "few factors are more important than this if the United States is to compete successfully in the 21st century" (p. 114).

Why is investing in science and math education important? National academy of Sciences in their 2007 report entitled *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, answered this question in the following manner: "today, much of everyday life in the United States and other industrialized nations, as evidenced in transportation, communication, agriculture, education, health, defense, and jobs, is the product of investments in research and in the education of scientists and engineers" (p. 41).

Educational games might help to mitigate the problem

Learning through games is not a new phenomenon. According to Bradshaw and Lowenstein (2007) the use of games for learning is a rather ancient technique, for example, games were used to coach soldiers for war. The much quoted work by Avedon and Sutton-Smith (1971) made the following observations about the benefits of using games as educational tools:

1. Games with simulated environments engender more student interest than the more conventional classroom activities.
2. By participating in games, students will learn more facts and principles than by studying in the conventional manner.
3. Students will retain information learned in games longer than information presented through conventional methods.
4. Students will acquire more critical thinking and decision-making skills by participating in games with simulated environments.
5. Student's attitudes will be significantly altered by taking part in games.

Though in 1971, what Avedon and Sutton-Smith mentioned looks like a theoretical framework for the use of games in education that is still pertinent today. More and more studies are proving that these ideas indeed have empirical support.

Currently, gaming is one of the biggest industries and makes more money, followed only by movies, music, followed by other entertainment industries. Research shows that, on an average, a teenager spends 14 hours per week playing video games (Martin & Oppenheim, 2007). Martin and Oppenheim (2007) said that, "the average 8 to 12 year old now plays 13 hours of video games per week; while the average 13 to 18 year old plays 14 hours video games per week" (p. 1). So, we can say that students are naturally motivated to play games. If education can

be fostered through such a highly motivational media, it will be a win-win situation for everyone involved in the field of education.

For the past three decades scholars (Nelson, 1989, 2008; Nelson 1999; Terenzini & Pascarella, 1994) predicted that traditional tools such as class lectures, reading and writing assignments, tests, field trips, discussions, laboratory reports, and such others, for teaching science may not be effective teaching tools. Nelson (1999) mentioned,

> Today's science textbooks and methods of instruction, far from helping, often actually impede progress toward science literacy. They emphasize the learning of answers more than the exploration of questions, memory at the expense of critical thought, bits and pieces of information instead of understandings in context, recitation over argument, reading rather than doing. They fail to encourage students to work together, to share ideas and information freely with one another, or to use modern instruments to extend their intellectual capabilities. (p. 16)

On the contrary, new instructional techniques such as using video games make “players think, talk, and act” and their rich virtual environments are what make games powerful contexts for learning (Shaffer, Squire, Halverson, & Gee, 2005). Squire and Jan (2007) said that schools lag behind in producing appropriate learning in today’s knowledge-based economy:

> Science education needs to prepare students for a future world in which multiple representations are the norm and adults are required to ‘think like scientists.’ Location-based augmented reality games offer an opportunity to create a ‘post-progressive’ pedagogy in which students are not only immersed in authentic scientific inquiry, but also required to perform in adult scientific discourses. (p. 5)

While concluding, Squire and Jan mentioned that augmented reality games on handhelds "hold the potential for engaging students in meaningful scientific argumentation" (p. 5). While talking about how to teach the present generation students about Newtonian Physics, Jenkins (2002) mentioned that computer games could augment teaching by motivating students. They offer rich and compelling problems, modeling the scientific process and the engineering context and enabling more sophisticated assessment mechanisms. Jenkins, Klopfer, Squire, and Tan (2003) echoed an idea that was similar to Nelson's (1989, 2008) views about new teaching tools. They argued that traditional pedagogical tools such as lectures, discussions, laboratory reports, homework, field trips, tests, and textbooks can be positively augmented using games. Gee (2008) stated that a good video game helps in deeper learning: "good video games make players think like scientists. Game play is built on a cycle typical of experimental science: 'hypothesize, probe the world, get a reaction, reflect on the results, re-probe to get better results'" (p. 1028).

Instructional games provide one means to bridge the gap in student achievement. Since students are naturally motivated to play games, why not use them as a tool for teaching? Well-designed instructional games can engage students in the learning process. This can be done through the use of virtual environments that provide students with scenarios where they can engage in problem solving activities, and therefore enhance learning.

Not just for entertainment, games can also have educational value

Many may think of games as being purely for entertainment. According to Dickey (2005), video games can be more than just entertainment: "Within the context of completing the assigned task, students play the role of explorer as they both discover concepts and connections and interact with the material and resources" (p. 70). Further, Dickey argued that "depending on the genre and individual game, players may be required to analyze, synthesize, and use critical

thinking skills in order to play and execute moves" (p. 67). The teacher's role is to create activities and environments that allow learners to engage in meaningful experiences. As the student explores, the teacher guides and provides scaffolding.

Squire (2006) argued that "educators (especially curriculum designers) ought to play closer attention to video games because they offer designed experiences, in which participants learn through a grammar of doing and being" (p. 19). He saw three main spheres of research related to games:

- Games as participation in ideological systems
- Learning as performance
- Games as design experiences.

It is time, Squire suggested, for curriculum developers to shift the focus from designing content to designing an experience.

Within this approach, the focus is on learning by doing, which includes both success and failure. As Squire (ibid) argued "the focus is on experience that enables students to develop situated understandings, to learn through failure, and to develop identities as expert problem solvers" (p. 26). The same idea was reiterated by Goodman (2010), that a game-based education might actually prepare students to face real world problems. Based on these scholarly works, we could argue that games can be effectively used as a tool to improve students' critical and creative thinking to solve problems.

Research purpose

This study has two main purposes: first to find out whether instructional games support effective learning, and secondly to determine whether the factors of challenge and fantasy in instructional games impact learning outcomes.

I. Games in effective learning

Though using games in education is a very old technique, it is a rather young research topic. Many scholars have expressed their opinions or ideas about the potential of the games in education, but there are few empirical studies. One of the purposes of this study is to find out empirically whether games augment effective learning.

II. Challenge and fantasy in an instructional game

The second purpose of this study is to find out the impact of challenge and fantasy features on learning in an instructional game. Rieber and Matzko (2001) mentioned that merely importing design features into educational gaming environments from traditional classroom curriculum design and delivery contexts, will not positively affect either the educational aspect or the game engagement of the students. There are not many studies conducted on the specific game features that would effectively augment learning (Garris, Ahlers & Driskell, 2002). Further Garris et al. (2002), said, because of such lack of research on the features of instructional games, "We run the risk of designing instructional games that neither instruct nor engage the learner. Bargain bins in software stores attest to the difficulty in designing appealing and instructionally sound computer games." (p. 442). Finally, Garris et al. (2002) mentioned that there are six key features that characterize games:

(a) Fantasy

(b) Rules or goals

(c) Sensory stimuli

(d) Challenge

(e) Mystery

(f) User Control

These features will be discussed in more detail in Chapter 2 and their definitions are included in the glossary (Appendix H). Though these features could be considered as essential ingredients for a successful entertainment game, there is not much research about the essential features for a successful educational game. Kirriemuir and McFarlane (2004) acknowledged that the pursuit of playing computer games will continue to grow, since many young people spend their leisure time playing games, and games will be expected to support their learning as well. However, they also concluded the following:

> Though a rapidly growing and maturing body of research is helping to develop a clearer understanding of the educational potential of games, there are as yet a small number of games that have a clear contribution to make to the educational agenda. (p. 28)

The lack of research in this area shows the importance of continued research in this area. It is in this context that this study was conducted. One of the outcomes of this research is to inform instructional designers and game designers about features that are important in creating engaging edutainment solutions.

Expected research contribution

Children and adults like playing games. Gaming is one of the biggest industries and makes more money next to movies, followed by music and other entertainment industries. However, such a successful industry fails when it attempts to blend entertainment and education into what is often referred to as edutainment. Edutainment is a “hybrid genre” (Okan, 2003, p. 255) that has both a learning objective as well as visual material with narratives and or games. The purpose of edutainment is to attract and maintain the attention of learners through this mix of learning objectives and entertaining features. Green and McNeese (2007) said that the edutainment should be fun in such a way that learners get lost in the edutainment, that they don't realize they are also learning along the way. Further Green and McNeese (2007) say that “unfortunately, most commercial edutainment software is inferior to the popular games” (p. 6). Probably this is the reason why, students enjoy entertainment but not edutainment games. Therefore it is very important to find out what features will make edutainment games enjoyable and consequently a learning experience.

This research will add to the existing knowledgebase on games and learning, which is still relatively a young field of study. As of now there have been only a few studies providing some empirical evidence available to propose what game features will effectively result in learning, not sufficient to consistently arrive at a model for developing successful educational games. This study will not only provide empirical evidence to the question of whether games positively or negatively impact learning, but will also throw light on the important educational game features, and how they are linked to learning outcomes.

The instructional gaming industry has two important communities: instructional designers and game designers. This study's results might be helpful for both these communities. The findings might be helpful in designing more effective educational games.

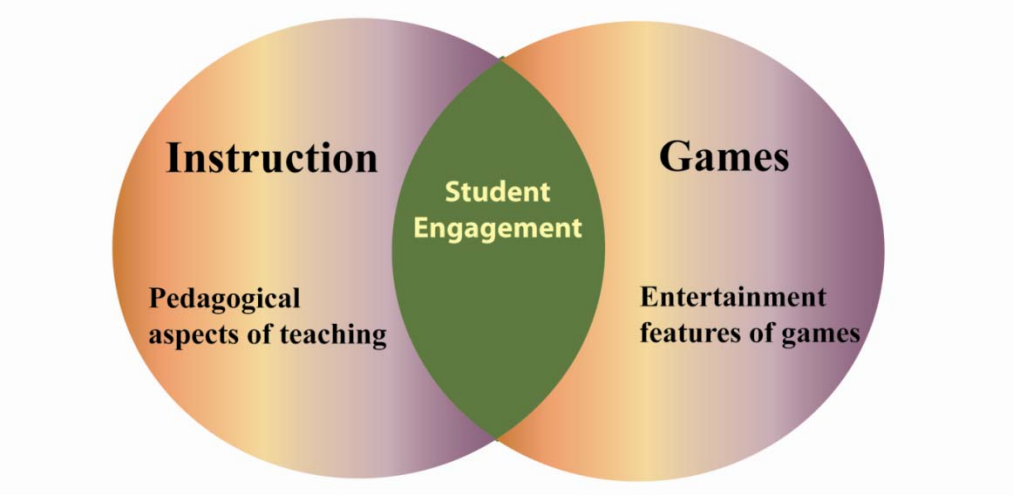
Further, as it has been mentioned earlier, science and math achievement is on the decline in the United States. Through the latest gaming technology, students may be motivated to perform better in science and math. As a result of this study, it will be possible to evaluate whether science and math achievement can be improved using gaming technology.

This study will also pave the way for further research in instructional games. Laurel (2003) commented that many educational games look like broccoli covered in chocolate. Many educational games do not provide students with any new kinds of learning but rather a version of drill-and-practice learning that is easier to swallow (Klopfer, 2008). Norman (1993) has provided a practical solution to this chocolate covered broccoli problem:

> Educators know what needs to be learned; they are simply pretty bad at figuring out how to get the intense, devoted concentration required for the learning to take place. The field of entertainment knows how to create interest and excitement. It can manipulate the information and images. But it doesn't know what to teach. Perhaps we could merge these skills. The trick is to marry the entertainment world's skills of presentation and of capturing the users' engagement with the educator's skills of reflective, in-depth analysis. (p. 39)

This study can help to determine what would be a good mix of pedagogical features and entertainment aspects as illustrated in Figure 1. Student learning occurs, when pedagogical component is presented in an entertaining manner.

Figure 1 – *An effective educational game will have a good mix of both pedagogical features and entertainment aspects*



As shown in the figure above, games tend to engage students, so could increase engagement in instruction. The expected research contribution of this study therefore is to throw light on the features of instructional games that players enjoy, and therefore keep them engaged increasing the chance they will learn at the same time. This study will add to the existing knowledgebase of empirical studies on instructional games and learning, and provide guidance to the community of instructional designers and game designers regarding the right mix of pedagogical and entertainment features. In doing this, it is hoped that the research will contribute to better instructional/educational games specifically in science and math, thus improving science and math achievement in the US.

Definition of the term "game" by various scholars

Before moving on, it is important to note how the term game is defined by scholars and used in this study. It is interesting to note that many non-English scholars used the two words 'game' and 'play' interchangeably in their definitions. This synonymous treatment of the two

words is due to the fact that the definition of game has been written in many languages "and when translated to English there was some slippage between 'play' and 'game' (Salen & Zimmerman, 2004, p. 73). Dutch scholar Huizinga (1950), and Caillois (1961), a French scholar, used these two words (or at least their English translators have used it) interchangeably. From the following passages, it is evident that in their attempt to give a general definition about games, both the terms (game and play) were used by these two scholars. But it is worth mentioning that the Oxford English Dictionary treats these two words as different words and yet related. But unlike their non-English speaking counterparts, English speaking scholars such as Avedon and Sutton-Smith (1971), Chris Crawford (1982) and Salen and Zimmerman (2004) consistently used the word 'game'.

Scholars are in agreement that there is no one single definition that would encapsulate every characteristic attributed to the word 'game'. Game historian David Parlett (1999) went to the extent of saying that the word 'game' "is used for so many different activities that it is not worth insisting on any proposed definition… and it is a slippery lexicological customer, with many friends and relations in a wide variety of fields" (p.1). But it is rather important to define this key word *game* which is at the heart of this research.

Dutch historian Johan Huizinga's book *Homo Ludens*, originally published in 1938 and later reprinted several times, is often quoted by many scholars. One idea expressed by Huizinga (1950) is that most explanations about game and play by various scholars tend to overlap rather than exclude one from another. Salen and Zimmerman (2004) while trying to define the word 'game' analyzed different definitions made by Huizinga and other scholars. These definitions are discussed below. We can see from the discussions that there is overlap, rather than exclusion, in the various definitions of 'game' by different scholars.

Huizinga defined play as:

> a free activity standing quite consciously outside ‘ordinary’ life as being ‘not serious’, but at the same time, absorbing the player intensely and utterly. It is an activity connected with no material interest, and no profit can be gained by it. It proceeds within its own proper boundaries of time and space according to fixed rules and in an orderly manner. It promotes the formation of social groupings, which tend to surround themselves with secrecy and to stress their difference from the common world by disguise or other means. … a contest *for* something or a representation *of* something. These two functions can unite in such a way that the game “represents” a contest, or else becomes a contest for the best representation of something. (p. 13)

According to Huizinga, following are the characteristics of a game:

a. A free activity, and not a forced engagement
b. Outside ordinary life (fantasy)
c. Not serious but absorbing players intensely
d. Not be associated with any material interest
e. Has its own boundaries of time and space
f. Has fixed rules
g. Forms social groups
h. A contest (challenge)

As I continue to provide the definitions given by other scholars, one could see the similarities among these definitions.

Caillois (1961), attempted to define play, which sounds very similar to Huizinga's definition of play in his *Man, Play and Games,* as an activity which is essentially:

1. *Free*: in which playing is not obligatory; if it were, it would at once lose its attractive and joyous quality as a diversion
2. *Separate*: circumscribed within limits of space and time, defined and fixed in advance
3. *Uncertain*: the course of which cannot be determined, nor the result attained beforehand, with some latitude for innovations being left to the player's initiative
4. *Unproductive:* creating neither goods, nor wealth, nor new elements of any kind; and, except for the exchange of property along the players, ending in a situation identical to that prevailing at the beginning of the games
5. *Governed by rules:* under conventions that suspend ordinary laws, and for the moment establish new legislation, which alone counts
6. *Make-believe*: accompanied by a special awareness of a second reality or of a free unreality, as against real life. (p. 9 & 10)

Avedon and Sutton-Smith (1971), two scholars profoundly quoted in much game related literature, tried to define games as follows: "A game is an exercise of voluntary control systems, in which there is a contest between powers, confined by rules in order to produce a disequilibrial outcome" (p. 405). Further, they said that games are composed of the following ten elements:

1. *Purpose of the game:* aim or goal
2. *Procedure for action:* specific operations, required courses of action, method of play
3. *Rules governing action:* fixed principles that determine conduct and standards for behavior

4. *Number of required participants*
5. *Roles of participants*
6. *Results or pay-off:* values assigned to the outcome of the action
7. *Abilities and skills required for action:* aspects of the three behavioral domains utilized in a given activity: Cognitive, Sensory-motor and Affective domain
8. *Interactions patterns:* eight types of possible interaction between an individual and the group
9. *Physical setting and environmental requirements:* man-made physical setting or natural setting in which action takes place
10. *Required equipment:* man-made or natural artifacts employed in the course of action. (p. 422 – 425)

Game designer Chris Crawford (1982) said that there are four fundamental elements that constitute a game: representation, interaction, conflict, and safety.

> *Representation:* A game creates a subjective and deliberately simplified representation of emotional reality. A game is not an objectively accurate representation of reality; objective accuracy is only necessary to the extent required to support the player's fantasy. The player's fantasy is the key agent in making the game psychologically real. (p. 9)

> *Interaction:* Interaction is important for several reasons. First, it injects a social or interpersonal element into the event. It transforms the challenge of the game from a technical one to an interpersonal one. Second, interaction transforms the nature of challenge from a passive challenge to an active challenge. Computer games seldom provide a human opponent, and so they lack the social element that other games offer.

> They can, however, present an illusory personality against which the player must work. (p.11)
>
> *Conflict:* Conflict is an intrinsic element of all games. It can be direct or indirect, violent or nonviolent, but it is always present in every game. (p.12)
>
> *Safety:* Games provide safe ways to experience reality. Special cases abound, but the central principle remains: games are safe. (p.13)

Finally, it is worthwhile to mention the definition given by Katie Salen and Eric Zimmerman (2004), who tried to synthesize a definition after summarizing eight scholars: “A game is a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome” (p. 80). Their definition has the following six primary ideas:

> **System:** A typical system has four components: *Objects*, which are the parts within the system, an *Attribute* or quality or the property of the system, *Internal relationships* among the objects and *Environment* which is the context that surrounds the system.
>
> **Player:** A game is something that one or more participants actively play. Players interact with the system of a game in order to experience the play of the game.
>
> **Artificial:** Games maintain a boundary from so-called “real life” in both time and space. Though Salen and Zimmerman use the word artificial, nevertheless they imply fantasy.
>
> **Conflict:** All games embody a contest of powers. For the present research, this is defined as challenge in a gaming environment.
>
> **Rules:** Rules provide the structure out of which play emerges, by delimiting what the player can and cannot do.

> **Quantifiable outcome:** At the conclusion of a game, a player has either won or lost or received some kind of numerical score, which is what distinguishes a game from less formal play activities. (p. 80)

All the above definitions in fact have a lot of overlapping ideas and are presented in each scholar's own style.

Working definition of "game" in the present study

For the purpose of this study, the researcher would like to define the term "game" as follows:

> A game is an active (could be mental, physical or both) environment with the following characteristics:
>
> - The game is autotelic. There is no intended purpose but to play the game.
> - The game is intrinsically motivating. It is not an act of obligation.
> - The game has rules that govern the game.
> - The game has fantasy elements.
> - The game poses challenges.
> - The game has interactivity.
> - The game has definitive results.

This definition of the term "game" was synthesized from the various definitions provided by scholars that were discussed earlier. This is the definition of the term "game" used for the purpose of the present study.

Working definition of video games

Games that are generally played in electronic devices such as computers, game consoles and mobile gadgets are known as digital games. They are classified based on the platform in which they are played. For example, computer based video games are one of the genres. Then, there are console-based digital games such as Sony PlayStation®, Nintendo (DS and 3DS)®, Nintendo-Wii® and Microsoft Xbox ®. Another emerging area of digital games is based on mobile devices such as smart phones, e-readers and other hand-held devices.

Each game can be classified (whether it is computer based or console-based or mobile devices based) into single player games and multiplayer games. Further these games are classified as: Action games, Adventure games, Strategy games and Process-oriented games (Egenfeldt-Nielsen, Smith & Tosca, 2008).

Kirriemuir and McFarlane (2004) defined video games as follows:

- Video games provide some visual digital information or substance to one or more players
- Video games take some input from the players
- Video games process the input according to a set of programmed game rules
- Video games alter the digital information provided to the players. (p. 6)

For the present study, the above definition of video games was used as the working definition. The Humatan game which was created for the purpose of this study was a single player computer based video game having both adventure as well as action.

Chapter summary

The main purpose of this study is twofold: One is to find out whether instructional games are effective in learning. The second purpose of this study is to find out the impact of challenge and fantasy features on learning in an instructional game. Striking a balance between entertainment and educational aspects is very important to the success of an instructional game. Scholars are of the opinion that instructional games should not become 'chocolate dipped broccoli'. Stimulating educational games are needed to teach science in an effective manner. In this dissertation, first I present a review of the relevant literature. I then present my research methodology and finally present the findings based on the data analysis. One main goal is to determine whether games could be used as an effective tool to improve learning. The second is to determine whether the specific features of challenge and fantasy are important features of an effective instructional game, and find out empirically whether, and if so, how these game features enhance learning.

The researcher attempted to synthesize a definition of games from scholarly works by reviewing existing literature. Game is a motivating, interactive, challenging, and make-believe activity, where players play for the sake of play and have rules followed by results. Digital games are played on a computer, or on a console or on a smart phone or other hand-held devices. Based on the storyline embedded within the game system, a game can be classified as action, adventure, and strategy or process-oriented.

Chapter II: Literature review

Introduction

Games and play are one of the ancient forms of human activity. Dr. Stuart Brown of the Institute of Play asserted (p. 53, as cited in Cross, 2007), “what do most Nobel Laureates, innovative entrepreneurs, artists and performers, well-adjusted children, happy couples and families, and the most successfully adapted mammals have in common? They play enthusiastically throughout their lives.” While collecting data for this study at one of the schools, a student asked us whether he could get a copy of the Humatan game to play later. When I told the students that, after the data collection was completed, the Humatan game would be made available through their School district, the entire class applauded cheerfully.

There are two main purposes for this study: The first objective is to find out whether instructional games are effective in learning. The second purpose is to find out the impact of challenge and fantasy features on learning in an instructional game. In this chapter, the review of literature is presented under the following topics:

a. Why study games? The importance of games, and the need to study games.
b. A multi-disciplinary approach to games and how the concept of games has been addressed historically in various disciplines, such as anthropology, psychology, and education.
c. The origin and present status of digital games, and the historical timeline of video games.
d. Why do people play games? What kind of motivation do games offer?
e. The theoretical underpinning of educational games: constructivism.

f. The important features of educational games as discussed in scholarly articles.

Why study games?

It is rather easy to answer this question in today's predominantly capitalist world; the sheer economic implications (16 billion US Dollar in sales in 2010) of this very fast growing industry are phenomenal. Anthropologist Brewster (1979) tried to answer this question by citing Dr. Padmanabhachari:

> Human life and human institutions can be better understood by – and indeed cannot be thoroughly understood at all without – a study of the life of primitive peoples including even their pastimes, the games they played, the sports they engaged in… Play patterns are an integral part of all human culture wherever mankind is found and in whatever state of advancement the culture may be. A study of the play of primitive peoples will throw much needed light on the nature of the play tendencies of mankind as a whole. Moreover, a study of games and sports will reveal to us the nature and extent of civilization of the race. (As cited in Brewster, 1979, p. 11)

Brewster also made a point that studying games will also benefit philosophers, psychologists, educators, artists, musicologists, choreographers, and workers of mental and physical therapy as well. While talking about how studying games will benefit educators, Brewster comments:

> He (educator) will probably be surprised to learn that number games were being played by children of so-called primitive societies long before they were introduced into modern education as a teaching technique, and may well be amazed at the youngsters' skill in mental computation and at their grasp of the principle counter distribution. (p. 16)

Gee (2005) successfully summarized all of the above and more when he mentioned that research about games could serve as a converging point for various disciplines such as entertainment, art, media, cognitive science, society, technology, education, and learning.

Games in various disciplines

Many scholars have approached the concept of game in a philosophical manner. In fact the Vedanta philosophy of India says this entire cosmos is "Lila Vibhuthi." "Lila" is a Sanskrit word for play or sport and "Vibhuthi" means wealth. Anthropologist Don Handelman (1992) mentioned the following about the views expressed in Indian Vedanta:

> In Indian cosmology, play is a top down idea. Passages to play and their premises are embedded at a high level of abstraction and generality. The qualities of play resonate and resound throughout the whole. But more than this, qualities of play are integral to the very operation of the cosmos. To be in play is to reproduce time and again the very premises that inform the existence of this kind of cosmos... Now in cosmologies where premises of play are not embedded at a high level and are not integral to the organization of the cosmos, as in Western society, the phenomenon of play seem to erupt from the bottom. By bottom up play I mean that play often is phrased in opposition to, or as a negation of, the order of things. This is the perception of play as unserious, illusory and ephemeral, but it is also the perception of play as subversive and resisting the order of things. (p. 12)

Similarly, in Christianity, in the Bible, many Gospels mention that the Kingdom of God is "pictured as a spirited life of play, where play is not laborious, as work is, but labor is playful just as games are" (Miller, 1970, p. 112). Miller (1970) further stated that there is a similarity in thoughts between the Hindu (Vedanta) scriptures and the Bible:

> The Wisdom Literature interpretation of God creating man and the world (see Proverbs 8:22 – 31) pictures God at play when he fashions the world and it shows man at Edenic play in the pleasurable presence of God. It pictures this childlike play just as compelling as does the Vedanta interpretation of ancient Hindu creation accounts. (p. 101)

Hence, the element of play is even beyond humans and existed before the evolution of man. Eigen and Winkler (1981) asserted:

> The history of play goes back to the beginnings of time. The energy released in the 'big bang' set everything in motion, set matter whirling in a maelstrom of activity that would never cease. The forces of order sought to bring this process under control, to tame chance. The result was not the rigid order of a crystal but the order of life. … Chance and rules are the elements that underlie games and play. Play began among the elementary particles, atoms, and molecules, and now our brain cells carry it on. (p.3)

Further Eigen and Winkler (1981) said, "Human beings did not invent play, but it is the play and only play that makes man complete" (citing Schiller, Friedrich von 1793-94, p. 3). Huizinga (1950) mentioned that game presupposes civilization. Eigen and Winkler (1981) said that almost everything that happens to a human is play: a play of limbs and muscles followed by aimless grasping and kicking of an infant later develops into careful coordinated movements. Playful curiosity makes us seek knowledge. Play of color, shapes, and sounds results in an art form. It is rather quite interesting to see how philosophers, anthropologists, psychologists and so many other scholars who belong to various disciplines dealt with the concept of game and its importance to the human race.

Games and culture

Huizinga (1950), a historian who is noted for his ground-breaking work in the area of play, and who has been profoundly quoted in game related literature said that play is older than even culture, since animals also indulge in play. Different cultures played similar games with their own versions. For example the game called Mankala is played in different variations throughout sub-Saharan Africa, Middle East, Central, South, Southeast Asia (Townsend, 1979). Townsend also mentioned that the diffusion of Mankala could be either from Africa to Asia or vice-versa or "multiple independent inventions" (Townsend, 1979, p. 794) and scholars could not determine the origin or the date exactly. Mahabharata, which was written in the third century B.C., mentions Chaturanga, a forefather version of present day chess, a game that looks like a combination of our modern day chess and dice game. In Sanskrit "chatur" is the word for four and "anga" means parts. Chaturanga means "having four parts" which means a formation of army with four parts: chariots, cavalry, elephants, and infantry. H.J.R. Murray, a chess historian from Britain, mentioned that chess or the war game was first played in ancient India and later spread to other parts of the world (H.J.R. Murray, 1913). Murray further said that Indians have played "ashtapada", which seems to be identical in shape with the present chessboard or draught board. Murray explained that "ashtapada" is Sanskrit for "a board in which each line has 8 squares" (p.33). All these ideas suggest that strategy games were an integral part of ancient civilizations.

Anthropologists mention that throughout the history of mankind, games met general human needs (Roberts, Arth & Bush, 1959). Roberts et al. analyzed about 100 different tribes from a wide geographical distribution and cultural variability. They argued that games are intertwined with various needs of the society:

> Many games of physical skill simulate combat or hunting, as in boxing and competitive trap shooting. Games of strategy may simulate chase, hunt, or war activities, as in backgammon, fox and geese, or chess. The relationship between games of chance and divining (ultimately a religious activity) is well known. (p. 599, Roberts et. al., 1959)

Some scholars linked games to the political systems followed in various cultures. Games that employ strategy are attributed to having a strong relationship to sociopolitical structures. A game of strategy has been viewed as a tool for socialization of children in the norms of their native culture (Peregrine, 2008).

In ancient Greece, in order to get social recognition, apart from being valorous, a man has to be good at sporting events as well. In Homer's Odyssey, Euryalos, winner in wrestling, mentioned the following to Ulysses:

> I gather, then, that you are unskilled in any of the many sports that men generally delight in. I suppose you are one of those grasping traders that go about in ships as captains or merchants, and who think of nothing but of their outward freights and homeward cargoes. There does not seem to be much of the athlete about you. (Homer, translation by Samuel Butler, 1999)

Ulysses has been attributed here as a maritime merchant who seeks profit rather than glory. The biggest insult was that Ulysses was not an athlete or a gamer, which seemed inherent to manliness. For this Ulysses replied that he was indeed very skilled in games and showed his talent by throwing the largest of varying discuses and was congratulated by Athena who appeared in disguise. Greeks as a matter of pride assembled once in four years at Olympia for Ancient Olympic Games (Kyle, 2007). Similarly from chariot races to gladiatorial combats,

Romans were also very passionate about games and their popularity, scale, and architecture. The Roman Colosseum has space for 50,000 spectators to view sports events, with optimum visibility and safe entertainment (Kyle, 2007, p. 321). Huizinga (1950) has shown that from Greek to Roman to the Middle Ages to the Renaissance, in every phase of the world's civilizations, play has been personified in various art forms such as architecture, sculpture, poetry, and such others. He further said that real civilizations cannot exist in the absence of play-elements. From ancient cultures to present day civilization, games have not only been viewed as a means of entertainment but also an important thread in the social fabric.

Technology in teaching and learning

The previous sections gave a historical and philosophical account of games. Before talking about games in the present day's context, this section discusses the advances in technology and the importance of incorporating technology in teaching and learning. This will act as a precursor to a discussion of video games, their origin and current status.

Computers and the information super highway known as the Internet play a very important role in every aspect of today's society. Technology has a tremendous influence on education as well. Due to the rapid boom in technology, the practices of our classroom teaching and learning have been deeply impacted (Wang, 2000). Also research shows that computer literacy and technological sophistication have become necessities, not mere novelties for enjoyment (Dyrli and Kinneman, 1994). Selwyn (2007) made a strong claim that educational institutions should adopt educational technologies and be ready to get transformed or they will die. Many of the latest technologies such as games and simulations have the potential to improve teaching methods, learning and practice, and can also motivate students (Johnson, Graham & Hsueh, 2006). Researchers are constantly looking for ways to incorporate current technologies in

learning environments. Klopfer and Squire (2008), after exploring the uses of handheld computers in a K-12 school, concluded that the use of such technology could be successful in formal learning environments. Maloney (2007) said, in the present conditions, teachers may find it difficult to teach without the use of Internet, course-management systems, Microsoft Office, e-mail, and other technological applications. Research shows that the present student community also uses latest technologies such as Internet heavily. Wang (2007) mentioned that “Eighty-six percent (86%) of college students are online users, compared with 59% of the general population. Growing up in the digital age, college students integrate the Internet into their daily life routine” (p. 279).

Video games: Origin and the present status

There were early attempts by several computer scientists to bring artificial intelligence to computers so that they could play games with machines. In 1951, the British computer company Ferranti showcased their first computer game that could play Nim, a math strategy game, where two players alternatively remove objects from distinct heaps. The guide book that accompanied Nimrod, as the computer exhibit was named, mentions the following:

> It may appear that, in trying to make machines play games, we are wasting our time. This is not true as the theory of games is extremely complex and a machine that can play a complex game can also be programmed to carry out very complex practical problems. (Donovan, 2010, p. 5)

Almost fifty years later, the same kind of argument was made by Squire and Jenkins (2003) and this time the case was for humans: "Games are not simply problems or puzzles; they are microworlds, and in such environments students develop a much firmer sense of how specific

social processes and practices are interwoven and how different bodies of knowledge relate to each other" (Squire & Jenkins, 2003, p. 15). Further they said,

> We have come to think of games not as replacing traditional resources such as maps, texts or educational films. Rather, students are motivated to return to those media to do better in the game. They don't memorize facts; they mobilize information to solve game-related problems. (p 14)

After reviewing several scholarly works (Kent, 2001; Egenfeldt-Nielsen, Smith & Tosca, 2008; Donovan, 2010) it is apparent that there is no unanimity among the researchers about the origin of video games. The common idea found in several of the above video games history related studies is that several scientists were working independently to create games such as Tic-Tac-Toe, and other such games using gigantic mainframe computers across the continents. In 1962, MIT lab's Wayne Witanen, J. Martin Graetz and Stephen R. Russell created the first computer game (Graetz, 1981; Hunter, 2000) called *Spacewar*. Almost a decade later, in August 1972, Magnavox sold 100,000 units of a home video game called *Odyssey* that was programmed to play 12 games such as Ping-Pong, volleyball, handball, tennis, or hockey by switching game cards and control knobs (Hunter, 2000). In the same year, Nolan Bushnell, who later founded the Atari Corporation created a massively successful game called Pong (Winter, 2010; Egenfeldt-Nielsen et al., 2008). Following the success of Atari's Pong, a holiday season competition erupted among various video game vendors. In the 1980s, a lot of strategy games were created based on board games and were mainly war games (Egenfeldt-Nielsen et. al, 2008). With the advent of computer technology, action and adventure games were introduced in the 1990s. Games such as *Doom* and *Half-life,* which belong to a genre known as first person shooter games were made very popular during the mid-1990s. In the year 1995, Sega's console Saturn was

introduced at the Los Angeles Electronic Entertainment Expo for $399 and a day later Sony announced the PlayStation for $299 (Kent, 2001). In the same year, Nintendo released its game console known as Nintendo 64 (N64) at the Shoshinkai Trade show in Japan (Kent, 2001). Tomb Raider which came from the Hollywood blockbuster action movie in 1997 boosted the sale of Sony PlayStation, and by the end of year 2008, 35 million units of Tomb Raider were sold on various platforms (Tomb Raider Chronicles, 2008). Though there were earlier attempts made to incorporate 3D graphics into video games, the availability of cheaper 3D graphics hardware and increased hardware capabilities in the early 2000 are the main reasons behind the current explosion of video games (Donovan, 2010; Egenfeldt-Nielsen et al., 2008).

Role Playing Games such as *Grand Theft Auto* (first released in 1997, and the current version 4 which was released in 2009) and *SimCity* almost became icons of pop culture. More recently, role playing has extended to virtual worlds, most notably to *Second Life*. San Francisco's Linden Lab created a virtual world called *Second Life,* where people connect with each other, doing business, socializing and expressing themselves in creative ways that may not be possible in a real-world situation (Donovan, 2010). Second Life also allows users to create Avatars, a user's online manifestation or personification. The word Avatar came from Sanskrit, based on Hindu mythology, which means incarnation or manifestation. As mentioned above, role-playing in gaming and virtual worlds has become a part of popular culture. Just as video games have evolved over time, game controllers or the hardware devices used to play these games have also evolved as seen next.

Gaming hardware has come a long way. Early controllers were a keyboard and mouse. Later joysticks were introduced, and presently we have sophisticated wireless controllers which can be used as a handheld pointing device that can detect movements in 3D. Microsoft calls its

wireless handheld device as Kinect Motion sensor, Nintendo calls it MotionPlus, while Sony calls it Move. In a nutshell, it is my opinion that video games and gaming hardware have progressed more rapidly in the last decade. This progress can be attributed to the following factors:

1. **Availability of immersive environments for an affordable price for the general consumers:** Computers and consoles which can render compelling 3D environments seamlessly with excellent audio and interactive features are now available. It is my view that such computers and consoles with high-end multimedia capabilities are very competitive in their pricing, thus making them affordable for the general consumers. This idea was echoed by Donovan (2010), as well as Egenfeldt-Nielsen et al. (2008).
2. **Video games are accepted as part of the pop culture:** Video games are in fact accepted as a cultural phenomenon, and as Donovan (2010) mentioned, it is fashionable to talk about Lara Croft of Tomb Raider in the public and make virtual friends in the massively multiplayer online role-playing games (MMORPG) and even do business transactions with fake currency and materials bought with real currency.
3. **Commercial response:** From the researcher's observation, because people have more interest in video games, corporate giants invest more money. Because more money is invested, video game manufacturers continue to research designing a variety of games that would cater to different people's interests, and this feeds into more people buying it again. This cyclic reaction and response contribute to the rapid progress of the video game industry. Thus the consumers' buying trend and the continued interest in investing in the game industry by big corporations is evident from the 2010 video games revenue

($15.4 to $15.6 billion) as reported by NPD (2011), a New York based global consumer and retail market research company.

Why do people play games? Games and motivation

Why do people play games? What would be the purpose? Russian psychologist Vygotsky (1976) said that the activity of play should not be conceived as purposeless, it is rather a purposeful activity for a child. Salen and Zimmerman (2004) showed that pleasure is the main experience most intrinsic to games. They further said that pleasure is something that cannot be easily explained but something people desire to experience. “Delight, amusement, gratification, satisfaction, or happiness” (Salen & Zimmerman, 2004, p. 332) are some of the words which describe the experience of pleasure. Salen and Zimmerman (2004) considered games as non-utilitarian. For example, architecture provides houses and shelters for dwelling and automotive design provides mobility. Games, however, are being played for the sake of playing them. In the present study, I agree with Salen and Zimmerman’s assertion. Some might argue that players play games to win. If winning is the sole motivation behind participating in games, probably the Olympics by this time would have been reduced to an arena of a few dozen countries. Several countries participate in the Olympics despite not getting even a single medal for several years, because they want to participate in the game for the sake of participation. Artists may say that all forms of art are for art’s sake. Salen and Zimmerman argued that the games are an end by themselves and not a means to attain something. Even if the players get some award, it is still a fringe benefit, rather than the sole purpose of their participation. Because of such strong intrinsic motivation or goals, participating in games is considered a non-utilitarian activity.

Scholars mention that motivation can be divided into two categories: External factors or *extrinsic* and, internal reasons or *intrinsic* (Smith & Ragan, 2004). If there is a reward for doing a

work or even a punishment for not doing the work, both these aspects can be attributed as extrinsic motivational factors. Course grades for students and awarding a bonus for taking risks in a corporate world, can be termed as extrinsic motivational factors. Extrinsic motivation yields short-term benefits and Kohn (1987) warned that extrinsic factors can erode intrinsic interests. In the case of intrinsic motivation, the outcome is immaterial (Deci, 1975; Ryan & Deci, 2000). When we feel a flower or look at a piece of art, there is no outcome for such an experience. The experience itself is probably the reward, so to speak. For a creative mind to sustain creativity, intrinsic motivation is very essential. Ryan and Deci (2000) further emphasized that intrinsic motivation results in "high-quality learning and creativity" (p. 55). Deci (1975) quoted American painter and teacher, Robert Henri that, "intrinsic motivation is at the back of every true work of art" (p. 47).

Intrinsic motivation has some specific characteristics (Smith & Ragan, 2004):

1. Competence (For example, challenge of a task)
2. Curiosity (For example, complexity, incongruity, surprises)
3. Autonomy (For example, control of environment and self-determination)
4. Volition (For example, process of internalization)
5. Goal-orientation (For example, orientation towards performance goals, orientation towards learning goals)

Extrinsic and intrinsic motivation is explained in different terms by positive psychologist Mihalyi Csikszentmihalyi (1991). Csikszentmihalyi explained the term enjoyment as *autotelic*, which means: "self (auto) goal (telos)" (p. 67). Csikszentmihalyi (1991) further said:

> Autotelic is Greek for something that is an end in itself. Some activities such as art, music, and sports are usually autotelic. There is no reason for doing them except to feel

> the experience they provide. Most things in life are exotelic. We do them not because we enjoy them but in order to get at some later goal. And some activities are both. The violinist gets paid for playing, and the surgeon gets status and good money for operating, as well as getting enjoyment from doing what they do. (p. 113)

Learning is generally perceived as exotelic (like securing a good career) and game play is considered as autotelic. Csikszentmihalyi (1991) mentioned, "if work and family life become autotelic, then there is nothing wasted in life, and everything we do is worth doing for its own sake" (p. 113). Similarly, educational games offer both exotelic and autotelic activities. Oblinger (2004) said, "games also offer advantages in terms of motivation. Oftentimes students are motivated to learn material (e.g., mythology or math) when it is required for successful game play – that same material might otherwise be considered tedious" (p. 13). Scholars agree that games are highly motivational agents. Such a naturally motivating technique can be effectively used in learning environments.

Piaget and Vygotsky on play and games

Jean Piaget (1896 – 1980) and Lev Vygotsky (1896 – 1934) are two of the most acclaimed researchers in the area of child developmental psychology. When scholars talk about games and their influence over humans, they invariably quote from Piaget and Vygotsky's work. Both Piaget and Vygotsky strongly believed that children acquire knowledge through games. Based on a previous experience, the child uses simple pattern recognition to identify things. A child explores the world through simple sensory-motor skills, to gain more knowledge of the world and acquire more sophisticated exploratory skills (schema), and later applies the schemas to new situations (Piaget, 1976). Piaget (1976) called the application of schema to new situations

as assimilation. Further he said, "…all schemas are capable of giving rise to pure assimilation, whose extreme form is play" (p. 169).

According to Piaget (1962), cognitive development grows sequentially in a similar manner to playing games, starting with practice games, symbolic games, and games with rules. Practice games without symbols, make-believe or rules are characteristic of games played by animals. Piaget (1962) gave an example of this activity:

> When a kitten runs after a dead leaf or ball of wool, we have no reason to suppose that these objects represent mice for it. When a cat plays with her kitten, using claws and teeth, she knows, of course that the fight is not in earnest, but there is no need to explain it by saying that the cat imagines what the fight would be if it were real. It is enough that the actions which usually serve the cat for this adaptation are controlled by maternal love and therefore are carried out 'uncharged,' not as they would be in the presence of a dangerous enemy. (p. 110)

Further Piaget explained that in the case of children, practice games are played very early during their preverbal development.

The second in the sequence is known as symbolic games. Symbolic games imply representation of an absent object. For example, when a child pushes a box and imagines it as a car, the box is a symbolic representation of the car, and according to child, the box is the car. Between the ages of 4 – 7 years a child is able to perceive and imagine intuitively.

Finally Piaget called the third category as "games with rules" (Piaget, 1962, p. 112). Rules mean how one is conducting himself or herself in a social and inter-individual relationship. Between the ages of 7 – 11 years, a child can form a more accurate representation of its

environment and during 11- 15 years a child's skills become socialized, refined and expanded. All the three categories are indeed three stages of child development: sensory-motor, representational, and reflective. Hence, a child's assimilation of objects or acquiring intelligence is essentially through play. But the same play can also be just an activity, whose purpose is not to learn but only a happy display of known actions.

Like Piaget, Vygotsky also believed in the vital role of play in a child's development. "Play contains in a concentrated form, as in the focus of a magnifying glass, all developmental tendencies" (Vygotsky, 1978, p.74). One of the key ideas of Vygotsky was the Zone of Proximal Development (ZPD). Vygotsky (1978) defines ZPD as follows: "It is the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (p. 86). Further Vygotsky (1976) argued that,

> Play is the source of development and creates the zone of proximal development. Action in the imaginative sphere, in an imaginary situation, the creation of voluntary intentions and the formation of real-life plans and volitional motives – all appear in play and make it the highest level of pre-school development. (p. 552)

Vygotsky (1976) posited that make-believe play is both social and cultural. Playing the roles of real life characters (for example, a mother or a doctor), children achieve a mental representation of social roles and the rules of society. The toys and gestures that children play with are a representation of their social and cultural setting. Therefore, through play, children construct meanings of their culture and society.

Constructivism epistemology: Theoretical framework for educational games

Scholars who believe in pedagogical advantages of games take their theoretical underpinnings from the constructivists' perspective of the learning process. In the constructivist view of learning, the role of teachers is to guide on the side rather than be a sage on the stage (Jonassen, 1994). According to Jonassen (1994) the idea that individuals are responsible for their own knowledge is in sharp contrast to objectivism where content is considered as being passed from an instructor to a student. The verb "to construct" came from the Latin word *construere*, which means to arrange or give structure (Mahoney, 2004). According to constructivists, the nature of learning is interactive, and knowledge is gained through the learner's perspective and is constantly evolving. Learners construct knowledge as they learn (Jonassen, 1991; Rieber, 2004).

The origin of constructivism was attributed to 18th century German philosopher, Immanuel Kant (Jonassen, 1991; Steffe & Gale, 1995). According to Kant, knowledge of self and the environment comes from within (Steffe & Gale, 1995). Steffe and Gale (1995) illustrated this with the following example: When a child wants to touch a lizard, the child's father warns not to touch it as it might hurt the child. When the child goes ahead and touches the lizard and gets hurt, the child reasons two things at least because of the experience it has from the incident: one, the lizard when touched might hurt, and second, the father predicts correctly (p. 12). Steffe and Gale further said that "you construct others out of elements of yourself, and soon these others contribute to the image of yourself" (p. 12). Jonassen (1991) called this mental model of learning as "a priori knowledge" that happens before all reasoning. Bruner (1966) believed that each individual's perception of reality is a symbolic construct of his or her own mind (p. 95).

One of the several corollaries of constructivism is learning by active engagement, such as learning by doing, by students with the support of teacher and resources, which will enable them

to construct knowledge (Rieber, 2004). Therefore, the learner takes an active role in the process of acquiring knowledge and thus the learner has an authentic context and relevance behind the learning (Jonassen, 1991). These conditions prompt constructivists to believe that knowledge gained in an educational set-up can be successfully transferred to real-world situations.

John Dewey's (1916 & 1938) views about progressive school based on the "philosophy of experience" are very similar to the present day constructivism. Dewey mentioned that when learners interact with their environment, it provides a better experience. This in turn provides students with a better preparation for a lifetime of independence and development. While describing the nature of experience, Dewey (1916) mentioned that there are two components involved: an active element and a passive element. Dewey further explained:

> On the active hand, experience is trying -- a meaning which is made explicit in the connected term experiment. On the passive, it is undergoing. When we experience something we act upon it, we do something with it; then we suffer or undergo the consequences. We do something to the thing and then it does something to us in return: such is the peculiar combination. The connection of these two phases of experience measures the fruitfulness or value of the experience. (p. 163)

Therefore learning is not only being in an environment such as a classroom as a passive participant but also an active engagement by the learner. As Rieber (2004) noted, the lack of success of Dewey's ideas in the first half of the twentieth century was because of non-availability of resources that lead to rich and authentic learning environments. Dewey himself acknowledged that an authentic progressive school is not easy or simple to create (1938). It is only very recently that students have been able to access simulated interactive experiences in

various complex domains such as mathematics and science that are similar to real world experiences that a mathematician or a scientist is exposed to (Rieber, 2004).

Radical and Social Constructivism

Learners of constructivism can traverse two paths: Radical constructivism and Social Constructivism. Ernst von Glasersfeld propounded radical constructivism and Kenneth Gergen advocated the social version of constructivist epistemology (Phillips, 2000; von Glasersfeld, 1995, 2000; Gergen 1998, 2000). The following sections elaborate these two schools of thought.

Radical constructivism

Radical constructivism was propounded by the American psychologist Ernst von Glasersfeld (1995). Some scholars also called this version of constructivism as an "individualistic version of psychological constructivism" (Phillips, 2000). Ernst von Glasersfeld (1995) defines radical constructivism (the name radical constructivism was given by von Glasersfeld himself) as follows:

> What is radical constructivism? It is an unconventional approach to the problems of knowledge and knowing. It starts from the assumption that knowledge, no matter how it be defined, is in the heads of persons, and that the thinking subject has no alternative but to construct what he or she knows on the basis of his or her own experience. What we make of experience constitutes the only world we consciously live in. …all kinds of experience are essentially subjective, and though I may find reasons to believe that my experience may not be unlike yours, I have no way of knowing that it is the same. The experience and interpretation of language are no exception. Taken seriously, this is a profoundly shocking view. (p. 1)

Ernst von Glasersfeld's own assessment of radical constructivism as "unconventional" and "profoundly shocking" has been shared by many scholars. Their main objection to the idea of individualistic construction of knowledge is that individual knowledge seekers can construct their own version of truth without need of corroboration from outside of the knowledge constructor, and hence there is a possibility of many "number of truths" (Howe & Berv, 2000).

Regarding the reality that exists outside of one's self, von Glasersfeld (1995) mentioned that radical constructivism should not be confused with "solipsism", (the idea that nothing exists outside peoples' heads). René Descartes (1596 – 1650) laid the foundation for solipsism as "cogito, ergo sum", which is Latin for, I am thinking, therefore I exist (Phillips, 2000).

While von Glasersfeld (1995) speaks to the individual nature of knowledge construction, radical constructivism does not carefully address the idea that one's experience happens within a social context. So while individuals may construct their own understanding, this happens through social engagement. This is the center of the social constructivist approach discussed in the next section.

Social constructivism

Social Constructivism is another variant of constructivist epistemology. Karl Marx and Emile Durkheim are considered as the proponents of social constructivism (Phillips, 2000). Lev Vygotsky later extrapolated Karl Marx's ideology into psychological learning (Phillips, 2000). Vygotsky (1978) argued that learning is simply not assimilation and accommodation of new facts; it is rather a social process. It is worth quoting Vygotsky (1978) here:

> Every function in the child's cultural development appears twice: first, on the social level and, later on, on the individual level; first, between people (interpsychological) and then

> inside the child (intrapsychological). This applies equally to voluntary attention, to logical memory, and to the formation of concepts. All the higher functions originate as actual relationships between individuals. (p. 57)

As Vygotsky discusses here, learning is social. Gergen, McNamee, and Barrett (2001) mentioned that knowledge is acquired through transformative dialogs. They mentioned that such transformative dialogs are required not only to gain knowledge, but also to answer the "major challenge of the 21st century" (p. 681). Transformative dialogue is a way for groups of different culture and ethnicity to find common ground.

> Transformative dialogue may be viewed as any form of interchange that succeeds in transforming a relationship between those committed to otherwise separate and antagonistic realities (and their related practices) to one in which common and solidifying realities are under construction. (p. 682)

Gergen (1994) explained that whenever we attempt to talk about "self" or "the nature of truth" we invariably "enter the world of discourse" (p. 207). Thus Gergen's (1994) social constructionism,

> places the locus of knowledge not in the minds of single individuals but in the collectivity. It is not the internal processes of the individual that generate knowledge, but a social process of communication. It is within the process of social interchange that rationality is generated. Truth is the product of the collectivity of truth makers. (p. 207)

According to Gergen, we construct our reality or knowledge through social interactions and through the medium of language.

It is quite interesting to note the lack of unanimity about constructivism among scholars. From the existing literature, the following can be concluded: constructivism is still considered as an epistemology rather than a learning theory. As Murphy (1997) mentioned, constructivism is not just about learning. It addresses larger questions such as: What is the truth? What is reality? How is knowledge gained? In the constructivist's paradigm, learning emphasizes the process and not the product. Some scholars have called it post-epistemological. It is not just another epistemology, or a way of knowing. Rather, constructivism is a way of thinking about knowing, a referent for building models of teaching, learning, and curriculum (Tobin & Tippins, 1993). In other words, it is a philosophy.

Constructivist's approach to instructional design

Smith and Ragan (2004) gave suggestions on how constructivism can inform instructional design and provide some prescriptions. Specifically Smith et al. said instructional designers can develop creative strategies to utilize technology in significant ways. Such use of technologies could act as a catalyst in such a way that learners could construct their knowledge in an authentic manner. Smith et al. further say that constructivist instructional designers should give priority "to the development of meaning and understanding rather than training of behavior" (p. 16, citing Cobb, 1996). Jonassen (1994) pointed out that there cannot be an instructional theory based on constructivism. Since the learner actively constructs truth, and the teacher's role is that of a guide or facilitator, constructivism instructional theory is an oxymoron. However, he did give eight ideas for instructional designers who believe in constructivism, on how to design learning environments that support a learner centric instructional approach:

1. Constructivist learning environments provide multiple representations of reality.

2. Multiple representations avoid oversimplification and represent the complexity of the real world.

3. Constructivist learning environments emphasize knowledge construction instead of knowledge reproduction.

4. They emphasize authentic tasks in a meaningful context rather than abstract instruction out of context.

5. They provide learning environments such as real-world settings or case-based learning instead of predetermined sequences of instruction.

6. They encourage thoughtful reflection on experience.

7. They enable context and content dependent knowledge construction.

8. They support collaborative construction of knowledge through social negotiation, not competition among learners for recognition. (p. 35)

All the above eight characteristics of constructivist learning environments are grounded in both radical and social constructivism ideas. For instance the sixth point in the above list says that the constructivist's learning environment encourages thoughtful reflection on experience. A meaningful reflection could occur on an individual level (radical constructivism) or in a group discussion (social constructivism). There is some difference in the emphasis that these two approaches to constructivism have placed on each of these eight characteristics. A good example is characteristic eight, in which Jonassen mentioned that constructivist learning environments support collaboration of learners through social interaction to acquire knowledge. This characteristic places more emphasis on social constructivism.

Jonassen's (1994) ideas about constructivist learning environments have contributed to the creation of instructional games. For example *River City* is a research project from Harvard University which is an interactive computer simulation and game in a Multi-User Virtual Environment (MUVE) for middle school students (Ketelhut, Dede, Clarke & Nelson 2006). The River City curriculum intends to teach epidemiology, scientific inquiry, and experimentation. Ketelhut, Dede, Clarke & Nelson (2006), argued that while students navigate through this virtual environment, they observe, pose questions, and propose answers, explanations, and predictions. River City provides Jonassen's (1994) real-world setting, encouraging thoughtful reflection, enabling context and content dependent knowledge construction and it also supports collaborative construction of knowledge through social negotiation, since students have to interact with each other while in the virtual environment. Therefore, instructional games have the philosophical underpinning of the constructivist's idea about learning and the following section elaborates how constructivism influences the design of instructional games.

Constructivist's approach to instructional game design

Gee (2003) mentioned that video games exemplify the nature of knowledge as situated and embodied. As one of the core aspects of constructivism, "they are also capable of capturing – and allowing players to practice – a process that is the hallmark of "reflective practice" in areas like law, medicine, teaching, art, or any other area" (p.90). Another important feature of constructivism is that it supports reflection and meta-cognition. Prensky (2006) said that it is a challenge and an opportunity to include reflection and critical thinking as part of their learning process for the current generation of students. Squire and Jenkins (2003) said that students can be allowed to play an instructional game outside the classroom and teachers can bring in meaningful discussions during class time to analyze and make conclusions about the topic being taught.

Since the teachers' role is to facilitate the discussion, a constructivist learning environment is established during such an analysis. Squire (2003) reiterated this idea further:

> However, the educational value of simulations does not necessarily lie in the program itself, but rather in the overall experience of the simulation... learners need opportunities to debrief and reflect, and the amount of time spent on reflection should equal the amount of time engaging in a game or simulation... Instructors play an important role in this process fostering collaboration, promoting reflection, and coordinating extension activities. (p. 6)

Meta-cognition is another important ingredient of constructivism. Papert (1993) said that games support meta-cognition. According to Papert, educators encourage "learning about learning" (p. 49-50) by "engaging children about strategies for learning" (p. 50) when they are playing video games. He even suggested the meta-activity of creating "a family game out of collecting strategies" (p. 50) related to games (and other pursuits).

An important aspect of constructivism is providing meaningful feedback. Friedman (1995) while talking about computer games and other 'traditional' narrative forms, such as novels, noted that the provision of interactivity such as a 'feedback loop' (from player to the computer game) is one of the main differences between games and other narrative forms.

Friedman (1995) posited:

> Computer games reveal their own constructedness to a much greater extent than traditional texts. The player molds his or her strategy through trial and error experimentation to see 'what works'—which actions are rewarded and which are punished. Likewise, the extensive discourse on game strategy in manuals, magazines,

> bulletin boards and guides like The Official SimCity Planning Commission Handbook exposes the 'inner relationships' of the simulation to help players succeed more fully. (p. 75)

Games allow students to analyze, critically think through problems, synthesize and arrive at a solution. During this process, they are given feedback to reflect on their actions as well.

So far instructional games and their philosophical underpinning namely constructivism have been discussed. The next two sections discuss two essential characteristics of instructional games: fun and learning.

Instructional games: Can they be fun?

The origin of the word fun came from "fonn", which means pleasure in Gaelic (Koster, 2004). Huizinga (1950) gave a more philosophical explanation for fun and play:

> What actually is the fun of playing? Why does the baby crow with pleasure? Why does the gambler lose himself in his passion? Why is a huge crowd roused to frenzy by a football match? This intensity of, and absorption in, play finds no explanation in biological analysis. Yet in this intensity, this absorption, this power of maddening, lies the very essence, the primordial quality of play. Nature, so our reasoning mind tells us, could just as easily have given her children all those useful functions of discharging superabundant energy, of relaxing after exertion, of training for the demands of life, of compensating for unfulfilled longings, etc., in the form of purely mechanical exercises and reactions. But no, she gave us play, with its tension, its mirth, and its fun. (p.2 & 3)

Salen and Zimmerman (2004) said that fun is a combination of many emotions, such as, the kind of emotions that we feel and go through and enjoy and find, that in some mysterious ways

enlarge our spirits. Another example is the exultation and the sense of triumph we feel when we succeed.

With regard to fun in games, Fullerton, Swain and Hoffman (2004) gave a more tangible definition of fun in game designing:

> Games are voluntary activities; they require player participation – a high level of participation. Unlike movies or television, the 'show' does not go on if players cease to play. So, if your game has no emotional appeal, players are apt to stop playing, or never pick it up in the first place. So, fun appeals to the emotions. And all of the emotional and dramatic elements that drive a player to pick up your game, to try it out, and to continue to play it, are usually what players cite when asked about what makes a game 'fun.' (p. 264)

When players play a game, they go through three stages: Enter, play, and stay (Salen & Zimmerman, 2004). All the three stages are challenging for a game designer. A game designer has to make a game that has the "magic circle" (Salen & Zimmerman, 2004, p. 333), through which a gamer will enter, and remain there until the magic circle dissolves, and return to the ordinary world. This magic circle is none other than the fun element.

From the above discussion we can see that games are engaging because they are considered as fun. As mentioned earlier, currently instructional games are neither educating nor entertaining. As Norman (1993) says, "the trick is to marry the entertainment world's skills of presentation and of capturing the users' engagement with the educator's skills of reflective, in-depth analysis" (p. 39). In the following sections, I present a review of literature on how instructional games can support learning by engaging a learner through important features of

games. Later I also present how challenge, fantasy and feedback are the most important features of educational games that can lead to both fun as well as learning.

Instructional games and learning

Learning is facilitated by engagement (Carini, Kuh & Klein, 2006) and from the above literature review we could see that games are engaging. Carini, Kuh and Klein (2006) further said that "the very act of being engaged also adds to the foundation of skills and dispositions that is essential to live a productive and satisfying life after college" (p. 2). Given this, it would seem that games would be able to provide an ideal learning situation. This section discusses the research related to instructional games and the impact of games on learning.

Several studies (Kebritchi, Hirumi & Bai 2010; Coller & Scott, 2009; Frederick, 2009; Papastergiou, 2009; Tuzun, Yilmaz-Soylu, Karakus, Inal & Kizilkaya, 2009; Ke & Grabowski, 2007; Ke, 2008; Vogel, Vogel, Cannon-Bowers, Bowers, Muse & Wright, 2006; Lee, Luchini, Michael, Norris & Soloway, 2004) have investigated the effect of instructional games on learning. In a study conducted by Papastergiou (2009) 88 high school students were randomly assigned to two groups: one of which used an educational game (Group A, N = 47) and one that did not (Group B, N = 41). A Computer Memory Knowledge Test was used as the pretest and posttest. Results showed that the gaming approach was both more effective in promoting students' knowledge of computer memory concepts as well as more motivational than the non-gaming approach. Papastergiou (2009) also found that the game was found to be equally motivational for boys and girls. Tuzun et al. (2009) created an educational game to teach geography to fourth and fifth graders and they found that the students made significant learning gains by participating in the game-based learning environment. When compared to traditional teaching environments such as class lectures, students felt better motivated in the game-based

learning environment. They also had a decreased focus on getting grades and were more independent while participating in the game-based activities. Ke and Grabowski, (2007) and Ke (2008) found that computer games, compared with paper-and-pencil drills, were significantly more effective in promoting learning motivation but not significantly different in facilitating cognitive math test performance and meta-cognitive awareness. Lee, Luchini, Michael and Norris and Soloway (2004) conducted a study with a math facts game and they found that the math game encouraged students to solve a greater number of problems, nearly three times more problems in 19 days when compared to children who used a paper worksheet. Kebritchi, Hirumi and Bai (2010) in a study examined the effect of a computer game on students' mathematics achievement, in which 193 students and 10 teachers participated. Their study results indicated a significant positive effect on students' mathematics achievement. In a meta-analysis study of 32 empirical studies by Vogel et al. (2006), the authors concluded that games and simulations were more effective than traditional classroom instruction. Coller and Scott (2009) used educational video games in their undergraduate mechanical engineering curriculum and reported that students who took a game-based course showed a deeper learning compared to other students who took a traditional lecture/textbook-based course. This shows that games can facilitate learning, but does not talk about the specific features of games that may further enhance learning.

Gender and Games

Studies have been conducted about the role of gender in educational games and the results are mixed. In the following passages different studies and their results have been discussed. Kinzie and Dolly (2008) conducted a research involving 42 middle-school students. They studied the students' primary preferences for activity mode (active, explorative, problem-

solving, strategic, social, and creative) in game play and reported that a significant difference existed between boys and girls. Boys preferred the active and strategic modes, whereas girls preferred the explorative and creative modes of video gaming. Boyle and Connolly (2008) argue that educational games might motivate male students towards learning more than female students:

> It seems likely that boys in particular will benefit from the engagement and excitement provided by computer games for learning. While recognizing that ideally new educational methods should be 'gender neutral', in an educational climate which is currently more favorable to girls and where many boys do not thrive, it is tempting to argue that we should welcome any new teaching method that might help to re-capture boys' interest and re-engage them in school (p. 73).

In a study (n = 223) done by Hartmann and Klimmt (2006), the results concluded that females preferred games with opportunities for social interaction with other virtual characters. They also preferred a non-sexualized role for the female protagonist in a non-aggressive storyline. Hartmann and Klimmt (2006) also found that females portrayed themselves as less competitive and winning was less important for them than their male counterparts. Female students also felt that they were less self-confident about their ability to master competitive game situations.

There are studies in which no significant difference was found between the male and female students while using an instructional game. Annetta, Mangrum, Holmes, Collazo, and Cheng (2009), in their study did not find any significant difference between male and female subjects. Similarly, Ke and Grabowski (2007) tested the differential effect of games on the math achievement of 5th-graders of both genders. The study did not observe any significance in the

main effect for gender or in the interaction effects between gender and computer games for the math achievement of 5th-graders. Papastergiou (2009) investigated the effects of computer games on science achievement of 88 high school students and found no gender based differences. Kim and Chang (2010) found a gender based differential effect of computer games on math achievement. The computer game was significantly associated with males' math achievement, but not with females' achievement.

So, from the literature there is conflicting evidence suggesting both significant difference between the genders as well as no difference between the genders. Therefore, this study will try to answer whether there is indeed a significant difference between male and female students in the overall increase in achievement scores, after playing an instructional game.

Important features of instructional games

From the above section we can see that instructional games facilitate learning. To see what features of instructional games support effective learning, this section presents literature on what scholars believe to be important features of games in general, and also features that promote learning. Since, the area of instructional game design is relatively new, parallels have been drawn from the literature on general game design to make an argument for important features of instructional games.

There are scholarly articles (e.g. Malone, 1981a; 1981b; Malone & Lepper, 1987; Gredler, 1994; Prensky, 2001; Dickey, 2005; Kirkley & Kirkley, 2005; Shaffer, 2007) published in the last 30 years that mention the important features of games. In several game related studies and books, these scholars have been frequently mentioned by researchers. Malone's (1981) seminal work, which has been quoted in many scholarly articles, identified three important characteristics of intrinsically enjoyable computer games:

1. Challenges
2. Fantasy
3. Curiosity

Under the Curiosity category, Malone mentioned that informative feedback is one of the specific principles needed for designing games. If we fast forward in time, Dempsey, Haynes, Lucassen, and Casey (2002) mentioned that "players want challenging games with clear and concise instructions, help functions, and control over gaming options such as speed, difficulty" and most importantly, feedback. Prensky (2001) mentioned the following about games:

1. Games are interactive. That gives us doing.
2. Games have outcomes and feedback. That gives us learning.
3. Games have conflict/competition/challenge/opposition. That gives us adrenaline. (p. 05)

While talking about the characteristics that ensure effectiveness of game-based learning, scholars (Gredler, 1996; Price, 1990; Provenzo, 1992) have mentioned engagement, interactivity, and active participation. Further, games provide a great deal of highly interactive feedback, which is crucial to learning (Gredler, 1994; Malone, 1980; Prensky, 2001; Rieber, 1996a, 1996b).

Scholars did differ in their perception about what features would make an instructional game interesting without losing the educational aspect. As Garris et al. (2002) mentioned many instructional games neither instruct nor engage learners. When Squire and Jenkins (2003) asked MIT students how they perceived the current state of educational games and what they would like to see in an instructional game, one student answered:

> If people are going to learn from the games and want to play them, they'd better be damn good games (on par with commercial console games in terms of graphics, sound, and

playability). I played ‘educational’ type games for the computer a long time ago in middle school (remember Math Blaster?) and they sucked. (p.11 & 12)

Although scholars agree that at present many educational games neither instruct nor entertain, there is no agreement on what would make an educational game both interesting and at the same time pedagogically valuable. The aim of the current study is two-fold: to find out from literature what features would make an educational game effective, and to verify empirically whether these features are indeed effective in promoting learning.

The passages that follow conclude that challenge, feedback, and fantasy, were the three important features suggested in various literatures that could lead to effective learning in instructional games.

Challenges

Cambridge Advanced Learner’s Dictionary defined challenge as “something needing great mental or physical effort in order to be done successfully and which therefore tests a person's ability.” In a gaming context, Fullerton, Swain and Hoffman (2004) distinguished the challenges of everyday life, tasks that are hard to accomplish, from the challenge of games, “tasks that are satisfying to complete, that require just the right amount of work to create a sense of accomplishment and enjoyment” (p. 82). One of the key elements of the enjoyment experienced by video game players is challenging and competitive situations (Vorderer, Hartmann & Klimmt, 2003). Vorderer et al mentioned that video games offer certain possibilities to act, and a specific necessity to act. Players use the possibilities to resolve the necessity, which results in the enjoyment felt by the player.

Game designer Crawford (2003) said that challenge is one of the basic elements of human nature:

> In the universe of possibilities that encompasses what we could be, it is the challenges we face up to that delineate who we actually are. We therefore go through life seeking new challenges that permit us to expand our identities. Once a challenge has been overcome, it is no longer a challenge, and we move on to a new challenge. We seek our challenges in all spheres of our lives: social, work, romantic, and artistic. Sometimes we fail and adjust our challenges accordingly. Sometimes we succeed and raise the notch a level. But no matter the outcome, we continue our quest for challenges that expand our identities. (p. 37)

So, we are constantly in pursuit of challenges which lead to self-gratification. Crawford's idea about challenge is also consistent with Deci's (1975) view of intrinsic motivation. Deci said that humans not only try to win over challenges as and when they are presented, but they also look for optimally challenging situations. In an educational setting, Harter, Whitesell and Kowalski (1992) found empirical evidence that the degree of gratification is positively related to the amount of challenge which the task provides. Further, Harter et al. said, "the greatest pleasure was derived from the solution of the most challenging problems, easily solved problems produced relatively little gratification" (p. 788).

Richard Rouse III, a game design director, who has created several bestselling games, mentioned that players do not like games that are unchallenging (Rouse & Ogden, 2005). He mentioned:

> A challenge necessarily implies that the players will not succeed at first, and that many attempts must be made to overcome obstacles before they are finally successful. A victory that is too easily achieved is a hollow victory. It is not unlike winning a fistfight with someone half your size. (Rouse & Ogden, 2005, p. 14)

While answering a question “what do players want?” Rouse and Ogden (2005) mentioned the following, which highlights the relationship between challenge and learning:

> When a person faces a challenge and then overcomes it, that person has learned something. It does not matter if that challenge is in a math textbook or in a computer game. Challenging games can be learning experiences. Players will learn from games, even if that learning is limited to the context of the game, such as how to navigate through the forest, survive a particularly hairy battle, or convince the duke that their intentions with his daughter are honorable. In the best games, players will learn lessons through gameplay that can be applied to other aspects of their life, even if they do not realize it. This may mean that they can apply problem solving methods to their work, use their improved spatial skills to better arrange their furniture, or perhaps even learn greater empathy through role-playing. Many players thrive on and long for the challenges games provide, and are enriched by the learning that follows. (p.2)

Roger Caillois (1961), a French writer and philosopher, who is considered as “one of the most influential thinkers on game and play” (Salen & Zimmerman, 2006, p. 122) classified games into four categories: Agón, Alea, Mimicry, or Ilinx (Caillois, 1961). Though Caillois’s categorization is very important in any game related study, it is based on a taxonomy which goes beyond the boundaries of definitions of games (Salen & Zimmerman, 2004). Agón is a group of games where competition or challenges are the dominant feature. Agón is a classical Greek word which means, competition or challenge. Alea are chance-based games, in which the player has no control over the outcome (examples given by Caillois are games of dice, roulette, heads or tails etc.) Mimicry is an activity in which the players pretend to be someone else in an imaginary world. Finally Ilinx is based on the pursuit of vertigo and some of the examples are “tightrope,

falling or being projected into space, rapid rotation, sliding, speeding" (Caillois, p. 24). Salen and Zimmerman (2004) said that only Agón and Alea fall under game categories and mimicry and ilinx categories go beyond a description of games. They are rather playful recreation activities. But Caillois' work has been quoted by several scholars in game related articles. It is evident from his classification of games that challenge takes a predominant role.

Not only in games, but also in instruction, challenge is considered as one of the many motivational factors. In the ARCS (Attention, Relevance, Confidence, Satisfaction), under confidence strategies, Keller (1983) posited that learners are more motivated when challenge is balanced in such a way that the learning process is neither so easy that the learner gets bored, nor so difficult that success is unattainable. Founder of the Cognitive Science Society, Dr. Norman (1993) mentioned why games motivate and engage players:

> Games, especially action games, are stimulating and compelling because they are event-driven activities, always presenting some new challenge to the player, maintaining attention by continual new stimulation, new challenges. This is one of the powers of the experiential mode: The mind is externally driven, captured by the constant arrival of a barrage of sensory information. (p. 35)

On the other hand, Norman mentioned that, today's education is delivered through hour-long lectures, to which students are unable to pay any attention and are inclined to think about anything except what the teacher is talking about. Norman (1993) also gave a solution by saying that a game like environment where students have "continual stimulation, simulated worlds, and the proper social interaction with other players and teachers to ensure that there is guidance and feedback, so that the activity is a true learning, coaching, training activity-in short, so that it is educational" (p. 37) is what is needed in education.

Albert Bandura (1997) mentioned that perceived self-efficacy which is the core aspect of his cognitive theory, "refers to beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (p. 3). A strong sense of self-efficacy produces personal accomplishments, reduces stress and lowers vulnerability to depression. Further Bandura (1994) mentioned that the way to develop self-efficacy is through challenge:

> If people experience only easy successes they come to expect quick results and are easily discouraged by failure. A resilient sense of efficacy requires experience in overcoming obstacles through perseverant effort. Some setbacks and difficulties in human pursuits serve a useful purpose in teaching, in that success usually requires sustained effort. After people become convinced they have what it takes to succeed, they persevere in the face of adversity and quickly rebound from setbacks. By sticking it out through tough times, they emerge stronger from adversity. (p. 72)

Young, Peng, Carroll, Franklin, Liu, and Chelberg (2009) found that self-efficacy increases when students play a science learning game. Vorderer, Klimmt and Ritterfeld (2004) mentioned that any computer based game play experience is associated with self-efficacy.

Scholars profoundly quote the works of Csikszentmihalyi who propagated the theory of “optimal experience,” or flow, when they talk about games and motivation. Salen and Zimmerman (2004) mentioned the connection between flow and game design as follows: “the heightened enjoyment and engagement of the flow state is exactly what game designers seek to establish for their players” (p. 336 & 337). Flow is a state that goes beyond the area of games. Csikszentmihalyi (1991) defined optimal experience or flow as follows:

> It is what the sailor holding a tight course feels when the wind whips through her hair, when the boat lunges through the waves like a colt – sails, hull, wind, and sea humming a

> harmony that vibrates in the sailor's veins. It is what a painter feels when the colors on the canvas begin to set up a magnetic tension with each other, and a new thing, a living form, takes shape in front of the astonished creator. Or it is the feeling a father has when his child for the first time responds to his smile. (p. 3)

One of the conditions that can result in flow is "a challenging activity that requires skills" (p. 49). He asked an important question (p.71): "why is playing a game enjoyable, while the things we have to do every day, like working or sitting at home—often so boring?" and gives an answer while talking about conditions of flow. He said, "…games offer opportunities to go beyond the boundaries of ordinary experience in four different ways. In agonistic games, the participant must stretch his/her skills to meet the challenge provided by the skills of the opponents" (p. 72). Later in the same chapter, Csikszentmihalyi gave an example of a boy learning to play tennis. He elaborated that in order to avoid anxiety and boredom (neither of them are pleasant experiences) the boy has to increase the challenges. One of the purposes of his book on flow, Csikszentmihalyi explained, was "to explore ways in which even routine details can be transformed into personally meaningful games that provide optimal experience" (p. 51).

Studies show that challenging activities improve student engagement not only in games but in classrooms as well. Shernoff, Csikzentmihalyi, Schneider and Shernoff (2003) concluded that students experience increased engagement:

1. When they encounter a highly challenging activity and perceive that they have the appropriate skills needed to complete the task.
2. The instruction is relevant.
3. The learning environment is under their control.

After conducting a study that involved more than 40 educational games, Dempsey et al. (2002) reported that “learners are likely to sustain interest in games that are challenging and goal oriented” (p. 166). Fong-Ling, Rong-Chang and Sheng-Chin, (2009) concluded, after evaluating four instructional games, that challenge is one of the main factors that makes an educational game effective. Lucas and Sherry (2004) studied gender differences in video game play and reported that for both male and female players, challenge is one of the top-ranked gratifications to play a game. Video game players enjoyed being faced with challenging and competitive circumstances and it was one of the fun elements of video games (Vorderer, Hartmann & Klimmt, 2003). The human need to have challenges is rooted in a desire to achieve, which goes back to the McClelland, Atkinson, Clark, and Lowell (1958) theory of achievement. McClelland et al. (1958) defined the need for achievement as “success in competition with some standard of excellence. That is, the goal of some individual in the story is to be successful in terms of competition with some standard of excellence" (p. 181). This idea was echoed by Daft (2008) who says that achievement is “the desire to accomplish something difficult, attain a high standard of success, master complex tasks, and surpass others” (p. 233).

Deci (1995) said that the function of competition is to provide challenge and thus provide an opportunity for people to test themselves and to improve. Further, Deci (1995) said, that challenges accompanied with autonomy, to make appropriate decisions, will provide optimal challenges and lead to better results. This idea is similar to Shernoff et al. (2003) findings that students experience increased engagement when they think they have control over their learning environment. Malone and Lepper (1987) said that both cooperation and competition elicit and harness motivation among students. Finally, we can conclude the concept of challenge in Dutch historian Huizinga words (1950):

> Play is ‘tense’ as we say. It is this element of tension and solution that governs all solitary games of skill and application such as puzzles, jig-saws, mosaic-making, patience, target-shooting, and the more play bears the character of competition the more fervent it will be. (p. 11)

From these observations it is clear that optimal challenge is enjoyable and that people perform better with such challenges. It is therefore important to investigate how challenge in instructional games can impact learning.

Fantasy

Fantasy is defined as an environment that “evokes mental images of physical or social situations not actually present” (Malone & Lepper, 1987, p. 240). Many scholars have agreed that the fantasy feature in a game is meant to create intrinsic motivation to play the game (Malone, 1980; 1981a; Malone & Lepper, 1987; Garris et al., 2002). Some scholars have also mentioned that meaningful and appealing fantasy contexts enhance users’ interest in playing the game while at the same time promoting learning (Parker & Lepper, 1992).

Before getting into the importance of fantasy in an educational gaming environment, it is important to know the connection between games and fantasy through important scholarly works (Huizinga, 1950; Bateson, 1973). While defining what play is, Huizinga (1950) said the following: “play is not ordinary or real life. It is rather a stepping out of ‘real’ life into a temporary sphere of activity with a disposition all of its own. It is only pretending, only for fun” (p. 8). Huizinga further illustrated this stepping out of real life into pretended reality through an anecdote told by the father of a child: The child is playing trains, sitting at the front of a row of chairs. As the father hugged the child, the boy said: “Don't kiss the engine Daddy, or the carriages won't think it’s real” (p. 8). So, the element of fantasy itself may not be true, but the

experience of fantasy is rather true. Gregory Bateson (1973) outlined this idea in his book *A Theory of Play and Fantasy*.

Bateson (1973) observed monkeys in the San Francisco zoo, where he saw one monkey appear to bite another monkey. Though the bitten monkey started chasing the biter monkey, at the end it was not confrontational. Rather it was more playful. So, Bateson deduced that monkeys do understand the difference between a serious act and a playful act. Bateson mentioned that when we enter into play activity, we are inside what he calls a "play frame". While we are inside this play frame, we treat the activities as serious but at the same time we do know that they are not real. Bateson said that this is "the paradox of play". When players come out of the play frame, they probably discovered something new, tackled an opponent, or solved a puzzle and in essence explored new options and experimented with them. This is precisely what a game is supposed to do. So, one could even say, for any game to be interesting, one needs to enter into this world of fantasy or "play frame" and while the experience is true, the fantasy by itself is not true. For instance, in the "Grand Theft Auto" game, a player is considered as a good player if he/she does everything that is prohibited in a civilized society. Though the players' experiences while playing the game are true, the actions such as stealing a car or killing someone inside the game environment did not happen in reality. So, we could argue that fantasy is not only an essential feature, but that, without the fantasy aspect there is no game. This view of fantasy being an important feature of games has wide support from various scholars. George Herbert Mead (1934), a social psychologist, in his *Mind, Self and Society* said that play is an activity in which children pretend to be "a mother, at being a teacher, at being a policeman; that is, it is taking different roles…" (p. 151).

Malone's dissertation work is one that is often quoted in scholarly articles. Malone's initial work created a classification of features that would make a game intrinsically motivating. Later through two more scholarly publications (Malone & Lepper, 1987; Lepper & Malone, 1987) both Malone and Lepper revised these set of taxonomy of features to the following: challenge, curiosity, control, and fantasy. Similarly, Parker and Lepper (1992) found that the students' learning was enhanced when the educational content was presented in fantasy contexts. Parker and Lepper (1992) empirically verified the effects of fantasy in educational games. In two studies, Parker and Lepper (1992) found that:

> 1. Addition of even relatively minimal fantasy embellishments can significantly enhance the motivational appeal of common educational activities for children.
>
> 2. The provision of an appealing fantasy context still produced significant increases in student learning. (p. 631)

Later, Cordova and Lepper (1996) examined the effect of fantasy, and personalization of the fantasy environment. They found that contextualization of fantasy, personalization of fantasy, and provision of choices all dramatically increased students' motivation, engagement in learning, the amount they learned in a fixed time period, and their perceived competence and levels of aspiration (Cordova & Lepper, 1996).

Cassell and Ryokai (2001) posited that fantasy has an important role to play in a child's development. Through fantasy activities such as role-playing, dress-up, and storytelling with objects such as stuffed animals, children explore different possibilities in their life without the risk of failure and frustration. Thus fantasy plays an important role in children's emotional and social development. Further, fantasy also fosters children's cognitive and language skills. By fostering the development of children's symbolic imagination and providing a field for its

exercise, fantasy play and narrative activity prepare the way for the development of abstract thinking and higher mental processes (Cassell & Ryokai, 2001).

Kenny and Gunter (2007) argued that it is essential for both game designers and instructional designers to use the fantasy feature properly. Fantasy plays an important role when a player decides whether to play a game or not. Players might choose a game that has a strong and interesting fantasy. Similarly, in an educational context also, learning content coupled with fantasy is more appealing and leads toward a better retention of the modules learnt (Kenny & Gunter, 2007). Game designer Marc LeBlanc (2004) defined fun using eight different terms and fantasy is one of them. He said fantasy is the make-believe aspect of a game that resonates with the gamer and thereby makes the game more enjoyable.

Fine (1983) defined fantasy as the "free play of a creative imagination" (p. 3). Further, Fine mentioned that game fantasy is a mix of present reality, and how players interpret past or futuristic settings. Further, game "engrossment" needs fantasy:

> A key concept is the engrossment of players in the game. For the game to work as an aesthetic experience, players must be willing to 'bracket' their 'natural' selves and enact a fantasy self. They must lose themselves to the game. This engrossment is not total or continuous, but it is what provides for the 'fun' within the game. The acceptance of fantasy world as a (temporarily) real world gives meaning to the game, and the creation of a fantasy scenario and culture must take into account those things that players find engrossing. (p. 4)

Game designer Rouse (Rouse & Ogden, 2005) said that many people want to be transported to a fantasy world, which is more glamorous than their own. The fantasy element is

one of the biggest motivational features of games. Rouse (2005) emphasized the importance of the fantasy element in games in the following paragraph:

> Computer games, then, have the potential to be an even more immersive form of escapism. In games, players get the chance to actually be someone more exciting, to control a pulp-fiction adventurer, daring swordsman, or space-opera hero. While in books or films the audience can merely watch as the characters lead exciting lives, in a well-designed computer game, players will actually get the chance to live those lives themselves. Even better, these fantasy lives are not weighed down with the mundane events of life. In most games, players do not have to worry about eating, needing to get some sleep, or going to the bathroom. Thus, a game can create a fantasy life without the tedious details. And, most importantly, the level of fantasy immersion is heightened from that of other art forms because of the interactive nature of gaming. (p. 7)

While trying to distinguish games from simulations, Charsky (2010) described fantasy as an element that is not present in simulations. He further mentions that because of the lack of fantasy in simulations, learners are geared toward learning a specific task. Charsky argued that even the so-called flight simulators should be called games and not simulations because they incorporate elements of fantasy and competition.

According to Garris et al, (2002), individuals interact in situations that are not part of their real life through fantasies. These imaginary situations increase intrinsic motivation by satisfying some of their individual needs. For example, a player can become successful, powerful or become a celebrity in the virtual gaming world, which might not be possible in a real world environment. Brown (2008) observed that,

> Video games actualize what religions only promise: not only the grand gifts of immortality and cosmic coherence, but also the more immediate certainty that the existence of the individual person means something. In this sense … video games, might in fact, speak to the deepest psychological or spiritual needs that only religion and the most sublime art can satisfy. (p. 111)

Therefore, searching for fantasy is a human tendency. Games, like most of the sublime forms of art, offer this most gratifying experience to the players and make it meaningful.

Endogenous and Exogenous fantasy

Rieber (1996a) classified fantasy as endogenous and exogenous to the content of the game. Endogenous fantasy is defined as one in which the learning of content is highly related to the game's storyline (Kenny & Gunter, 2007). Rieber (1996a) defined exogenous fantasy as a "sugar coating" over educational materials and explains that there is no integration between the game's storyline and the learning of content. When exogenous fantasy is employed, learning activities that players perform are not seamlessly integrated with the fantasy roles they play in the game (Van Eck, 2006). Gaming content is superimposed on top of the game. For example, students may learn mathematical formulae such as addition or subtraction during the game play. Such games where exogenous fantasy is employed are likely to be more engaging than a long page of multiplications but would not trigger a deep investment or an extended engagement (lots of effort and practice) on the part of the player (Rieber, 1996; Gee, 2003). In an endogenous fantasy, players can learn and practice skills as a strategy to accomplish game goals or as a part of the game characters they take on, thus deeming learning as a meaningful and intrinsically motivational function (Gee, 2003). Malone (1980) explained that, when the fantasy in a game is

intimately related to the material being learned, the players are able to exploit analogies between their existing knowledge about the fantasy world and the unfamiliar things they are learning.

While many scholars suggest that fantasy is a very important motivating factor in an instructional game, others differ arguing that fantasy is not a sufficient condition for learning (Asgari & Kaufman, 2004; Kenny & Gunter, 2007). Fantasy might lead to distraction and cognitive overload as well. Mayer and Moreno (2003) mention that cognitive overload occurs when "the processing demands evoked by the learning task may exceed the processing capacity of the cognitive system" (p. 45). Further they say that "the ever-present potential for cognitive overload is a central challenge for instructors (including instructional designers) and learners (including multimedia learners); meaningful learning often requires substantial cognitive processing using a cognitive system that has severe limits on cognitive processing" (p . 45).

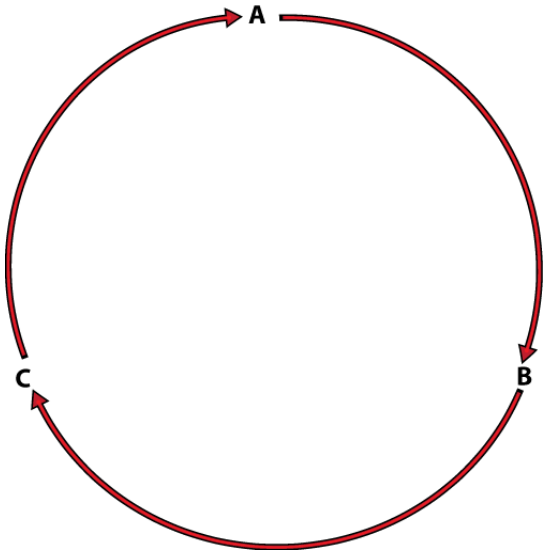
Therefore this study will empirically verify whether fantasy augments learning or proves to be a distraction towards learning.

Feedback

The concept of feedback dates back to the 3rd century. It was during this time that feedback control was used to create simple instruments and devices such as, water clocks (Mayr, 1970). Scholars assert that the concept of the feedback loop is a contribution of Cybernetics, the scientific study of communication and control in animals and machines (Mindell, Segal & Gerovitch, 2003). One of the main contributions of cybernetics is the comparison between living organisms and machines. A crucial aspect in the research of Mathematician Norbert Weiner (1948), who coined the term "cybernetics", is the idea of the feedback loop. Weiner defined feedback as "control of a machine on the basis of its actual performance rather than its expected performance" (cited in Capra, 1996, p. 57). A feedback loop, shown in Figure 2 below, is a

cyclic arrangement of linked nodes, in which an initial input is provided as the starting point. This input propagates to the first node which passes its output to the next node and so on and the last node passes its output again back to the starting node. This implies two things: Each node affects the next and "results in self-regulation of the entire system, as the initial effect is modified as it travels round the cycle" (Capra, 1996, p. 56).

Figure 2 – *Circular causality of a feedback loop (Capra, 1996, p.56)*



In the educational field the concept of feedback is often confused with that of reinforcement in the behavioral psychologist school. Kulhavy and Stock (1989) termed this as "fitting a round peg of feedback into the square hole of reinforcement" (p. 280). Mory (2003) made an important distinction about the nature of feedback between behaviorists and constructivists. According to behaviorism and information processing, instruction presents real world knowledge to the student, who in turn tests and gives back this knowledge to demonstrate effective learning. Feedback is given to students to correct any misinformation that may be present in their knowledge. According to constructivism, feedback would "provide intellectual

tools and serve as an aid to help the learner to construct his or her internal reality" (Mory, 2003, p. 772). Winne's (1997) review of self-regulated learning, which is the kernel of the constructivist's approach, advocates a shift from outcome-oriented feedback toward more cognitive types of feedback that support self-regulated engagement and enhance self-calibration. While feedback is considered as a summative evaluation of instruction by behaviorists, constructivists consider providing feedback as a formative evaluation. It would become more of a tool for self-analysis (Jonassen, 1991). The big difference between the behavioral school and the constructivists' idea about feedback is (Kulhavy & Stock, 1989):

1. Behaviorists viewed feedback as a corrective mechanism to strengthen correct responses through reinforcement and weaken incorrect responses through punishment.
2. Constructivists viewed feedback as a formative mechanism to help individuals to learn and construct their knowledge through scaffolding.

Johnson & Johnson (1993) defined feedback as follows: "Feedback is information made available to individuals that makes possible the comparison of actual performance with some standard of performance" (p. 135). In a traditional instructional setting, such as a classroom, where students are asked to write a paper about a specific topic, the teacher gives feedback, that could be oral or written, that takes students to the next step in their learning. In games and other technology-augmented learning environments, a multi-dimensional and complex feedback is possible, which can be quite powerful (Johnson & Johnson, 1993).

Wager and Wager (1985) said that feedback in a computer based instruction is any message or display that the computer presents to the learner after a response (cited in Sales, 1993, p. 161). Sales (1993) further said:

> It is possible to utilize any of the following modes, or combination of modes, as channels for feedback: visual (text, computer graphics, computer animations, digitalized still images, video); auditory (computer-generated sounds: beeps, clicks, simple melodies, digitized audio effects, and digitized speech); tactile (pressing key and buttons, rolling track balls, moving joysticks, touching the monitor screen, movement), and olfactory (odors, fragrances). (p. 162)

In fact Rieber (1996b) found that graphical feedback was better than textual feedback in a computer based game. Dickey (2005) identified a number of key factors that make games compelling. One of the key factors identified was immediate feedback. Dickey, (2005) while trying to connect instructional strategies and the gaming environment, mentioned that hooks, which are defined as "anything that requires the player to make a decision that relates to the game, and thus keeps them playing" (p. 77 citing Howland, 2002) are essential for a game. These hooks are part of the feedback system of the game. Following are some examples of these hooks which can be used to give feedback to the gamer or learner (Dickey, 2005):

- Action hooks: Quests, missions, and navigational choices, communication with other learners and non-player characters.
- Resource hooks: Libraries, maps, text, images, statistics, etc.
- Tactical hooks: Strategies, allocating resources, way finding.
- Time hooks: Temporal limits

Dirksen (2010) mentioned how feedback is presented in games and simulations:

Multifaceted – Feedback comes in the form of sounds, visuals, story narration, and interactions with characters, points and rewards.

Less Absolute – Feedback in games can be more subtle than correct or incorrect or ABCDF, or 97% — frequently it can be the reaction of a game character or a slight differentiation in points for one action over another.

Surprising – Good games frequently have unexpected rewards or achievements, which go a long way in maintaining attention and engagement.

Immediately related to the behavior – Game feedback can almost always be related to a direct behavior, and the player can frequently feed the new knowledge learned from that feedback directly back into their game play. This idea of immediacy is very similar to the timing of feedback research done by Kulik and Kulik (1988). A feedback is in fact effective when it is given in a timely fashion. Delay in providing students feedback diminishes its value for learning (Kulik & Kulik, 1988).

Rieber (1996b) said that learning is not simply determined by the amount of surface level interactivity in a learning task, but is a function of how meaningful the feedback is to the learner (p. 8). Even negative feedback, as suggested by Carroll and Swain (1993) when provided explicitly does contribute to learning. Ellis (2005) said that negative feedback can lead to better learning if it is given at a level appropriate to the learner's developmental stage. One of the events in Gagnè's (1985) Nine Events of Instruction is providing feedback. Similarly, in a meaningful game, proper and immediate feedback is an essential component. This feedback could be from a referee (if it is a field game such as basketball or cricket), or from the system

itself if the game is played on a board or with a computer. Csikszentmihalyi (1991) mentioned that meaningful games will lead to a state called *flow*. According to Csikszentmihalyi, flow is an emotional and psychological state of focused and engaged happiness when a person feels a sense of achievement and accomplishment, and refers to the optimal experience. While describing the optimal experience, Csikszentmihalyi gave a number of examples which includes, making music, rock climbing, dancing, sailing, chess and so forth. Further he explained that what makes these activities conducive to flow is that they have rules that require the learning of skills, they set up goals, they provide feedback, and make control possible (p.72). Salen and Zimmerman (2004) posited that players experience pleasure intrinsically while playing games, which is an essential ingredient for game play. Such game play is directly related to flow (p.337). Csikszentmihalyi (1991) admitted that it is rather easy to enter flow in games (p. 29) at least in part because games, like other flow activities, "provide immediate feedback" (p. 30). As an integral part of the learning process, feedback provides students with a sense of satisfaction and/or accomplishment. Such satisfaction results in extrinsic and intrinsic motivation (Cameron & Dwyer 2005).

Verificative feedback and Elaborative feedback

Kulhavy and Stock (1989) classified feedback messages into two categories based on content, namely, verificative feedback and elaborative feedback. Verificative feedback is the dichotomous message such as "simple yes or no" or right or wrong. Elaborative feedback consists of "anything more than yes-no or right-wrong" and substantive information (Kulhavy & Stock, 1989, p. 285). Further citing Roper (1977), Kulhavy and Stock (1989) said that the yes or no and elaborative feedback groups showed a significant increase in performance compared to the 'no' feedback control group. Even between the two types of feedback messages (verificative and elaborative), Clariana (1993) found that elaborative feedback is more effective. In 2005,

Cameron and Dwyer found that an instructional game with elaborative feedback is more effective in facilitating learning. Cameron and Dwyer (2005), in their experiment, created an instructional game that would teach the description, cyclic functions, and parts of a human heart. Four hundred and twenty two college level students were divided into four groups and the subjects were randomly assigned. Group 1 students received only instructional materials and did not play the educational game that would reinforce the instruction. Group 2 students played the game along with instructional materials, but without any feedback. Group 3 students played the game and were provided with simple yes or no feedback. Finally group 4 students played the game and were provided with elaborative feedback. Cameron and Dwyer found that the instructional game with questions and elaborative feedback was found to be significantly more effective in facilitating learning compared with the other three groups. Similarly, Mandernach (2005) found that students who received simple verificative feedback desire a more elaborative feedback. An elaborative feedback is more effective, since it gives more contextual information than a simple yes or no and thus makes students to think through the process to arrive at a solution.

Chapter summary

Games have been studied and discussed by scholars belonging to a broad spectrum of disciplines such as religious philosophers, anthropologists, psychologists, instructional designers and game designers. From east to west, every civilization and every ancient culture have realized the importance of games. Scholars say the play-element is an integral part of any real civilization (Huizinga, 1950). For the present generation, the play-element is manifested in many ways and video games are one such manifestation. Games are intrinsically motivating. Winning a game or rewards or awards are all considered as fringe benefits and the core reason for anyone to play is

the experience of the play itself. The core philosophy behind using games for educational purposes is based on constructivism. Both the flavors of constructivism, that is, radical constructivism and social constructivism support the idea of using games for educational purposes. Though scholars support the idea of using games for instructional uses, there is little research or empirical evidence available on what features are important in an educational game. It is worth quoting Kafai's (2006) words here: "With thousands of instructional computer games on the market, including popular titles such as Math Blaster, we know little about which features make an educational game good for learning" (p. 37). After an extensive review of literature, the researcher concluded that there are three important features that are required for an effective educational game. They are: challenges, fantasy and feedback. An instructional game should educate as well as entertain. In the above mentioned three features, fantasy makes the entertainment part. Challenge can be construed as both a pedagogical feature as well as an entertainment aspect. Feedback makes the pedagogical component.

Chapter III: Methodology

Introduction

The goal of this study is two-fold:

a. To determine whether instructional games augment learning.
b. To find out the impact of the challenge and fantasy features on learning in instructional games.

As mentioned earlier, the theoretical framework for educational games is based on constructivism. One of the main tenets of constructivism is that students construct their own knowledge. As Bruner (1966) mentions:

> The will to learn is an intrinsic motive, one that finds both its source and its reward in its own exercise. The will to learn becomes a 'problem' only under specialized circumstances like those of a school, where a curriculum is set, students confined and a path fixed. The problem exists not so much in learning itself, but in the fact that what the school imposes often fails to enlist the natural energies that sustain spontaneous learning. (p. 127)

It is evident from Bruner that instructional games should motivate students to construct their own reality. In the previous chapter, it was established from instructional game related literature that the most important features or design elements were identified as challenge, fantasy and feedback. Among these three features, feedback was identified as an important factor that contributes towards effective learning and retention. While feedback is considered an important feature, in this research, feedback is held constant for all versions of the video game created for this study. Since the positive impact of feedback on learning has already been well established in existing literature, feedback was not considered as an independent variable in the current study.

More specifically, following were some of the reasons for keeping feedback as a constant feature in the game that was created for this study:

1. There is sufficient literature to support the role of feedback in an instructional environment. Scholars who have done extensive research on feedback mention that any feedback (Wager & Wager, 1985; Kulhavy & Stock, 1989; Johnson & Johnson, 1993; Sales, 1993; Rieber, 1996a & 1996b; Dickey, 2005; Kulik & Kulik, 1988; Dirksen, 2010) positively augments learning and retention. For that matter, even negative feedback enhances learning retention (Carroll & Swain, 1993; Ellis, 2005).
2. By completely eliminating feedback from the game, the game would become artificial and that would be considered as a threat to the external validity of the study.
3. Another important question to ask is whether we can eliminate feedback in a computer based video game. Dirksen (2010) says that feedback comes in the form of sounds, visuals, story narration, and interactions with characters, points and rewards. So we can argue that there cannot be a video game without the feedback feature. It is important to note that we can reduce the two independent variables challenge and fantasy to a bare-minimum level and still consider the resulting version as a videogame. If however we try to reduce feedback to a bare-minimum level, we would no longer have a video game as any form of interaction with the video game system is considered a feedback (Dirksen, 2010).

Therefore the study examines the impact of fantasy and challenge in instructional games on learning while holding the feedback feature as a constant.

This chapter has the following sections:

1. Research questions and hypothesis
2. Theoretical model and research variables defined
3. Study design explained
4. Context of the study
5. Intervention, i.e. Humatan game explained
6. Pilot study
7. Data collection
8. Data preparation and logging
9. Data analysis

Research questions

The broad question that this study aims to answer is: what are the important features of an instructional game that make it entertaining as well as educational? Since fantasy and challenge are known to be effective features in gaming from previous literature, it is important to see their effect on learning in educational games.

More specifically the questions are:

1. Is there a correlation between the pretest score and the posttest score?
2. What is the impact of including challenge as a design feature of an educational game?
    - In a statistical framework, this question can be stated as: Are there significant mean differences for achievement scores between students who play games with the challenge feature turned on and those with the challenge feature turned off? This is one of the main effects that the researcher would like to find from the study.
3. What is the impact of including fantasy as a design feature of an instructional game?

- In a statistical framework, this question can be stated as: Are there significant mean differences for achievement scores between students who play games with the fantasy feature turned on vs. those with the fantasy feature turned off?

The above two questions denote the main effects that the researcher would like to find from the study. The above questions look at these main effect individual. To test each of these, only the given feature is turned on.

In addition to testing for the effects of each factor individually, a two way ANOVA will evaluate mean differences that are the result of unique combinations of levels of the two factors, fantasy and challenge. The study also tries to answer the following additional questions:

4. Statistically can we state whether or not there is a significant interaction on achievement scores between students who play games with both the fantasy feature turned on and the challenge feature turned on?

The gender, GPA, game skillfulness, and pretest scores are also variables that might influence or be related in some way to the gain score, which is the dependent variable of the study. Hence, these are considered as covariates in the present study. It follows that we must account for the effects of these covariates before we try to find the main and interaction effect of challenge and fantasy. Therefore, the following additional questions will be answered from this study:

5. Are there significant mean differences for achievement scores between Male and Female students?
6. Are there significant mean differences for achievement scores between students with high GPA and low GPA?

7. Are there significant mean differences for achievement scores between students with high SES and low SES?
8. Are there significant mean differences for achievement scores between students with different levels of students' perceptions about their game skillfulness?
9. Are there significant mean differences for achievement scores between students of various ethnic backgrounds?

To answer the main research question of the study regarding game features, there were three hypotheses stated in the study and it is important to note that these hypotheses are stated as alternative hypotheses. But it was recognized that the statistical testing was conducted against the null hypotheses.

H1: A game that has challenge will positively impact learning.

H2: A game that has fantasy will positively impact learning.

H3: A game that has both challenge and fantasy features will have a higher positive impact on learning than a game with one of these features as well as a game with none of these features.

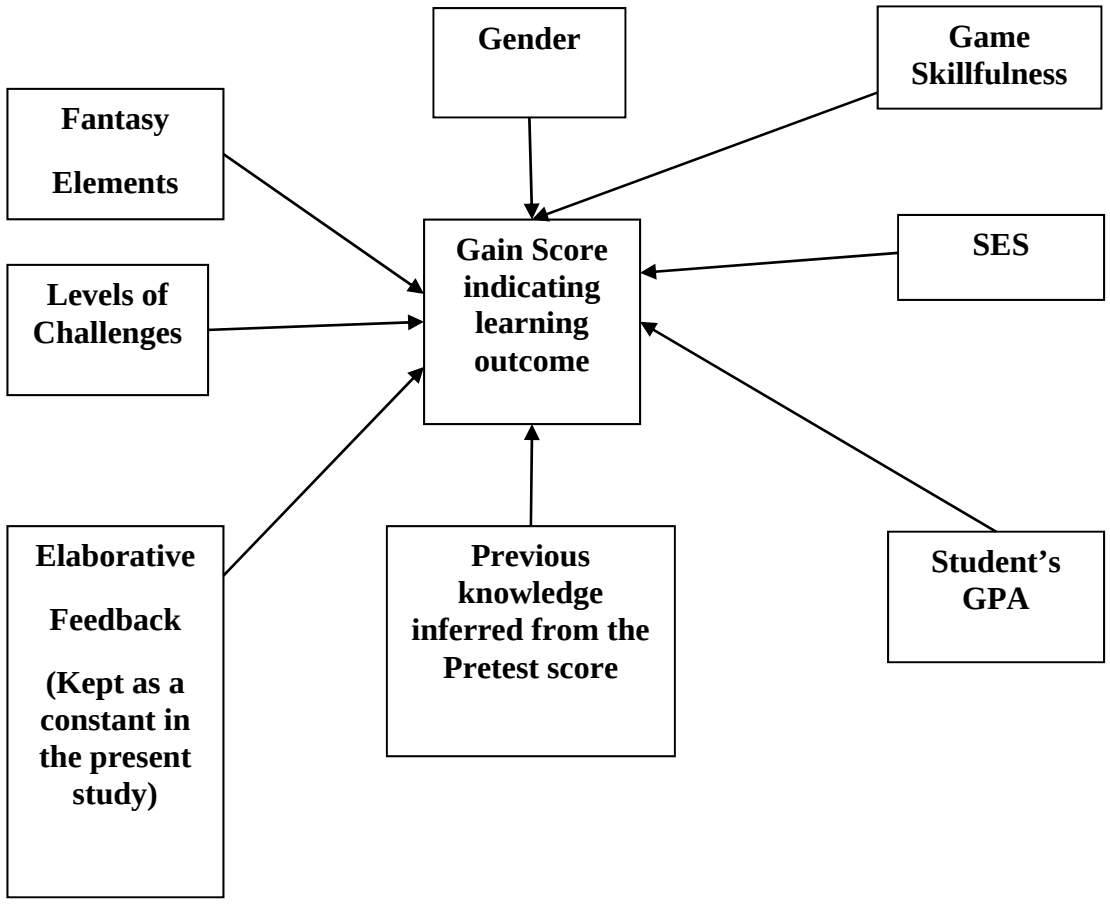
Theoretical model and research variables defined

In this section a theoretical model for various game features and other variables and their relationship to learning in an instructional game is shown in Figure 3. In this section, the model is presented followed by an explanation of the model. Later, each variable will be discussed in detail.

The theoretical model of game features and other covariates that influence learning is shown in Figure 3. In this model the dependent variable is the gain score (posttest score minus

pretest score). Improvement in learning was measured in this study using the gain score. The alternate hypotheses suggest that video game features such as challenge, fantasy, and feedback should positively impact learning. Along with these features, there are learner characteristics that could be confounding variables that may also impact learning: gender, grade point average (GPA), socio-economic status (SES), game skillfulness, and prior knowledge. A pre-test was administered to assess the prior knowledge, before the intervention. These variables are explained in more detail below:

Figure 3 – *Game features and other covariates that influence learning*



A. Dependent Variable

The dependent variable is the measure of the learning outcome. In this study, the measure used is the gain score. Gain score is the difference between the posttest and the pretest scores. The posttest score and pretest scores are obtained by summing up the identification test score, terminology test score, and the comprehension test scores. All the six tests (three pretests and three posttests) are attached in the Appendix A - F. These tests are designed to

measure the overall achievement of the learning objectives presented in the curriculum followed by the Baltimore County Public Schools (BCPS).

B. **Independent Variables: Video Game Features**

The features of video games and their importance were examined in the previous chapter. Based on the previous literature and scholarly work, and the theoretical framework established by the constructivist's school of thought, this study examines the following as independent variables: challenge, fantasy and feedback. The importance of each of these is defined below. The operationalization of these variables will be discussed later in this chapter.

Feature: Challenge

Whether in a game or in an educational setting, challenge motivates people. As discussed in the literature review chapter, games that include any form of challenge including conflict, competition, and/or opposition give gamers an adrenaline rush (Prensky, 2001). Gamers love such challenges. Challenge makes instructional games interesting as well as pedagogically effective.

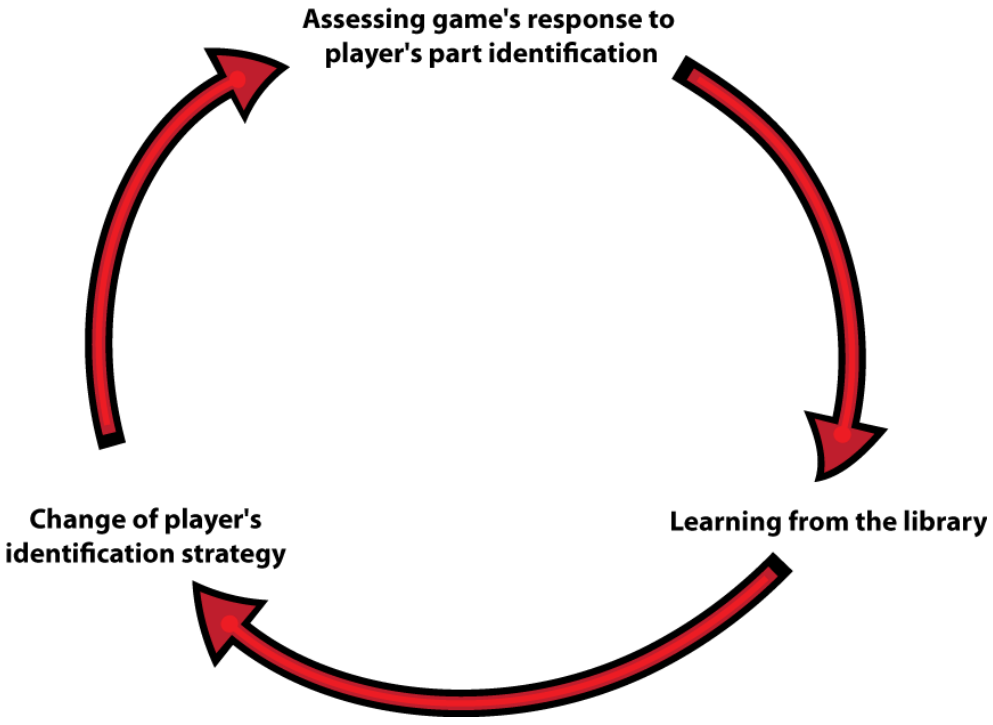
Feature: Fantasy

Scholars say that fantasy plays an important role in a child's development. It positively supports language and social skills through role-playing (Cassel & Ryokai, 2001). In an edutainment setting, meaningful and appealing fantasy contexts enhance users' interest in playing the game while also promoting learning (Parker & Lepper, 1992). The literature review chapter of this dissertation discusses several scholarly works that support the role of fantasy in an educational game.

Feedback

From existing literature, it is apparent that feedback is a very important component for better learning (Wager & Wager, 1985; Kulhavy & Stock, 1989; Johnson & Johnson, 1993; Sales, 1993; Rieber, 1996; Dickey, 2005; Kulik & Kulik, 1988; Dirksen, 2010), and that even verificative feedback messages (simple yes/no) are a subset of elaborative feedback. Because any feedback is found to be effective it will be kept as a constant in all the variations of the Humatan game. Capra's 1996 causality of a feedback loop for Humatan level 2 is represented here for the present context in Figure 4:

Figure 4 – *Representation of feedback implementation in the Humatan game*



C. Confounding Independent Variables

The following variables might influence or be related in some way to the gain score, which is the dependent variable of the study:

I. **Gender:** As discussed in chapter 2, there is a discrepancy between male and female students in their attitude towards video games in general. In a study conducted by Hartmann and Klimmt (2006), it was found that girls and women are less involved with video games than are boys and men, and when they do play, they often prefer different games. However recent indications from the industry give a slightly different picture. According to the entertainment Software Association (ESA), the number of girls vs. boys as video game players is changing in the recent times. According to ESA, women constitute 42% of all game players. Women over the age of 18 represent 37% of the game playing population, whereas boys of age 17 or younger represent only 13% of the game playing population (The Entertainment Software Association, 2011). This study will test whether the Humatan game has the same effect on learning for both male and female students. Hence gender is considered as a confounding independent variable and is coded 0 = Female; 1 = Male.

II. **GPA:** GPA is commonly used as a measure of academic performance (Spitzer, 2000). GPA is also linked to academic self-efficacy, intrinsic motivation and self-regulation. Therefore, GPA is considered as one of the covariates, since literature suggests that students who have a good GPA may tend to perform better overall.

III. **Game skillfulness:** Game skillfulness refers to the participants' perceptions of their game skills and familiarity with different video game consoles. The survey (Appendix G) asked students how skillful they were at playing video games. Since research

interest in the field of instructional gaming is rather recent, there were no surveys available in the literature which could be adapted for the present study. Hence the researcher prepared a survey instrument, and this survey instrument was sent to the Survey Research Lab at University of Illinois at Chicago for review. The final version of the survey instrument was based on the feedback received from the Survey Research Lab of University of Illinois at Chicago. Game skillfulness is an ordinal measure with three categories of low skilled gamer, moderately skilled gamer and highly skilled gamer. The calculation of this measure will be described in more detail later in this chapter.

IV. **SES:** The Socioeconomic status (SES) information refers to the percentage of students enrolled in the free and reduced meal scheme offered by BCPS. This data was provided by BCPS.

V. **Ethnicity:** Students were asked to provide their ethnic background in the survey.

This study considers the effect of these confounding independent variables on gain scores in finding out the main effects and interaction effects of the primary independent variables. Any variable that theoretically correlates with the dependent variable in a research study should be considered as a covariate (Stevens, 2001; Mertler & Vannatta, 2010). A covariate is an independent variable that is not controlled by the researcher but affects the dependent variable.

The model described here contains a dependent variable (gain score), two independent variables (challenge and fantasy), and five covariates (gender, GPA, SES, game skillfulness and ethnicity). In this study, data was collected to determine how the independent variables and covariates impact the gain score. In the next section of this chapter the following aspects are explained:

1. Study design
2. Context of the study
3. Intervention: Design of the game “Humatan”
4. Operationalizing the independent variables: Game features
5. Operationalizing the confounding independent variables
6. Data collection

Study design

This study is a univariate. A univariate study has only a single dependent variable. The univariate case of ANOVA is a hypothesis testing procedure that simultaneously evaluates the significance of mean differences on a dependent variable between two or more treatment conditions or groups (Agresti & Finlay, 2009). In this study the single dependent variable is the gain score, the indicator of the learning outcome. The treatment conditions or groups are defined by the various levels of the independent variable in ANOVA terminology. Studies that include more than one factor or variable are known to follow a factorial design. In this study, the researcher has included the following independent variables:

1. Game features (has four levels: challenge on, fantasy on, both on and none on),
2. Gender (has two levels: male and female)
3. GPA (has four levels based on BCPS GPA classification: low, medium-low, medium-high, high)
4. SES (has two levels based on BCPS SES data: middle and high)
5. Game skillfulness (has three levels: low, moderate and high)
6. Ethnic origin (has six levels: African, Asian, European, Hispanic, Middle-Eastern, Native American)

To find the main effects of the game features, a univariate analysis was used. To find out the individual differences the study used the X x Y factorial design model in this study. A typical factorial design is represented in Table 1 shown below (based on Trochim, 2000):

Table 1 **–** *Factorial design representation*

R	X_{11}	O
	X_{12}	O
	X_{21}	O
	X_{22}	O

R= Random Assignment; X=Intervention; O=Observations or measures

Table 2 illustrates the levels for the independent variable feature and the covariate gender. Table 3 shows how these levels and factors combine to form a factorial design based on Trochim's idea.

Table 2 **–** *Levels of Independent variable feature and confounding variable gender*

IV: Factor A: Feature	
Level 1	Challenge feature turned on (Fantasy off)
Level 2	Fantasy feature turned on (Challenge off)
Level 3	Both features turned on
Level 4	None of the features turned on

IV: Factor B: Gender	
Level 1	Female
Level 2	Male

These two factors form a 4X2 factorial design, as shown below in Table 3:

Table 3 **–** *Factors and their levels*

		Gender (Factor B)	
		(Level 1) Female	(Level 2) Male
Features (Factor A)	(Level 1) Challenge on	Gain Scores	Gain Scores
	(Level 2) Fantasy on	Gain Scores	Gain Scores
	(Level 3) Both the features turned on	Gain Scores	Gain Scores
	(Level 4) None of the features turned on	Gain Scores	Gain Scores

Factorial design not only tests the significance of group differences (due to the levels of the independent variables), but also tests for any interaction effects between levels of independent variables (Mertler & Vannatta, 2010). In the current context, factorial design not only tests how challenge and fantasy features affect the learning outcome, but also tests the combined effect of gender, GPA, SES, game skillfulness and ethnic origin on the learning outcome measured by the gain score.

Context of the Study

The research was conducted at the Baltimore County Public Schools (BCPS). The BCPS Director of Science and Technology Program agreed to carry out the study in the high schools within BCPS. There are twenty five high schools within BCPS. Not all the schools follow the same state curriculum. The Humatan game was designed to incorporate the following standards:

1. Para-medical Biology: The Human Body (standard 20.4)
2. Human Anatomy: Support, Protection and Movement (standard 12.3)

Those schools which followed either or both the above standards were identified for the current research by the school district's Office of Science PreK-12. A total of ten schools were selected out of the twenty-five high schools by the BCPS. A detailed description of the sample will be provided later in this chapter.

Intervention: Design of the game "Humatan"

Humatan is an instructional game where high school students will learn to identify and assemble human skeletal structures. This game is specifically developed to address the following standards of Baltimore County Public Schools (high school) curricula:

1. Para-medical Biology: The Human Body (20.4)
2. Human Anatomy: Support, Protection and Movement (12.3) of the BCPS Curriculum

Storyline of the game

It is 1369 BC. King Akhenaton is Egypt's ruler, with Queen Nefertiti by his side. They don't have any children yet. A learned scribe has told the King that the ancients had been aware of this and had, with their immense skills, created two little human bodies, that of a male child and a female child, with all the body parts separated and hidden away in the royal palace rooms long ago. This scribe knew how to pray to Lord Anubis to bring the children back to life provided they could find all the body parts hidden in the palace and assemble them together.

It is now up to the player to find all the parts, get them to the court room, and assemble them correctly to make the new heir to the throne come alive. The player is made aware that during the quest there could be all sorts of danger lurking everywhere.

On the opening screen of the game (Figure 5), the player is given the storyline (please see more on turning the fantasy “On/Off” for the variations of the opening screen) and asked to board a ship to travel in time to reach Egypt in 1369 BC.

Figure 5 – *Humatan Opening Screen*

Game levels

There are three levels in the Humatan game. These levels are described in detail below.

Level 1

When a player arrives at the palace of King Akhenaton and Queen Nefertiti, the player is informed that the palace is under attack by the enemies from the Hittites empire and that the player needs to shoot down all the enemies and collect the labeled parts of the skeleton that are

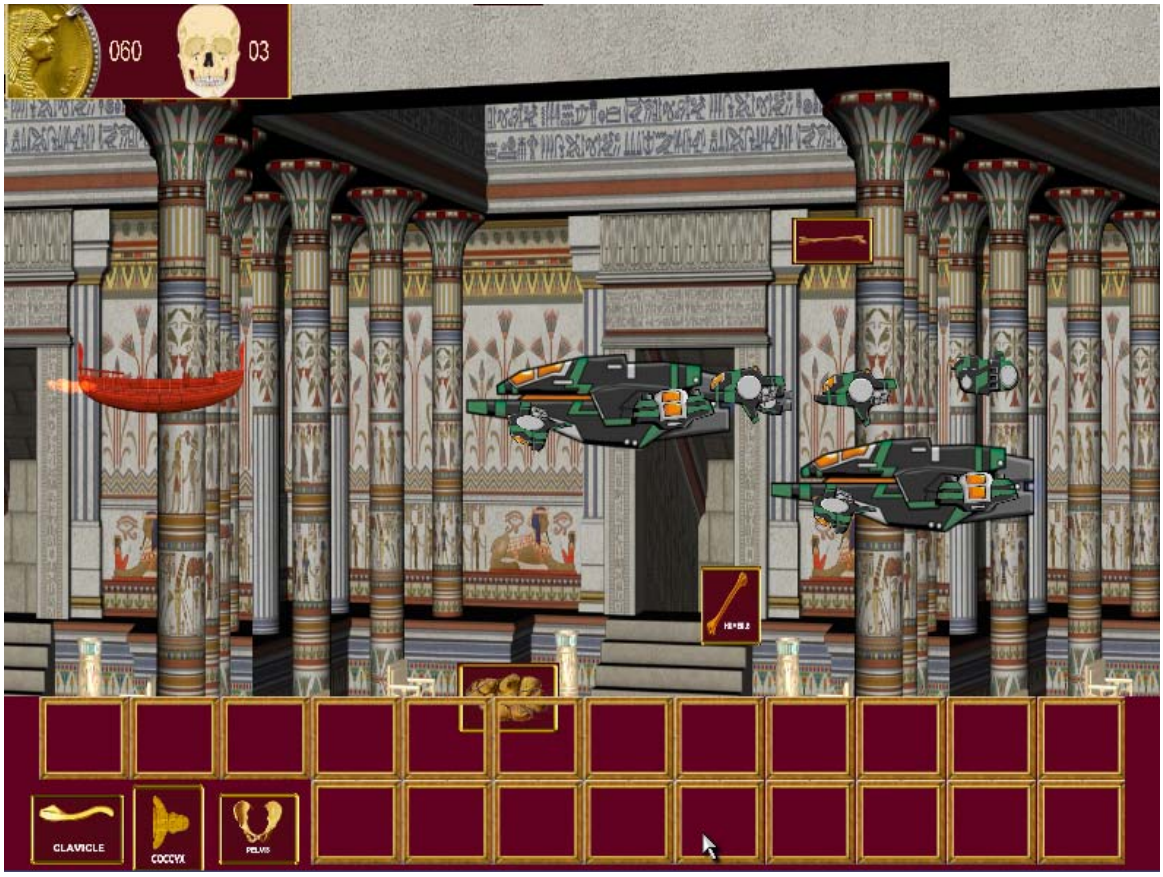
being dropped from the top. This level (Figure 6) enables the player to be adventurous, escape from, and shoot the enemy ships. This level is comparable to a first-shooter game genre within which the player is also learning the parts of the skeleton. This level also enables the player to acquire points by shooting the enemy ships and the mega-ships.

Instructional strategy

1. **Challenge:** Enemy ships add to the challenge aspect of the game, making it difficult for the player to stay alive in the game. The purpose is to motivate the player to play the game again and again to get higher scores, so that the visual feedback is repeatedly reinforced.
2. **Fantasy:** When the fantasy aspect is turned on, an Egyptian palace theme will be applied, and the room will appear to be in constant relative motion, giving the feeling that the player's vehicle is traversing through the palace.

In the Humatan game for the first level, students have to pick-up the skeletal parts. Figure 6 shows a snapshot of this level.

Figure 6 – *Humatan Game Level 1: Picking up Parts*

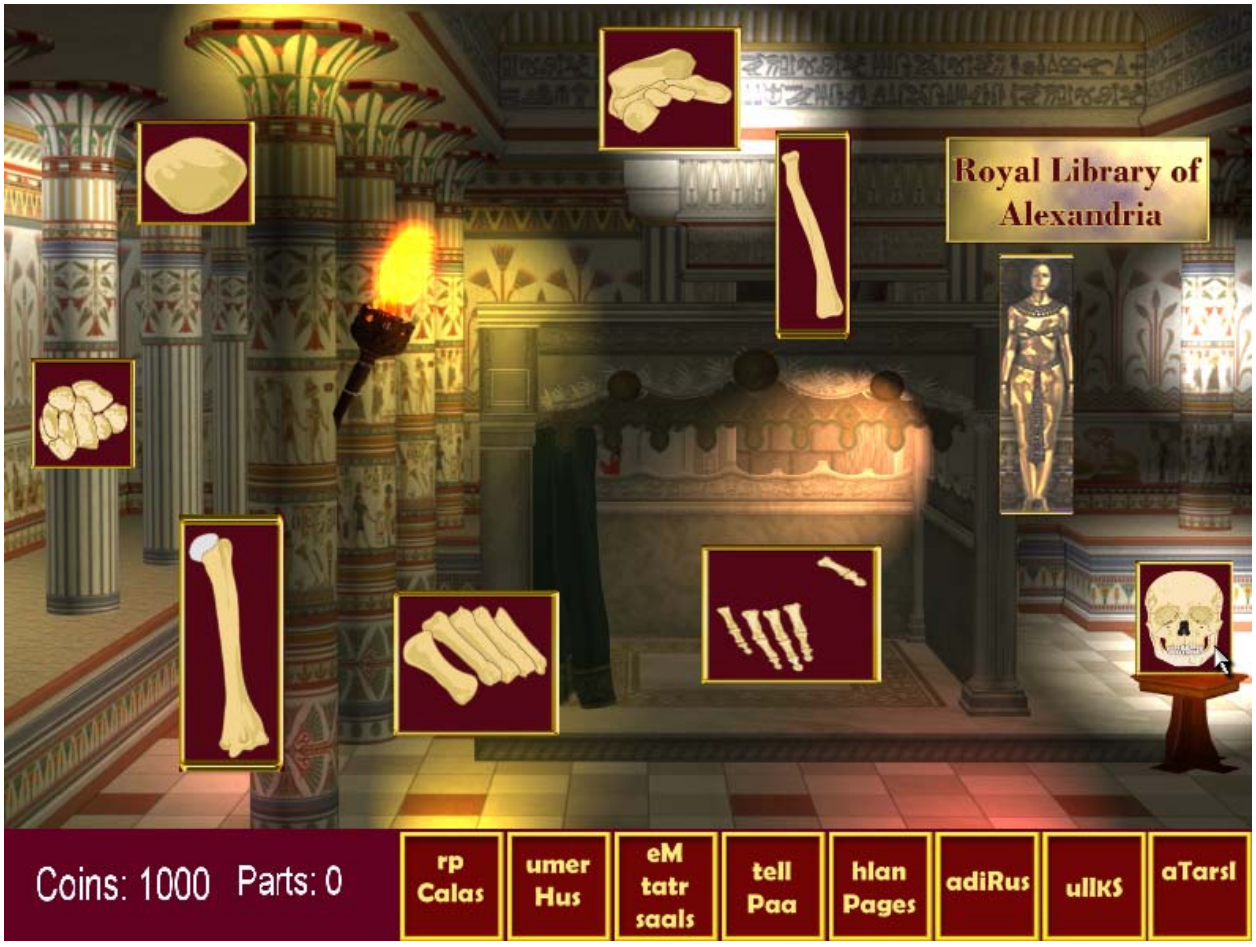


Level 2

At Level 2 (Figure 7), the player tries to identify the parts. The following storyline was shown: “Congratulations! You picked up all the parts. Now the Scribe wants you to prove that you know what each part is. So, please identify them before you can assemble them.”

In this level, the parts of the skeletons are spread out in a room. All the skeletal parts’ names are shown as scrambled word tiles on the bottom of the screen and the player has to drag and place them on top of the right part.

Figure 7 – *Humatan Game Level 2: Identification of Parts*

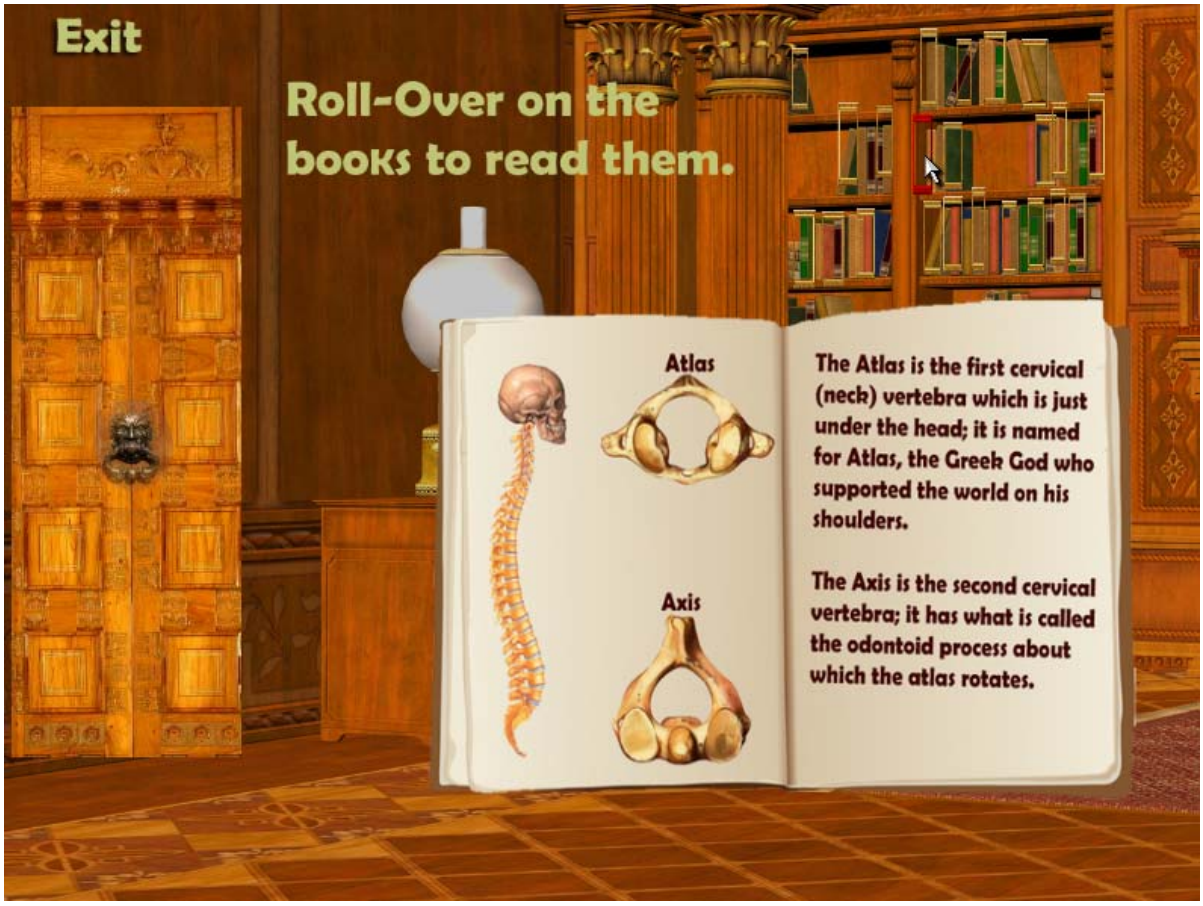


Instructional strategy

1. **Challenge:** All the body part labels are jumbled and the player has to first understand the word correctly and then try to match with the appropriate parts and the labels.
2. **Fantasy:** The narrative from the scribe, the Egyptian room, and the Alexandria library are the fantasy aspects in this level.

Figure 8 shows the library, where students can get more information about each skeletal part.

Figure 8 – *Reference Library available in all variations of the game to keep feedback as a constant*



Level 3

During the third level the player enters a room where a body outline is displayed. The player is able to drag and drop various skeletal parts to assemble the body to give life to the prince or princess. All the skeletal parts are kept in the room for the player to drag and drop.

Instructional strategy

1. **Challenge:** During the third level, Humatan is played as a Quest game. Various body parts are embedded in different places on the screen and the player is challenged to find the right parts to place it in the right position in the body.
2. **Fantasy:** The Egyptian theme background, storyline, mummy case for skeleton, and finally Lord Anubis gives life back to the heir. Once the parts are successfully acquired, labeled, and put together, the scribe then prays to give back life to the correctly constructed skeletons, since their bodies are now ready. Lord Anubis now is seen granting life to the prince or princess to be.

Operationalization of independent variables: Game features

In order to define the game variables challenge and fantasy into quantitatively measurable factors, they have to be operationalized. In this section I will describe how the variables in this study were operationalized. Figure 9 illustrates the relationship between the instructional game features and other covariates that influence learning. The feature held constant in all versions of the game is feedback. The operationalization of feedback feature at each level is illustrated in Figure 10.

Figure 9 – *Game features and other covariates that influence learning*

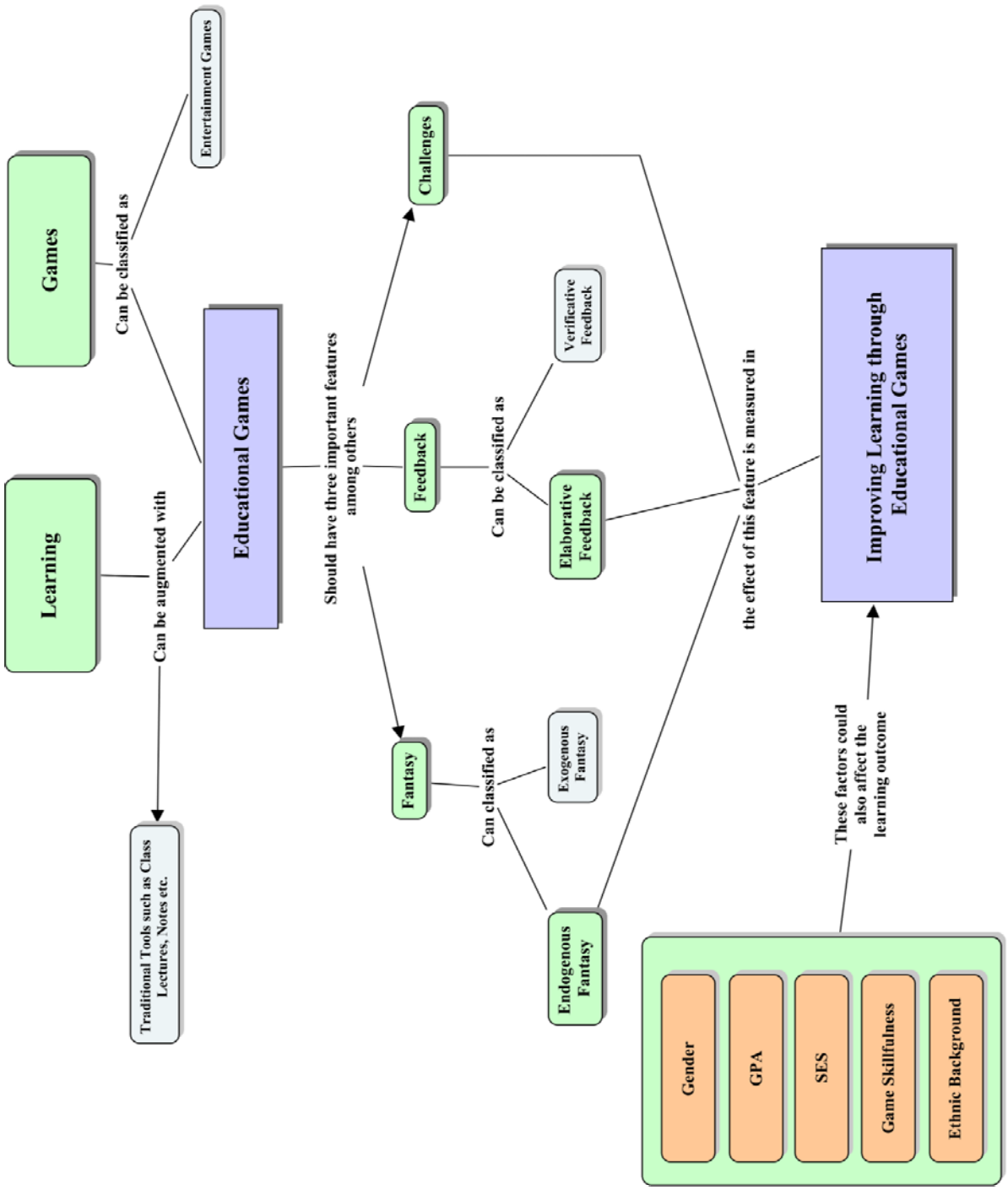
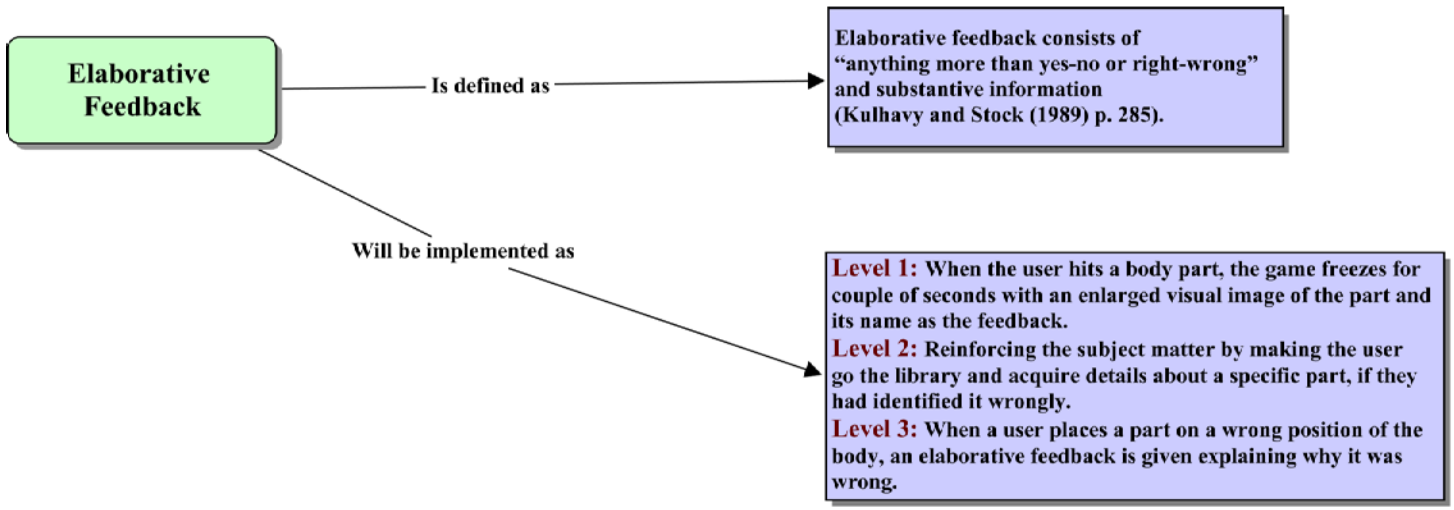


Figure 10 – *Elaborative Feedback implementation in the Humatan game*



Operationalizing the Elaborative Feedback Feature in Humatan Game

Elaborative Feedback will be kept as a constant in all the four variations of the Humatan Game

I. **Turning Fantasy on/off**

Table 4 shows how the fantasy feature is operationalized in the present study:

Table 4 – *Operationalization of Game Variable – Feature: turning Fantasy on/off*

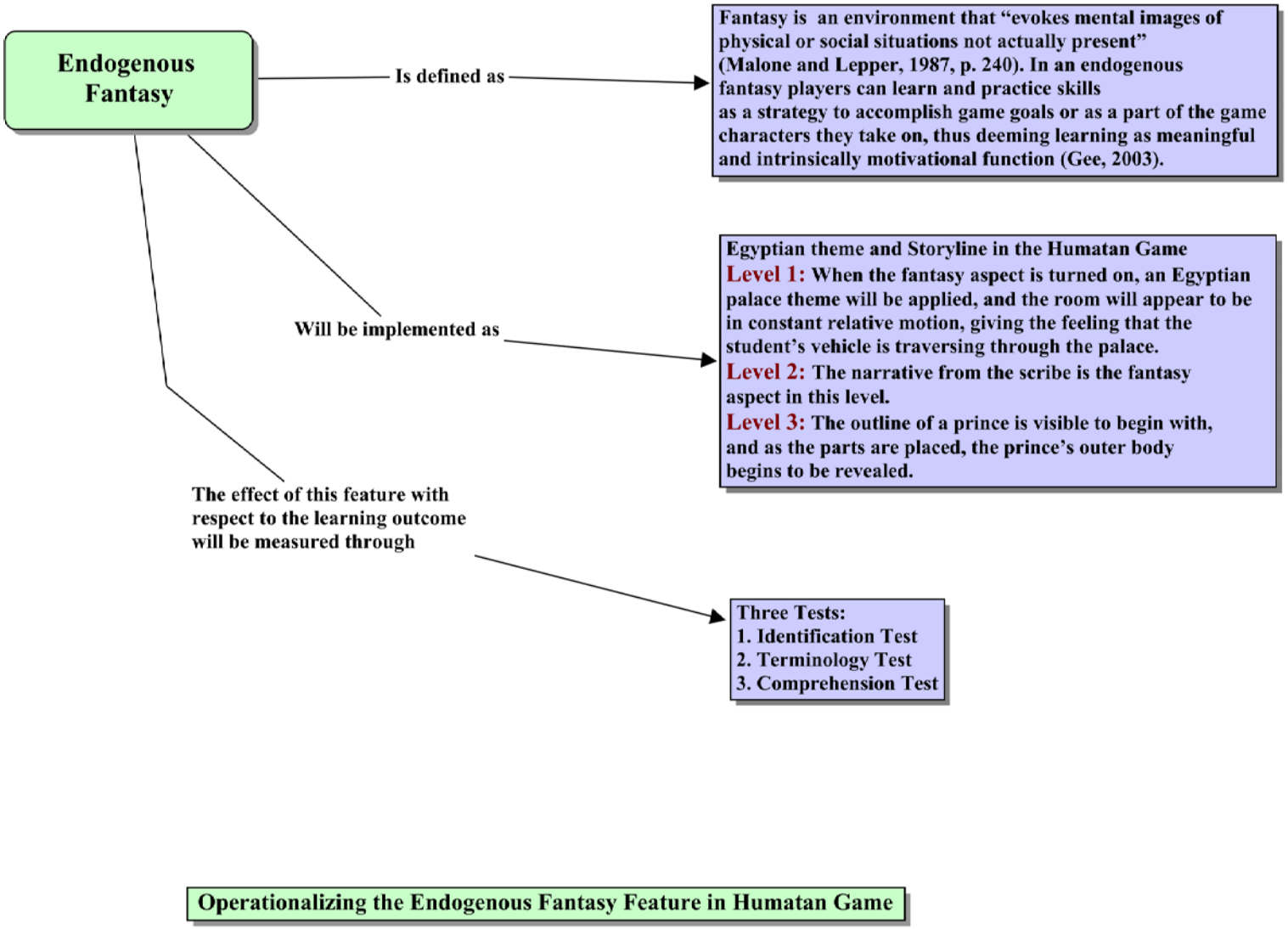
Game Levels / Fantasy	Level 1 Acquiring Parts	Level 2 Identifying Parts	Level 3 Assembling Parts
On	Egyptian environment, goal is to get parts for a prince.	Egyptian environment. Scribe will tell a story to identify the parts.	Egyptian environment. Lord Anubis will grant life.
Off	No environment or narration.	No environment or narration.	No environment or narration.

The following features were turned off or on:

1. When the fantasy aspect is switched off, the player plays in an environment where there is no narration or compelling Egyptian theme. The goal for the player is to pick-up, identify and assemble the skeleton. The starting screen has instructions on how to play the game and the following screen has a black background and contains bare minimum images and text.
2. When the fantasy feature is switched on, the player plays in an Egyptian environment with all the narration and Egyptian characters. The goal for the player is to time travel and bring to life the Heir to the throne.

The definition of fantasy and how this feature was operationalized in each level is shown in Figure 11.

Figure 11 – *Endogenous Fantasy feature implementation in the Humatan Game*



II. **Turning Challenge on/off**

Table 5 shows how the challenge feature was operationalized in the present research.

Table 5 – *Operationalization of Game Variable – Feature: turning Challenge on/off*

Game Levels / Challenge	Level 1 Acquiring Parts	Level 2 Identifying Parts	Level 3 Assembling Parts
On	The player will have to shoot and avoid getting hit and acquire all the parts before they fall down. Otherwise they need to play the level again.	The player will have to identify the parts with scrambled labels, and has to complete the identification process.	The player will have to first find the parts in order to complete the assembly process.
Off	Only the parts will fall down at a slow pace and the player must pick them up.	No scrambling of labels will be there. Players can see the correct labels for the parts when they play the level.	The parts will be easily displayed. Players can take the parts and drag it onto the skeleton to play the level.

The following aspects were turned off or on:

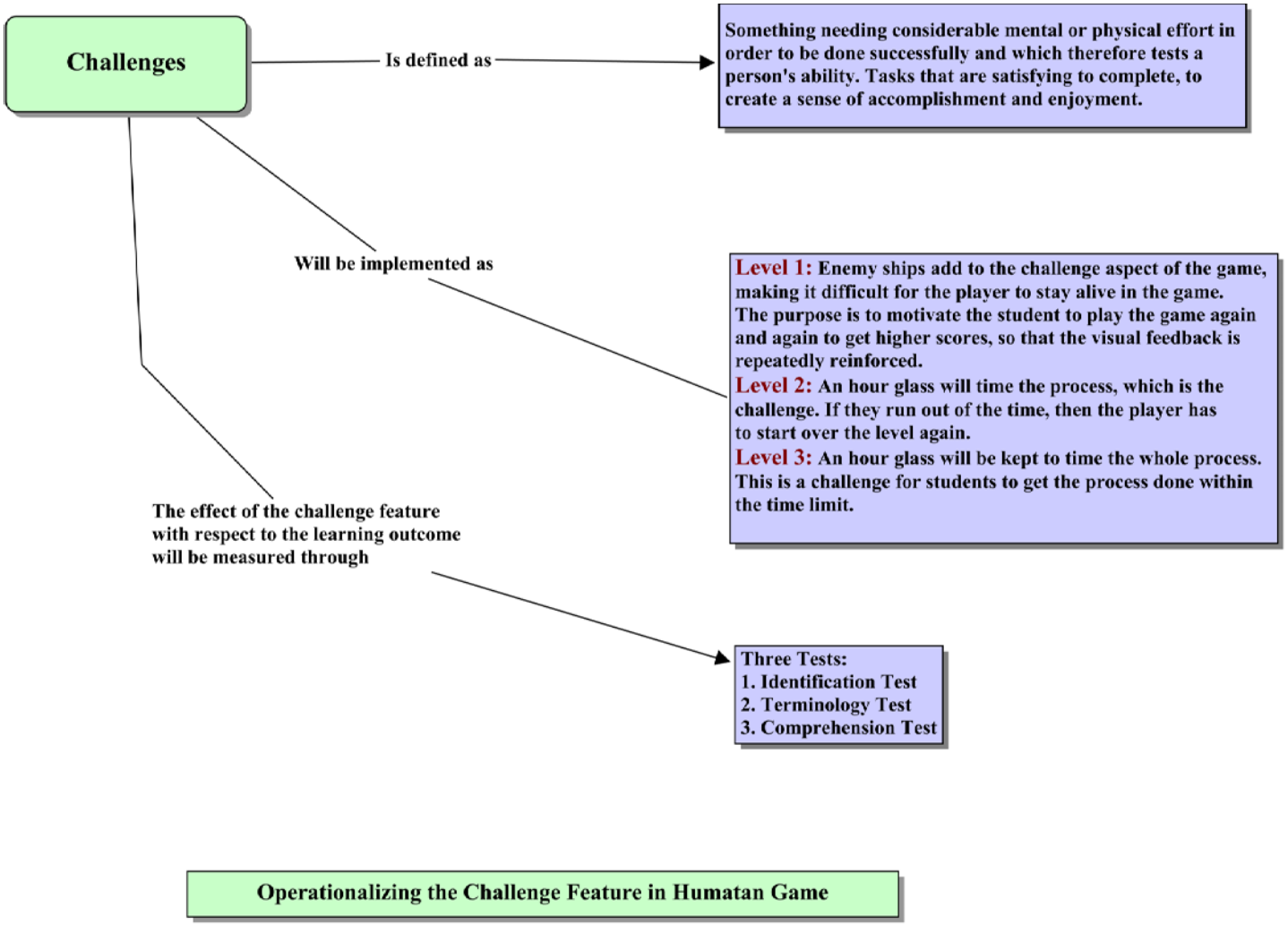
1. When the challenge feature is switched off, the game version will not have the mentioned features pertaining to challenge. This may mean less time spent in the learning environment, since the player will complete each level easier and may not revisit a level. One thing to note is that in the challenge off version of the game, the game may be

considered to have some bare minimum level of challenge since the players do need to perform some actions. For example, in level 1 they must still pick up the parts. However the challenge in this version of the game is kept very minimal.

2. When the challenge feature is switched on, the player is constrained with shooting enemy ships, identifying scrambled part labels, and with a quest for parts. This enhanced challenge, as compared to the minimal level on the challenge-off version, may result in spending more time in the learning environment.

The definition of challenge and how the challenge feature was operationalized in each level is shown in Figure 12.

Figure 12 – *Challenge feature implementation in the Humatan Game*



Humatan game variations

The Humatan game was made in such a way that the various features (variables) were turned on and off. Four variations of the game were created and students were randomly assigned to play each variation of the game. Table 6 shows the four variations of the game created for the present study:

Table 6 – *Game Variations*

	One game with challenges alone (No fantasy)
	One game with fantasy alone (No challenges)
	One game with both variables
	One game with none of the variables

Operationalizing the confounding independent variables

As discussed earlier, there are confounding independent variables in this study: gender, GPA, game skillfulness, SES and ethnic origin. Operationalization of each of these variables is described here:

I. **Gender:** Gender was included as a question in the survey (See Appendix G). The variable was coded 0 = Female; 1 = Male.

II. **GPA:** While doing statistical analysis, the range of high school GPAs was split into four groups and coded as shown below. In the present study, GPA was entered by students in the survey by selecting one of the options given below. The

classification of GPA shown here was adopted from a study conducted by Waugh and Micceri (1994).

a. 1 – low (< 2.5)

b. 2 – medium-low (2.5–2.9)

c. 3 – medium-high (3.0–3.4)

d. 4 – High (> 3.4)

III. **Game skillfulness:** Game skillfulness was an ordinal measure with three categories of low skilled gamer, moderately skilled gamer and highly skilled gamer.

1. Low skilled gamer coded as 0 [0 – 33.32%]
2. Moderately skilled gamer coded as 1 [33.33 – 66.65%]
3. Highly skilled gamer coded as 2 [66.66% - 100%]

The researcher arrived at the above percentages by combining the individual coding for questions 1 – 7 on the game skillfulness survey as follows:

$$Xgs = X1/N1 + X2/N2 + X3/N3 + X4/N4 + X5/N5 + X6/N6 + X7/N7$$

$$\text{Game Skillfulness} = Xgs/7 * 100$$

Xgs = Combined Coding for Game skillfulness

Xi = Coding for Response to Question Qi by the student

Ni = Maximum Possible Coding for Response to Question Qi

The above scheme of coding is illustrated for question number one:

Question: How much enjoyment do you get from playing video games?

a) A great deal

b) A lot

c) A moderate amount

d) A little

e) Not at all

Suppose a student picked answer “b” (a lot), then, b was coded as 4. When applying the above formula:

X1/N1 = Code Value for b / Maximum Possible Coding for Q1

= 4/5

= 0.8 (which is equivalent to 80%)

IV. **SES:** The Socioeconomic status (SES) information was obtained from the percentage of students enrolled in the free and reduced meal scheme offered by BCPS. It is important to note that the SES information was not obtained directly from the students. The BCPS district office provided aggregate data for each school.

V. **Ethnic origin:** Students were asked to select from one of the following options from the survey about their ethnic background: African, Asian, European, Hispanic, Middle-Eastern, and Native American.

Pilot study

In March of 2010, a pilot study was conducted in one of the schools affiliated to the BCPS. Both female and male students participated and played a prototype version of the Humatan game and gave several comments to improve the game experience and usability. For example, in the first level when a body part was captured, one student mentioned that it would be nice to see a bigger version of the skeletal part, so that they can learn that part clearly. Students also achieved multiple levels quickly, which showed the researcher that data collection could be done within 45 – 60 minutes. The game was also tested by the BCPS Office of Science PreK-12 for its content and usability.

Data collection

Data was collected at nine BCPS high schools. The data collection steps are elaborated in this section.

The researcher approached the Office of Science at BCPS, since he was living in the Baltimore County. The Office of Science sent out a memo to various high schools and 10 schools expressed their desire to participate in the study. The Office of Science provided the list of biology and para-medical teachers and their contact information to the researcher. After Syracuse University and BCPS approved the study, the researcher contacted the teachers and explained to them the nature of the study. A date, time, and classroom location was identified by the teacher for each school. On the identified day, the researcher went to the specified classroom on the specified date and time, and explained the study to the students, in the presence of the teacher. During this time, students who were under 18 years were given both an assent form (See Appendix L) as well as a parental consent form (See Appendix K). These students were asked to get parental consent by getting one of their parents' signatures in the

parental consent form as well as have them sign the assent form if they wanted to participate in the study. Students who were 18 years or older were given a written consent and were asked to sign the written consent if they wanted to participate in the study (See Appendix J). If the parents and/or student did not want the student to participate in the research, they were not required to sign the written consent/assent documents.

The researcher went to each school again to collect all the signed consent and assent forms. At this point, the teacher was requested to leave the classroom until all the consent forms were collected from the students. When collecting the assent forms from the under 18 age group of students, the researcher verified that a signed parental consent form also accompanied the assent form.

After receiving the signed assent and consent forms, a date was fixed for each school to conduct the study in consultation with the teachers. The Humatan game was deployed on each computer at the school on the day before data collection in the assigned computer lab and was tested thoroughly. The researcher visited the classroom again to inform every student that whoever had given their consent to participate in the study should come to the computer lab during the specified date and time.

Finally, on the day of the data collection, in the absence of the teacher, the students were given a final opportunity to withdraw from the study. The researcher explained the study one more time orally and the students were told that they could at that time also withdraw from the study.

Thus, it was explained to the students on three occasions the purpose of the study and the voluntary nature of the research:

1. In the beginning, when the researcher went to the classroom and explained the study
2. On a second occasion through the parental consent form, written consent and assent forms
3. Finally, on the day of the research, an oral explanation right before the start of the data collection procedure

Therefore the students had sufficient opportunities to think about the study and make an informed decision about their participation.

Step 1: Students who had the consent and/or assent forms properly filled-in and who had agreed to participate in the study were randomly assigned to different computers on the day of data collection.

Students were randomly assigned to one of the following four groups:

1. One group played the game with only fantasy turned on.
2. One group played the game with only challenges turned on.
3. One group played the game with both features turned on.
4. One group played the game with neither feature turned on.

Step 2: Each computer was installed with one of the game variations (Challenge On, Fantasy On, Challenge and Fantasy On, Challenge and Fantasy Off). Each computer having a particular game variation was considered a separate instance of the game variation. In order to start, each student clicked on a link, which generated a unique ID based on the variation and instance of the game installed on the computer and this unique ID was pre-programmed electronically into each form in each computer.

Thus, when students were randomly assigned to a computer, they automatically got assigned to a particular variation and instance of the game, and thereby to a unique ID.

The forms in the computer did not display the ID to the student, but were tagged with the ID internally. When the form data was stored, it was stored along with this ID, and was in no way connected back to the student.

Step 3: How was the unique ID assigned to the student? When a student sat next to a particular computer, the unique ID pre-programmed in the computer was automatically assigned to the student. The student did not know the unique ID. The forms in the computer also did not display the unique ID but were automatically tagged with the appropriate unique ID. This step was used to avoid human error in mistyped ID.

Step 4: When students clicked on the Internet link shortcut icon, they were presented with pretests (See Appendices A – C). Once they completed the pretests, they began playing the game. At the end of the game, the students were shown the posttests (See Appendices D – F). Once they completed the posttests, the students were shown the survey form. The survey was designed not to ask students for any personally identifiable information such as name or student ID. Question number 12 on the survey instrument was intended to capture the student's GPA range as follows:

Under what range does your current Grade Point Average (GPA) fall? (Circle only one choice. Please do not provide the actual GPA.)

4.0 – 3.5

3.0 – 3.4

2.0 – 2.9

Below 2.0

Step 5: On completion of the survey, the students submitted the form, and exited the system. The pretest, posttest and survey forms were automatically saved into a password protected online database.

The pretest and the posttest consist of identification test, terminology test and comprehension test. These tests were modeled after Dwyer and Dwyer (1987) and Cameron and Dwyer (2005) criterion tests. There were two versions of each test, one pretest and one posttest. All the six tests (three pretests and three posttests) are attached in the Appendix A - F.

Identification test

The purpose of the Identification test was to assess student ability to identify the skeletal parts. The skeleton of a human body was shown, marked with numbers. The students were asked to match the appropriate skeletal parts with numbers. Please see the Appendix A for the pretest identification test instrument.

Terminology test

The Terminology test was designed to assess whether students could identify the bone and its common name. For example a picture of the clavicle was provided with the following options:

Clavicle

A. Collarbone
B. Jawbone
C. Wrist
D. Spine

Comprehension test

This Comprehension test was intended to evaluate students' knowledge of specific parts of the human body associated with specific skeletal structure. For example:

Q: Where is Ulna placed?

A: Ulna is placed at the medial side of the forearm.

B: Ulna is placed at the medial side of the leg.

C: Ulna is placed at the frontal side of the forearm.

D: Ulna is placed at the medial side of the rib cage.

The pretest and the posttest are similar in format with different content. So the posttest also consists of an Identification Test, a Terminology Test, and a Comprehension Test.

Survey

Apart from testing the effectiveness of the game and its educational features through the pretest and posttest, a survey was administered to get details such as game skillfulness and demographic details such as gender, ethnic background and GPA range.

The following information was collected through the survey:

- Gender
- GPA
- Game skillfulness
- Ethnicity

The survey is attached in Appendix H.

Gender information

Gender information was collected against the student ID and this information was treated as a covariate in the statistical analysis. The following question seeks gender information:

What is your gender?

a. Female

b. Male

GPA information

In order to get accurate GPA range, and avoid asking students to recollect from memory, BCPS was requested to release the GPA scores to individual students by their teacher. The GPA information was released only to students. The students did not report the GPA in the survey, but only selected the GPA range in the survey. This ensured that there was no violation of the Family Educational Rights and Privacy Act (FERPA).

The entire process took about 45-60 minutes and it was done during the regular class time, when Biology was taught. The subject matter addressed in the Humatan game is the Human Skeletal System, which is part of the biology curriculum. Biology teachers were requested to give one class period to conduct the research.

SES information

The Socioeconomic status (SES) information was obtained from the percentage of students enrolled in the free and reduced meal scheme offered by BCPS. Table 7 shows the income level eligibility for free and reduced meal scheme:

Table 7 – *Income Eligibility Chart for the free and reduced meal scheme* (Effective July 1, 2010 to June 30, 2011)

Household Size	Annual	Monthly	Twice Per Month	Every Two Weeks	Weekly
1	$20,036	$1,670	$ 835	$ 771	$ 386
2	26,955	2,247	1,124	1,037	519
3	33,874	2,823	1,412	1,303	652
4	40,793	3,400	1,700	1,569	785
5	47,712	3,976	1,988	1,836	918
6	54,631	4,553	2,277	2,102	1,051
7	61,550	5,130	2,565	2,368	1,184
8	68,469	5,706	2,853	2,634	1,317
For each additional member add	$ 6,919	$ 577	$ 289	$ 267	$ 134

The SES information was obtained from the percentage of students who receive free and reduced-meals from the school to see whether it had any effect on the learning outcome. The data was provided by BCPS and has been used in the analysis. It is important to note that the SES information provided by BCPS is not for individual students but for the entire participating school. Some scholars disagree on how to define and categorize SES. Scholars (Arhar & Kromrey, 1995, Astin & Oseguera, 2004) classify SES as high, middle and low.

Schools were divided into three SES levels, namely, high, middle, and low. Schools having below or equal to 33.33% of farms data (students who receive free or reduced-meal) were classified as a high SES school. Schools with 33.34% to 66.67% of students who receive free and reduced-meal were categorized as middle SES. Anything above 66.67% was classified as low SES.

Table 8 shows the Socioeconomic Status classification for the schools that participated in the study, based on the information provided by BCPS.

Table 8 – *SES classification levels for participating schools*

Schools	Percentage of students receiving Free and Reduced-Meal (FARMS)	SES classification
Catonsville	27.2%	High
Chesapeake	60.6%	Middle
Dundalk	66.1%	Middle
Hereford	6.9%	High
Lansdowne	53.3%	Middle
Loch Raven	26.0%	High
Perry Hall High	23.1%	High
Towson High	14.6%	High

Game skillfulness information

The survey contains questions regarding students' perception about their game skills and familiarity with different video game consoles, apart from the demographic details mentioned previously such as gender and grade level, and additionally ethnicity. The game skillfulness survey can be found in Appendix G.

Data preparation and data logging

All the initial data was entered onto an Excel file and later transferred to the standard statistical package SPSS. A codebook was developed for the survey instrument. The important aspect of the codebook was to allocate an identifying number or code to each answer. By doing this, we are converting our human-readable-survey to machine-readable data. Each answer to a particular question was given a distinctive code. This code was fed into the computer and the code thereafter represented a particular response to a given question. The survey codebooks are attached in Appendix H and Appendix I.

Code checking procedures

For the present study, SPSS statistical software package was used to do the data-entry. While entering the data, to ensure a high level of data accuracy, a double entry procedure was followed. The double entry procedure was meant to check the second entries against the first entries and report any discrepancy. No discrepancy was found in the data.

Using SPSS, the researcher also checked the validity of the range of data entered into the statistical package. Any code outside the range specified (as mentioned under 'valid codes' in the code book) was considered invalid and needed correction. In SPSS, the researcher set the frequencies at the data entry stage, and made sure that correct data was entered.

Data analysis

A total number of 254 students from nine high schools in BCPS participated in the study. Out of 254 students, only 202 students successfully completed all the steps of the data collection:

Step 1. Taking the pretest

Step 2. Playing the game

Step 3. Taking the posttest and the survey

The remaining 51 students took only the pretest and played the game, but were unable to complete the posttest. The reason for this non-usable data can be attributed to the following reasons:

1. The Humatan game has multiple levels. Unless students finish one level, they cannot proceed to the next level in order to complete the game. Students kept playing the game and spent more time in the game, and hence did not have time to attempt the post-test. Despite reminding the students how much time they had left to complete the game and the posttest, some of them continued to play the game.

2. During data collection in one school, right after the students started playing the game (after finishing the pre-test), a small fire broke-out and it became necessary to evacuate everyone from the building. Students were allowed back only after two hours and they could not complete the study.

3. Due to excess heat in Baltimore, many classes were shortened on some of the data collection days. Consequently the students hardly had time to complete the study.

Demographics of the participants

Table 9 gives the demographic details of the students who participated in the study.

Table 9 – *Students Demographics*

Total number of schools participated	9
Total number of participants	254
Total number of participants who completed both pre and posttests	202
Students' gender*	
Number of female participants	121
Number of male participants	79
Average GPA of the participants***	3.0
Students Ethnic Background**	
African descent	56
Asian	12
European	112
Hispanic	9
Middle-Eastern	1
Native American	5
Students and game features	
Number of students who played the game with only challenge-on	48
Number of students who played the game with only fantasy-on	52
Number of students who played the game with only both-on	52
Number of students who played the game with only none-on	50

* 2 participants did not report their gender.

** 7 participants did not report their ethnic background.

*** 2 participants did not report their GPA.

Validity check

There is a widespread agreement among scholars that the "interaction of pretesting and treatment comes into play when the pretest sensitizes participants so that they respond to the treatment differently than they would with no pretest" (Dimitrov & Rumrill, 2003, p. 160). As Bellini and Rumrill (2009) mention that there are several threats to the external validity of the study. These threats include interaction effects of selection biases and treatment, reactive interaction effect of pretesting, reactive effect of experimental procedures, and multiple-treatment interferences. In an experiment design where subjects are assigned randomly, a testing threat arises when the pretest and posttest are the same. The potential for testing threat can affect the internal validity of the study. This is because the pretest may prime the subjects toward the posttest, which may result in a better posttest score where the improvement in the scores is not due to intervention (Shadish, Cook & Campbell, 2002, Trochim, 2000).

In the current study, in order to avoid pretest sensitization, the researcher had similar and equivalent tests with a different set of questions. Both the tests contained 40 questions each. Out of these 40 questions, 60% of the questions (24 questions) were exactly the same. The remaining 40% of the questions were different. Another consideration is that, when the time difference between the pretest and the posttest is short, students might get even more sensitized because of the pretest. The duration between the pretests and posttests was about 20-25 minutes, during which the students played the Humatan game. Thus in order to reduce the chances of getting primed due to pretest, 40% of the questions was changed.

When the pretest is different from the posttest, the internal validity of the study is susceptible to instrumentation threat. In order to eliminate the instrumentation threat, a

comparison was made between the pretest and the posttest taking only the common questions from both tests.

So, first the testing threat was minimized by having non-equivalent pretests and posttests. Later, only common questions were taken from both the sides to minimize the instrumentation threat.

Gain scores

Scholars suggest two main ways to estimate the average treatment effect in a pretest posttest experiment: the gain score and the covariance adjustment estimator. The gain score is obtained using the following formula: Gain Score = Posttest Score – Pretest Score. In the analysis of covariance (ANCOVA), the posttest is the dependent variable and the pretest is the covariate. For the present study the researcher used ANOVA on gain score instead of ANCOVA. There is a growing literature (Cribbie & Jamieson, 2004, Dimitrov & Rumrill, 2003) that supports the use of ANOVA on gain score over ANCOVA. ANOVA on gain score tests the hypothesis of equivalence of mean differences, regardless of the pretest differences between groups (Cribbie & Jamieson, 2004). Further Cribbie and Jamieson maintain that gain scores are "assumed to yield unbiased estimates of a treatment effect which is additive and independent of pretest level" (p. 38). Dimitrov and Rumrill (2003) emphasize that "the reliability of gain scores is high in many practical situations" (p. 164).

Chapter summary

Challenge and fantasy were identified as the two main instructional game features to be studied in this research. This section discussed one important independent variable known as feature with four levels: challenge on, fantasy on, both on and none on. The feedback feature was

kept as a constant. Gender, GPA, game skillfulness, SES and ethnicity were considered as covariates. Gain score (posttest score – pretest score) was identified as the dependent variable. To answer the main research question of the study regarding game features three hypotheses stated. It is important to note that these hypotheses are stated as alternative hypotheses. It was recognized that the statistical testing was conducted against the null hypotheses.

H1: A game that has challenge will positively impact learning.

H2: A game that has fantasy will positively impact learning.

H3: A game that has both challenge and fantasy features will have a higher positive impact on learning than a game with one of these features as well as a game with none of these features.

To test the hypotheses, an instructional game called Humatan was designed to teach human anatomy to high school students. Four different versions of the game were used to find the effect of challenge and fantasy on learning in an instructional game. A total number of 254 students from nine schools affiliated to BCPS participated in the research study. Out of 254 students 202 students completed all the required steps of the data collection.

Chapter IV: Results

Introduction

A good friend of mine once said that she did not like Chemistry for the simple reason that invariably she would fall asleep in class because the teacher would never engage the students. The teacher constantly lectured or wrote some formulae and notes on the blackboard. Now when she looks at the potential of video games and how they engage students, she said that she would love to go back and learn Chemistry again. Marc Prensky (2001) shows the contrast between the Electronic Expo (E3) in Los Angeles, an event focused on electronic and video games, and the American Society of Trainers and Developers (ASTD)'s annual convention, an educational conference:

> And everywhere, amid the sound, lights, music and dancing girls, shines the glow of thousands of the latest, largest, flat-panel computer screens with the newest, greatest, still-to-be-finished games set out like appetizers to be test-driven by attendees. Many have waiting lines several people deep, despite multiple instances. The crowd is young, almost exclusively in their 20s and early 30s, and full of energy. They are not skeptics, but participants — possibly even addicts — eager for this year's new dose. This is FUN! This is the entertainment world. These, ladies and gentlemen, are today's trainees. (p. 2)

Now the teachers:

> Dallas, just one week later. The American Society of Trainers and Developers (ASTD)'s annual convention. The total exhibit floor is less than one tenth the space of E3 — less than only one of its big halls. Most booths are the minimum 4 ft x 8 ft, and no booth is larger than eight or ten of the smallest ones. There is no music. No fancy lights. No noise.

> No lines. *Certainly* no dancing girls. The energy level is low — maybe 1/50th off that of E3. There are maybe 1/50th of the people as well, mostly in their 30s, 40s and 50s, meandering at glacial speeds along straight aisles from tiny booth to tiny booth. …This is BORING! *This* is the learning world. These, Ladies and gentlemen, are today's trainers (p.2).

Marc Prensky goes on to comment that the first group is today's trainees, the second is today's trainers, and notes that "the learning world" (p. 2) is boring. His idea directly relates to my friend's dislike towards Chemistry. Teachers do not engage the student community in ways students would consider fun. During this study, the overall reaction towards the Humatan game was that the students had fun playing the game. And the best part of it was one of the teachers expressing his surprise that the students remained engrossed in the Humatan game for the entire duration of the study without getting distracted.

There were many similar anecdotal evidences that support the use of games for instructional purposes. The goal of this study is to determine whether instructional games augment learning and secondly to find out the impact of the challenge and fantasy features on learning. In this chapter I describe various quantitative analyses of the data. In order to compare the effect of two independent variables described in the hypotheses namely, challenge and fantasy, a one-way between subjects fixed factor Analysis of Variance (ANOVA) was conducted. Several factorial ANOVAs were also conducted to find the effect of Gender, GPA, SES, Ethnic Origin and Game skillfulness.

Statistical analysis

This section describes the various statistical analyses conducted and the results. In the current study we used pre and posttests to measure learning. The reliability of the instruments can be determined in two ways (Zumbo, 1999): one is through test – retest approach and the other is by calculating the Cronbach Alpha. Often times test – retest is impractical and the Cronbach alpha gives a way to measure the reliability of measurement intended in a study (Zumbo, 1999). Therefore in order to determine the reliability of measurements in the study, the reliability test for the pretest and posttest was conducted.

Rationale to determine Cronbach Alpha coefficient

The need to determine the Cronbach Alpha coefficient for the current study can be illustrated with a small example: Assume that a student knows answers to 90 questions out of 100 questions in an exam, but by sheer guessing (or chance), the student obtained a score of 95. So, the true score of the student is 90 and the observed score is 95 due to a measurement error. A reliable test instrument should reduce the measurement error, so that the relationship between the true score and the observed score is strong. The relationship between the true and observed scores is examined through the Cronbach Alpha coefficient. The reliability is the proportion of the true score to the observed score, and the higher the proportion is, greater the consistency of the resulting measures (Sprinthall, 2003). For the present study, the Cronbach Alpha coefficient was .889, which shows that both pre and posttests have a good internal consistency by conventional standards. Gliem and Gliem (2003) mention that the closer Cronbach's Alpha coefficient is to 1.0 the greater the internal consistency of the items in the scale.

Paired Samples t-test

Next a paired samples t-test was conducted in order to find whether games (the intervention) made a difference in the pretest vs. the posttest. If there is no difference in the scores between the pretest and posttest, then there is no need for further statistical analysis, because the intervention, namely the game, did not improve learning. However, if there is a difference in the scores between the pretest and posttest, that shows the intervention did improve learning, and thus it is important to find where this difference comes from (for example, which group; the group that played challenge only version; or the group that played both the versions turned on etc.). In order to find the differences, an Analysis of Variance (ANOVA) needs to be conducted. Thus a paired samples t-test needs to be conducted first:

A paired samples t-test was conducted to see if there is a significant difference between the pretest and posttests and the findings are reported in Table 10:

Table 10 – *Paired Samples Statistics*

	Mean	N	Std. Deviation	Std. Error Mean
Pre Score	11.80	202	5.703	.401
Post Score	15.20	202	5.892	.415

From the paired samples t-test results we can see that there was a significant difference in the posttest scores (M=15.20, SD=5.892) and the pretest scores (M=11.80, SD=5.703); t (201) = -13.182, p = 0.000. These results suggest that the Humatan game does facilitate learning. Specifically, the results suggest that when students play an instructional game, their learning does increase as reported in the posttest scores. Also, there is a strong positive correlation (r = .800), which indicates that the students who did well on the pretest also did well on the posttest. This result is in concurrence with previous studies (Kebritchi, Hirumi & Bai 2010; Coller &

Scott, 2009; Papastergiou, 2009; Tuzun, Yilmaz-Soylu, Karakus, Inal & Kizilkaya, 2009; Ke & Grabowski, 2007; Ke, 2008; Vogel, Vogel, Cannon-Bowers, Bowers, Muse & Wright, 2006; Lee, Luchini, Michael & Norris, 2004) which have investigated the effect of instructional games on learning achievement. The discussion section of this dissertation compares and contrasts the significant results obtained in the current study with previous research studies.

Analysis of variance

There were three hypotheses stated in the study:

H1: A game that has challenge will positively impact learning.

H2: A game that has fantasy will positively impact learning.

H3: A game that has both challenge and fantasy features will have a higher positive impact on learning than a game with one of these features as well as a game with none of these features.

To test the study's research hypotheses, the researcher looked for the main effects of challenge and fantasy on the dependent variable posttest score minus pretest score, known as gain score. Since the hypotheses stated above are directional, a one-way between subjects ANOVA was conducted to compare the effect of the two features challenge and fantasy on student learning while playing an educational video game. Group means and standard deviations of the gain score are reported in Table 11, which contains descriptive statistics for the study.

Table 11 – *Descriptive Statistics for Gain Score*

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
None on	50	2.98	3.43	.48	2.01	3.95	-3.00	11.00
Challenge on	48	5.08	3.33	.48	4.12	6.05	.00	12.00
Fantasy on	52	2.73	4.29	.59	1.54	3.93	-4.00	16.00
Both on	52	2.92	3.09	.43	2.06	3.78	-3.00	9.00
Total	202	3.40	3.67	.26	2.89	3.91	-4.00	16.00

There was a significant effect on learning at the $p<.05$ level for the instructional game with features, $F (3, 198) = 4.71$, $p = 0.003$ (Table 12). Post hoc comparisons using the Tukey HSD test (Table 13) indicated that the mean score for the game that had the challenge feature enabled ($M = 5.08$, $SD = 3.33$) was significantly different than the game that had the fantasy feature enabled ($M = 2.73$, $SD = 4.29$). However, the game wherein both the features were turned on ($M = 2.92$, $SD = 3.09$) did not significantly differ from the game wherein bare minimum features were turned on ($M = 2.98$, $SD = 3.43$). Taken together, these results suggest that the presence of the challenge feature has a significant effect on learning. Specifically, our results suggest that when an instructional game has the challenge feature, learning improves. However, having a fantasy element can distract the students, resulting in a lower score. In this study, when challenge and fantasy were combined together, fantasy actually lowered the overall posttest score. The current results suggest that having a challenge feature positively augments learning and having a fantasy feature in an educational game does not support learning.

Table 12 provides the ANOVA results indicating that an instructional game like Humatan causes a significant increase in learning indicated by increased gain scores.

Table 12 – *Analysis of Variance*

Gain Score

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	179.950	3	59.983	4.708	.003
Within Groups	2522.570	198	12.740		
Total	2702.520	201			

Table 13 provides the results of performing a multiple group comparison using the Tukey test to find out which means are significantly different from one another.

Table 13 – *Multiple Group Comparisons: Post Hoc Tests*

Gain Score: Tukey HSD

(I) Feature	(J) Feature	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
None on	Challenge on only	-2.10333*	.72127	.020	-3.9721	-.2345
	Fantasy on only	.24923	.70697	.985	-1.5825	2.0810
	Both on	.05692	.70697	1.000	-1.7748	1.8887
Challenge on only	None on	2.35256*	.72127	.020	.2345	3.9721
	Fantasy on only	2.16026*	.71444	.006	.5015	4.2037
	Both on		.71444	.015	.3092	4.0114
Fantasy on only	None on	-.24923	.70697	.985	-2.0810	1.5825
	Challenge on only		.71444	.006	-4.2037	-.5015
	Both on	-.19231	.70001	.993	-2.0060	1.6214
Both on	None on	-.05692	.70697	1.000	-1.8887	1.7748
	Challenge on only		.71444	.015	-4.0114	-.3092
	Fantasy on only	.19231	.70001	.993	-1.6214	2.0060

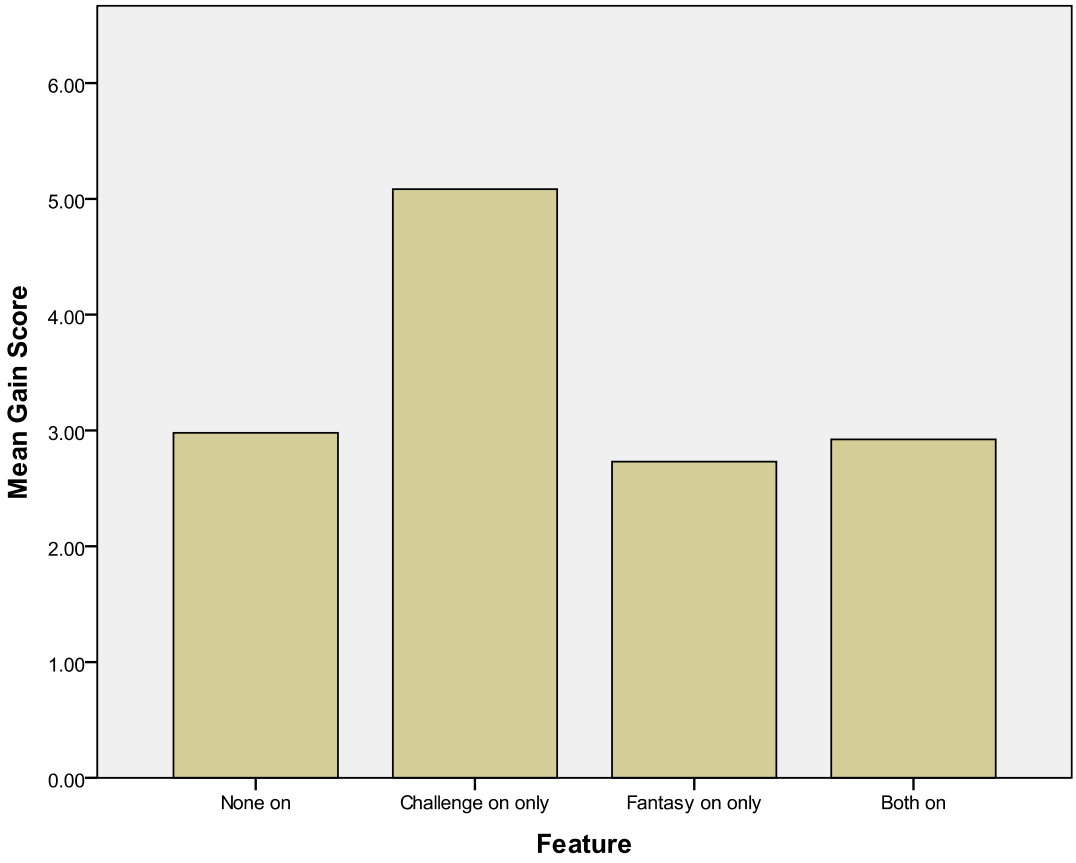
*. The mean difference is significant at the 0.05 level.

One of the assumptions of ANOVA is that groups have approximately equal variance on the dependent variable, that is, the gain score. Levene's test of homogeneity of variances was performed in order to check the validity of the equal variance assumption. From Levene’s Test of homogeneity of variances, it is evident that the significance is .467, which is greater than .05,

and it can be assumed that the variances are approximately equal and the study met one of the assumptions of ANOVA.

Figure 13 gives a graphical representation of the mean gain scores obtained by students who played different variations of the Humatan game.

Figure 13 – *Mean Gain Score for the different variations of the Humatan game*



Factorial design analysis

In order to determine whether gender, GPA, SES, game skillfulness and ethnicity contribute to any of the variances, individual factorial design analysis was conducted to find out the main effects and the interaction effects of these covariates. Specifically, the factorial design analysis was conducted to address the following research questions which were posed earlier:

1. Are there significant mean differences for achievement scores between Male and Female students?

2. Are there significant mean differences for achievement scores between students with high GPA and low GPA?

3. Are there significant mean differences for achievement scores between students with high SES and low SES?

4. Are there significant mean differences for achievement scores between students with different levels of students' perceptions about their game skillfulness?

5. Are there significant mean differences for achievement scores between students of various ethnic backgrounds?

Gender

A two-way between-groups analysis of variance was conducted to find the effect of game features and gender on gain score. A total of 121 female students and 79 male students participated in the study. Table 14 shows the mean scores of each gender in different game versions. Four groups of students played four different versions of the game containing the following features: Both On, Challenge On, Fantasy On, and None On.

Table 14 – *Descriptive Statistics*
Dependent Variable: Gain Score

Feature	Gender	Mean	Std. Deviation	N
None on	Female	3.0938	3.37313	32
	Male	2.7778	3.60646	18
	Total	2.9800	3.42553	50
Challenge on only	Female	5.5185	3.57739	27
	Male	4.3500	2.94288	20
	Total	5.0213	3.33942	47
Fantasy on only	Female	3.4688	4.71774	32
	Male	1.6316	3.33684	19
	Total	2.7843	4.31423	51
Both on	Female	2.9333	2.91173	30
	Male	2.9091	3.39340	22
	Total	2.9231	3.09234	52
Total	Female	3.6942	3.80973	121
	Male	2.9367	3.39812	79
	Total	3.3950	3.66279	200

Table 15 shows the interaction effects of gender and the game features. The interaction effect between gender and game feature was not statistically significant, F (3, 192) = .65, p=.59. There was a statistically significant main effect found for game feature F (3, 192) = 4.26, p=.006. Post-hoc comparisons using the Tukey HSD test indicated that the mean score for the challenge feature (M =5.02, SD =3.43) was different from none on feature (M = 2.98, SD =3.43). Both on (M = 2.92, SD = 3.09) and Fantasy on (M=2.78, SD = 4.31) features did not differ significantly from either challenge or none on. The main effect of gender, F (1, 192) = 2.61, p=.11, did not reach statistical significance.

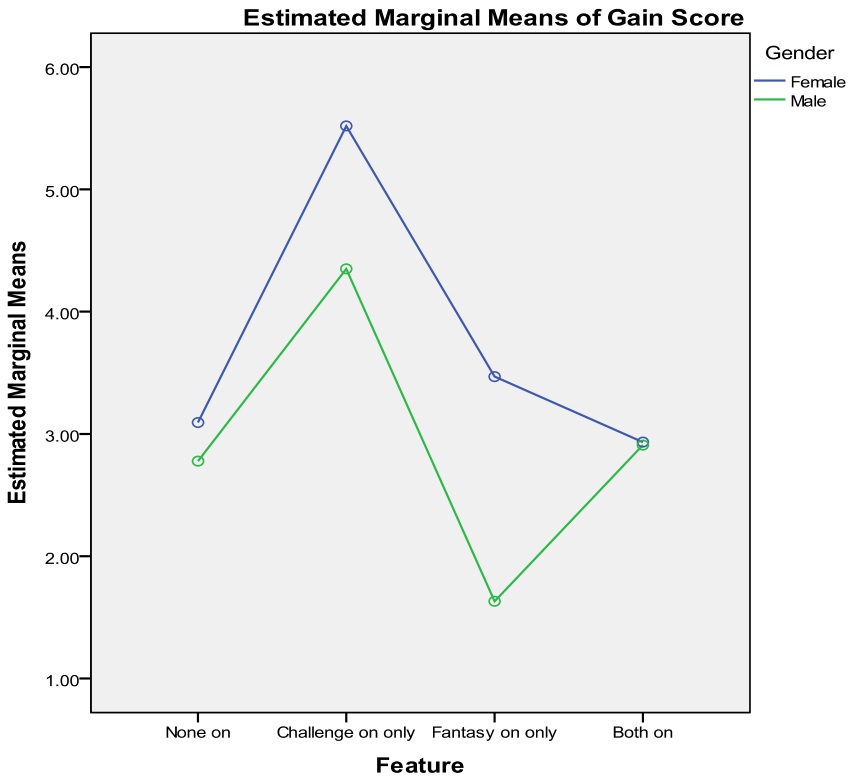
Table 15 – *Tests of Between-Subjects Effects: Gender and Features*
Dependent Variable: Gain Score

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	220.60[a]	7	31.51	2.47	.019	.083
Intercept	2115.74	1	2115.74	165.86	.000	.463
Feature	162.89	3	54.30	4.26	.006	.062
Gender	33.27	1	33.27	2.61	.108	.013
Feature * Gender	24.697	3	8.23	.65	.587	.010
Error	2449.20	192	12.76			
Total	4975.0	200				
Corrected Total	2669.80	199				

a. R Squared = .083 (Adjusted R Squared = .049)

Figure 14 is a graphical representation of the mean gain scores achieved by male and female students for different variations of the Humatan game.

Figure 14 – *Profile plots for the different variations of the Humatan game based on gender*



GPA

Students were asked to report their GPA in the survey and they were asked to select from the following GPA ranges as approved by BCPS:

a. 4.0 – 3.5

b. 3.0 – 3.4

c. 2.0 – 2.9

d. Below 2.0

In order to find the effect of game features and GPA on gain scores a factorial ANOVA was conducted. A total of six students reported their GPA below 2.0. 49 students reported their GPA in the range 2.0 - 2.9. 75 students reported their GPA in the range 3.0 - 3.4 and 70 students

reported their GPA in the range 3.5 - 4.0. Table 16 shows the mean scores of each GPA group in different game versions.

Table 16 – *Descriptive Statistics for students with different GPA range*

Dependent Variable: Gain Score

Feature	GPA	Mean	Std. Deviation	N
None on	below 2.0	10.0000	.	1
	2.0 - 2.9	1.9000	2.72641	10
	3.0 - 3.4	3.4444	3.38927	27
	3.5 - 4.0	2.2500	3.51943	12
	Total	2.9800	3.42553	50
Challenge on only	2.0 - 2.9	4.6364	3.13920	11
	3.0 - 3.4	4.0625	2.95452	16
	3.5 - 4.0	6.0952	3.54831	21
	Total	5.0833	3.33156	48
Fantasy on only	below 2.0	-.6000	2.40832	5
	2.0 - 2.9	5.0000	3.05505	7
	3.0 - 3.4	3.3810	5.30543	21
	3.5 - 4.0	2.2222	3.22774	18
	Total	2.8039	4.29893	51
Both on	2.0 - 2.9	3.1429	3.13506	21
	3.0 - 3.4	2.9091	3.08073	11
	3.5 - 4.0	2.8947	3.16043	19
	Total	3.0000	3.07246	51
Total	below 2.0	1.1667	4.83391	6
	2.0 - 2.9	3.4898	3.14988	49
	3.0 - 3.4	3.4800	3.84975	75
	3.5 - 4.0	3.5714	3.69320	70
	Total	3.4450	3.65840	200

Table 17 shows the two-way ANOVA results, which was conducted to see whether GPA had any interaction effect with the Humatan game features. The interaction effect between GPA and game feature was statistically significant, $F(7, 186) = 2.34$, $p=.026$; however, the effect size

was small (partial eta squared = .08). To confirm such a small effect size, another one way ANOVA between the GPA and the gain score was conducted and the results were not significant. There was a statistically significant main effect found for game feature F (3, 186) = 4.21, p=.007. Post-hoc comparisons using the Tukey HSD test indicated that the mean score for the challenge feature (M =5.02, SD =3.43) was different from none on feature (M = 2.98, SD =3.43). Both on (M = 2.92, SD = 3.09) and Fantasy on (M=2.78, SD = 4.31) features did not differ significantly from either challenge or none on. The main effect of GPA, F (3, 186) = .32, p=.81, did not reach statistical significance.

Table 17 – *Tests of Between-Subjects: GPA and Features*
Dependent Variable: Gain Score

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	389.75[a]	13	29.98	2.45	.004	.146
Intercept	857.41	1	857.41	70.14	.000	.274
Feature	154.25	3	51.42	4.21	.007	.064
GPA	11.77	3	3.92	.32	.810	.005
Feature * GPA	200.52	7	28.65	2.34	.026	.081
Error	2273.64	186	12.22			
Total	5037.00	200				
Corrected Total	2663.40	199				

a. R Squared = .146 (Adjusted R Squared = .087)

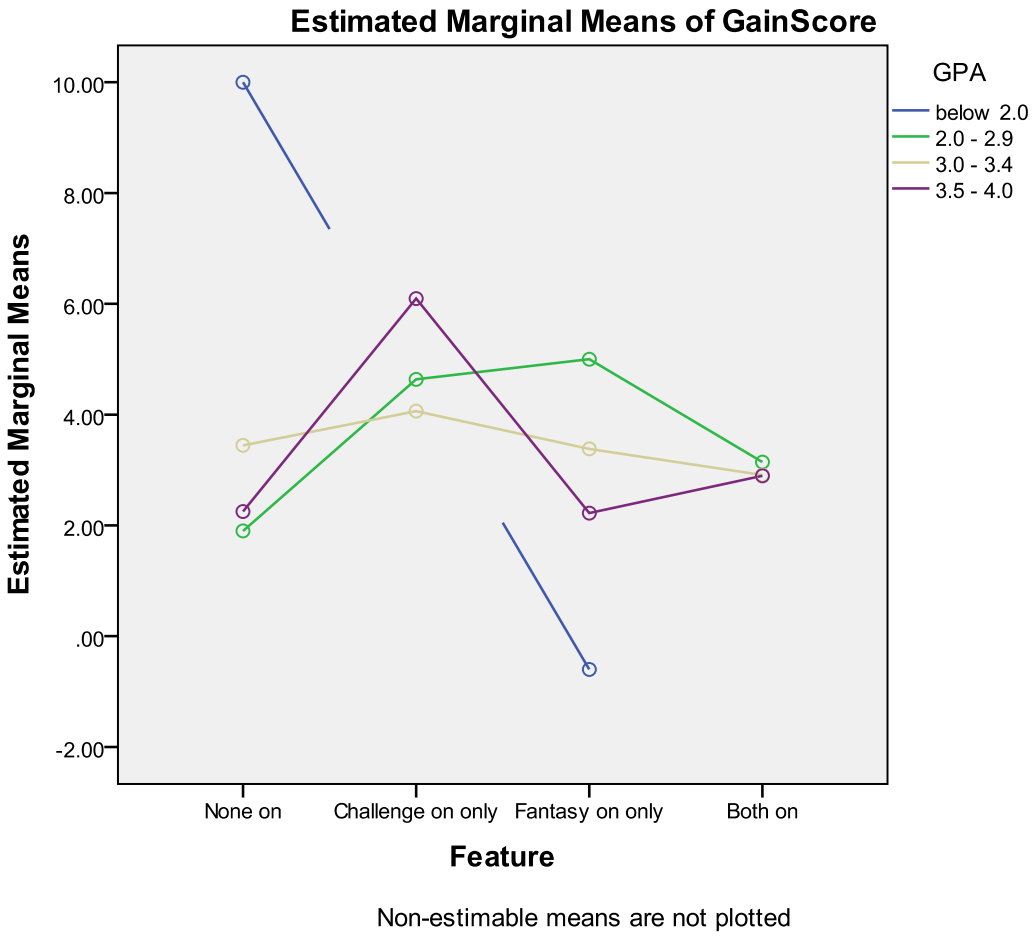
Significant interaction: Paradoxical effect

For students whose GPA range was between 2.0 – 2.9, the gain score was high for the group with challenge on (M = 4.64, SD = 3.14) and higher still for the group with fantasy on (M =5.0, SD = 3.06), but when both fantasy and challenge were turned on, the gain score was lower than with the individual features turned on. For students whose GPA range was between 3.0 -

3.4, the feature of challenge was the most helpful (M = 4.06, SD=2.95) while fantasy (M = 3.38, SD = 5.30) and no-feature (M = 3.44, SD=3.39) had a low gain score. For students whose GPA range was between 3.5 – 4.0 however, having both features together (M = 2.89, SD = 3.16) actually showed an increased gain score in comparison with those in the same GPA range who played with no features (M= 2.25, SD= 3.51) as well as those who played with the fantasy feature on (M = 2.22, SD= 3.23). Also, it was this group (3.5 – 4.0) that showed the highest gain score in comparison with the other GPA ranges when they played with only the challenge feature turned on (M = 6.09, SD = 3.55). The interaction effects do not seem to follow any specific pattern or logic. Such interaction effects are known as “paradoxical effects” (p. 342, Sprinthall, 2003).

From Figure 15, we can see that the mean gain scores obtained by students GPA ranges do not follow any specific patterns, which is known as a paradoxical effect.

Figure 15 – *Profile plots for the different variations of the Humatan game based on GPA*



SES

In order to find the effect of game features and the Socioeconomic Status (SES) of the students on the gain score, a two-way ANOVA was conducted. As mentioned earlier, the SES status was obtained from the percentage of students who receive free and reduced-meal data provided by BCPS. The data provided was aggregated data for the schools. Out of 202 students, 65 students attended from schools classified as middle SES and 135 students attended schools classified as high SES. Table 18 shows the interaction between SES and game features, and from the results we can see that there is no significant interaction between SES and the features on the gain score.

Table 18 – *Tests of Between-Subjects: SES and Features*

Tests of Between-Subjects Effects
Dependent Variable: Gain Score

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	206.919[a]	7	29.560	2.298	.029	.077
Intercept	1989.298	1	1989.298	154.642	.000	.444
Feature	164.018	3	54.673	4.250	.006	.062
Socioeconomic Status	5.739	1	5.739	.446	.505	.002
Feature * Socioeconomic Status	19.860	3	6.620	.515	.673	.008
Error	2495.601	194	12.864			
Total	5039.000	202				
Corrected Total	2702.520	201				

a. R Squared = .077 (Adjusted R Squared = .043)

Game skillfulness

A two-way between-groups analysis of variance was conducted to find out the effect of game features and game skillfulness on gain score. Out of 202 students, 31 perceived that they were low skilled gamers. 106 students perceived that they were medium skilled gamers and 65 students reported that they were high skilled gamers. The interaction effect between game skillfulness and game feature was not statistically significant, F (6, 190) = .92, p=.48. There was a statistically significant main effect found for feature F (3, 190) = 5.01, p=.002. Table 19 shows the main effect of game skillfulness, F (2, 190) = 1.24, p=.29, and we can infer that the effect of game skillfulness on gain score did not reach statistical significance.

Table 19 – *Tests of Between-Subjects: Game Skillfulness and Features*

Dependent Variable: Gain Score

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	289.578[a]	11	26.325	2.073	.024	.107
Intercept	1809.662	1	1809.662	142.497	.000	.429
Feature	191.012	3	63.671	5.014	.002	.073
Game skillfulness	31.396	2	15.698	1.236	.293	.013
Feature * Game skillfulness	70.036	6	11.673	.919	.482	.028
Error	2412.941	190	12.700			
Total	5039.000	202				
Corrected Total	2702.520	201				

a. R Squared = .107 (Adjusted R Squared = .055)

Ethnic origin

Finally, we asked students to report their ethnic origin. Out of 202 total participants, 56 students were of African descent, 12 students of Asian descent, 112 students of European background, one student from Middle Eastern descent, five students from Native American descent, and nine students from Hispanic descent. Seven students did not report their ethnic background. A two-way between-groups analysis of variance was conducted to find the effect of game features and ethnicity on gain score. From the Table 20, we could see that the interaction effect between ethnicity and game feature was not statistically significant, F (12, 180) = 1.31, p=.22. The main effect of the game feature was not statistically significant F (3, 180) = 1.45, p=.23. The main effect of ethnicity, F (6, 180) = .78, p=.58, did not reach statistical significance.

Table 20 – *Tests of Between-Subjects: Ethnicity and Features*

Dependent Variable: Gain Score

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	419.964[a]	21	19.998	1.577	.059	.155
Intercept	393.590	1	393.590	31.038	.000	.147
Feature	55.224	3	18.408	1.452	.229	.024
Ethnicity	59.613	6	9.935	.784	.584	.025
Feature * Ethnicity	198.523	12	16.544	1.305	.219	.080
Error	2282.556	180	12.681			
Total	5039.000	202				
Corrected Total	2702.520	201				

a. R Squared = .155 (Adjusted R Squared = .057)

Chapter summary

High school students from Baltimore County Public Schools (n=202) were randomly assigned to play one of the following four versions of the Humatan game after taking a pretest on human anatomy:

- A game with only the challenge feature turned on
- A game with only the fantasy feature turned on
- A game with both the challenge and fantasy features turned on
- A game with challenge and fantasy turned off

After playing the game, they also took a posttest and a survey to obtain information related to their Grade Point Average (GPA), Socioeconomic Status (SES), game skillfulness, gender, and the ethnicity. First in order to find the reliability of the study's measurement, Cronbach Alpha was calculated and the pre and post tests were found to have a good internal consistency with a .889 Cronbach Alpha coefficient. Such a high Cronbach Alpha value indicates that the measurements used in the study are reliable. If the Cronbach Alpha value was low then the gain score variance was due to chance and not because of the intervention, namely playing the game.

A paired sample t-test results indicated a significant difference in the posttest mean and pretest mean, which shows that games do motivate students towards better learning. A one-way between subjects ANOVA was conducted to compare the effects of challenge and fantasy on learning. Levene's test of homogeneity of variances showed that the experimental groups had equal variances on the gain score. A significant improvement in learning was indicated with both challenge and fantasy features turned on. A post-hoc comparison found that the impact of the challenge feature was statistically significant, $F(3, 198) = 4.71$, $p = .003$. Students who played

with only the fantasy feature turned on (n=52) obtained the lowest average gain score. This implies that the challenge feature significantly improved learning and the fantasy feature did not significantly improve learning. The other covariates such as gender, GPA, SES, Ethnicity, and game skillfulness did not affect the learning outcome in a statistically significant manner. The next chapter contains a discussion of the implications of these results.

Chapter V: Discussion

Introduction

Institute of Play is a corporation founded in 2007 by a group of game designers. Their purpose is to promote learning through play. New York Times (2010) published an article about their efforts and here is what a student had to say about these efforts during a video interview:

> I thought it was pretty weird ‘cause I thought that the game would be boring. But it was pretty fun. I actually enjoyed myself. My guess is parents would not bother you a lot because this is like, an educational game, so you can play as much as you want (Corbett, 2010, 4:01)

Anecdotes like this lead us to believe that students like the gamification of the learning process and parents support it. Scholars are increasingly interested in research that could lead to designing educational games that are pedagogically effective as well as motivationally interesting.

The current study tries to arrive at a roadmap for effective educational game design. In this chapter, the results of the current study and how it might affect the future of instructional game design are discussed. A comparison is drawn between the current study results and previously conducted studies. Further in this chapter, implications of the present study in instructional game design, limitations of the study and consideration for future research are also addressed.

Discussion of the Findings

Overall, the Humatan game did motivate students to learn better, as indicated by the overall increase in achievement scores. Several studies (Kebritchi, Hirumi & Bai 2010; Coller &

Scott, 2009; Frederick, 2009; Papastergiou, 2009; Tuzun, Yilmaz-Soylu, Karakus, Inal & Kizilkaya, 2009; Ke & Grabowski, 2007; Ke, 2008; Vogel, Vogel, Cannon-Bowers, Bowers, Muse & Wright, 2006; Lee, Luchini, Michael & Norris, 2004) have investigated the effect of instructional games on learning achievement. The current study's findings support these previous research studies.

In contrast to the studies mentioned above, Frederick (2009), through an empirical study, concluded that using digital games was a motivating instructional method and students enjoyed game based learning. However, Frederick's study found no advantage in improving achievement using text-based or video games over the traditional paper-based worksheets method. The present study results were not in support of Frederick's findings.

The focus of this study was to examine the impact of the challenge and fantasy features on learning. These features, along with feedback, have been identified by scholars as the most important features of an effective instructional game. Following were the three hypotheses stated in the study:

H1: A game that has challenge will positively impact learning.

H2: A game that has fantasy will positively impact learning.

H3: A game that has both challenge and fantasy features will have a higher positive impact on learning than a game with one of these features as well as a game with none of these features.

The following sections discuss each hypothesis and whether the study results support the hypothesis, followed by the study results compared and contrasted with previous research findings.

Challenge as a feature

In the current study, the first hypothesis, a game that has challenge will positively impact learning, has empirical support, which is in congruence with earlier scholarly views about the role of challenge in an instructional game (Shernoff, Csikzentmihalyi, Schneider & Shernoff, 2003; Fong-Ling, Rong-Chang & Sheng-Chin, 2009; Lucas & Sherry, 2004). Current study results show that games with challenges lead to better learning. Challenge may aid in learning because students feel a sense of achievement, and it may keep them engaged. Also, according to positive psychologist Csikszentmihalyi (1991), when challenges go beyond one's ability to meet them, a person begins to feel anxiety. If a person's ability is above the challenge that is provided then the person experiences a sense of boredom. Since challenge as a feature consistently has a significant mean score among several factors such as gender, GPA, SES and ethnicity, we can assume that the Humatan game has provided an optimal level of challenge to students.

In his often-cited dissertation, Thomas Malone (1980) says that in order to make an instructional game interesting, challenge is an important ingredient. To make a game interesting challenge should have the following characteristics:

1. Variable difficulty level (can be determined by the game itself based on how well the player does, or can be chosen by the player)
2. Multiple level goals (players are challenged at multiple levels)
3. Hidden information (surprise elements which provoke curiosity also contribute to the challenge of the game)

4. Randomness (the outcome of a game is made uncertain)

Out of these four characteristics, the Humatan game had two: Multiple level goals and hidden information. Even with these two characteristics, the results are significant and in concurrence with Malone's views about challenges in an instructional game. One of the contributions of the current study is the empirical evidence of the role of challenge in an instructional game. Previously scholars have identified challenge as an important element for entertainment games as well as learning (Malone, 1981a; 1981b; Malone & Lepper, 1987; Norman, 1993; Bandura, 1997; Vorderer, Hartmann & Klimmt, 2003; Shernoff, Csikzentmihalyi, Schneider & Shernoff, 2003; Fong-Ling, Rong-Chang & Sheng-Chin, 2009; Lucas & Sherry, 2004). Many of the ideas expressed by scholars are theoretical and the current study adds empirical evidence to the notion that the challenge does play an important role in an instructional game. One of the ways the current study adds to the existing literature is previous studies did not manipulate challenge as a variable. In the current research, challenge was manipulated as a variable in an experimental study design, in which the participants were assigned randomly to play the different versions of the Humatan game. It is a difficult task to program multiple versions of a game in such a manner that the challenge variable can be turned on or off, and this process is one of the ways in which the current study adds to the existing literature.

Fantasy as a feature

With respect to the second hypothesis that having fantasy elements will positively augment learning, and the third hypothesis that, both challenge and fantasy will positively impact an instructional game, the findings were not statistically significant. Hence these two hypotheses were not supported in the results of the current study. When compared to a game that had no feature on, or a game that had only the challenge feature on, the mean gain scores were low in

the game that had only fantasy turned-on and the game that had both challenge and fantasy turned-on. We suspect that the low mean gain scores were due to the presence of the fantasy feature in the game. The reasons for this conclusion are as follows:

1. Students showed a statistically significant improvement in learning in the game with the challenge feature turned on.
2. They did not show a statistically significant improvement in learning in the game with the fantasy feature turned on.
3. The mean gain scores of the group that played with both challenge and fantasy features turned on were lower (M = 2.92) than the group that played with bare minimum features turned on (M = 2.98).

Though there is a strong support in literature that endogenous fantasy helps in learning (Malone, 1980; Rieber, 1996; 1996a; Van Eck, 2006; Gee, 2003; Kenny & Gunter, 2007), the researcher did not find statistical support for the same in this study. The fantasy feature was presented through an Egyptian storyline and imageries used in the game. One explanation could be that these imageries and the storyline were rather distracting to the students and did not help them to learn better. For the past thousands of years, one of the ways of passing on knowledge from generation to generation was through stories and anecdotes. Fantasy is one of the main ingredients of storytelling. Many stories are meant to convey a viewpoint or a moral that can be extended to present scenarios. As mentioned in the literature (Parker & Lepper, 1992) one would expect that fantasy leads to long-term retention of learning, as well as long-term attraction to the game to repeatedly motivate them to play the game, which would again lead to long-term revision and re-establishment of learning in the student. In an earlier study by Parker and Lepper (1992), elementary school students (n=32) played a math game teaching geometry with fantasy

and a version with less fantasy. The group that played with fantasy achieved a significant increase in learning when a delayed posttest was conducted after two weeks. The group also achieved an increase in learning in an immediate posttest for general learning of geometric concepts, however this increase did not attain statistical significance. The current study differs from Parker and Lepper in the following aspects:

1. In the present study, the group that played with less fantasy scored higher than the group that played with more fantasy. Whereas Parker and Lepper showed that the group that played with less fantasy scored lower than the group that played with more fantasy in the immediate posttest results.
2. The present study manipulated fantasy along with challenge, and the results showed that the fantasy feature pulled down the positive effect of challenge, when the two features were combined together.
3. The current study also differs from Parker and Lepper's research in the context of high school students studying biology and para-medical studies vs. elementary school students using Logo programming for drawing shapes.
4. Also, the graphics capabilities and technologies available in the early 90s were less immersive than the technology capabilities available today.

From the current study one could infer that in the short term, fantasy can probably be construed as a distraction, as it takes away interest from learning, and instead places the interest on the fantasy itself. In the present study, the total time to take the pretest, play the game, and take the posttest, took only 45-50 minutes. In this short duration, the fantasy element probably held the students' attention more than the subject being learned. This could have resulted in more distraction or cognitive overload.

Cognitive overload

As mentioned earlier in the literature review chapter, scholars do mention that fantasy is not a sufficient requirement towards learning (Asgari & Kaufman, 2004; Kenny & Gunter, 2007). Fantasy might distract students, and competing graphics and text might lead to cognitive overload as well. Earlier I talked about Mayer and Moreno's (2003) idea about how meaningful learning "requires substantial cognitive processing using a cognitive system that has severe limits on cognitive processing" (p . 45).

By including fantasy as an endogenous feature of the game, the learner might have been subjected to cognitive overload, as two channels of information were being shown simultaneously: the fantasy storyline, and the educational information. Thus, the learner might have had to simultaneously process both the channels, and hence had a cognitive overload, when compared with the game versions with challenge only, or no features turned on. From the pictures provided here, we can see how the Egyptian background could be construed as distracting when compared to the clean black background in the second level of the Humatan game.

Another point to note is that fantasy environments invoked by stories and storytelling improves information recall in the long term, whereas this study was conducted in a short duration of 45 minutes. Weiten (2010) cites the experiment of Bower and Clark (1969), about how narrative methods such as story construction increase the meaningfulness of the subject learned and their recall. So, an interesting future study could be whether an educational game with the fantasy feature, administered to students for a longer period of time, increases learning or not. Another point to note is that fantasy environments are hooks to attract students to engage in educational games. Thus, when considered over a longer period, students who have fantasy

environment based games would be more compelled to play the game several times over the period, which could result in better learning. Anecdotally, when a student saw the game that had both fantasy as well as challenge features turned on, she told the researcher that she would rather play that version of the game, than the one she was given, that had no fantasy feature turned on.

A longitudinal study about the effects of fantasy in an instructional video game might help to give insights into whether fantasy helps to improve learning in the long term. Yet another possible study could be about how much fantasy should be included in a game. In the first level of the Humatan game, apart from the Egyptian fantasy storyline, the researcher added motion to the game, so that it seemed like the players were in constant motion inside the palace. This could be a cognitive distraction, which could have led to poorer absorption of the educational information. Similarly, in the second level, there were several items in the room, like brightly animated flame torches, Egyptian artifacts, which again, could have caused cognitive overload, and the student may not have concentrated as well as in the other versions of the game. Similarly, in the third level, the background had several compelling graphical elements. Probably, there is a need to study the right amount of fantasy that when included, enhances learning, but at the same time, does not distract the learner from the subject being studied. Figures 16 and 17 show the difference between the game variations, when the fantasy feature is turned on versus when kept at bare minimum. From these two figures we can see that a non-distracting background helped students to learn better.

Figure 16 – *Humatan Game Second Level: Challenge-on Game version (Students gained high scores when they used the Challenge-on game version)*

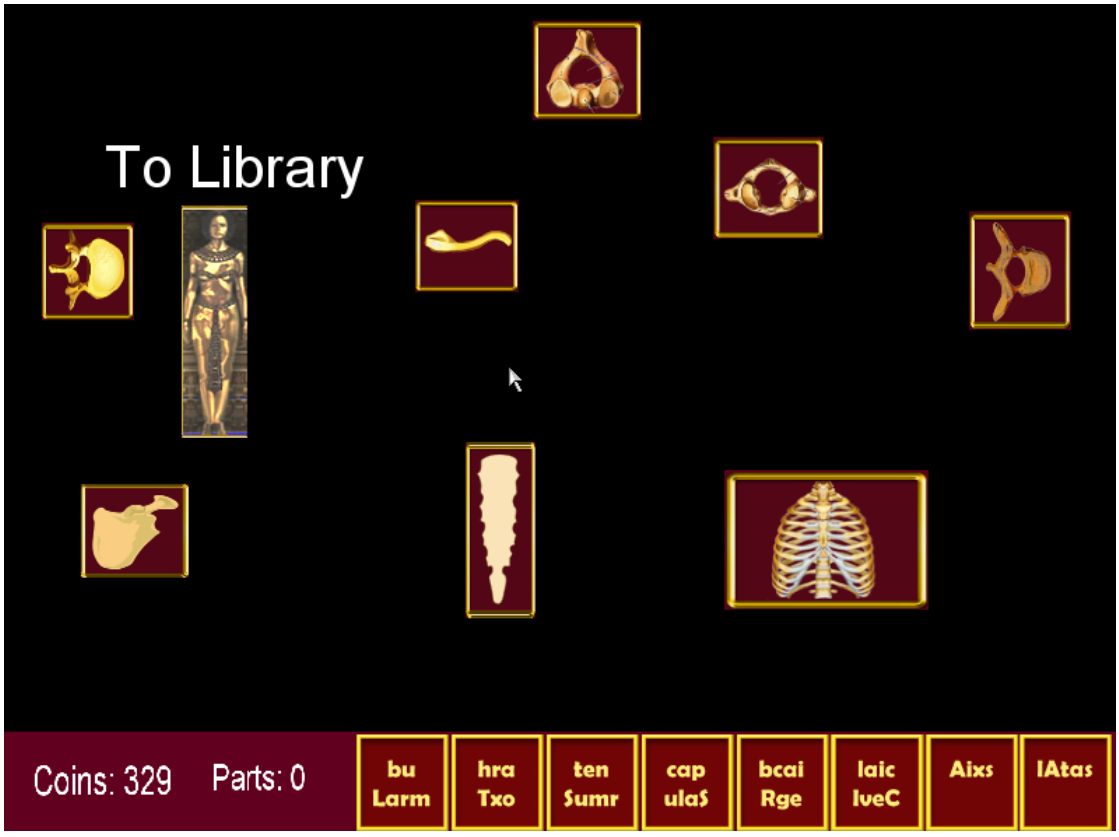
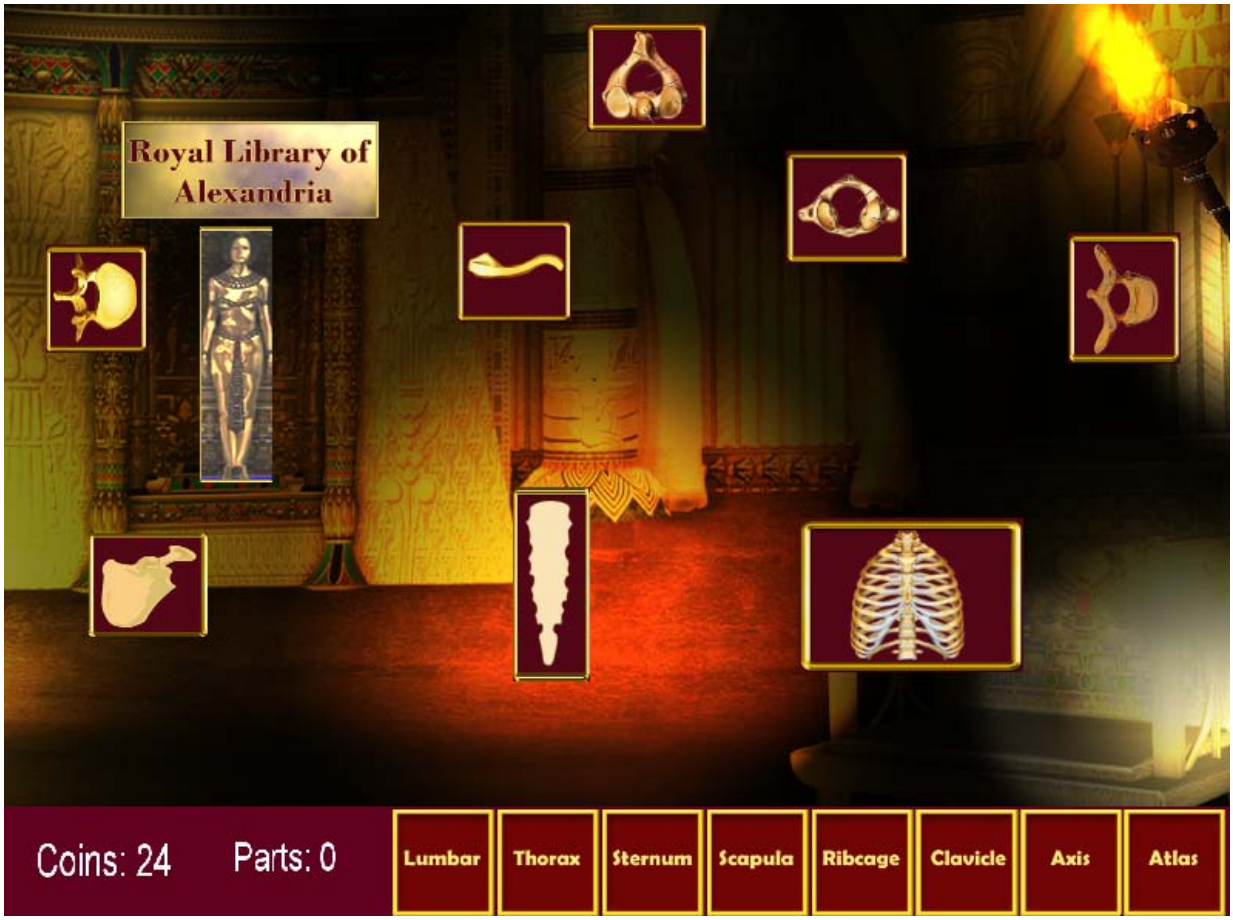


Figure 17 – *Humatan Game Second Level: Fantasy On Game version (Students got low scores when used the Fantasy On feature game)*



Gender

As mentioned earlier in the literature review section, previously many studies have been conducted on gender differences when an instructional game is used for learning (Kinzie & Dolly, 2008; Boyle & Connolly, 2008; Hartmann & Klimmt 2006; Kafai, 1998; Annetta, Mangrum, Holmes, Collazo, & Cheng, 2009; Ke & Grabowski, 2007; Papastergiou, 2009; Kim and Chang, 2010). Some of these studies, for example Kinzie and Dolly (2008) studied the students' primary preferences for activity mode (active, explorative, problem-solving, strategic, social, and creative) in game play and reported that a significant difference existed between boys and girls.

In another study, Hartmann and Klimmt (2006) concluded that females significantly differed with respect to virtual social interactions in a gaming environment and portrayed themselves as less competitive. For female students, winning was less important than for the male counterparts, and they felt less self-confident about their ability to master competitive game situations.

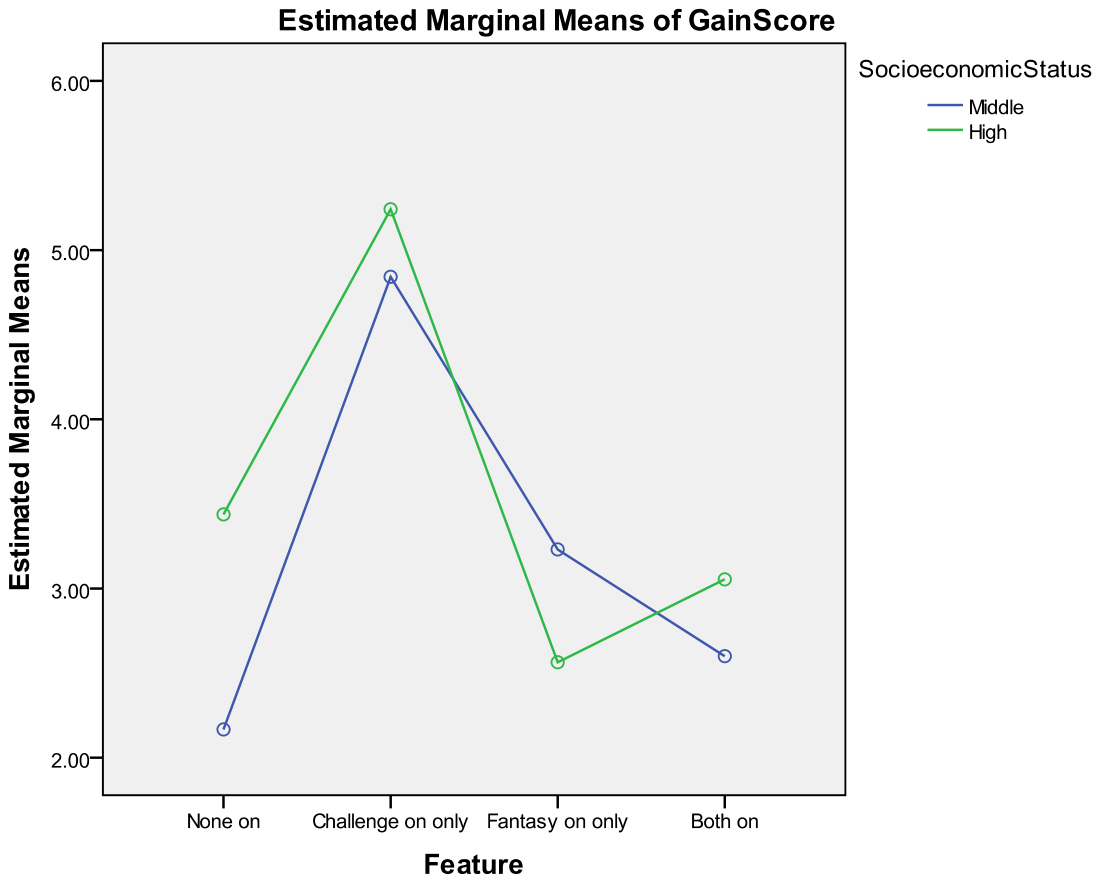
Similarly, there are studies in which no significant difference was found between male and female students while using an instructional game (Annetta, Mangrum, Holmes, Collazo, & Cheng, 2009; Ke & Grabowski, 2007; Papastergiou, 2009). So, from the literature there is supporting evidence for both significant difference between the genders and no difference between males and females. In the current study, there was no significant difference between male and female students in the overall increase in achievement scores.

Socioeconomic Status

There was no statistical significance with respect to Socioeconomic Status main effects on gain score. This supports previous research done by Ke and Grabowski (2007), in which the

researchers found no statistical significance of SES on math performance using an instructional game. However from figure 18, we can find that the challenge-on version helped students in the high SES group perform better than the middle SES group. Including both features yielded a paradoxical effect (Sprinthall, 2003), in which high SES students did better than middle SES students. Figure 18 shows the paradoxical effect of Socioeconomic Status on gain score, which does not seem to follow any specific pattern or logic. This study also recognizes that the SES information was obtained from the BCPS as an aggregate data by school, and not individual data from the students. This is a big limitation and needs to be remembered while reading the effects of SES on learning.

Figure 18 – *SES Main effect on Gain Score*



GPA

There was no statistical significance of the main effect between students' reported GPA and the gain score. However, the Humatan game with the challenge-on feature helped students to achieve better for the following GPA group: 2.0 – 2.9, 3.0 – 3.4, 3.5 – 4.0.

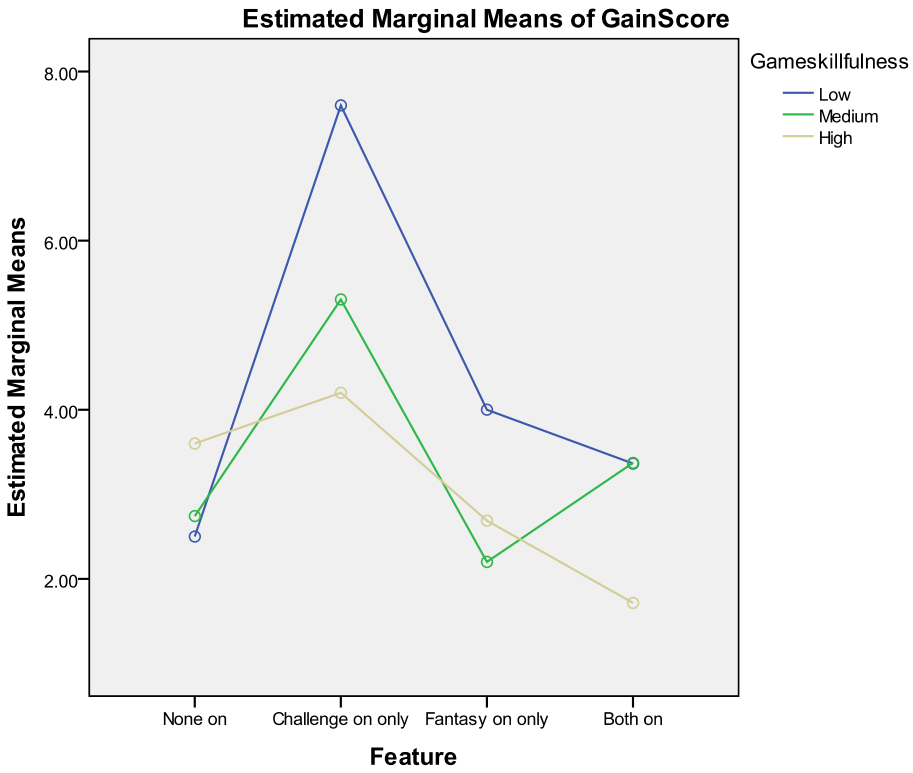
Game skillfulness

There was no statistical significance in the correlation between the perceived game skillfulness of the students and the gain score. Students who perceived their game skillfulness as

high when compared with students who felt their game skillfulness ranged from medium to low, did not show a significant higher mean gain score.

From the profile plot (Figure 19), it can be seen that the Humatan game seemed to help low-skilled gamers to achieve more increase in gain score when compared with the medium and high-skilled gamers, although the difference did not reach statistical significance. The difference was apparent, particularly, in the case of low-skilled gamers who played the game with only the challenge feature turned on. The reason for this could be attributed to the fact that the challenge feature helped to retain the player at the same level for a longer period of time than the medium and high-skilled players, who quickly passed the various hurdles to reach the end of the game. This extra time spent by the low-skilled players meant more time spent absorbing the educational portion of the game, and could therefore have caused this additional increase in the gain score. According to flow theory, when challenge is not optimal, a person either reaches boredom or anxiety. So, one recommendation for an effective instructional game is that it is important to have challenge levels as an adjustable feature, so that students can select their level of challenge (low, medium or high), and the challenge levels can be adjusted to their game skillfulness level.

Figure 19 – *Profile plots for the different variations of the Humatan game based on Game Skillfulness*



Ethnicity

In the study survey, students reported their ethnic background. Statistically the ethnic background did not have a main effect on the gain score. The challenge-on game version helped all students from all ethnic backgrounds.

Implications of the study

This study's findings have both theoretical and practical implications. Some of salient points are discussed below:

1. **Games and motivation**

   From the findings of this study we can make an assertion that instructional games do help to improve learning science subjects such as biology. Games can motivate the present generation of students who already spend many hours playing video games. By these assertions we are not saying that computer games are the panacea or magic wand that can immediately make students learn the subject matter instantaneously. But it has a very high potential for motivating students to engage with the subject matter.

2. **Games and instructional design**

   Anecdotally, during the data collection phase of the study, a teacher mentioned “your game made students sit in front of the computer for 50 minutes without any distraction, which in itself shows the effectiveness of the Humatan game.” Games do have the tendency to distract students from learning, and students might just concentrate only on the entertainment aspect, rather than getting educated. However it is in the game designer’s hand to make a game that motivates students to focus on the educational aspect while they derive fun from the game. The proper mix of both the fun aspect and the educational aspect is a key ingredient for designing a successful instructional game. This kind of focus can lead to less chocolate-dipped broccoli kind of games in the edutainment market. In order to achieve an effective instructional game, it is important that both game designers and instructional designers understand that educational games have two sides: entertainment as well as pedagogical aspects and a proper mix is the essence of instructional game design.

3. **Educational game features**

   As mentioned earlier, challenge is a very important feature and it positively augments learning in an educational game. If the challenge feature can be adjusted according to the player's preference, then the game will neither be boring nor create anxiety for the players. Players can choose the optimal challenge based on their skill levels. Endogenous fantasy is a helpful hook to attract students towards an educational game. However, if the fantasy element is too compelling, then the game might become less educational, and more entertaining. Individual differences due to GPA, SES, gender, and ethnic background were not significant in the study, which tells us that the importance of design features is extremely crucial for a successful instructional game design and if the game features are properly present, the individual differences in the students do not impact the learning significantly.

Limitations of the study

This research study has several limitations that are inherent to a quantitative research in social science. Some of these limitations are discussed herewith:

1. The total time to conduct the data collection was approximately 45 - 50 minutes. Since the pre and posttests were done in a short span of time, we could not tell whether an instructional game such as Humatan would facilitate long-term knowledge retention. Probably a longer treatment time could be helpful to ascertain the differential effects of instructional game features.
2. The Socioeconomic Status data was derived from the information given by BCPS. The aggregate data given by BCPS was meant for the entire school. In this study only a small group of students participated from each school. Since students were not

asked directly about their SES, it is not clear to what SES category individual participants belonged.

3. There are many features such as good graphics, audio, and 3D navigation capabilities required for a game to be successful in the entertainment world. This study focuses only on the two most important variables mentioned in literature: challenge and fantasy.
4. There are many important aspects of video games that are not addressed in this study. Violence in video games is one such aspect. This research is rather limited to looking at important design features needed for an educational game, which might inform instructional designers and game designers about creating compelling instructional games.
5. The researcher lives closer to Baltimore County Public Schools and the selection of the school district could itself lead to some sampling bias. Despite this sampling bias, there could be much interest in the data and the outcome of this study, which might lead to better design of educational games.

Recommendations for future research

Video games and education is a relatively young field of research in educational psychology. There is a tremendous scope for future research in this field. Specific to the current study, following are a few recommendations for future research:

1. A longitudinal study about the effects of fantasy in an instructional video game might help to give insight into whether fantasy helps to improve learning in the long term. Yet another possible study could be about how much fantasy should be included in a game.

2. A more detailed research is needed to find out whether and how other features such as audio, 3D graphics might help to deliver compelling educational games.
3. A more detailed research is also needed to find out whether game features such as challenge and feedback help towards long term retention of knowledge.

Chapter summary

Instructional games or serious games have the potential to motivate students to learn in a better manner, provided they have the right blend of educational and entertainment features. Among the various features, challenge is one of the important elements, which positively augments learning. Fantasy does not seem to help toward learning, and distracts students from the educational aspect of the game. It remains to be seen whether fantasy will have a positive effect in motivating students to learn in the long-term. Additionally, future research may be able to throw light on what amount of fantasy would be suitable for a positive impact on learning. Gender, GPA, game skillfulness, ethnicity, and socio-economic status did not impact learning in a statistically significant manner. Future research studies can explore long term knowledge retention through the challenge and fantasy features in instructional games, and also study the effect of including other features such as good graphics, audio, and 3D navigation capabilities. While games are not the magic wand to promote learning, games can be used as a powerful tool toward effective learning. A collaborative approach between game designers and instructional designers can lead to effective instructional video games with a good blend of entertainment and pedagogical features.

Appendices

A. Identification Test (Pretest)

B. Terminology Test (Pretest)

C. Comprehension Test (Pretest)

D. Identification Test (Posttest)

E. Terminology Test (Posttest)

F. Comprehension test (Posttest)

G. Survey Instrument

H. Survey code book

I. Variables Codebook

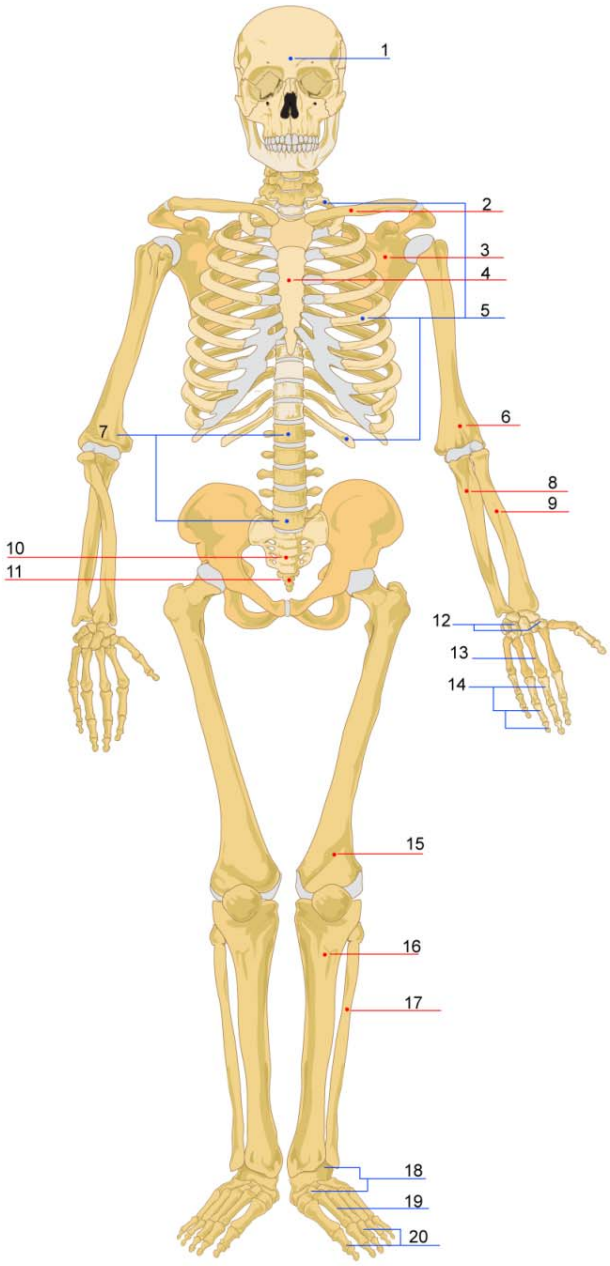
J. Adult Consent Form

K. Parental Consent Form

L. Child Assent Form

Appendix A: Pretest Identification test

Directions: In the table to the right of the diagram, write the correct name of the bone identified by the numbered line.



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Appendix B: Pretest Terminology test

Directions: Please match the bone with its common name.

Clavicle

a. Collarbone
b. Jawbone
c. Wrist
d. Spine

Scapula

a. Breast Bone
b. Shoulder Blade
c. Funny Bone
d. Thigh Bone

Mandible

a. Skull
b. Jawbone
c. Kneecap
d. Spine

Vertebrae

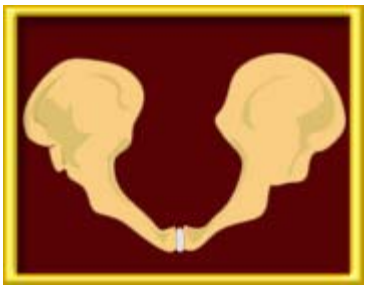
a. Hip
b. Thigh Bone
c. Neck Bone
d. Spine

Metacarpals

a. Ankle
b. Finger Bones
c. Shin Bone
d. Wrist

Patella

a. Upper Arm Bone
b. Lower Leg Bone
c. Upper Leg Bone
d. Kneecap



Pelvis

a. Hips
b. Spine
c. Lower Arm Bone
d. Upper Arm Bone

Tarsal

a. Lower Leg Bone
b. Ankle
c. Thigh Bone
d. Lower Spine

Sternum

a. Collarbone

b. Shoulder Blade

c. Breast Bone

d. Upper Spine

Humerus

a. Shin Bone

b. Funny Bone

c. Wrist

d. Lower Leg

Appendix C: Pretest Comprehension test

Directions: Read each question carefully and select the answer that best completes the statement or answers the question.

1. How many bones are there in a normal adult body?
    a. 206
    b. 208
    c. 300
    d. It differs for each person and is based on the body composition of an individual.

    Answer:

2. The skeletal system consists of:
    a. All the bones in the body.
    b. All the organs and glands.
    c. All the bones and the tissues that connect them.
    d. All the muscles and tendons.

    Answer:

3. The hollow space in the middle of the bones is filled with:
    a. Bone cells
    b. Bone marrow
    c. Blood
    d. Air

    Answer:

4. The name of the bone that protects the brain:
    a. Calcium
    b. Cerebrum
    c. Cerebellum
    d. Cranium

5. _____ is the name of the tissue that connects muscle to bones.

6. Human skeletal system is a non-living supporting structure:
    a. True
    b. False

    Answer:

7. There are three types of joints. They are _____,
    _____ , _____

8. The spinal column consists of:
    a. 33 vertebrae
    b. 31 vertebrae
    c. 207 vertebrae
    d. Vertebrae differ from person to person.

    Answer:

9. The main difference between compact bones and spongy bones is:
    a. They differ in their bone marrow
    b. Compact bones are made of silica and spongy bones are made of calcium
    c. The bone cells are packed closely in compact and they are spread apart in spongy cells.
    d. Their bone cells are of different sizes.

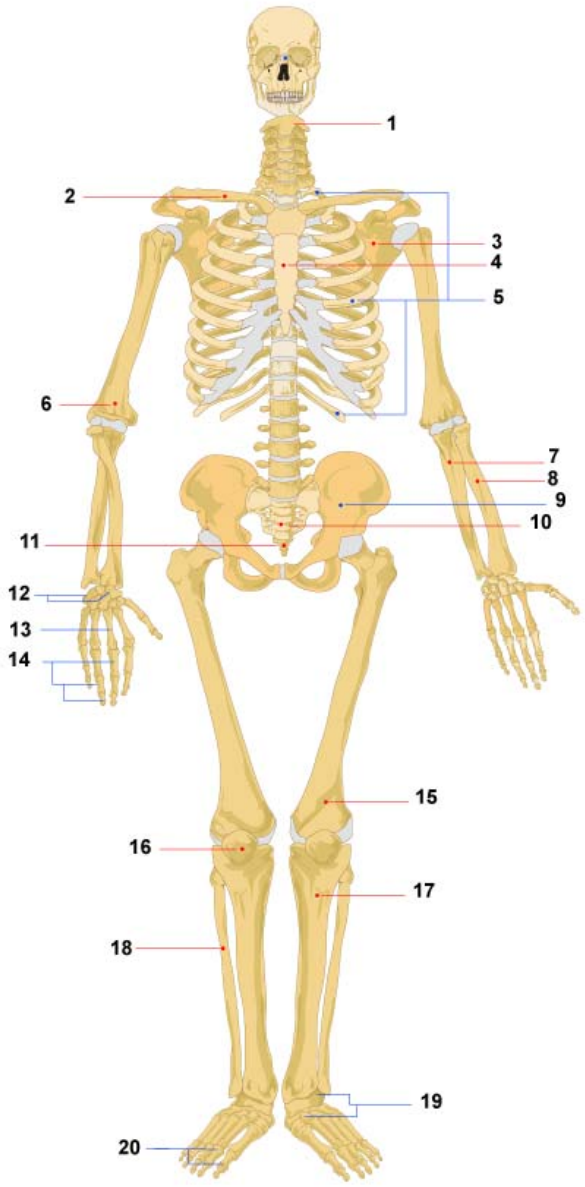
10. Bones are very strong because they are made of:

    a. Titanium
    b. Calcium and phosphorous
    c. Silica and calcium
    d. Blood and marrow

    Answer:

Appendix D: Posttest Identification test

Directions: In the table to the right of the diagram, write the correct name of the bone identified by the numbered line.



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Appendix E: Posttest Terminology test

Directions: Please match the bone with its common name.

Carpal

a. Wrist
b. Upper Arm Bone
c. Lower Spine
d. Lower Leg Bone

Tibia

a. Thigh Bone
b. Upper Spine
c. Ankle
d. Shin Bone

Cranium

a. Skull
b. Breast Bone
c. Jawbone
d. Collarbone

Humerus

a. Upper Arm Bone
b. Kneecap
c. Lower Leg Bone
d. Spine

Scapula

a. Hand Bones
b. Hips
c. Shoulder Blade
d. Breast Bone

Femur

a. Thigh Bone
b. Lower Leg Bone
c. Spine
d. Lower Spine

Mandible

a. Lower Spine
b. Upper Spine
c. Jawbone
d. Funny Bone

Coccyx

a. Ankle Bone
b. Upper Arm Bone
c. Toe Bones
d. Tail bone

Metatarsal

a. Heel Bone
b. Ankle
c. Foot Bone
d. Toe Bone

Humerus

a. Patella Kneecap
b. Thigh Bone
c. Shin Bone
d. Funny Bone

Appendix F: Posttest Comprehension test

Directions: Read each question carefully and select the answer that best completes the statement or answers the question.

1. The main function of a tendon is:
    a. To link muscles to ligaments
    b. To link bones to bones
    c. To link muscles to bones
    d. To link compact bone and spongy bone

    Answer:

2. A bone is where most blood cells are made and also serves as a storehouse for various minerals:
    a. True
    b. False

3. The number of bones there in an average person's body is _____

4. Which of the following joint that would allow bones to move only in one direction:
    a. Pivot
    b. Ball and Socket
    c. Hinge
    d. Ellipsoidal

    Answer:

5. In an adult body, the place where blood cells are made is known as:
    a. Bone marrow
    b. Body's capillaries
    c. Lungs
    d. Arteries

    Answer:

6. The name of the tissue that connects a bone to another bone is _____

7. The cells that are responsible for bone formation are known as:

    a. Osteoclasts
    b. Osteoblasts
    c. Lining Cells
    d. Red blood cells

    Answer:

8. The main difference between cartilage and bone is:
    a. Bone is cushiony, and cartilage is firm.
    b. Cartilage is cushiony, and bone is firm.
    c. Bone is a more primitive tissue than cartilage.
    d. Bone is inside the body, and cartilage is outside.

    Answer:

9. Besides brain the cranium also protects:
    a. Eyes
    b. The sense organs
    c. Chest and lungs
    d. The diaphragm

    Answer:

10. The largest bone in the body is _____.

Appendix G: Game skillfulness survey

Games and skills survey

Please select any one of the options for each question below, except Question 6 where you can select more than one option:

1. **How much enjoyment do you get from playing video games?**
    a. A great deal
    b. A lot
    c. A moderate amount
    d. A little
    e. Not at all

2. **I play video games regularly.**
    a. More than 8 hours a week
    b. 6-8 hours a week
    c. 4-6 hours a week
    d. 2-4 hours a week
    e. 0-2 hours a week
    f. I do not play video games at all.

3. **How much time does it take you to learn a new game?**
    a. 4-6 hours
    b. 2-4 hours
    c. 0-2 hours
    d. I don’t need any training; I will figure out while I am playing the game.

4. **I have been playing video games for the past:**
    a. 6 years or more years
    b. 5 years
    c. 4 years
    d. 3 years
    e. 2 years
    f. 1 year
    g. Less than 1 year

5. **Do you believe that video games are fun?**
    a. A great deal
    b. A lot

c. A moderate amount
d. A little
e. Not at all

6. Which of the following game systems do you play? (Please check all the systems you play.)

a. Nintendo DS
b. Nintendo Wii
c. Sony PlayStation
d. X-Box
e. PC platform
f. Online Games

7. Where do you play? (Please check all the places you play.)

a. At my home
b. At my school
c. At my friends' place
d. Other (like mall, game arcade etc.)

8. What is your gender?

a. Female
b. Male

9. What is your current grade in school?

a. 10^{th} grade b. 11^{th} grade c. 12^{th} grade

10. What do you consider your main ethnic or national group to be?

a. African American
b. Asian American
c. European/Caucasian
d. Hispanic or Latino origin
e. Middle Eastern
f. Native American

11. Age: _____ Years

12. Under what range does your current Grade Point Average (GPA) fall? (Circle only one choice. Please do not **provide the actual GPA.)**

a. 4.0 – 3.5
b. 3.0 – 3.4
c. 2.0 – 2.9
d. Below 2.0

Appendix H: Survey Codebook

Variable Label and Description	Variable Name	Variable Width
ID Number **01 – n**	ID	4
Game enjoyment 0 – Not at all 1– A Little 2 – A moderate amount 3–A lot 4– A great deal 99 – No response	Q1	2
Time spent on video games 0 – I do not play video games at all. 1 – 0-2 hours a week 2 – 2-4 hours a week 3 – 4-6 hours a week 4 – 6-8 hours a week 5 – More than 8 hours a week 99 – No response	Q2	2
Time to learn a video game 0 – 4-6 hours 1 – 2-4 hours 2 – 0-2 hours 3 – I don't need any training; I will figure out while I am playing the game. 99 – No response	Q3	2
Familiarity with video games 0 – Less than one year 1 – 1 year 2 – 2 years 3 – 3 years 4 – 4 years 5 – 5 years 6 – 6 years 99 – No response	Q4	2

Perception about video games: Fun or not? 0 – Not at all 1 – A Little 2 – A moderate amount 3 – A great deal 99 – No response	Q5	2
Video game systems played: 0 – No system/No response 1 – One system 2 – Two systems 3 – Three systems 4 – Four systems 5 – Five systems 6 – Six systems	Q6	1
Number of places video games are played: 1 – One place 2 – Two places 3 – Three places 4 – Four places	Q7	2
Respondent's Gender: 1 – Female 0 – Male 99 – No response	Q8	2
Academic Status: 10 – 10th Grade 11 – 11th Grade 12 – 12th Grade 99 – No response	Q9	2
Ethnicity: 1 – African 2 – Asian 3 – European 4 – Middle Eastern 5 – Native American 6 – Hispanic 99 – No response	Q10	2

Age: Valid data in terms of number of years.	Q11	2
Current GPA 1.00 – Enter the self-reported GPA (up to 2 decimal points) 99 – No response	Q11	4

Appendix I: Variables Codebook

Variable Label	Variable Name	Variable Width	Column	Variable Type
Pretest Composite Score	Pretest_score	2	1	Scale
Posttest Composite Score	Posttest_score	2	1	Scale
Feature	Feature	1	1	Nominal: 1 = Challenge on 2 = Fantasy on 3 = Both on 4 = None on

Appendix J: Adult Consent Form

SYRACUSE UNIVERSITY

Instructional Design, Development and Evaluation

Adult Consent Form

My name is Kannan AMR and I am a doctoral student at Syracuse University, Syracuse, NY. You have been invited to take part in a study named **Learning through Games: Essential Features of an Educational Game.** There are two purposes of this research study: Firstly, to find what are the important features of an instructional game, and secondly to find out how these game features enhance learning. The research is being conducted by Kannan AMR, as part of his Doctoral Dissertation. The faculty sponsor of this work is Dr. Rob Pusch, Associate Director, Project Advance, Syracuse University.

If you wish to participate in the study, you will

1. Take a short pre-test on human skeletal system.

2. Play an educational game called as “Humatan”, which will teach the human skeletal system.

3. After playing the game, you will be asked to take a short post-test that will test your understanding of the human skeletal system. The content of the Humatan game will cover only human skeletal anatomy. The game will not contain any content on anatomical components that may be considered inappropriate for public viewing. Your participation will take about an hour.

There may be minimal risks associated with your participation in this research. You will be asked to take a short test before you start playing the game and you will be asked to take another test after you play the game and a small survey about your video game skills. You may be embarrassed if you do not know the answers to the questions. In order to avoid this risk of embarrassment, you will not be asked for your name in the pre and post tests as well as in the survey. The survey, pre and post tests will have an identification number which will be used to track results and conduct data analysis and which will not be linked with you. Therefore, no link will be made between any test results or the survey questionnaire and you and thus your privacy will be protected. Please know that the aim is to learn about your experiences with the game and not to evaluate your performance. If you are not comfortable to take the exam you do not need to participate in the study.

Although you will not receive any direct benefits for participation in this study apart from playing an educational game, it will make you more aware of the human skeletal system and help me to

understand better how the educational games impact students' learning and what are the important game features that will positively augment learning.

Taking part in this study is voluntary. There is no monetary compensation and no class credit will be provided to participate in this study. Not taking part or withdrawing after the study has begun will not affect your grade or academic standing in any way. If you decided to withdraw at any time, no credit but also no penalty will be given. You have the right to skip or not to answer any questions that you prefer.

In order to protect your privacy, I will not collect any personally identifying information about yourself such as name etc. The data from the study will be kept at least until 5 years after publication, as recommended by the American Psychological Association. When it is destroyed, hard copies will be shredded and the computer data will be erased.

If there is anything about the study or taking part in it that is unclear or that you do not understand, if you have questions you may contact Kannan AMR at 330 Huntington Hall, Syracuse University, Syracuse, NY 13244 or through phone: 410-988-3015 (Home) 443-825-7239 (Cell) or through email: kamr@syr.edu, or the faculty sponsor, Dr. Rob Pusch, at 400 Ostrom Ave, Syracuse, NY 13244 or through Phone: 315-443-5706, or through email: rpusch@syr.edu. If you wish to report a research-related problem or for questions about your child's rights as a research participant, you may contact the Office of Research Integrity and Protections, 121 Bowne Hall, Syracuse, New York 13244-1200; Phone: 315.443.3013; Fax: 315. 443.9889; e-mail: orip@syr.edu

Sincerely,

_____ _____

[Signature] Date

_____

[Typed name]

All of my questions have been answered, I am over the age of 18 and I wish to participate in this research study. I have received a copy of this consent form to keep for my records.

_____ _____

Signature of participant Date

_____

Printed name of participant

330 Huntington Hall / Syracuse, New York 13244-2340 / 315-443-3703 / Fax: 315-443-1218

Appendix K: Parent Consent Form

SYRACUSE UNIVERSITY

INSTRUCTIONAL DESIGN, DEVELOPMENT AND EVALUATION

Parental/Guardian Permission form

Your child, _____, is invited to take part in a study named Learning through Games: Essential Features of an Educational Game. There are two purposes of this research study: Firstly, to find what are the important features of an instructional game, and secondly to find out how these game features enhance learning. The research is being conducted by Kannan AMR, as part of his Doctoral Dissertation. The faculty sponsor of this work is Dr. Rob Pusch, Associate Director, Project Advance, Syracuse University.

If you give permission for your child to be in this study, he/she will be asked to: 1. Take a short pre-test on the human skeletal system. 2. Play an educational game called "Humatan", which will teach the human skeletal system. 3. After playing the game, your child will be asked to take a short post-test that will test your child's understanding of the human skeletal system. The content of the Humatan game will cover only human skeletal anatomy. The game will not contain any content on anatomical components that may be considered inappropriate for public viewing. Before your child starts the study, a thorough verbal explanation of the study will be given to him/her.

There is minimal risk associated with your child's participation in this research. They will be asked to take a short test before they start playing the game and they will be asked to take another test after they play the game and a small survey about their video game skills. Your child may be embarrassed if he or she does not know the answers to the questions. In order to avoid this risk of embarrassment, the student will not be asked for their names in the pre and post tests as well as in the survey. The survey, pre and post tests will have an identification number which will be used to track results and conduct data analysis and which will not be linked with the student. Therefore, no link will be made between any test results or the survey questionnaire and the specific student and thus your child's privacy will be protected. The researcher will also explain to your child that the aim is to learn about his/her experiences with the game and not to evaluate his/her performance. If they are not comfortable to take the exam they will not be forced to participate in the study.

Although your child will receive no direct benefits for participation in this study apart from playing an educational game, it will make him or her more aware of the human skeletal system and help the investigator understand better how educational games impact students' learning and the important features that will positively augment learning.

330 Huntington Hall / Syracuse, New York 13244-2340 / 315-443-3703 / Fax: 315-443-1218

Taking part in this study is voluntary. There is no monetary compensation and no class credit will be provided to participate in this study. Not taking part or withdrawing after the study has begun will not affect your child's grade or academic standing in any way. If your child withdraws at any time, no credit but also no penalty will be given. Your child has the right to skip or not answer any questions he or she prefers.

Confidentiality of your child's research records will be strictly maintained by not collecting any identifying information such as name etc. about your child. The data from the study will be kept at least until 5 years after publication, as recommended by the American Psychological Association. When it is destroyed, hard copies will be shredded and the computer data will be erased.

If there is anything about the study or taking part in it that is unclear or that you do not understand, if you have questions you may contact Kannan AMR at 330 Huntington Hall, Syracuse University, Syracuse, NY 13244 or through phone: 410-988-3015 (Home) 443-825-7239 (Cell) or through email: kamr@syr.edu, or the faculty sponsor, Dr. Rob Pusch, at 400 Ostrom Ave, Syracuse, NY 13244 or through Phone: 315-443-5706, or through email: rpusch@syr.edu. If you wish to report a research-related problem or for questions about your child's rights as a research participant, you may contact the Office of Research Integrity and Protections, 121 Bowne Hall, Syracuse, New York 13244-1200; Phone: 315.443.3013; Fax: 315. 443.9889; e-mail: orip@syr.edu

Sincerely,

_____ _____

[Signature] Date

_____

[Typed name]

All of my questions have been answered, I am over the age of 18 and I wish my child to participate in this research study. I have received a copy of this consent form to keep for my records.

Permission

_____ _____

Signature of parent or guardian Date

_____

Printed name of parent or guardian

_____

Printed name of student

Appendix L: Informed Assent form

SYRACUSE UNIVERSITY

INSTRUCTIONAL DESIGN, DEVELOPMENT AND EVALUATION

Informed Assent form

My name is Kannan AMR, and I am from the School of Education, at Syracuse University (SU). I am asking you to participate in this research study because you are a high school student studying at a school affiliated to Baltimore County Public Schools.

PURPOSE:

A research study is a way to learn more about people.In this study, I am trying to learn more about the important features of an instructional game, and secondly to find out how these game features enhance learning.

PARTICIPATION:

If you decide you want to be part of this study, you will be asked to

1. Take a short written quiz on the human skeletal system.

2. Play an educational video game called “Humatan”, which will teach the human skeletal system.

3. After playing the game, you will be asked to take a short quiz that will test your understanding of the human skeletal system.

All of this should take about an hour.

RISKS & BENEFITS:

There are some things about this study you should know. You may be embarrassed if you do not know the answers to the questions. To avoid this risk of embarrassment, please do not write your name in the quiz papers. When I write my report, I will not include your name or that you were in the study. Through this study I want to understand how students learn through games and what game features help them most. If you do not want to be in this study, you can withdraw at any point of time.

330 Huntington Hall / Syracuse, New York 13244-2340 / 315-443-3703 / Fax: 315-443-1218

Not everyone who takes part in this study may benefit. A benefit means that something good happens to you. We think the benefits might be that you will be allowed to play a video game which may be fun for you. Also while playing you will learn about the human skeletal system, which might help you in your Biology subject.

REPORTS:

When I am finished with this study I will write a report about what was learned. This report will not include your name or mention that you were in the study. When I talk to others about my study, I will not mention your name, so that no one can tell whether you have participated or not.

VOLUNTARY:

"Voluntary" means that you do not have to be in this study if you do not want to be. Your parents or guardian have to say it's OK for you to be in the study. After they decide, you get to choose if you want to do it too. If you don't want to be in the study, no one will be mad at you. If you want to be in the study now and change your mind later, that's OK too. You can stop at any time.

You can also talk with your parents, grandparents, and teachers (or other adults if appropriate) before deciding whether or not to take part. You can also skip any of the questions you do not want to answer.

QUESTIONS: You can ask questions now or whenever you wish. If you want to, you may call me at 410-988-3015 or you may call Dr. Rob Pusch at 315-443-5706**.** If you are not happy about this study and would like to speak to someone other than me, you or your parents may call the Syracuse University Institutional Review Board (IRB) at 315-443-3013.

Please sign your name below, if you agree to be part of my study (signature line needed for participants 7-17; if participants are below the age of 7, only the researcher should sign at the completion of assent process). You will get a copy of this form to keep for yourself.

Signature of Participant _____ Date _____

Name of Participant _____

Signature of Investigator or Designee _____Date _____

330 Huntington Hall / Syracuse, New York 13244-2340 / 315-443-3703 / Fax: 315-443-1218

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Curriculum Vitae

Kannan AMR

Kannan Aranappakkam Mudumbai Rajagopalan

Skills Summary

Instructional experience: I have about 6 years of experience as a full-time faculty, and 6 years as an adjunct faculty in higher education universities.

Project management: I have successfully managed several projects, starting from needs analysis, defining project scope, managing schedules, and deliverables in my capacity as Instructional Technology Consultant at Syracuse University, and as Assistant Professor at Stevenson University and currently as an Assistant Professor at the University of Wisconsin-Whitewater.

Administrative experience: I have participated and lead several administrative and curriculum planning and revision committees.

Multimedia Technology Skills: I am proficient in various cutting edge technologies ranging from Game engines, graphical & layout design tools, animation and simulation/modeling tools, DVD/Video editing software, 3D modeling, sound editing Tools, web design and development tools, Web 2.0 (Social Networking, Podcasting, and Webinars), statistical analysis tools, and content management systems.

Communication: My background as a photojournalist, faculty member, and a graduate in Visual Arts and Interactive Communications has helped me to become an effective communicator.

Researcher: I am proficient in conducting research studies, quantitative and qualitative data analyses, and interpretation of results. I have experience in conducting research studies in public schools.

Grant proposal writing: I have experience in writing and assisting faculty members with writing RFPs.

Conference and publications: I have submitted papers to peer-reviewed conferences and conference proceedings have been published.

Education

School of Education, Instructional Design, Development and Evaluation (IDD&E), Syracuse University, Syracuse, NY
Successfully defended dissertation, “Learning through games: Effective features of an educational game” on December 16, 2011. I will be graduating in spring 2012.

School of Education, IDD&E, Syracuse University, Syracuse, NY
MS in Instructional Design, Development & Evaluation, fall 2010

S.I. Newhouse School of Public Communications, Syracuse University, Syracuse, NY
MS Visual and Interactive Communications, August 1999

Madras University, Madras, India
MA Political Science, 1993

Conference Presentations and Publications

Lombardi, J. A, AMR, K. & Kayla, T. (2010). Reflections on social change by design: how students created a service learning website. *Proceedings of the Service-learning and civic engagement conference: planting seeds of service: cultivating civic engagement*. Towson, MD: Towson University.

AMR, K. & Hostalka, A. (2009). Keynote speakers for the *Center for Talented Youth Odyssey Series: Visual and Performing Arts program at Johns Hopkins University* on March 28, 2009.

AMR, K. & Tiedemann, D. (2008). Challenges in Technology Integration in a Higher Education Institution: A case study at Syracuse University. *Association for Educational Communications & Technology (AECT) 2008 Conference Proceedings*, Orlando, FL: AECT.

AMR, K. (2007). Constructing Knowledge through Games: Essential factors for an effective educational game. In *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2007* (pp. 1601-1609). Chesapeake, VA: AACE.

AMR, K. & Firmin, M. (June 2005). "Incentives and Impediments to Using Technology in Higher Education: A Qualitative Case Study." A paper presented at the 17th Annual Conference on Ethnographic and Qualitative Research in Education, Cedarville, OH.

AMR, K. (2004). Instruction through Multimedia: Creating an online quiz using Macromedia Flash MX 2004. Association for Educational Communications &Technology (AECT) 2004 Conference Proceedings, Chicago, IL: AECT.

AMR, K. (2004, 2003 & 2002). Multimedia Workshops on Flash MX / Dreamweaver MX. Hands-on workshops conducted at the Empire State School Press Association, Syracuse, NY.

AMR, K. (2002, 2001). Pedagogical use of Macromedia Flash 5.0. Hands-on workshop conducted at the Teaching Tools Conference, Syracuse, NY.

Association Memberships

Association for the Advancement of Computing in Education (AACE)
Association for Computing Machinery (ACM)
Association for Educational Communications and Technology (AECT)
Special Interest Group on Computer Graphics and Interactive Techniques (SIGGRAPH)

Teaching Experience

Assistant Professor (January 2012 – present)
Media Arts and Game Development Program, Communication Department, University Wisconsin-Whitewater, Whitewater, WI

As an assistant professor I teach four courses per semester on web development, game design and photography. I am also involved in the Media Arts and Game Development program curriculum development. As an advisor to students I perform the following duties:

- Support students in their efforts to learn about degree and graduation requirements.
- Explain major requirements, help with registration and aid in course selection and class scheduling.
- Listen to and review students' academic and career plans, suggesting alternatives if necessary.
- Provide information on resources and opportunities.

Courses I am currently teaching:

- MAGD 270: Web Development
- Journalism 310: Publication Photography

Assistant Professor (Fall 2006 – Summer 2011)
Art Department, Visual Communication Design, Stevenson University, Stevenson, MD

I have taught four courses per semester pertaining to visual communication and design. I was involved in design, development and evaluation of the curricula within the visual communication design major with specialization in graphic design, animation, photography, web, and motion graphics. I also actively pursue my research in games for improving science education for high school students in the US. I acted as an advisor for Visual Communication Design major students.

Courses Taught:

- IS 124 – Introduction to Computer Graphic Design
- IS 224 – Graphic Design Practicum: Intro to InDesign
- VCD 306 – Web Design I
- VCD 308 – Web Design II
- VCD 480 – Studio Design
- IS 224 – Graphic Design Practicum: Intro to Dreamweaver
- Photo 140 – Introduction to Photography
- Photo 240 – Intermediate Photography
- Photo 260 – Digital Photography
- Photo 340 – Advance Photography

Adjunct Faculty (May 2000 – Summer 2006)
School of Education, Department of Instructional Design, Development & Evaluation, Syracuse University

IDE 552 – Digital Media Production

This is a graduate level course, providing an introduction to digital media production within an instructional design environment. The goal is to introduce students to the crucial concepts of digital media, equip them with the necessary skills and concepts in cutting edge digital technology, and to make them think critically about the use of digital media in their everyday work requirements.

Adjunct Faculty (Fall 2003)
S.I. Newhouse School of Public Communications, Syracuse University
ICC 555 – Communicating With Computers

This is a graduate level course, with the expected outcome of introducing students to the emerging area of interactivity, providing students with the principles of human computer interaction, making the students skilled in various tools and techniques that enhance interactivity, and add value to content. This course is meant to give students hands-on experience in designing an interaction for a given audience.

Adjunct Faculty (Fall 2002)
S.I. Newhouse School of Public Communications, Syracuse University
ICC 500 – New Media Concepts

This is a graduate level course to teach design and development of cross-platform, low-bandwidth animations, presentations and web applications using Macromedia Flash MX. It is a task-based hands-on course, focusing on best design practices, disciplined programming, usability, optimization, and performance.

Administrative and Service Experience

- Media Arts and Game Development Program curriculum development committee: Spring 2012 – present
- Graduate Faculty Committee: Spring 2012 – present
- Visual Communication Program curriculum assessment and review committee: Fall 2010 – Spring 2011
- Faculty Welfare Council: Fall 2010 – Spring 2011
- Photography Adjunct faculty search committee: Spring 2010 – fall 2010
- General Education Curriculum Planning Committee (Critical Thinking and problem solving sub-committee): Spring 2009 – Fall 2009
- General Education Curriculum Planning Committee (Common Grounds – Diversity sub-committee): Fall 2009 – Spring 2010
- Dean Search Committee: Spring 2009
- Graphics Facilitator - University Restructuring Task Force (URTF): Fall 2008 – Spring 2009
- Student feedback sub-committee (Chair): Fall 2008
- Information Systems (IS) Program curriculum review committee: Fall 2008
- Visual Communication Program curriculum assessment and review committee: Fall 2007
- Motion Graphics new curriculum design committee: Fall 2007 – Spring 2008
- New Animation curriculum design (Chair): Spring 2008
- Faculty welfare committee: Fall 2007

Instructional and Corporate Experience

Instructional Technology Consultant (August 2002 – June 2005)
Faculty Computing & Media Services, Syracuse University, Syracuse, NY

Responsible for providing consultancy for web development tools, and graphic/image processing tools, multimedia design and production for offline content like CD-ROMs, DVD-ROMS, and print media, and online content for the Web, and on demand streaming media. I provided instructional and technical consulting on computing to faculty, by analyzing individual computing needs and developing specific training sessions. I acted as a team-lead for Web, CD and DVD based projects. These collaborative projects were designed as instructional tools for the campus community.

Multimedia Specialist (Sep 1999 – Aug 2002)
E.S. Bird Library, Syracuse University, Syracuse, NY

Responsible for instructing students, faculty and staff in the use of multimedia workstations, digital imaging and video capture units. Throughout the Academic year, I have conducted several workshops on web design, Flash and streaming video and audio. Responsible for troubleshooting system and application software problems on Mac and PC workstations, and for assisting with the department's web site design and Library's newsletter layout.

Media Lab Manager (Jan 1998 to Aug 1999)
S.I. Newhouse School of Public Communications, Syracuse University, Syracuse, NY
From January 1998 to August 1999 I worked as a Media Lab Manager and Teaching Assistant at Newhouse computer graphics lab. Responsibilities included instructing students in design, layout and illustration using major graphics software applications.

Principal Photographer (Dec 1995 – Aug 1997)
The Peninsula, Doha, Qatar
I worked as the Principal photographer from December 1995 to August 1997. I have covered a wide range of general and sports beats, special supplements and variety of news assignments. I independently coordinated the photographic requirements of the newspaper.

Staff Photographer (Mar 1994 – Dec 1995)
Indian Express, Madras, India
I worked as a staff photographer for this national newspaper of India from March 1994 to December 1995. I covered a wide range of outdoor and indoor assignments.

Multimedia Design & Production Skills

The following is a listing of my multimedia design and production skills.

Area of Proficiency	***Software Tools***
Data Analysis	SPSS
Gaming	Torque 2D, TGB Scripting, GameSalad and Storyboard Pro
Graphical & Layout Design Tools	Photoshop CS5 Illustrator CS5 QuarkXPress 8.0 InDesign CS5
Animation and Simulation/Modeling tools	Flash CS5 Captivate 5
DVD/Video Editing Software	Final Cut Pro DVD Studio Pro After Effects CS5
3D Modeling	3ds Max and Poser
Sound Editing Tools	Audition and Audacity
Web Design and Development tools	Dreamweaver CS5, Flash Builder (Flex), Action Script 3.0 ColdFusion Studio SQL, MS Access HTML, XML, and CSS DHTML, JavaScript, Content Management Systems (Drupal, Joomla and Dot Net Nuke)