IRP: VR in the Past – Game Based Learning of Archaeological Processes

•Motivation:

The principal goal is to develop an application using virtual reality technology to increase public engagement in archaeological processes. The overall objective is to create engaging narratives using cost effective VR setup through the manipulation of virtual objects using natural user interfaces through simple gesture and pose controls.

Though Science literacy, alone, is of primary important in educational and cultural values; it can be better coupled, in a timely manner, with video games to take advantage of improved cognitive, metacognitive and motivational gains [McGonigal, J. (2011)]. Such literacy forms a base of "content knowledge, process skills and understanding the nature of science" when employed as a cultural tool [Vygotsky, L.S. (1986)] in educating the students. Different motivational scaffolds like curiosity, feedback, praise, motivation orientations, fun failure, rewards, and flow states have been explored in this regard. The cognitive scaffolds are "simulations, situating cognition, distributed knowledge/virtual collaboration, values and identity, preparation for real world problem solving through embedded reasoning skills". And, the metacognitive scaffolds form "metacognitive knowledge, context, identity adoption, metamemory and meta-strategic competence through constrained learning". However, given the scarcity of proven results in this domain area by National Research Council [National Research Council (2010)] and studies done by researchers like Tobias and Fletcher, Young et al. only suggest that additional research of games being applied in education proactively is necessary. My MSc dissertation proposal is an effort towards, significantly, strengthening this research work further with evidential, experimental, user-study based results.

To strengthen the premise, let me highlight the feasibility and novelty of such game based learning where larger part of the society, both academic and commercial, play a role of a beneficiary. Science and scientists are critical resources for the proactive development of our society. The goals set by individual scientists are defined considering the probable applications to overall society. Also, often, such scientists work in groups to form hypothesis, evaluate it with experiments and revise such hypothesis based on the results derived from those experiments [National Research Council (2012)]. Similarly, video games give freedom to the players to form an assumption (such an assumption might defy the physics) to follow along abstract logical reasoning such as in fantasy games like World of Warcraft to take on a role of protagonist or simple game like Cut the Rope [Amsel, E., Cottrell, J., Sullivan, J. and Bowden, T. (2005)]. Again, similar to any scientific research, the goals can be a mixture of both instructions [Klahr,

D. and Chen, Z. (2011)] and discovery [Schwartz, D. L., Chase, C. C., Oppezzo, M. A. and Chin, D.B. (2011)]. Any more of these strategies can lead to boredom or a feeling of anxiety and if controlled proportionately, can create rewarding, educating and motivating experience to the player with appropriately defined “flow states” [Przybylski, A.K., Rigby, C.S. and Ryan, R.M. (2010)]. Given the popularity of Serious Games (SG), it is evident that their application as educational aid can improve upon the process skills and problem solving skills in a controlled game environments. While doing so, they, sure, will not be replacing the teachers but only assisting them in improving the way certain laboratory experiments and assignments are currently completed. This way, games need not be next “educational panacea” and might promote effective science education through different developmental mechanisms. Just like the feedback received on scientific assignments, the ongoing in-game feedback only motivates the student to improve upon their skills. Given the different available genre of games, like role playing in Crystal Island/ River City or teaming with online players to solve the environmental puzzles in the games like Journey or Minecraft, such assessments provide an authentic context to demonstrate student’s learnings unlike traditional (written) tests only [McClarty, K.L., Orr, A., Frey, P.M., Dolan, R.P., Vassilev, V. and McVay, A. (2012)]. Parallels can be easily drawn between scientific research and video games. The scientific research is based on prior belief and mathematical reasoning. Similarly, videos games are also based on prior belief and rely on such reasoning (“literacy, numeracy, and technology”) to progress. The feedback, in video games, is defined through a set of levels to hon the player’s skills where a player can revisit particular level to practise and improve the necessary skillset. Feedback can be provided based on the player’s effort and trait. Rewards increase their interest to keep trying to abide by the rules to earn trophies, special accessories just like the traditional letter grading system. Likewise, games are considered to provide positive affect and improve player’s problem solving skills. Therefore, the video games have potential to contribute to modern education through gamification of particular elements of science education [Morris, B., Croker, S., Zimmerman, C., Gill, D., & Romig, C. (2013)].

Computer games portray complex virtual entertaining worlds. They can 1. Support Cultural heritage purpose, 2. Support Historical teaching and learning, and 3. Enhance museum visits. Few games, can be quoted, in reference to cultural heritage context like a. Civilization [Apperley, T.H. (2006)], b. Total War series, c. Revolution [Francis, R. (2006)], and d. Virtual Egyptian Temple [Jacobson, J., Holden, L. (2005)].

Games attract young audience and therefore can be made a medium of sharing pedagogical values the fun way while collaborating through 3D spaces [Malone, T.W., Lepper, M.R. (1987)] like ‘Roma Nova’ – Experiencing ‘Rome Reborn’ as a game. They can allow for reconstructions of ancient sites and monuments with affordable basic hardware setup. The scope of designing such games can vary from being purely virtual through mixed reality applications. Two approaches are followed are as below.

1. Exploring case studies of games: Their strength lies in communication, visual and sonic expression, collaboration mechanisms, interactivity and entertainment. The games studied are Roma Nova, Ancient Pompeii, and Parthenon Project. Virtual museum studied are Virtual Egyptian Temple, The Ancient Olympic Games, Virtual

Priory Undercroft. Commercial historical games studied are History Line: 1914-1918, Great Battles of Rome, and Total War.

2. Advanced technologies behind high end computer games and their usefulness in creating cultural heritage educational games. A game engine has different modules like Graphics engine, physics engine, animation engine and AI Engine for example. Modern game engines provide multiple rendering views to facilitate coordination between different users. The game can take the form of as simple as a simulation walkthrough to as complex as online multiplayer real time multi-role playing game. It might involve the use VR technology to increase the level of virtual immersion. Just like the innovations in computer technology, game engines also undergo revisions to better support the gameplay elements be it graphics, VR, AI or all of them put together. There are open source game engines like Nebula Device [R´emond, M., Mallard, T. (2003)], OGRE [Wright, T., Madey, G. (2008)] or ODE (Open Dynamics Engine) [Macagon, V., W¨unsche, B. (2003)] with sufficient quality. They might lack, however, the content creation tools otherwise made available in their commercial counterparts.

•Background:

To shed further light on the topic of gamification of historically accentuated learning, I outline the overall trends in prior research below. Major conflicts in such research exists in the form of a gap where not much of the work has been done in the applicability of natural user interfaces along with the cost effective (VR) solution, generally accessible (web based) to all audience groups like students and museum visitors. Some games make use of web based gameplay, others make use of VR while the rest make use of controller/gamepad feedback thereby combining such processes to some length. However, scope exists to develop a game from these accumulated processes to address the domain of archaeological excavation and correlated investigative gameplay. My purpose of this review is to propose a web based, natural user interface driven, VR game to put together the best of both the worlds (technology and archaeology).

So far, gaming is predominantly considered as a means to pass the time. The technology behind the scene involves real time CG effects, VR, AR along with both scripted and unscripted AI. With the potential of computer networks, it becomes quite social with multiple players coordinating and competing for the credit points. This report sheds light on theories, methods and technological breakthroughs used in heritage games through historical teaching and learning thereby enhancing museum visits [Anderson, E. F., McLoughlin, L., Liarokapis, F., Peters, C., Petridis, P., & De Freitas, S. (2010)].

Two overarching paradigms, in this respect, are gamification of the past and historical boundary structures. While the former defines the playability with the given constraints and what artifacts fits in while others need to be discarded for such playability concerns. In other words, historical aspects are adapted so as to make them playable while gamifying the different aspects of historical events, places or artifacts. The later, on the other hand, defines the boundaries in time to decide upon the playability of some “pasts” as fair-game while others as out-of- bounds for play. Contemporary culture and politics influence such decisions to avoid concerns of wider backlash or boycotts. This way, a bridge of communication between student and teacher can be formed where the conception/misconception learned through video games prior to classes can be discussed with ease [Metzger, S. A., & Paxton, R. J. (2016)].

As long as UIs are considered, they can be VR goggles or Augmented Reality (for a mixed reality experience). Virtual object can only be viewed after it has been rendered whereas a real object can be viewed directly but it must be synthesized. So, in short, the displayed object may appear real but its appearance does not infer that it is real. Also, if the lighting conditions are simulated correctly then the difference between real and virtual scene blurs out and a human mind could register the virtual world as a read one instead. The alternative to HMDs now exist. They are like CAVE and Responsive Workbench. Online VR communities also contribute to them significantly. Also, the innovations in internet technologies offer virtual experiences to the users of World Wide Web (WWW). This became possible because of the increased efficiency of Internet connections help transmit media files correlating to virtual museum exhibitions succinctly and in near real time. Web3D offers virtual reality modelling language. X3D can be used in creation of an interactive virtual museum. COLLADA offers physics functionality such as collision detection and friction. Freely available OpenSceneGraph has high performance 3D graphics toolkit and a variety of 3D game engines [Anderson, E. F., McLoughlin, L., Liarokapis, F., Peters, C., Petridis, P., & De Freitas, S. (2010)].

•Methodology:

Research perspective:

I propose to make use of Web Graphics Language (WebGL) with HTML5 compliant 3D models making use of native JavaScript engine within web browsers like “Firefox, Mozilla Servo, Mozilla Nightly, Oculus Carmel, Chrome and Samsung Internet” along with technology framework “A-Frame”. Such a system will not only include 3D-artifact models but also models of surrounding landscapes (near and far) so as to simplify analysis and understanding of the correlation amongst human settlements within their geographical contexts. One such archaeological information system consists of “a headboard multimedia platform framework” tested on Mokarta archaeological site, Trapani, Sicily. It allows the user to explore 3D model of the current state, its virtual reconstruction and respective documentation. Along these lines, the Web along with open source tools, like WebGL libraries, Blender and Three.js, will pave the way for a cost effective new theme for “valorisation of archaeological heritage (AH)” in ongoing research activities [Scianna, A., La Guardia, M., & Scaduto, M. L. (2016, October)].

Unlike the traditional approach to exploring gaming systems with the help of keyboards and mouse/gamepads (while playing computer/console games), I suggest considering the possibilities of using Natural User Interfaces (NUIs) to make such exploration more intuitive and approachable through the use of sensory control hardware-software setup like latest gamepads from Oculus Rift, Gear VR controller and “WebSpeech” API for example [Butnariu, S., Georgescu, A., & Gîrbacia, F. (2016)].

Potential backup plan is to adapt the resources as per availability making use of only one VR gear instead of 2 (Samsung Gear VR and Oculus Rift); instead of actual dimensioned models, of skeletal remains (“Ava”) and artifacts, from excavation site, making use of similar (skull and beaker) models available readily from, laboratories.

Skills perspective:

The essential and desirable skills are HTML, CSS, JS, C++, 3D graphics and WebVR, WebVR API, OpenGL, PWA, WebRTC, WebSockets, Gamepad APIs, A-Frame respectively.

Gameplay Part I [Locating site for excavation]

1 Player assess the excavation site while referring to outlines, historical documents, aerial photographs, (documented) ideas from people and (found) pottery fragments (in earlier attempts, in case if any).

2 Player starts digging with this knowledge and priori assumptions (for example, if there are a lot of pottery fragments found near the surface then there should be something important underneath it).

3 System to either reward/penalize based on time spent in excavation.

4 System to end gameplay after particular number of trials, say 5/after certain time, say 20 minutes.

5 Earned reward points would be budgeted for second part of the gameplay.

Gameplay Part II [Carrying out excavation from a given set of tools and methods]

1 Player initiates analysis of found artefacts (like beaker) or human remains (like Ava’s skull remains)

2 System presents a set of tools and processes to carry out analysis to arrive at some fundamental results

3 Player, with prior knowledge and what has been found, selects a tool and a process

4 As a result, gameplay design renders the result visually

5 Gameplay design, following the decision tree, rewards/penalizes the player for such choice of tool and process along with proper justification thereby imparting learning in the process

6 Gameplay, like part I, terminates after a set of successive wrong trials, say 5/after certain time, and say 20 minutes of incorrect/illogical gameplay.

Decision Tree Basis

The decision tree will be based on factual archaeological tool and process knowledge as shown in below table.

Assessment Order	With Process	With Tool
[I] Identification (Presence of artefacts, human and animal remains, including the identification of diagnostic artefacts and pathologies)	[A] Macroscopic Analysis	[1] Expert in field (Example, Osteoarchaeologist for human remains) ~Free
[II] Dating of inorganic material (Example, Ceramic pottery)	[B] Thermoluminescence Dating	[2] Riso Minisys Machine ~£250 per sample
[III] Dating of organic material (human remains, flora and fauna)	[C] Radiocarbon Dating	[3] Accelerator Mass Spectrometry ~350 per sample

So, player would be free to mix and match any order of precedence with any process and any tool as per initial understanding by investing certain credit points from a given quota. For example, if player selects step II to start with. And, selects process C with tool 1 then system would render some inappropriate visual result, penalize user by withdrawing further credit points and justifying the first correct step I with process A and tool 1 instead of earlier choices thereby initiating knowledge transfer. This way, gameplay would have a finite number of trials/finite time frame too.

•Metrics for evaluation:

The game's objective of following up with the processes of excavation and investigating the found human remains/artifacts would be assessed by conducting a User Study.

Such a study would assess the participants following both formative and summative evaluation methodologies from ALEs (Adaptive Learning Environments). Evaluation can include design, usability of the interface, correctness of system knowledge, accuracy of user model, model of theory implemented in the system, performance of an algorithm and effectiveness of the system where applicable.

•Outcomes

1. Design a game that allows excavation of the virtual site
2. Build investigative methods into the game to allow users to mine information about the past from the excavated artefacts.
3. Incorporate an incentive scheme (e.g. points, stickers, etc.) to improve public engagement.
4. Develop a VR application using an open-source game engine.
Embed data from the Achavanich Beaker Burial Project
5. Evaluate the game with a user-study

• Application:

The developed game will be tested with students and museum visitors.

•Research Plan:

Week 1 through Week 3: Gathering the specifications about technology stack and researching about earlier work/proof of concepts/correlated open source repositories/APIs/algorithms

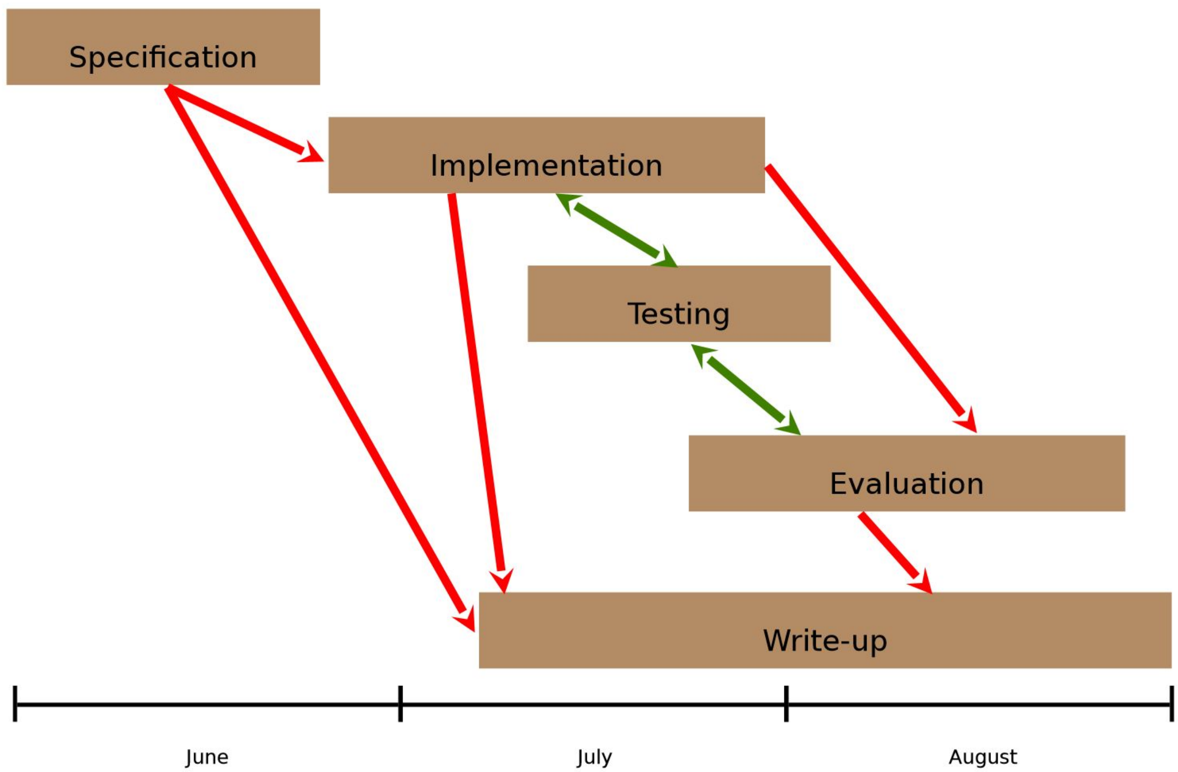
Week 4 through Week 8: Starting out with actual implementation while leveraging the technology and available tool stack to their potential

Week 6 through Week 8: To test the ongoing implementation with functional and integration tests

Week 7 through Week 10: To evaluate the system considering both formative and summative evaluations methods as applicable

Week 6 through Week 10: To write up the dissertation report

My research plan, in the form of “Gantt chart”, is depicted below. ‘Red’ indicate dependent activities while ‘green’ indicate supporting activities.



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Gantt chart: http://www.inf.ed.ac.uk/teaching/courses/irp/irp_slides_current.pdf