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Teaching history and bringing the past back to life with serious games.

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Abstract

Serious games are often characterised as being games developed and used for educational or non-entertainment purposes. The academic literature is saturated with definitions and developed games surrounding the concept. Despite this, there is a lack of quality meta-analytical and longitudinal analysis studies associated with use of serious games. One area where serious games have pedagogical potential is in teaching historical subjects and in displaying historical artefacts. Serious games, combined with evolving 3D modelling techniques and Virtual Reality (VR) capabilities can replicate historical events, artefacts, and environments. The creation of a serious game or even virtual museum that informs individuals about the past have the potential to provide a sense of historical realism or immersion. In the context of Covid-19 and the current global impact to the tourist industry, the application of serious games for such purposes has undoubted significance. This paper reviews the academic literature surrounding the concepts of content and assessment integration in relation to developing historical games for pedagogical and knowledge sharing purposes. The research focuses on two points. Firstly, can serious games exhibit a sense of realism and immersion towards teaching and learning history. Secondly, what are the immersive characteristics needed to make a historical game immersive. Based on the literature this paper will provide a framework that identifies best practice towards making historical games immersive from a games design perspective. The paper also presents an example of a serious game intended to educate users about military machinery used in World War two. A display of 3D modelled Roman artefacts is also presented to document how 3D modelling can replicate an interactive and immersive virtual experience. The findings of the paper argue that there is a close interdependency between aesthetical and content design and learning outcomes towards depicting historical realism and immersion. Future empirical work is also discussed in the paper with the aim of evaluating the framework presented.

Keywords: Serious Games, Content and assessment integration, 3D modelling, Virtual reality, Historical realism, Games immersion.

1. Introduction

The Global pandemic is a singularity that it has altered our planet in such a way that there is no going back. This is particularly evident in education levels including Primary Education (PE), Secondary Education (SE) Higher Education (HE), Further Education (FE) and Informal Education. The pandemic has had catastrophic effects on the tourism industry not just because of governmental restrictions associated with travel but also that tourism hotspots such as museums, historical locations and points of interest are closed or restricted. Fortunately to ease the burden of the pandemic we live in an age where mobile, computer, VR, Alternate Reality (AR) and communication technology is ubiquitous and relatively advanced. Educationalists while always attempting to normalise innovative educational tools to increase motivation and engagement now realise that there is great potential in the area of serious games utilising advanced simulation and computer games technology to provide motivational, immersive, educational and cultural experiences. Serious Games have been utilised in many
educational areas (Boyle et al., 2016; Connolly et al., 2012) with varying degrees of success, however this paper is going to focus on serious games in the application of teaching History which can be in a the following scenarios: teaching about a historical period or event, allowing the player to experience a particular event or allowing them to visit a particular place or exhibits of historical interest.

This paper will perform a preliminary review of the literature on serious games, VR, AR, games-based learning and computer games technology in the application of teaching History including: historical events, virtual museums, periods in history and historical pedagogical content. We will then review content, assessment integration, game mechanics, and design taxonomies as well as relevant case studies to enable the formulation of a generalised serious games framework for the purposes of developing Historical Applications.

2. Previous Work

2.1 Applications for Teaching History

Serious Games can of course come in many forms whether that is a mobile game, AR, VR or computer games application. Even though they are becoming more popular serious games from their first inception have been utilised for the purposes of teaching History. One of the first, most influential and popular serious games of the 1970’s was The Oregon Trail where the application was education. The Oregon Trail was developed by three History teachers: Don Rawitsch, Bill Heinemann, and Paul Dillenberge in 1971 and produced by MECC (the Minnesota Educational Computing Consortium) in 1973/74. The player assumes the role of a wagon leader where the goal is to lead his party of settlers from Independence Missouri to Oregon’s Willamette Valley via The Oregon Trail on a Conestoga wagon in 1848. The game was originally a text-based strategy video game and can be played in its retro form to this day (https://classicreload.com/oregon-trail.html). The game is designed to teach History and the realities of 19th century pioneer life involving some of the following obstacles: going in the wrong direction, stolen supplies, severe weather, illness or death in relation to members of the company or the oxen and even snakebite. There is also a trading system in the game and hunting is important where players get to attack in the original text-based game by quickly typing in “BANG”, “WHAM” or “POW” and misspelling these words would lead to a failed hunt. The game was originally designed and delivered in a mainframe and was highly popular with Minnesota schools for five years in the seventies with thousands of monthly players. The two pieces of technological advancements that dramatically influenced the development and distribution of this serious game was the invention of the microprocessor in the early 1970’s and the increased popularity and introduction of home computers in the late 1970’s early 80’s such as the Apple II, Commodore 64 and the Atari 800. The game has been developed on multiple platforms throughout the consecutive decades and is still played on Facebook and mobile devices. The game is credited with being one of the most successful educational games of all time and fits into the educational categories of learning of Sawyers taxonomy of serious games. Figure 1a shows and original version of the game and Figure 1b shows a present day version which is still standing the test of time.

Figure 1a: The Oregon Trail first release 1973/74 Figure 1b: The Oregon Trail: Settler release 2012
Mortara et al., (2014) present a taxonomy of serious games for historical application and categorise them into the following:

- **Cultural Awareness** – immaterial heritage including: customs, languages, spiritual beliefs, folklore and societal behaviour with regards to how the past has affected these aspects. Example games include: *Real Lives 2010* and *Discover Babylon*. Some of these are supported by museums and include: *Fascinating Egyptian Mummies* and *The Great Bible Race*.

- **Historical Reconstruction** – reconstruction of events, historical period, or process. Many games fit into this category including: *The Ancient Olympia*, and strategy games re-enacting historical battles including: *1066, The Viking Quest*.

- **Heritage awareness (artistic/archaeological heritage, architectural/natural heritage)** – artistic/natural heritage encompasses a realistic reconstruction of a real location such as virtual/augmented cultural tourist games including: *Streets of Culture*, or *Tide City* utilising GPS for Smartphones. Cultural treasure hunts are popular for mobile devices allowing participants to explore cities. **Artistic/archaeological heritage** is where the player is in contact with the physical artefacts to learn about archaeology, art and society. Virtual Museums fall into this category and these games can either show real exhibits or utilise gamification to teach something such as arranging particular artefacts and paintings in a museum in *Thiatro*.

Commercial Of the Shelf Games (COTS) have also been utilised in the class room e.g. *SimCity, Assassins Creed* (Ubisoft) and *Civilization* due to their association with a particular content (Becker, 2017). Squire (2004) utilised *Civilization* in the classroom to improve knowledge of historical concepts because it represented world history as an “emergent process arising from overlapping, interrelated factors.” This leads to a further categorisation of historical games and Eberhardt and Caldwell (2016) citing McCall (2007) distinguish between historical simulation games and historical narrative games.

**Historical Simulation Games** for the purposes of teaching History in SE connect History to Social Studies by having some representative real-world system within the game such as economy, politics, or representation. **Historical Narrative Games** is where the player engages in the backdrop of History but the actions are not necessarily based on any form of historical system e.g. *Assassins Creed* and stealth assassination. Nevertheless, it is noted that these games have potential for understanding the use of narrative games in history with regards to reinterpretation.

VR is also gaining popularity due to its motivational, immersive, and interactive potential and while several empirical studies in pedagogical contexts have been undertaken there is still a requirement for more cross-comparative analysis to determine how VR can augment, supplement and be applied in different subject disciplines (Baxter and Hainey, 2019). There are of course obvious and clear potential applications of the use of VR for teaching history where the results statistically favour VR both in terms of motivation and academic performance in comparison with conventional teaching approaches, e.g., in PE teaching about “The Roman Civilisation” (Taranilla, Cózar-Gutiérrez, González-Calero and Cirugeda, 2019). Google Expedition is a popular example of widespread VR and AR utilised in the classroom by teachers and students to go on virtual field trips of historically interesting sites. This was of course highly popular pre-global pandemic but now has potentially even more importance due to travel restrictions and not simply expense and time presenting themselves as barriers. Participants download the app and use their mobile phone as a headset. Over 900 VR expeditions currently exist and 166 AR expeditions or virtual applications exist. This includes: *Volcanoes Around the World, WW1, WW2, Ancient Greek Art, Carmen’s Ancient Caper* (Google Expeditions, 2021).

### 2.2 Content Integration

Pedagogical content integration for serious games has always been recognised as a key challenge and it could be argued when referring to the application of high-fidelity VR in relation to an exhibit in the category of artistic/archaeological heritage displaying historical artefacts or architectural features that aesthetics and detail of particular content can be as important as the learning outcomes. Aldrich (2004, 2005) provides a simple categorisation of content in relation to simulation elements: linear, cyclical, system and open ended. Linear is a simulation from start to finish, cyclical allows for repetitive tasks, system exposes intertwined, complex relationships necessary for system operation and open ended for presenting a subject with no set experience. Content integration can be categorised utilising general methodologies in terms of how closely linked the learning outcomes and pedagogical content is to the
Vandercruysse et al., (2017) distinguishes between intrinsically and extrinsically integrated games-based learning (GBL) environments in the context of a mathematical game where extrinsically means that the mathematical content is not part of the core mechanics and the game world structure and intrinsically meaning that the mathematical content is delivered as part of the game and within the game world structure. The results of this study indicated that extrinsically integrated content was more motivational, had higher learning gains and a higher level of perceived usefulness which is contrary to other studies as intrinsic integration seems to be more desirable, however it is acknowledged that more investigation is required (Habgood and Ainsworth, 2011). Invariably intrinsic content integration is a highly important design component to consider particularly with the recent drive towards virtual instruction (Walkington, 2021). Another categorisation linked to intrinsic and extrinsic content integration is the idea of endogenous and exogenous fantasy in games. Habgood, Ainsworth and Benford (2005) define endogenous fantasy as: “the skill being learned and the fantasy depend on each other and there is an integral and continuing relationship between the fantasy context and the instructional content being presented.” Conversely exogenous fantasy is where the “fantasy depends on the skill being learned but not vice versa.” Molnar and Kostkova (2013) discuss intrinsic content integration and point out that regardless of the mechanism of delivery in terms of text or game mechanics that educational content must be seamless. Essentially the text has to be integrated into the narrative and the game mechanics have to be connected to the educational content. This follows that game mechanics have to be considered and there are a number of game mechanic categorisations such as: core and satellite mechanics including enhancement mechanics to enhance the already existing core mechanics, alternative mechanics providing an alternative to core mechanics with new learning being required and opposition mechanics to hinder the player (Maranhao, Menddonca, da Rocha Franco and Maia, 2016). Adam and Dormans (2012) a taxonomy of game mechanic cross referenced to genre displayed in Figure 2.

**Figure 2:** Taxonomy of Game Mechanics (Adams and Dorman, 2012)
The mechanics presented in the taxonomy are of course aimed at commercial games and it may be the case that these mechanics are not considered to such an extent in serious games. Nevertheless, the basic types of game mechanic may be useful to consider: points, risk and reward, action points, goals, cards, catch-up, dice, turns, resource management and races.

Serious games design and development frameworks that specifically consider learning theories and pedagogy, mechanics and fidelity have become more frequent and important in the academic literature. The boost in serious games in terms of frequency and publications has accelerated this as some of the following technological advances have begun to emerge in the 2010s including: mobile devices (phones, iPads, tablets), increased emphasis on touch technology, AR, VR, AI, and Machine Learning (Boyle, Hainey and Boyle, 2021). Arnab et al., (2015) presents the Learning-Game mechanics model linking game mechanics to learning mechanics based on Bloom’s taxonomy. A similar idea for attempting to appropriately analyse the relationship between game and pedagogical mechanics utilising thinking skills is the Serious Games Mechanics model presented by Suttie et al., (2012). Carvalho et al., (2015) developed an activity-based theory model for serious game analysis and conceptual design considering Bloom’s, Kolb’s, and Fink’s taxonomy in relation to gaming, learning, instruction sequence and mechanics and also taking into account: engagement, usability, context, activities and intrinsic and extrinsic instructional activity.

Rooney (2012) proposes a theoretical triadic framework for serious game design taking into account pedagogy, play and fidelity. Pedagogy in relation to looking at a variety of theories including situation learning, problem based and experiential learning. Play in relation to engagement, motivation, flow and immersion in terms of player positioning, narrative and interactive design. Fidelity is described as to the extent the game emulates the real world and is distinguished as: physical fidelity (the degree that the environment looks, feels, and sounds like the real world) and functional fidelity (the degree in which the game acts like the real world in terms of responses to players actions in combination with the narrative and interactivity).

One of the key aspects that makes a serious game, VR, AR, or games-based learning application for historic al education potentially more unique is the context i.e., the time and the place. Where it can be argued many serious game applications are situated in the present or perhaps have no real appreciation of chronological or situational context and these particular aspects are of course crucial to a Historical game. Another important key factor includes the key historical characters and how they interact with each other as well as the environment and the plot if there are subplots and how these plots are chronologically connected. McDaniel, Fiore, and Nicholson (2010) present a narrative taxonomy allowing the developer to specify useful details of the character, plot and environment which is particularly prevalent in relation to History related educational serious game applications. Table 1 shows an adapted version:

<table>
<thead>
<tr>
<th>Narrative Development Questions</th>
<th>Potential Options</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ENVIRONMENT</strong></td>
<td></td>
</tr>
<tr>
<td>Where does the story take place?</td>
<td>Ancient Egypt, Rome, space, underwater</td>
</tr>
<tr>
<td>When does the story take place?</td>
<td>1066, 1314, 1939-1945, 1883, 1888</td>
</tr>
<tr>
<td>Is the environment fantasy based?</td>
<td>Low – high level of fantasy</td>
</tr>
<tr>
<td>How does progression of time affect the environment?</td>
<td>Degrades over time or remains static</td>
</tr>
<tr>
<td>How realistic is the fidelity (functional, physical)</td>
<td>Very realistic, abstract, cartoons</td>
</tr>
<tr>
<td>Is the player constrained by the environment?</td>
<td>Attack of enemy forces, natural disasters</td>
</tr>
<tr>
<td>Is there environmental conflict?</td>
<td>War, volcanoes, pandemics</td>
</tr>
<tr>
<td><strong>CHARACTER</strong></td>
<td></td>
</tr>
<tr>
<td>Who is the protagonist of the story or who is the primary historical figure(s)?</td>
<td>Robert the Bruce, Julius Cesar</td>
</tr>
<tr>
<td>What is the protagonist point of view?</td>
<td>1st, 3rd person or hybrid, beliefs</td>
</tr>
<tr>
<td>What forces (internal or external) is the protagonist facing?</td>
<td>Leadership responsibilities, controversial, General, rebel, inventor</td>
</tr>
<tr>
<td>Does the primary character have a history?</td>
<td>Revealed through dialogue or context or no history.</td>
</tr>
</tbody>
</table>

Table 1: Adapted Narrative Game Taxonomy (McDaniel, Fiore, and Nicholson, 2010)
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Who are the external or supporting characters?</td>
<td>Mentors, supporters, enemies, adversaries.</td>
</tr>
<tr>
<td>Can the player control more than one character in the game?</td>
<td>Yes or no</td>
</tr>
<tr>
<td>How does the progression of time affect the characters?</td>
<td>Changes through age – a time limit is imposed.</td>
</tr>
<tr>
<td><strong>PLOT</strong></td>
<td></td>
</tr>
<tr>
<td>What type of major overarching plot does the story have? What are the subplots?</td>
<td>A war, a crusade, a movement, an important historical task</td>
</tr>
<tr>
<td>How is the high-level plot released during gameplay? At which points in the game are segments of the high-level story unveiled?</td>
<td>Plot point 1: Twin Towers are attacked by terrorists, point 2: extent of damage is displayed, point 3: player must assist injured citizens.</td>
</tr>
<tr>
<td>How plots are chronologically connected? Particularly in a historical context.</td>
<td>Linear time, flashbacks, flashforwards.</td>
</tr>
<tr>
<td>What enticement catalyst motivated that journey/story of the player?</td>
<td>The Archduke is assassinated, Krakatoa Erupts, Titanic hits an Iceberg</td>
</tr>
</tbody>
</table>

Aesthetics in games-based learning applications encompasses a number of aspects including: player positioning, game mechanics, environmental, narrative and character design (Dickey, 2015). One other consideration we would like to discuss in terms of content is the highly detailed reproductions that may be required in relation to VR and AR experiences such as the incorporation of 3D models and 3D printed artefacts allowing physical interaction with the artefact and the environment which is particularly relevant in historical reproductions, exhibits, archaeological sites, and virtual museums depending on the level of fidelity and haptic feedback required (Gauge *et al.*, 2018). This study is preliminary research for a larger project focused on producing a VR exhibit with potential gamification centred on the Roman and Vendel period. These assets created for this project are highly detailed and relatively complex to make in comparison with what we tend to think of as content in serious game applications. We would like to classify these as high fidelity, accurate, exhibit quality content. Some examples are displayed in Figure 3 and 4 displaying overall exhibits focussing on individual artefacts.

![Figure 3: Roman exhibit collection](image-url)
2.3 Assessment Integration

Assessment integration for an education game (if that is the intention) are also important aspects to consider. Like content integration, assessment integration can be categorised in a general way in relation to the link to the game, whether that is formative or summative assessment or embedded and external assessment. Formative assessment is generally as the player goes along at various points whether that is embedded into the game or external to it and summative assessment is really a one stop assessment generally at the end. Serious games have been used more frequently for formative assessment than summative assessment and empirical evidence associated with the use of serious games in summative assessment is relatively sparse (Hummel, Brinke, Nadolski and Baartman, 2017). Bellotti et al., (2013) citing Michael and Chen (2005) also distinguish between completion, in-process, and teacher assessment. Completion assessment being more suitably linked with summative assessment and in-process concerned with how and why the player did what they did and concerned with the formative assessment process i.e., alteration and correction as the player proceeds. Teacher assessment is concerned with the teacher’s observations of the student’s performance. Hainey et al., (2014) identified several mechanisms present in the academic literature to integrate assessment into a serious game including: monitoring of states, completion assessment, process assessment and teacher evaluation, quest types, use of an assessment model or profile, micro-adaptive non-invasive assessment of competencies, quizzes and peer assessment – assessment received from other players during the course of the game.

3. World War Two (WW2) Museum Case Study

Due to advances in Games Engines and computer games development/technology in general has become easier to investigate the use of gamification and assessment within virtual museum prototypes. As part of a Serious Games undergraduate HE course a small WW2 virtual museum was created to run a small pilot study to ascertain if the integration of quizzes in to virtual museums as progression mechanics made the experience more immersive and enjoyable. The preliminary results indicated that this was the case. Figure 5 shows the prototype Virtual museum implemented in Unity.
4. Towards a Framework for Immersive Historical Applications

We propose the following general framework and model for the design of Historical Applications taking into account a number of prevalent considerations to assist educationalists and industrialists. The model is shown in Figure 6.

**Figure 6: Historical Application Development Model**

- **Purpose:** Cultural, Historical, Heritage
- **Type:** Historical Narrative or Historical Simulation
- **Technology:** VR, AR, Serious Game, GBL application, Mobile
- **Mechanics:** core, satellite, physics, economy, progression, tactical manoeuvring, social interaction, basic
- **Narrative Taxonomy:** Environment, Characters, Plot
- **Content Integration:** intrinsic, extrinsic, linear, cyclical, system, teacher, highly detailed content for artefacts
- **Fidelity:** physical, functional, and level
- **Assessment:** completion, process, quizzes
- **Pedagogical Framework:** situation, PBL, experiential
- **Gamification:** required, not required, Play, Motivation Frameworks
### Table 2: Historical Application Development Framework

<table>
<thead>
<tr>
<th>Considerations</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Purpose</strong></td>
<td>• What is the purpose or educational purpose of the application? For cultural awareness, historical reconstruction of events, period, or process? Heritage awareness (artistic/archaeological heritage, architectural/natural heritage)?</td>
</tr>
<tr>
<td><strong>Type</strong></td>
<td>• Is it a historical simulation using real world systems or is it in the backdrop of history?</td>
</tr>
<tr>
<td><strong>Technology</strong></td>
<td>• What technology is going to be: AR, VR, Mobile App, Serious Game, GBL?</td>
</tr>
<tr>
<td><strong>Gamification</strong></td>
<td>• Is gamification required? Is it an exhibit? How is play handled? What motivational framework is utilised?</td>
</tr>
<tr>
<td><strong>Content</strong></td>
<td>• What type of pedagogical content is going to be integrated? Intrinsic, extrinsic, system, linear, high fidelity digital reconstructions with regards to architecture or artefacts?</td>
</tr>
<tr>
<td><strong>Fidelity</strong></td>
<td>• Level of physical fidelity in terms of how well the artefact is represented? Functional fidelity in terms of how representative the real-world system, artefact, or architecture is in terms of realism and interactivity.</td>
</tr>
<tr>
<td><strong>Assessment</strong></td>
<td>• Type(s) of assessment integrated? Quizzes, peer, completion assessment? Formative, summative? Embedded, External?</td>
</tr>
<tr>
<td><strong>Pedagogical Framework</strong></td>
<td>• Pedagogical framework adopted: situated, PBL or a specialised game model such as: Learning-Game mechanics model, theoretical triadic framework, activity-based theory model.</td>
</tr>
<tr>
<td><strong>Narrative Taxonomy</strong></td>
<td>• To specify the time, period characters, events utilising the Adapted Narrative Game Taxonomy (McDaniel, Fiore, and Nicholson, 2010)?</td>
</tr>
<tr>
<td><strong>Mechanics</strong></td>
<td>• Specifying the core and satellite mechanics, physics, economy, progression, tactical manoeuvring, social interaction, points, risk and reward, action points, goals, cards, catch-up, dice, turns, resource management and races.</td>
</tr>
</tbody>
</table>

### 5. Conclusions and Future Directions

This paper has presented a preliminary literature review that we have undertaken to construct a framework and model for the design of historical applications that will act as a list of key considerations for developers and educationalists. This framework was originally designed to inform our own design and practice when attempting to construct a prototype virtual museum with potential gamification elements. Future validation of the usefulness of the model and framework from a developer and designer point of view to ascertain if it is a useful process for educationalists and industrialists will be performed as it has assisted in our practice in a Serious Games undergraduate module.

Additional research directions uncovered during the preliminary review include: investigation of the organic integration of technology in to an educational or tourism setting (Shehade and Stylianou-Lambert, 2020). Different categorisations of technology have to be considered in terms of whether it is VR, AR, XR, mobile games, serious game or games-based learning application that is utilised for teaching History at various different educational levels (PE, SE, HE). It has also been highlighted that more research on the use of serious game applications must be performed to ascertain how effective they are for the purposes of summative assessment.

### References


