NORTH-WEST UNIVERSITY

SCHOOL OF COMPUTER SCIENCE AND INFORMATION SYSTEMS

The Qualities of Games for Use in Education

Author:
Joshua ESTERHUIZEN
30285976

Supervisor:
Prof. Günther DREVIN

A thesis submitted in fulfilment of the requirements for the degree of Bachelor of Science Honours in Computer Science and Information Technology

for the ITRI671 module

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NORTH-WEST UNIVERSITY

Abstract

Faculty of Natural and Agricultural Sciences
School of Computer Science and Information Systems

Bachelor of Science Honours in Computer Science and Information Technology

The Qualities of Games for Use in Education

by Joshua ESTERHUIZEN

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Introduction

1.1 Project Description

A student's learning experience is typically affected by their enjoyment of interacting with the material and their general interest in the topic material presented. As such, a student will have their own individual preferences and style of learning. Due to the rapid and prevalent development of technology, using video games as a means of teaching has been a topic of discussion.

This project aims to create an artefact in the form of a digital game and incorporate specific qualities into one level to demonstrate how a game may be used in a learning environment through the example of an "advanced game tutorial" that aims to not only act as the usual tutorial phase of the game but also to infer certain information about the game's assorted enemy types.

1.2 Project Contents

1.2.1 Problem Description and Background

Education as it stands is still built on a system that is no longer needed in modern society. Ackoff and Greenberg (2008) explain that the current traditional methods of teaching are no longer as relevant as they once were as it is aimed to produce members of society that were likely to not question any fundamental aspects of how things operated. It is largely a system that focuses on teaching while disregarding learning as the last major stride in development in education was to industrialise it – having them operate efficiently like factories. Ackoff (1991) discusses that while learning is the advancement of one's understanding and knowledge on a given topic or subject, this can happen in the complete absence of teaching, which is the explanation of a subject from one person to another. The opposite of this is also true, teaching may occur with no learning.

One major flaw with this system currently is that it stifles the creativity and drive of some students as each level of education is largely the same and as such monotonous. As such, education needs some form of system to create an interest in learning for the students or risk providing only a means of teaching without individual students learning (Ackoff and Greenberg, 2008). It is therefore vital to provide learners in all levels of education with engaging content or methods of delivery that they will enjoy will cause them to be more motivated to learn and look further into that specific topic (Ackoff and Greenberg, 2008).

With the recent developments in technology and the fact that technology, in general, becoming more accessible, some institutions have adopted some forms of digital learning or assist traditional teaching with digital assistance. Deshpande and Huang (2011) state that the current generation of students is the first to grow up with abundant access to technology. They continue to state that, on average, these students spend almost double the time playing video games as they do reading (Deshpande and Huang, 2011).

Virvou, Katsionis and Manos (2005) echo the point that computer games are popular among individuals who are in schools and as such could provide a means to deliver content in an interesting and engaging manner. As such, the motivation behind this study is to further investigate the possibility of using video

games as a means to encourage learning in teaching environments as current means of teaching may not be optimal for some individuals.

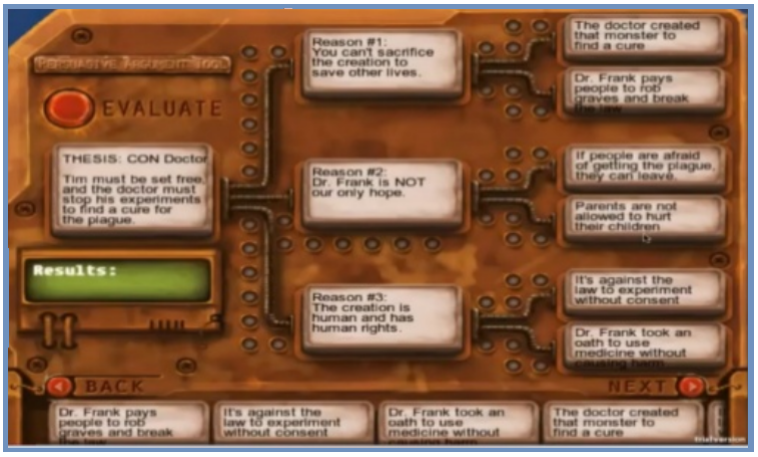


FIGURE 1.1: Example (Quest Atlantis) of an Educational Game

According to Annetta (2008), the movement for the inclusion of digital games to be used in teaching and training environments first started in 2003, two years after the field of ludology, the study of games, began to gain traction in academic literature. This initiative is what started the concept of a serious game as one that can be used in an academic sense to relay information. After this point in time, various examples of serious games were made for purely academic study purposes and had found a very large use in simulation for use as explanation aides and medical training.

The use of games as simulations may stretch the colloquial definition of a video game but in academic terms, this is one facet of video games. Frasca (2002) cites that simulations, such as the ones discussed above, can fall into one of two categories, namely; Paidea (play) and Ludus (game). "Play" refers to the simulations that lack any defined set of rules and conditions to meet a fixed goal while "Game" refers to a simulation that has these conditions and a user can directly, according to the predetermined rules, move towards a fixed goal (Frasca, 2002).

From the abovementioned definitions and examples, there is a loose description of what a serious game typically looks like and where it can be applied. However, the qualities needed by these games to effectively relay information has not been directly explained in any one piece of literature. There is also a lack of explanation on how these qualities can be applied to a game to result in what may be described as a serious game.

1.2.2 Overview of Related Literature

Annetta (2008) discusses multiple examples of these games, such as Discover Babylon and Quest Atlantis, that had been developed to immerse children and young adolescents in an academic environment. Further examples of the use of serious games have already had an impact on the military, medical and higher business education fields early in their conception and this trend continues to this day with most serious games being used within the medical fields specifically (Annetta, 2008).

Deshpande and Huang (2011) describe the use of games as a means of simulation for specific sections of work in physics and engineering courses as an addition to traditional teaching as it provides a relatively simple way to demonstrate certain phenomena. As such these authors discuss the simulation aspect of games rather than the narrative.

The endeavour to create serious games has yet to reach schools due to certain criticisms about games in general which hinder the adoption of games as a means of teaching and learning (Virvou et al., 2005).

The study of serious games became more theoretical and discussion-based at lower levels and more

applied with actual use at higher levels, with a great impact on medical fields and training. As such, there is a fair amount of theoretical research on specific aspects that relate to serious games as simulations and within ludology as a whole, but only a few mention the qualities a game needs to better present information to a user.

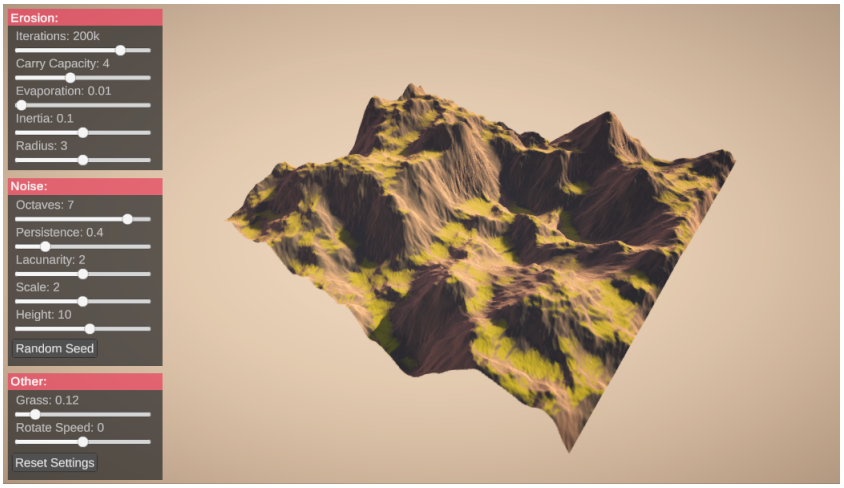


FIGURE 1.2: Example of Using a Game to Simulate Soil Erosion

1.2.3 Research Question and Expected Outcomes

The main research question this project is set out to answers is; "What qualities does a video game require in order for it to be useful in relaying certain information to a user whilst still maintaining proper engagement with the user?". The findings resulting from answering this question will be used in the development of a specific video game level that will attempt to teach users about the games various mechanics and enemy types presented.

The expected outcomes of this project is the aforementioned game as the artefact as well as a description of the qualities a game must exhibit to effectively relay information in an educational sense.

1.3 Aims and Objectives of Project

The primary aim of this study is to identify what qualities and principles can be applied to a video game to allow it to be used in a learning environment as a means to provide better engagement among certain students by providing an enjoyable delivery of information.

To effectively reach the aforementioned aim, all the following objectives will have to be met as certain objectives will benefit from the completion of others:

1. A literature study will need to be performed to gather information with a focus on:
   (a) Ludology, narratology and simulation to better understand the academia centred around this project;
   (b) Other implementations of serious games and the qualities they possess;
   (c) The impact and effects of games in early development as this is the main "target audience" if this project were to be implemented as well as in a more general sense;
   (d) Previous attempts to integrate game use in learning.
2. Collect examples of games that employ some form of teaching:
3. Where objective 1-ii focuses on examples already discussed in an academic sense, this objective will make use of more informal analysis

The next aim of this project is to develop an artefact which will require the following objectives:

1. Learn and understand how to use the chosen development platform and associated environments;
2. Develop a base to build other levels/scenes off of;
   (a) Development of basic scripts needed.
3. Create a specific scene/level within the aforementioned artefact that specialises in delivering information through various audio-visual stimuli that incorporates the principles and qualities found.

1.4 Procedures and Methods of Investigation

1.4.1 Research Paradigm and Methodology Used

The research aspect of this project will be conducted in accordance with the interpretivist paradigm. The main undertaking of this paradigm is to understand the world and its' various aspects according to the subjective experiences of people (Kivunja and Kuyini, 2017). It is due to this reason that this project uses this paradigm as what each student requires to efficiently learn is subjective to each individual. Kivunja and Kuyini (2017) further mention that the interpretivist paradigm makes use of subjective epistemology which allows the researcher to analyse the data, which in this project is the principles and qualities that allow for a game to be effective in a learning environment, through their individual cognitive processes.

Kivunja and Kuyini (2017) continue to list certain characteristics of research conducted under this paradigm typically possess. These include the understanding that the social world cannot be fully comprehended from one standpoint which is why this project makes use of various other studies in the compilation of the aforementioned principles and qualities. Another is that knowledge and its' understanding is developed through the findings of the study itself.

Design science is a methodology composed of using analytical techniques and can be used according to many paradigms to perform research in the information systems field (Vaishnavi and Kuechler, 2004). This means of research centres on the development of artefacts to better understand certain aspects through the creation of new knowledge and that assessment of an artefacts performance (Vaishnavi and Kuechler, 2004). This methodology was chosen as it provides certain outlines that will allow for the development and analyses of the principles and qualities for a game to be used academically through the creation of such artefact incorporation these qualities into its' design and development.

Design Science also provides a general structure as to how this project will be completed as shown in Figure 3 below taken from Vaishnavi and Kuechler's (2004) work. This process allows for the development of an artefact alongside the collection of information and knowledge that can be incorporated into the design and development of the artefact as well as the evaluation of the implementation of the qualities onto the artefact.

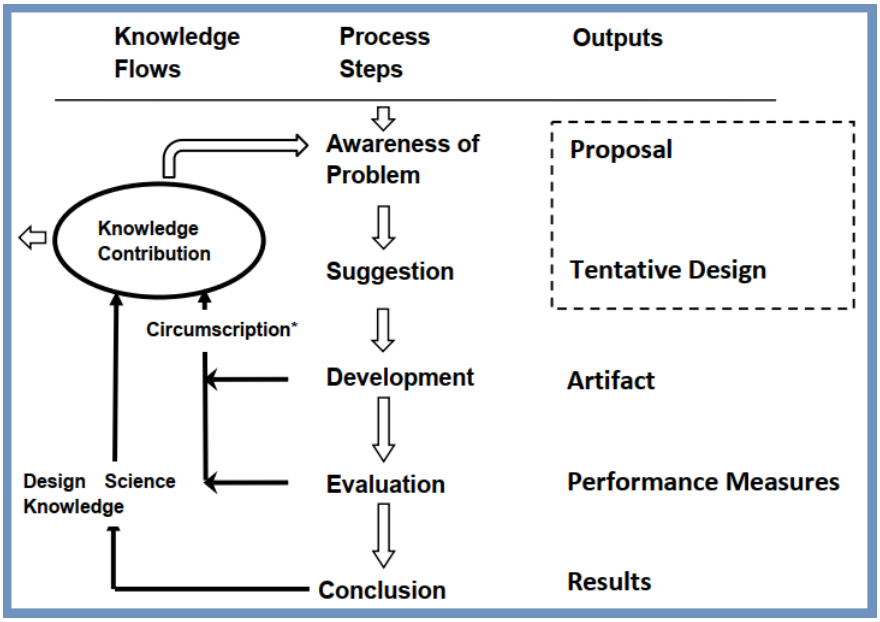


FIGURE 1.3: The Design Science Research Process (Vaishnavi and Kuechler, 2004)

1.4.2 Collection of Data

This project will collect data in the form of literary studies and real-world examples of serious and educational games. The main channel of processing this data will be in the form of a literature review and consequential implementation of the findings in an article.

1.4.3 Development of Artefact

The artefact that will be developed as a part of this project will be a computer video game that will be developed as a group effort. This game will be a standalone artefact with no major links to each group members research – it may, however, be influenced by them. Due to the expansive nature of game design, the Agile software development life cycle will be used. Following this cycle of development allows for the artefact to be developed in smaller increments through the use of iterative cycles and regular meetings about the design and features of the artefact (Highsmith and Cockburn, 2001). According to Highsmith and Cockburn (2001), Agile also allows for "dynamic prioritisation" which allows for the shifting of development to other aspects if they urgently require more attention over others on short notice. Agile also makes use of constant testing which ensures that defects and issues are found and dealt with quickly (Highsmith and Cockburn, 2001). Most importantly, the development of the artefact will be continuous from the start date and will make use of weekly scrums, or discussion-based meetings on what should be developed, to ensure a regular flow of development on the game.

1.4.4 Integration with Other Projects

The development of an artefact as part of this project is being conducted alongside two other students, one focusing on the different effects on cognition from various genres and the other dealing with the controls of games. These other projects are conducted by:

- GC Wehmeyer (29977339)
- Rickus Trollip (30083575)

These other projects only integrate with this one when concerning the artefact that will be developed as each will conduct a fully indecent research study and, if applicable, develop any other questionnaires or models independently. The development of the artefact will be done as a group effort and as such the computer game that will be developed for this project may be impacted by the findings of these other projects.

1.5 Approach to Project Management and Project Plan

1.5.1 Provisional Project Plan

The provisional project plan is discussed below and specific dates of completion may shift due to unforeseen circumstances. This project began on the 15th of February 2021 and will be fully completed by the 8th of November 2021. During this period the project has certain deadlines for particular deliverables that will need to be adhered to.

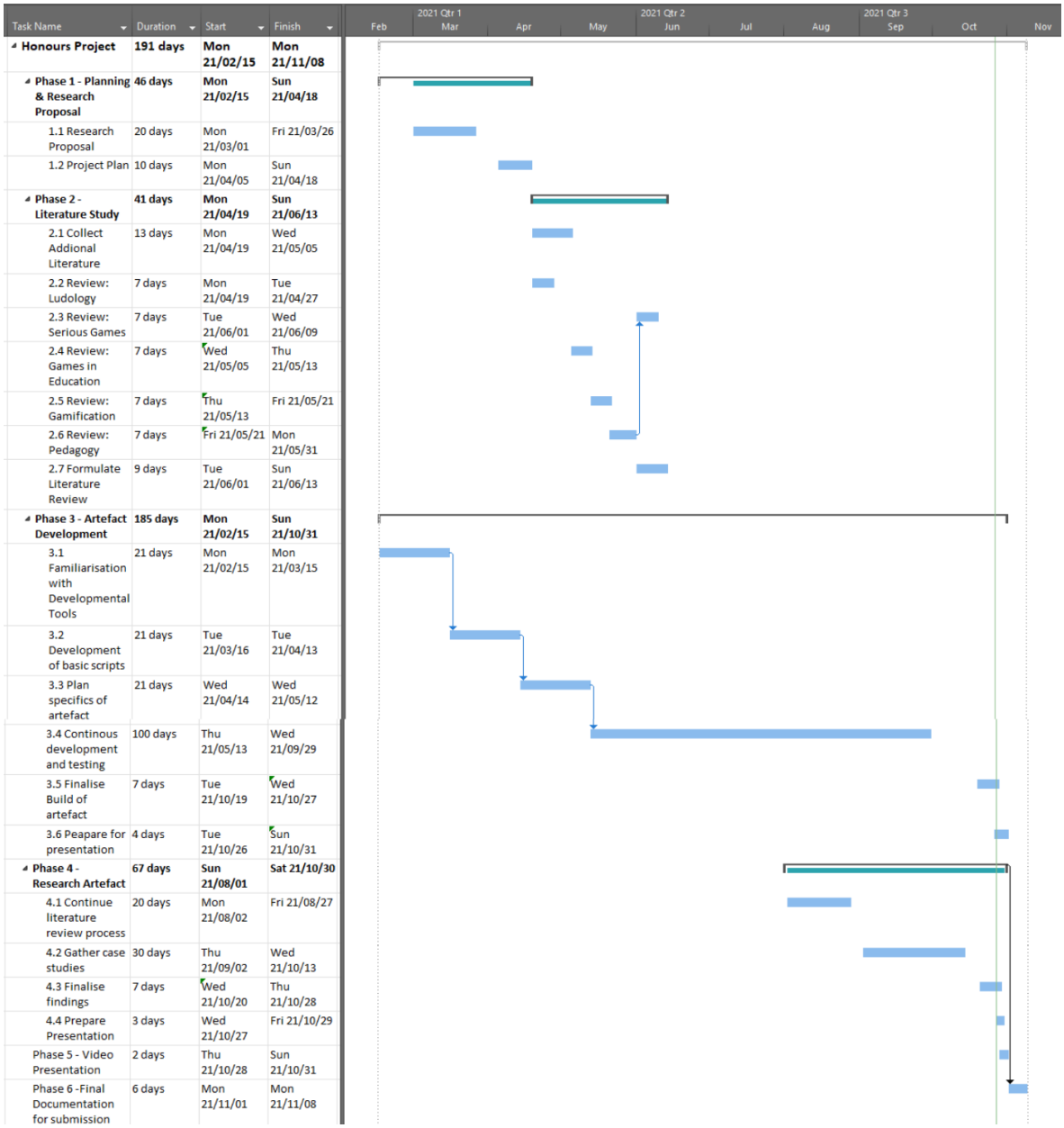
1. The first of these is the project planning and research proposal which must be completed and submitted by the 18th of April 2021. The research proposal will cover a substantiation of the project and its feasibility. The project planning includes a project description with the research question, the main aims and objectives of the project, a detailed explanation of the developmental process of the project, and a description of what will be used in the development of the project.

2. Following this, a literature study regarding Ludology as a whole, implementations of serious games, the qualities they possess, the impact and effects of games and previous attempts to integrate game use in learning. This literature review is set to be completed for submission by the 13th of June 2021.

3. The next deliverable for this project is the demonstration of the artefact and the development of a video presentation on the 1st of November 2021. This deliverable will be met by continuously developing the artefact according to provisional dates shown in Figure 4 below.

4. The final deliverable is the final documentation of the entire project that consists of all previous deliverables as one document with certain additions. This deliverable must be completed and submitted by the 8th of November 2021.

A more detailed breakdown of the project plan is presented in Figure 4 below with provisional dates for the deliverables and the anticipated objectives required to meet them.



Task Name	Duration	Start	Finish
Honours Project	**191 days**	**Mon 21/02/15**	**Mon 21/11/08**
Phase 1 - Planning & Research Proposal	**46 days**	**Mon 21/02/15**	**Sun 21/04/18**
1.1 Research Proposal	20 days	Mon 21/03/01	Fri 21/03/26
1.2 Project Plan	10 days	Mon 21/04/05	Sun 21/04/18
Phase 2 - Literature Study	**41 days**	**Mon 21/04/19**	**Sun 21/06/13**
2.1 Collect Addional Literature	13 days	Mon 21/04/19	Wed 21/05/05
2.2 Review: Ludology	7 days	Mon 21/04/19	Tue 21/04/27
2.3 Review: Serious Games	7 days	Tue 21/06/01	Wed 21/06/09
2.4 Review: Games in Education	7 days	Wed 21/05/05	Thu 21/05/13
2.5 Review: Gamification	7 days	Thu 21/05/13	Fri 21/05/21
2.6 Review: Pedagogy	7 days	Fri 21/05/21	Mon 21/05/31
2.7 Formulate Literature Review	9 days	Tue 21/06/01	Sun 21/06/13
Phase 3 - Artefact Development	**185 days**	**Mon 21/02/15**	**Sun 21/10/31**
3.1 Familiarisation with Developmental Tools	21 days	Mon 21/02/15	Mon 21/03/15
3.2 Development of basic scripts	21 days	Tue 21/03/16	Tue 21/04/13
3.3 Plan specifics of artefact	21 days	Wed 21/04/14	Wed 21/05/12
3.4 Continous development and testing	100 days	Thu 21/05/13	Wed 21/09/29
3.5 Finalise Build of artefact	7 days	Tue 21/10/19	Wed 21/10/27
3.6 Peapare for presentation	4 days	Tue 21/10/26	Sun 21/10/31
Phase 4 - Research Artefact	**67 days**	**Sun 21/08/01**	**Sat 21/10/30**
4.1 Continue literature review process	20 days	Mon 21/08/02	Fri 21/08/27
4.2 Gather case studies	30 days	Thu 21/09/02	Wed 21/10/13
4.3 Finalise findings	7 days	Wed 21/10/20	Thu 21/10/28
4.4 Prepare Presentation	3 days	Wed 21/10/27	Fri 21/10/29
Phase 5 - Video Presentation	2 days	Thu 21/10/28	Sun 21/10/31
Phase 6 -Final Documentation for submission	6 days	Mon 21/11/01	Mon 21/11/08

FIGURE 1.4: Provisional Project Plan

1.5.2 Scope

This project is split into two distinct parts. First is the research aspect that will be conducted individually which involves the review and analysis of literature and examples of serious games. This aspect aims to find and describe the qualities and principles that could allow a game to be used in a learning environment.

The second aspect of this project is the development of a computer game as the artefact. This artefact will be developed as a group effort with each member focusing on specific areas of development and all members having some contribution to other areas.

1.5.3 Limitations

The most notable limitation towards this project is that it must be completed according to a fixed time frame which is provisionally set out as follows:

- Submission of the project plan and research proposal on 18th April 2021
- Submission of the literature study on 13th June 2021

- Demonstration of the artefact and a poster on 1st November 2021
- Submission of the complete documentation of the project on 8th November 2021

Other time constraints will be applied according to certain aspects of development, such as meetings or self-imposed deadlines, which can only be set at a later date.

As will be discussed in 1.6, the artefact will make use of third party resources and as such is limited to what is publicly available at no cost as not to apply any financial constraints on the projects involved with the artefact.

Since the artefact developed is a digital computer game, the demonstration and development of it will require a system that meets the requirements for the associated development platform and environments. As such the artefact is limited to systems with the following minimum requirements - as described by Unity:

- Windows 7;
- Processor with x64 architecture;
- A capable graphics processing system with DX10, DX11 and DX12 functionality.

1.5.4 Risks and SWOT Analysis

The project will have risks associated with the artefact, which will be discussed below.

Firstly, is the risk of scope creep. As the planning only depicts and describes the basic structure and aims of the project, once development on the artefact begins the specifications and features may continue to increase in number which may cause the project to fail expectations set. As such, the intended features of the artefact should be discussed and solidified early on in its' development to mitigate this specific risk.

The artefact's development and the research aspect of this project is also at risk of unforeseen events. In an attempt to mitigate the harm that may be caused by these events, the artefact is being developed in such a manner to facilitate both contact sessions as well as fully digitally.

1.5.5 Contributions of Each Group Member

This project has an element of group work as the artefact that will be developed will be done as a group. Each member of the group will be responsible for different aspects of the development of the artefact such as, but not limited to;

- focusing on the animation of models,
- development of character controls,
- developing a simple artificial intelligence for the enemy characters;
- narrative design and
- level layout and design.

Members may be fully responsible for the contribution of the aforementioned areas while other aspects may be worked on by all members concurrently. The specific areas that a group member will contribute towards will be discussed when the artefact begins proper and continuous development.

However, it should be noted that each member is still solely responsible for their individual research study project that may directly or indirectly link to the artefact.

1.6 Development Platform, Resources and Environments

1.6.1 Development Platform

The main platform for the development of the artefact will be the Unity game editor developed by Unity Technologies. The 2019.4.22f version of the program will be used as it is marked as one of the publicly availably versions that is depicted to get long term support and as such should provide a fair balance of features and stability required for the development of this artefact. Unity is also equipped with various tools for the development of games, such as Probuilder which allows for the construction and editing of basic three-dimensional objects and will also be included in the development of the artefact. Other tools provided by Unity may also be employed in the development of the artefact as they become needed. Unity was chosen for the development of the artefact as it is a fairly popular game development platform and as such has a fair amount of introductory courses and tutorials on its' use.

GitHub will be used in the development of the artefact to allow for a simplified way to quickly share any changes made to the artefact and track the contributions towards the artefact's development by all members involved. Hence, a repository for the artefact's files will be initialised and then used throughout its' development life cycle. A programmer can quickly download (pull) and upload (push/commit) their changes to a project with this platform. The desktop client GitHub is used to facilitate all the operations discussed above. GitHub's repository features will be used for the ease it provides in communicating changes between the various developers of the artefact.

Other development platforms may be used in the development of the artefact if they are required. One such example of this is Blender, a 3D modelling program that allows for the creation of three-dimensional objects and models and may be used if need be in the editing of models used. As such other programs currently not specified may be used for the artefact's development; specifically, in areas that Unity does not directly cater for.

1.6.2 Resources

The Unity Asset Store will be used to acquire 3D models to be used within the artefact to complete the artefact within the given time frame since this is one aspect of game development that is very time-consuming. In a similar vein, Mixamo.com will be used to acquire animations for the artefact as this is another time-consuming process.

A list of all resources used will be compiled and the relevant creators and/or distributors will be referenced in the artefacts final documentation.

1.6.3 Environments

Microsoft's Visual Studio IDE will be used for the creation and development of most of the scripts and classes that will be implemented into the Unity game editor. This specific IDE was chosen as it has some basic integration with the Unity editor and can be installed directly from and during the Unity editor's initial installation.

1.7 Ethical Implications of Project

This project will not make use of external participants in a formal manner that would require any ethical implications as the only participants towards the development of this projects is the developers working on the artefact itself. The prescribed ethics form has been completed and attached.

1.8 Provisional Chapter Division

This document will contain a bulk of the final project documentation and the associated literature study. It will be divided into separate chapters which are listed below with a brief description of the respective

content.

Chapter 1: Introduction
The problem that is being researched, the qualities of games needed for use in education, is discussed in Chapter 1. Information on the background of this problem, similar research and the research contribution will be discussed. Furthermore, the aim of the study in addition to the planned method of conduct will be discussed.

Chapter 2: Literature Study
Chapter 2 will discuss the impact of games both in early development and in general in more detail, the accessibility of games as well as a focus on games being used in learning. It will attempt to find what qualities and principles work best to make a game a suitable means of learning.

Chapter 3: Development of Accompanying Artefact
The accompanying artefact that will be developed as a part of the study will be discussed along with the development process of the artefact.

Chapter 4: Review of Collected Data
The means of data collection, processing and analysis will be discussed in this chapter along with the results of this data. As this project pertains to the application of knowledge towards an artefact, this section will mostly discuss the underlying principles and qualities that make for a game to be used in a learning capacity.

Chapter 5: Discussion on Results
A discussion on the results obtained will be presented in this chapter. This chapter will focus more on the application of the acquired knowledge and principles towards the development of the artefact.

Chapter 6: Conclusion
The contents and results of the study will be briefly discussed and reiterated in an overview.

Reference List Contains all literary works referenced in the project.

Chapter 2

Literature Review

Bibliography

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Appendix A

Ethics Form

Name: Joshua Esterhuizen
Title of project: The Qualities of Games for Use in Education
Supervisor: Prof Gunther Drevin
Starting and end dates of project: 15-Feb to 8-Nov

1. Have you read the information available related to research ethics (Chapter 5 of Researching Information Systems and Computing; BJ Oates and Chapter 13 of Writing for computer science, J Zobel; Manual for post graduate studies, available on efundi)?	Yes X	No

2. Do you make use of people as source of data in your project (for example the completion of questionnaires or evaluation of products)?	Yes	No X

3. Are there any aspects of your research that you need permission from another party to use (for example use of property or tools)? If yes, provide more detail.	Yes	No X

4. Describe your research question and give a short description of your plans for the collection of data.

This project will attempt to find what qualities a game requires to be able to be used in an academic learning environment. The data collection to meet this goal will include the collection and review of various literature in the field of ludology with a specific look at serious games. Real-world examples of serious games will also be analysed in attempt to identify these qualities. As such the works of Frasca, G. will be a primary source of study.

5. Describe how you plan to provide information about yourself and the goals of your research to participants. No participants will be involved.

6. Describe what methods you will use to get permission from participants in your study. No participants will be involved. The publically available resources - assets, animations and anything else - will need to be cited however.

7. Will you be able to ensure that participants' information will be used in an anonymous, private and confidential way? How? No participants will be involved.	Yes X	No

8. Are there any foreseeable risks of damage (physical, social or psychological) to participants or the environment? If you answer yes, give detail of the preventative measures you will follow. No participants will be involved and the research and development of an artefact is done digitally.	Yes	No X

9. Are there any foreseeable risks to the NWU, for example lawful actions that may follow the research, or damage to the image of the university? If yes, give detail. As the artefact would use third party assets, it is important to properly reference those, however they are publically available.	Yes	No X

10. Are there any other ethical issues that may occur during the execution of the research (for example conflicting interests)? If yes, provide detail and explain how you plan to handle them.	Yes	No X
Since the artefact developed for this study is not intended for public distribution for any profits, there is no additional ethical issues. However, if it were to be distributed, the respective creators and distributors of the resources used, namely any assets and animations, would first need to be contacted for explicit permission to do so.		

I declare that the information contained in this form is accurate. I have attempted to identify the risks that may arise in conducting this research and acknowledge my obligations and the rights of the participants. I confirm that the research will be conducted in line with all University, legal and ethical standards.

Name of student: Joshua Esterhuizen

Signature: 

Date: 10 April

Name of study leader:

Signature:

Date:

Name of additional moderator:

Signature:

Date:

Appendix B

Research Proposal

SUBJECT GROUP COMPUTER SCIENCE AND INFORMATION SYSTEMS

Research Proposal for Honours project

1. Student initials, surname and student number

Initials	J	Surname	Esterhuizen	Student number	30285976

2. Degree for which student is registered

BSc Hons. Computer Science and Information Systems

3. Name of supervisor

Initials and surname	Prof Günther Drevin

4. Proposed title

Title (preferably not more than 12 words)	The Qualities of Games for Use in Education

5. Problem statement and substantiation

Provide the theme and link with gaps in the literature and recent research in the area. Indicate the research question, its actuality and how the research will endeavour to answer the question.

Education as it stands is still built on a system that is no longer needed in modern society. Ackoff and Greenberg (2008) explain that the current traditional methods of teaching are no longer as relevant as they once were as it is aimed to produce members of society that were likely to not question any fundamental aspects of how things operated. It is largely a system that focuses on teaching while disregarding learning as the last major stride in development in education was to industrialise it – having them operate efficiently like factories (Ackoff & Greenberg, 2008). One major flaw with this system currently is that it stifles the creativity and drive of some students as each level of education is largely the same and as such monotonous. As such, education is in need of some form of system to create an interest in learning for the students.

Virvou, Katsionis and Manos (2005) mention that computer games are popular among those in schools and as such provide a means to deliver content in an interesting and engaging manner. Providing learners in all levels of education with content or methods of delivery that they will enjoy will cause them to be more motivated to learn and look further into that specific topic (Ackoff & Greenberg, 2008). Annetta (2008) states that the movement to include video games in teaching and training began in 2003, two years after the field of ludology began to gain traction. These types of games are called “serious games”. These types of games have already had an impact on the military, medical

and higher business education fields early in their conception and this trend continues to day with most serious games being used within the medical fields specifically (Annetta, 2008). However, there were attempts to use serious games, as simulations, within physics and engineering (Deshpande & Huang, 2011). It is at this point that the study of serious games became more theoretical at lower levels and more applied at higher levels, with a great impact to medical fields and training. As such, there is a fair amount of theoretical research on specific aspects that relate to serious games as simulations and within ludology as a whole, but only a few mention the qualities a game needs to better present information to a user.

The main aim of this study is to answer the question: Can a digital serious game be effectively applied within a learning environment as a means to provide better engagement with content whilst still being enjoyable to learners? Thus, this study is conducted to collect information on what principles and qualities can be applied to a game in order to make it viable for learning as well as developing a level to demonstrate these principles.

6. Research aims and objectives

Provide the different general as well as the specific aspects which will form part of the research.

This study's primary aim is to determine if games as a whole can effectively be applied within a learning environment as a means to provide better engagement with content whilst still being enjoyable to learners. To reach this goal, an artefact in the form of a digital game will be developed that will involve specific sections which focus on other study's research in addition to this one. With regards to this study, the artefact will employ various audio-visual stimuli while adhering to the principles found to demonstrate how a game may be used in a learning environment.

To effectively reach the aforementioned aim, the following secondary objectives will have to be met:

1. A literature study will need to be performed with a focus on:
    i. Ludology, narratology and simulation;
    ii. The effects of games, both digital and analogue, in early development;
    iii. The effects of games in other stages of life;
    iv. Best games for learning
    v. Previous attempts to integrate game use in learning;
2. Collect examples of games that employ some form of teaching or learning
3. Create an artefact similar to a digital game that can be played
4. Create a specific scene/level within the aforementioned artefact that specialises on delivering information through various audio-visual stimuli that incorporates the principles and qualities

found.

7. Basic hypothesis (where applicable)

N/A

8. Method of investigation

8.1 Literature study

Provide an indication only of which literature will be used in the study with a few key references. A summary of the literature is not required here.

The following areas of study and literature will be researched for this study:

Impact of Games in Early Development

- The Effect of Adventure Video Games on The Development of Student's Character and Behavior (Kristiadi, Hasanudin, Sutrisno and Suwarto, 2019)
- The best game in the world: Exploring young children's digital game -related meaning-making via design activity (Mertala & Meriläinen, 2019)

Effects of Games in General

- A Meta-Analysis of the Cognitive and Motivational Effects of Serious Games (Wouters , Van Nimwegen, Van Oostendorp and Van der Spek, 2012)
- Extensive childhood experience with Pokémon suggests eccentricity drives organization of visual cortex (Gomez, Barnett, Grill-Spector, 2019)

Games Best Suited for Education

- Ludology from Representation to Simulation (Frasca, 2002)
- Simulation versus narrative: Introduction to Ludology (Frasca, 2013)

The Use of Games in Learning

- Computer Games in Education (Mayer, 2019)
- Learning by Teaching versus Learning by Doing: Knowledge Exchange in Organic Agent Systems (Fisch, Janicke, Kalkowski and Sick, 2009)
- Serious Games for education and training (De Gloria, Bellotti, Berta, Lavagnino, 2014)

8.2 Methods of investigation

The proposed design, data acquisition, procedures, data processing, funding sources (but not a budget), mathematical methods, computer methods, etc.

This study will be conducted using the interpretivist paradigm and design science research and will include:

- A literature study on the impact of games during early development, the general effects of games, an overview of game types using ludology determine the best type of game suited for education and the uses of games in education and learning.
- Finding and discussing examples of “serious” games.
- Designing and developing an artefact to aid in determining the viability of games in education.
- Determination on whether the research was appropriately applied to the artefact.

9. Provisional chapter division

Here it should be clear that there was proper reflection on the appearance of the final product (mini dissertation). Provide provisional titles of the various chapters, with a brief outline of the planned content of each.

The provisional chapter division is as follows:

Chapter 1: Introduction

The problem that is being researched, the viability of games in education and its affects during early development, is discussed in Chapter 1. Information on the background of this problem, similar research and the research contribution will be discussed. Furthermore, the aim of the study in addition to the planned method of conduct will be discussed.

Chapter 2: Literature Study

Chapter 2 will discuss the impact of games both in early development and in general in more detail, the accessibility of games as well as a focus on games being used in learning.

Chapter 3: Development of Accompanying Artefact

The accompanying artefact that will be developed as a part of the study will be discussed along with the development process of the artefact.

Chapter 4: Review of Collected Information

The means of data collection, processing and analysis will be discussed in this chapter along with the results of this data. This chapter will mostly deal with a review on what qualities and principles that could be applied to the artefact.

Chapter 5: Discussion on Results

A discussion on the results obtained will be presented in this chapter. As such, it will discuss how well the artefact demonstrates the qualities previously identified.

Chapter 6: Conclusion

The contents and results of the study will be briefly discussed and reiterated in an overview.

10. Literature references

Provide complete references to the literature referenced to in this proposal only.

Annetta, L. A. (2008). Video games in education: Why they should be used and how they are being used. *Theory into practice*, *47*(3):229-239.

Deshpande, A. A., & Huang, S. H. (2011). Simulation games in engineering education: A state-of-the-art review. *Computer applications in engineering education*, *19*(3):399-410.

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Virvou, M., Katsionis, G., & Manos, K. (2005). Combining software games with education: Evaluation of its educational effectiveness. *Journal of Educational Technology & Society*, *8*(2):54-65.

26/03/2021

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Student Supervisor Date

Appendix C

Research Project Artefact - Academic Article

Linking Gamification, Ludology and Pedagogy: How to Use Serious Games for Various Knowledge Domains

Joshua Esterhuizen
School of Computer Science and Information Systems
North-West University,
Potchefstroom, South Africa
joshua.esterhuizen27@gmail.com

Günther Drevin (Supervisor)
School of Computer Science and Information Systems
North-West University,
Potchefstroom, South Africa
Gunther.Drevin@nwu.ac.za

***Abstract*—Education as a whole has seen no major improvements for a long period of time while society has matured and grown rapidly in the same time frame. Due to this teaching and learning methods can be seen as stale to certain students. One way to solve this issue is with the implementation of some from of the technology that has developed over the years. This study looks at the possibility of adapting various domains of knowledge into digital games referred to as Serious Games. The implementation of serious games within teaching may help keep certain students engaged with the content being presented and create further interest in the topic. However, before reaching this stage the means to transform these knowledge domains into a serious games must be studied. This is done by focusing on three fields in particular, those being Gamification, Ludology and Pedagogy.**

***Index Terms*—Education, Gamification, Knowledge Domains, Ludology, Pedagogy, Serious Games**

I. Introduction

Education, as it stands, is still built on a paradigm that is no longer needed in modern society. One major flaw with the current system is that it stifles the creativity and drive of some students as each level of education is largely the same and is, as such, monotonous[2] Therefore, education requires some form of system to create an interest in learning for the students.

Ackoff and Greenberg[2] explain that the current traditional means of teaching are no longer as relevant as they once were as it is aimed to produce members of society that were likely to not question any fundamental aspects of how things operated. It is largely a system that focuses on teaching while disregarding learning as the last major stride in development in education was to industrialise it – having them operate efficiently like factories[2]. It is a system that is designed to keep moving often employing a "No Child Left Behind" policy which results in almost no time for anything other than the standardised and constantly measured curriculum[10].

However, with the shift into the "information age", the requirements of the workforce have also changed. The industrial age being a time of mass-production with the emergence of various new processing technologies and the information age being characterised by the fact that information is being transmitted and generated at an ever-increasing rate due to further technological developments[10, 17]. The most notable changes between these ages is that the industrial age focused on conformity and compliance while initiative and diversity - where greater value is placed on each individual's strengths and contribution to a project or organisation – is the focus of the information age[17].

Reigeluth[17] continues and states that the current paradigm of instruction is not focused on learning but rather categorisation. Ackoff[1] holds a similar viewpoint stating that there is more of a focus on teaching rather than learning. It should be noted that teaching and learning are very distinct from one another as both can take place without the other[1]. Learning is defined as increasing one's ability to perform an act effectively while trying to meet an objective through acquiring new knowledge whereas teaching is the process of providing this knowledge[1]. Through this, it is clear that institutions under this paradigm aim to give learners a verbose vocabulary to speak on topics that they do not fully comprehend[1].

Due to this aforementioned paradigm shifts between the ages and in what requirements are desired by most organisations in the information age, a shift in instructional theory is also needed – one such as going from making use of passive learning through traditional teaching means to one that is centred on active learning[17].

With the recent developments in technology and the fact that technology, in general, is becoming more accessible, some institutions have adopted some forms of digital learning or supplement traditional teaching with digital assistance. Deshpande and Huang[7] state that the current generation of students is the first to grow up with abundant access to technology. They continue to state that, on average, these students spend almost double the time playing video games

as they do reading[7]. It can be assumed that from when Deshpande and Huang's[7] published this work that this figure has increased as with technology and video games as industries.

Virvou, Katsionis and Manos[20] echo the point that computer games are popular among individuals who are in schools and as such could provide a means to deliver content in an interesting and engaging manner.

According to Annetta[3], the movement for the inclusion of digital games to be used in teaching and training environments first started in 2003, two years after the field of ludology, the study of games, began to gain traction in academic literature. This initiative is what started the concept of a serious game as one that can be used in an academic sense to relay information. After this point in time, various examples of serious games were made for purely academic study purposes and had found a very large use in simulation for use as explanation aides and medical training.

As such, the motivation behind this study is to further investigate the possibility of using video games as a means to encourage learning in teaching environments as current means of teaching may not be optimal for some individuals. This will be accomplished through studying literature in the relevant fields and identifying the instances where it is viable.

II. Literature Review

A. Serious Games and Ludology

Ludology is the formal and academic study of games and has roots in studying games through a cultural and social lens by discussing how each interacts with the so-called "spirit of play"[11]. However, relatively recently, as early as 2001, the field has shifted and now encompasses the study of digital computer-based games as this is when the first academic peer reviewed journal on the topic was published as well as several international conferences taking place[9].

As such, this study will use the definition provided by Gonzalo Frasca, "Ludology can be defined as a discipline that studies games in general, and video games in particular"[9]. Frasca[9] further elaborates on his statement that the field of ludology has a focus on discussing and understanding the individual elements of games as well as creating models to explain the various mechanics and rules of games.

"Serious games" were introduced as digital concepts in 2002 through the Serious Game Initiative which was spearheaded by David Rejeski and Ben Sawyer[6]. The initial intention for serious games was for them to be used as a means of training certain tasks and skills[6] – this was typically done through simulation type games which will be discussed in greater detail further on.

Squire[18] provides a definition for games as a simulation and states that these simulations attempt to model reality in a consistent manner usually through modelling physical or social systems through another system – which in this case would be a computer and the digital video game. There are two main types of simulations, Hi-fidelity and low fidelity. Hi-fidelity simulations attempt to model every possible interaction in a given system, phenomena or environment as accurately as possible[18]. In contrast, a low fidelity simulation will make use of a fair bit of abstraction as it aims to only demonstrate a few key characteristics of the phenomena or environment[18]. Games as simulations would comprise of both of these types depending on the content that it attempts to simulate.

Virvou, Katsionis and Manos[20] mention that the endeavour to create serious games has yet to reach schools due to certain criticisms about games in general that hinders this. This is due to the fact that discussions around games by educators have largely focused on the social consequences of playing games instead of the educational potential games hold[18]. Due to this the study of serious games became more theoretical and discussion-based at lower levels and more applied with actual use at higher levels. This can be seen by implementations implemented in several fields including medical rehabilitation, ecological studies, learning languages and business studies[4, 5, 16, 19]. These types of games have already had an impact on the military, medical and higher business education fields early in their conception and this trend continues to this day with most serious games being used within the medical fields specifically[3, 6]. However, there were attempts to use serious games, as simulations, within physics and engineering[7].

Deshpande and Huang[7] describe the use of games as a means of simulation for specific sections of work in physics and engineering courses as an addition to traditional teaching as it provides a relatively simple way to demonstrate certain phenomena. As such these authors discuss the simulation aspect of games rather than the narrative as when dealing with a simulation digital game it typical lacks most narrative elements in the traditional sense[7].

B. A Pedagogical Approach

Pedagogy is the filed that deals with the transferal of knowledge in an educational environment through several lenses such as social, political and cultural[14]. As such it encompasses the fields and discussions of instructional design and theory as well as any learning theories – of which several are particularly useful to this study.

Learning by doing functions on the principle that skills can be improved through practice and self-perfection on a particular topic or knowledge base[8]. This means of instruction has become increasingly popular amongst companies where they are able to make use of "on the job" training as it allows for a person to be productive immediately as well as become more proficient at tasks gradually[8].

The learning by teaching method works under the assumption that learners are able to increase their understanding of a certain topic by teaching it to other learners[8]. This method of learning has garnered more usage recently as it is a viable means of learning in environments with too few teachers or instructors and increases the overall learning process[8]. Learning methods that place the learner in control are very flexible and as such can be incorporated when attempting to teach various and different fields or subjects[1].

Gibson et al.[10] list and summarise several learning and instructional design theories that have the potential to be applied to a game used for learning. This study will, however, only look at Merrill's First Principles of Instruction as it is the most recent of the ones depicted and is one that is very expansive and as such can be used in a variety of manners[10].

Before discussing the principles that the name refers to in this theory, Merrill[15] provides a few definitions for the terms made use of. A principle in this context is a relationship that is always true regardless of the environment it is applied within – this being the driving factor for deciding to make use of this theory[15]. A practice is any instructional activity[15]. A program is a means of instruction that makes use of several practices[15]. Merrill[15] states that the first principles described are able to be implemented in any instructional system or environment as they are "design-oriented" and as such relate more to creating learning environments rather than describing the means of knowledge transfer. Each of the following principles is also accompanied by three "corollaries" each of which Merrill[15] likewise explains.

The first principle of Merrill's First Principles of Instruction is that the learning is problem centred. This principle describes three corollaries, the first of which being "Show Task" which states that learners should be shown the types of problems they will be solving or will be able to solve with the knowledge that they attain[15]. The next is the "Task Level" which explains that the problems presented should keep learners engaged due to the complexity and not just the action of solving it[15]. The last corollary, "Problem Progression" describes that the problems presented should have some form of increasing complexity while still being comparable to the previous iteration of the type of problem[15].

The second principle is Activation which means that learning happens whenever previous experiences are used[15]. The first corollary, "Previous Experience", states that the learning process is enhanced when a learner is able to draw upon relevant past experiences and apply the associate knowledge as a foundation for new knowledge[15]. "New Knowledge" is the second and explains that learners should be provided with a relevant experience as an additional foundation to add to their knowledge base[15]. The last corollary is "Structure" and details that learners should be encouraged to organise new knowledge according to some relevant structure[15].

The third principle, Demonstration, proposes that learning takes place when the activities that are undertaken impart the knowledge instead of stating the information[15]. "Demonstration Consistency" explains that any examples or visualisation should be kept in line with the original learning goals[15]. The next is "Learner Guidance" and states that learners should be shown where the relevant information for problems can be found be it in the form of comparative examples or various representation of one source[15]. "Relevant Media" explains that when media is used as a means of demonstration, different types can be used provided that they do not fight for a learner's attention[15].

The fourth principle is Application which states that learning takes place when learners actively solve problems with the new knowledge they have acquired[15]. "Practice Consistency" is similar to Demonstration consistency but with a focus on the application of knowledge[15]. "Diminishing Coaching" is where the learners are provided with relevant feedback, but it is slowly lessened over time[15]. It is also important that the problems provided to learners for practice have a good variety, as explained as "Varied Problems"[15].

The fifth, and final, principle is Integration which is when the knowledge a learner has acquired is used by them in their everyday life[15]. The first corollary, "Watch Me", explains that learners are provided to showcase the new knowledge or skill they have acquired[15]. "Reflection" deals with giving learners time to be able to debate with others on the topic involved[15]. Lastly, "Creation" states that learners should be able to make use of their new knowledge or skill in some personal capacity[15].

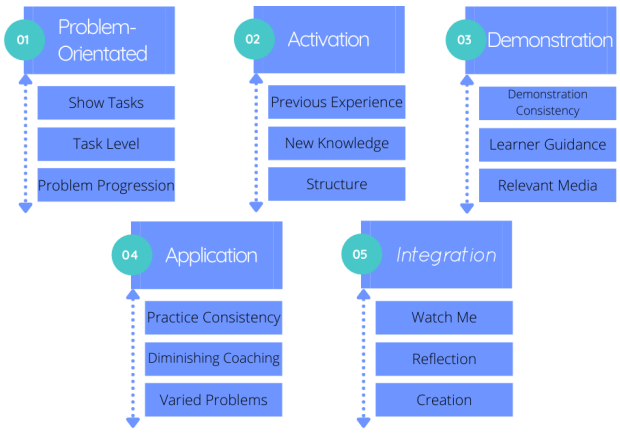

Fig. 1. Own Image summarising Merrill's First Principles

The principles and corollaries provided by Merrill[15] provide an expansive and detailed structure to be used when developing any learning opportunity making it an exceptional choice to adapt specifically to a digital game learning system.

It does, however, lack a comprehensive discussion on how to keep learners engaged with the content and, as such, the next subsection will discuss some theories pertaining to the role of motivation in learning.

Another important factor to consider is how to keep learners engaged and motivated with the instructional material. One model for motivating learners is the ARCS Model which was developed by John Keller which is frequently referenced in the aforementioned field of instructional design[12]. It is comprised of four main elements with each focusing on designing instruction in a different way[12].

The first of these is Attention and it is an element that is concerned with gaining and then keeping the learners' interest. There are three main methods to accomplish this with the first being gaining attention through the use of relatable examples or surprise. The next is to create curiosity within the learners through means such as role-playing or hands-on examples. The last means to keep attention is the variability which means periodically changing the method of delivery[12].

Relevance refers to having the content be relevant to the learner and Kapp[12] mentions that this can be done through orienting the environment around achieving goals, creating a link between the motives of learners and that of the instruction means, displaying that the content is in somewhat familiar to the learners and finally developing a model of the results of learning the presented knowledge.

Another element of this model, Confidence, is the expectations of success set by the learner and as such when they meet these expectations they are confident in their ability to do the work[12]. This can be aided by providing learners with clear expectations and requirements upfront about the skill or knowledge. It is also helpful to provide smaller opportunities to succeed as with each success the learners will become more confident[12].

The last element in the ARCS model is Satisfaction and is concerned with giving learners a sense of accomplishment and that the effort in the learning process has some value and weight to it[12]. This can be accomplished by allowing learners to see how their newfound knowledge can be used, either through the use of a real-world demonstration or via some form of simulation[12].

C. Gamification and the Knowledge Domains

Gamification can be defined as making use of game-like mechanics, aesthetics and thinking to create motivation, solve problems and produce a more suitable learning environment[12]. Kapp[13] states that while gamification makes use of game elements, it only makes use of a few of them as in a gamified system, in a gamification context, learners are not constantly engaged in playing the game as there are sections of respite from this, such as video explanations. While elements such as points and achievements are found in most games, gamification strives to add more than just these to a classroom as with the absence of other elements and only points and badges, the resulting system is one that is dull[13]. Kapp[13] continues stating that gamification adds much more to create an interesting system such as narrative aspects and continuous feedback to learners to create and upkeep their motivation and engagement with the system.

Gamification is often not implemented within a classroom but is rather presented to learners through some external means – such as a digital game [13]. It should be noted, however, that a serious game can be the result of the gamification of some content but gamification does not always have to produce a serious game as a result [13].

Kapp[12] describes various types of knowledge and how to begin developing a gamified system to effectively teach each of them. This provides the ground work for answering the question this study poses and as such allows for a more in depth discussion on how to implement serious games. These knowledge domains are described as[12]:

- Declarative Knowledge is usually comprised of facts and jargon within a topic.
- Conceptual Knowledge is the grouping of related information that have an underlying common descriptor.
- Rules-Based Knowledge is strict statements linking concepts.
- Procedural Knowledge is a progression based path to reach an outcome.
- Soft Skills are general strategies for dealing with various social interactions.
- Affective Knowledge deals with topics about subjective phenomena such as emotions.
- Psychomotor Domain deals with making use of cognitive knowledge through physical skills (hand-eye coordination is an example of this).

One important aspect to note about these knowledge domains is that they are not mutually exclusive as one particular topic can be placed in several of them as the components of that topic may require multiple domains to be properly contained under them.

III. Methodology

The following steps were taken to determine how serious games can be used for the various knowledge domains:

1) Literature surrounding the applicable fields was researched
2) Case studies concerning serious games was studied and similarities noted
3) Select theories that aid this process were pinpointed
4) From this research, recommendations for the knowledge domains were made

A. Sampling of Literature

During this phase key fields of study were identifies for use in working towards the goal of this study. As discussed above, these included the fields of pedagogy (the study of instructional theory), ludology (the study of games with a focus on digital games) and gamification (the use of game-like elements to solve problems). Studying the literature in each of these fields yielded literature that is undoubtedly useful to this study as pedagogy gave insight into instructional theories used in education, ludology provided the necessary understanding of how to study games and the elements that each uses and gamification provided insight into the different knowledge domains and how to best approach each in a teaching environment in addition acting as a bridge for connecting pedagogy to the serious games in ludology.

The bulk of this phase was spent reading articles and identifying which would be useful for this study. It was also during this phase that select case studies were found. These case studies proved useful as each made use of different design principles and as such became another set of literature to be studied.

B. Collection of Case Studies and Determine Similarities

As case studies were accumulated, only those found that discussed - either directly in great detail or indirectly during the game's description -the design principles followed were selected to be used. Notably, many of those chosen had a focus on some form of digital and cyber security including specific mentions to phishing and social engineering[**Sheng2007**, **Dincelli2020**].

The following step after finding these case studies was to identify their design principles and determine the major ones that most, if not all, made use of as well as how successful the game was found to be - which is determined in the individual publication either by trails of being judged by experts.

C. Pinpointing Connected Theories

Once enough literature had been acquired and studied, the connections between each of the fields' theory and case studys' design principles were noted. This was in attempt to identify an overall pattern in the development of serious games for use particularly for educational or training purposes. This included mapping the similarities between the instructional theories to the deign principles of each case study while noting which fields of knowledge the games are a part of.

D. Extrapolate to other Knowledge Domains

For the knowledge domains that the case studies do not directly relate to, recommendations for them will be generated out of what has been found. In addition to this, certain design principles used by the case studies can be directly applied to these domains.

IV. Findings

As described in the methodology, a large aspect of the findings comes from the literature review conducted. However, the literature review only provided segmented information that must still be distilled. This includes making note of what instructional theory is most pertinent to this study and breaking down the case studies. It also includes a short discussion on the initial reconsiderations from Kapp[12] regarding the knowledge domains.

A. Helpful Instructional Theories

B. Case Studies and the Similarities in Design Principles

TABLE I
Design Principles Defined by Case Study

SETA Artefact	***Anti-Phishing Phil***	***Happy Hippo***
Story-based	Story-based	Clear and Simple Goals
Reflection	Reflection	Quality of Feedback and Rewards
-	Conceptual-Procedural	Structure of the Challenge
-	-	Motion-based Interaction
-	-	Simplicity

C. Initial Knowledge Domain Recommendations

V. Synthesis from Research

A. Recommendations per Knowledge Domain

B. Limitations and Future Research

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C. Maintaining the Integrity of the Specifications

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VI. Prepare Your Paper Before Styling

Before you begin to format your paper, first write and save the content as a separate text file. Complete all content and organizational editing before formatting. Please note sections VI-A–VI-E below for more information on proofreading, spelling and grammar.

Keep your text and graphic files separate until after the text has been formatted and styled. Do not number text heads—LaTeX will do that for you.

A. Abbreviations and Acronyms

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Abbreviations such as IEEE, SI, MKS, CGS, ac, dc, and rms do not have to be defined. Do not use abbreviations in the title or heads unless they are unavoidable.

B. Units

- Use either SI (MKS) or CGS as primary units. (SI units are encouraged.) English units may be used as secondary units (in parentheses). An exception would be the use of English units as identifiers in trade, such as "3.5-inch disk drive".
- Avoid combining SI and CGS units, such as current in amperes and magnetic field in oersteds. This often leads to confusion because equations do not balance dimensionally. If you must use mixed units, clearly state the units for each quantity that you use in an equation.
- Do not mix complete spellings and abbreviations of units: "Wb/m^2" or "webers per square meter", not "webers/m^2". Spell out units when they appear in text: ". . . a few henries", not ". . . a few H".
- Use a zero before decimal points: "0.25", not ".25". Use "cm^3", not "cc".)

C. Equations

Number equations consecutively. To make your equations more compact, you may use the solidus (/), the exp function, or appropriate exponents. Italicize Roman symbols for quantities and variables, but not Greek symbols. Use a long dash rather than a hyphen for a minus sign. Punctuate equations with commas or periods when they are part of a sentence, as in:

$$a + b = \gamma \tag{1}$$

Be sure that the symbols in your equation have been defined before or immediately following the equation. Use "(1)", not "Eq. (1)" or "equation (1)", except at the beginning of a sentence: "Equation (1) is . . ."

D. LaTeX-Specific Advice

Please use "soft" (e.g., `\eqref{Eq}`) cross references instead of "hard" references (e.g., `(1)`). That will make it possible to combine sections, add equations, or change the order of figures or citations without having to go through the file line by line.

Please don't use the `{eqnarray}` equation environment. Use `{align}` or `{IEEEeqnarray}` instead. The `{eqnarray}` environment leaves unsightly spaces around relation symbols.

Please note that the `{subequations}` environment in LaTeX will increment the main equation counter even when there are no equation numbers displayed. If you forget that, you might write an article in which the equation numbers skip from (17) to (20), causing the copy editors to wonder if you've discovered a new method of counting.

BibTeX does not work by magic. It doesn't get the bibliographic data from thin air but from .bib files. If you use BibTeX to produce a bibliography you must send the .bib files.

LaTeX can't read your mind. If you assign the same label to a subsubsection and a table, you might find that Table I has been cross referenced as Table IV-B3.

LaTeX does not have precognitive abilities. If you put a `\label` command before the command that updates the counter it's supposed to be using, the label will pick up the last counter to be cross referenced instead. In particular, a `\label` command should not go before the caption of a figure or a table.

Do not use `\nonumber` inside the `{array}` environment. It will not stop equation numbers inside `{array}` (there won't be any anyway) and it might stop a wanted equation number in the surrounding equation.

E. Some Common Mistakes

- The word "data" is plural, not singular.
- The subscript for the permeability of vacuum μ_0, and other common scientific constants, is zero with subscript formatting, not a lowercase letter "o".
- In American English, commas, semicolons, periods, question and exclamation marks are located within quotation marks only when a complete thought or name is cited, such as a title or full quotation. When quotation marks are used, instead of a bold or italic typeface, to highlight a word or phrase, punctuation should appear outside of the quotation marks. A parenthetical phrase or statement at the end of a sentence is punctuated outside of the closing parenthesis (like this). (A parenthetical sentence is punctuated within the parentheses.)
- A graph within a graph is an "inset", not an "insert". The word alternatively is preferred to the word "alternately" (unless you really mean something that alternates).
- Do not use the word "essentially" to mean "approximately" or "effectively".
- In your paper title, if the words "that uses" can accurately replace the word "using", capitalize the "u"; if not, keep using lower-cased.
- Be aware of the different meanings of the homophones "affect" and "effect", "complement" and "compliment", "discreet" and "discrete", "principal" and "principle".
- Do not confuse "imply" and "infer".
- The prefix "non" is not a word; it should be joined to the word it modifies, usually without a hyphen.
- There is no period after the "et" in the Latin abbreviation "et al.".
- The abbreviation "i.e." means "that is", and the abbreviation "e.g." means "for example".

An excellent style manual for science writers is [**b7**].

F. Authors and Affiliations

The class file is designed for, but not limited to, six authors. A minimum of one author is required for all conference articles. Author names should be listed starting from left to right and then moving down to the next line. This is the author sequence that will be used in future citations and by indexing services. Names should not be listed in columns nor group by affiliation. Please keep your affiliations as succinct as possible (for example, do not differentiate among departments of the same organization).

G. Identify the Headings

Headings, or heads, are organizational devices that guide the reader through your paper. There are two types: component heads and text heads.

Component heads identify the different components of your paper and are not topically subordinate to each other. Examples include Acknowledgments and References and, for these, the correct style to use is "Heading 5". Use "figure caption" for your Figure captions, and "table head" for your table title. Run-in heads, such as "Abstract", will require you to apply a style (in this case, italic) in addition to the style provided by the drop down menu to differentiate the head from the text.

Text heads organize the topics on a relational, hierarchical basis. For example, the paper title is the primary text head because all subsequent material relates and elaborates on this one topic. If there are two or more sub-topics, the next level head (uppercase Roman numerals) should be used and, conversely, if there are not at least two sub-topics, then no subheads should be introduced.

H. Figures and Tables

a) Positioning Figures and Tables: Place figures and tables at the top and bottom of columns. Avoid placing them in the middle of columns. Large figures and tables may span across both columns. Figure captions should be below the figures; table heads should appear above the tables. Insert figures and tables after they are cited in the text. Use the abbreviation "Fig. 2", even at the beginning of a sentence.

TABLE II
TABLE TYPE STYLES

Table Head	**Table Column Head**		
	Table column subhead	***Subhead***	***Subhead***
copy	More table copy[a]		

[a]Sample of a Table footnote.

Figure Labels: Use 8 point Times New Roman for Figure labels. Use words rather than symbols or abbreviations when writing Figure axis labels to avoid confusing the reader. As an example, write the quantity "Magnetization", or "Magnetization, M", not just "M". If including units in the label, present them within parentheses. Do not label axes only with units. In

Fig. 2. Example of a figure caption.

the example, write “Magnetization (A/m)” or “Magnetization {A[m(1)]}”, not just “A/m”. Do not label axes with a ratio of quantities and units. For example, write “Temperature (K)”, not “Temperature/K”.

ACKNOWLEDGMENT

The preferred spelling of the word “acknowledgment” in America is without an “e” after the “g”. Avoid the stilted expression “one of us (R. B. G.) thanks . . .”. Instead, try “R. B. G. thanks. . .”. Put sponsor acknowledgments in the unnumbered footnote on the first page.

REFERENCES

Please number citations consecutively within brackets [**b1**]. The sentence punctuation follows the bracket [**b2**]. Refer simply to the reference number, as in [**b3**]—do not use “Ref. [**b3**]” or “reference [**b3**]” except at the beginning of a sentence: “Reference [**b3**] was the first . . .”

Number footnotes separately in superscripts. Place the actual footnote at the bottom of the column in which it was cited. Do not put footnotes in the abstract or reference list. Use letters for table footnotes.

Unless there are six authors or more give all authors’ names; do not use “et al.”. Papers that have not been published, even if they have been submitted for publication, should be cited as “unpublished” [**b4**]. Papers that have been accepted for publication should be cited as “in press” [**b5**]. Capitalize only the first word in a paper title, except for proper nouns and element symbols.

For papers published in translation journals, please give the English citation first, followed by the original foreign-language citation [**b6**].

REFERENCES

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