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# E-learning with docugames: AE2 Commander

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This paper describes outcomes from user acceptance testing of *AE2 Commander*<sup>1</sup>, a docugame released as alpha software in April, 2011. Docugames form a genre of serious games that employ digitized copy of historical sources as part of the game narrative. Design and development of AE2 Commander began in 2009, when the authors won an Ian MacLean Award from National Archives of Australia, to build an authentic World War I role-play game based on the exploits of the World War I Australian submarine AE2. The design brief required the designers to develop a strategy for incorporating digitized copy of archival records held by National Archives and to measure e-learning and engagement outcomes achieved with the docugame format.

In an earlier A&M article, the authors introduced the methods and technologies of computer game design and development used to produce AE2 Commander.<sup>2</sup> This paper reviews learning outcomes achieved with the game and player reaction to the inclusion of authentic digital re-creations of historical source records. The topic is significant within the context of e-learning, but more generally, as many cultural heritage institutions seek new ways of engaging audiences through the leveraging of serious games.

Categories and Subject Descriptors:

General Terms: Serious games, Docugames, E-learning

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## 1. NATURE AND ORIGIN OF DOCUGAMES

The *docugame* has emerged as a genre of computer games that embeds or 'posits' archival elements within a game environment. The term archival elements refers to digital renderings of historical sources such as records, manuscripts, sound recordings, movies and other cultural heritage formats. Grace (2011, p.172) uses the term docugame slightly more expansively to encompass serious games based on real events and games that support digital preservation:

*A docugame for preservation is a game which not only endeavors to accurately depict history; it posits archival elements into the game environment. These archival elements may be recordings of important speeches, photographs of historical events, or other elements of cultural heritage and history. As such it is not only a practice in recreation and model making, but in archiving and curating. The benefit of such practice depends on the subject and goal of the archive.*

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<sup>1</sup> Edith Cowan University. School of Computer and Security Science. (2011). *AE2 Commander*. Retrieved 3 July, 2012 from <http://ae2.ivec.org/>

<sup>2</sup> Brogan, M. and Masek, M. (2011). AE2 Commander: Simulation and serious games in the online cultural heritage space. *Archives and Manuscripts: The Journal of the Australian Society of Archivists Inc.*, 39(1), 85-106, Virginia, QLD.

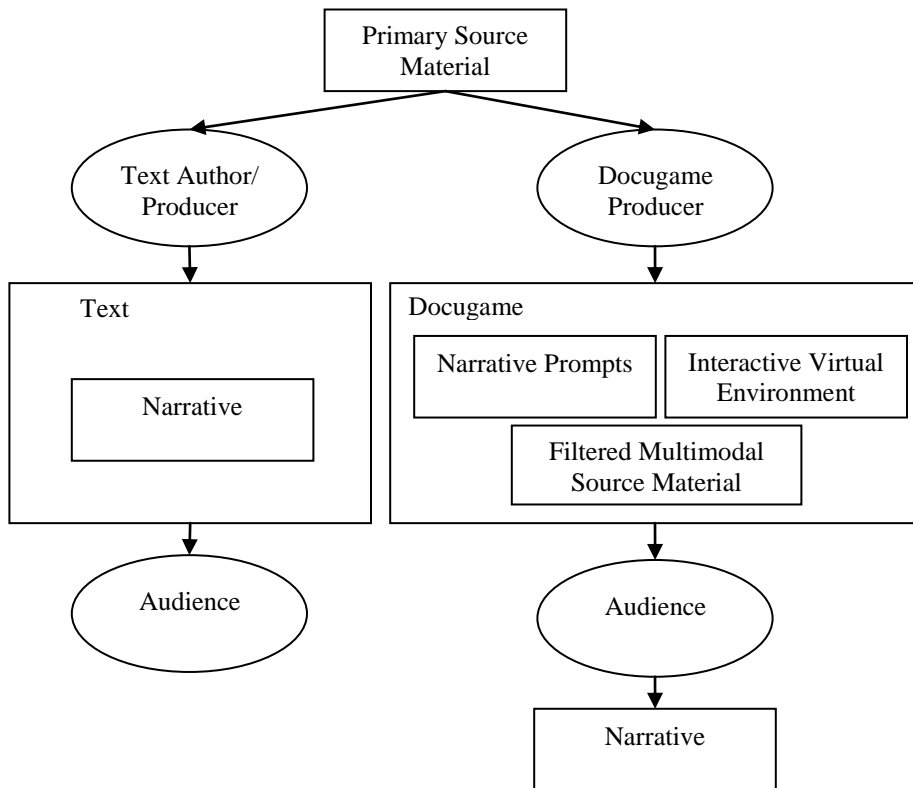
In a case study of eleven docugames, Grace (2011) concluded that factors such as the ‘non-linearity’ of games, reduced costs in game production and growth in game building communities have created opportunities to progress the genre. However developers face challenges, not least of all because there are “few models from which to derive an engaging game based on preservation” (ibid, p.174). In the absence of models, Grace argues that developers should employ the heuristics of effective game design. Of the eleven games surveyed, Grace (2011) found developers of docugames were fairly equally mixed between education institutions (4), artistic enterprises (4) and commercial entities (3). Seven games explicitly aimed to realize history, while the remainder worked to make players aware of a situation. Disappointingly, few of the games completely pursued the notion of a game based archive. Only two games incorporated archived media from their subjects. According to Grace, three high value attributes emerged as patterns in his study: - the value of realism, player determined experience and clarity of purpose.

So why the fuss over docugames? While many games and simulations reference real historical events, most provide only vicarious connection to cultural heritage collections. Docugames on the other hand, embed the experience of cultural heritage collections, making explicit connections with original sources in digital form. Experimentation with game concepts of this kind is strategically important in building engagement and learning with digitized national collections held by major libraries, museums and national and regional archives and records centers. As on demand and pre-emptive digitization bring important collections online, opportunities exist to engage new audiences and leverage this activity in ways that are transformative in terms of public perception of important cultural institutions.

However, with docugames, aspiring designers face difficult design decisions specific to the genre. For example, where a collection consists primarily of manuscript or typescript source documents, in game views may be difficult to achieve of such documents that are consistent with the look and feel of the game. Long documents might also detract from player engagement and immersion. Multimodality, the idea that multiples modes such as images, sound, animation or video might be used to deliver a text suggests as a solution, but this can have drawbacks. Actor animation in particular requires lip synchronization, which can add very substantially to the cost of game production. Important decisions must also be made about the role and significance of documents in the game narrative and learning experience. How should player interaction with documents take place? How should documents be integrated into the game narrative? Should they be used to foster exploratory learning, and if so, how? This is a small window into the many decisions that must be made during design.

The design model for a docugame is also fundamentally different from non-interactive works that use documentary sources such as manuscripts, archives, images and movies. Typically such works can be thought of as ‘texts’ of various kinds (for example written histories, exhibitions or video documentaries). In a non-interactive work, the audience is presented with a narrative constructed by the text author using documentary sources. On the other hand, in a docugame, the audience (the player) constructs their own narrative by interacting with the docugame. Thus the roles of the text author and the docugame producer are different. The difference is highlighted in the diagram in Figure 1, where the docugame producer, rather than having direct control of the narrative, presents the audience with content that guides their own narrative construction. Such content includes

filtered primary source material, such as digital reproduction of sections of documents, a virtual environment that affords interaction, and prompts which guide the audience's construction of the narrative.



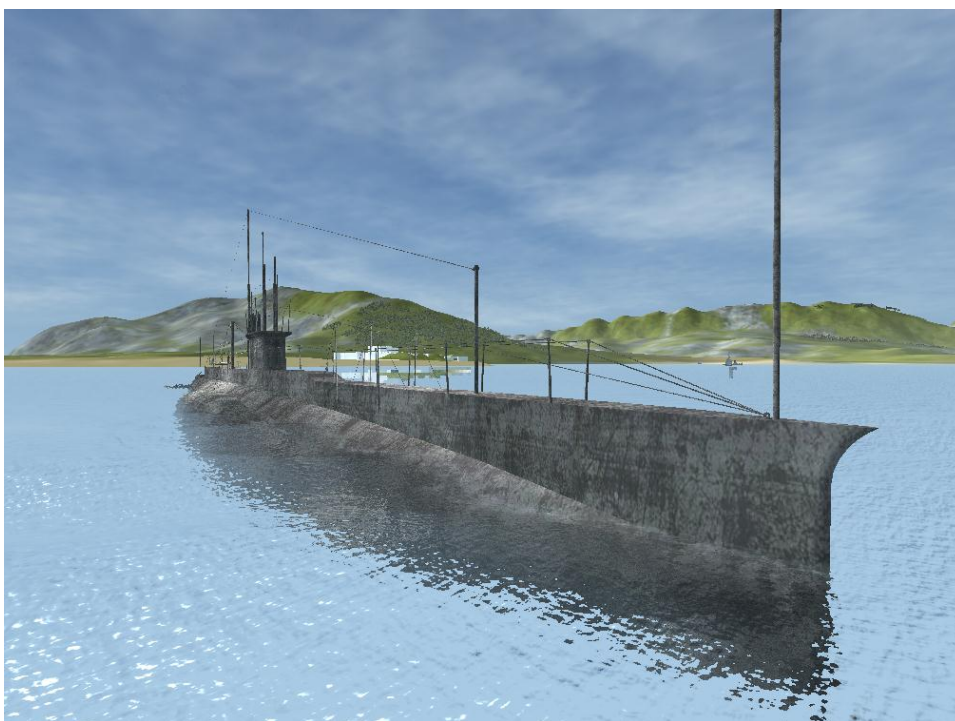
**Figure 1 – The Docugame design model is fundamentally different to that of a traditional non-interactive text. In a traditional text the narrative is constructed by the text author, whereas the audience constructs their own narrative in a docugame, guided by the material presented by the docugame producer.**

This change in role in who constructs the narrative can be a dilemma. The question arises: if the player constructs their own narrative, how can an authentic experience be re-created? The answer is through careful design of the environment and the mechanics of gameplay. Whilst the player might seem to be acting as a free entity in the game world, they are constrained by the virtual environment and other constructs within it. The key to keeping the player immersed is to make any constraints seem natural and consistent with the setting. For example, if the player is meant to re-trace the route of a historical mission as is the case with AE2, constructs such as invisible walls keeping them to the mission boundaries are jarring and not a good design choice. On the other hand, decreasing the chance of mission success through introduced hazards will encourage the player to follow the intended route naturally.

## 2. CASE STUDY: AE2 COMMANDER

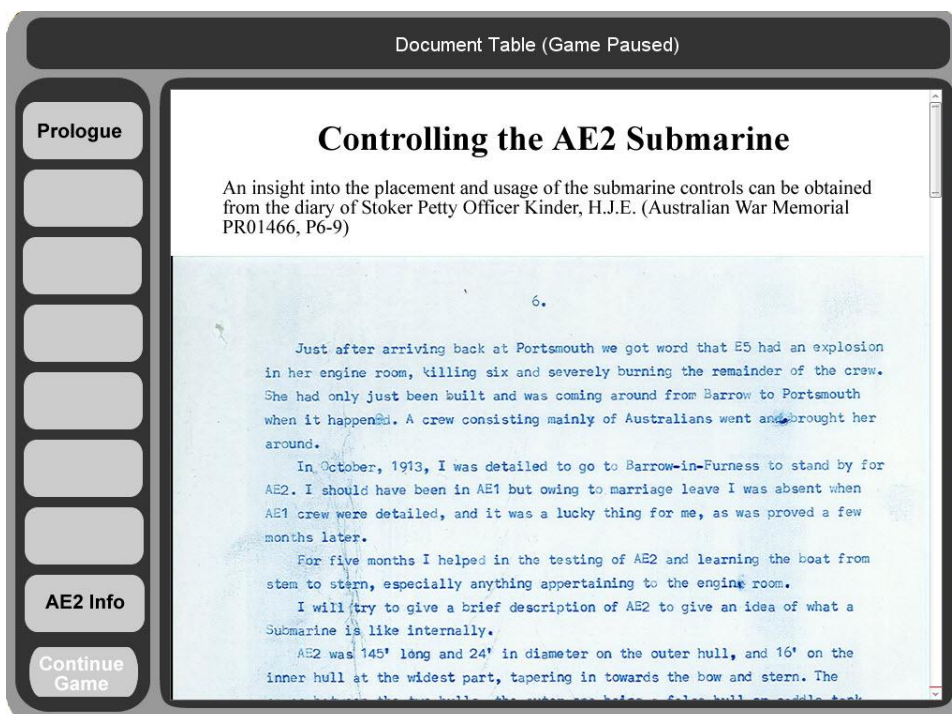
*AE2 Commander* is a role play e-learning docugame that authentically recreates an historical mission forming part of the unsuccessful Allied campaign on the Gallipoli Peninsula in April, 1915. On 25 April 1915, the Australian submarine AE2 began a mission to penetrate, undetected, the narrowest part of the Dardanelles Strait at Chanak. On the same day, Allied Forces landed on the Gallipoli Peninsula, initiating a protracted and brutal sequence of battles that ultimately resulted in Allied defeat and evacuation from the Peninsula. The Gallipoli campaign is estimated to have involved almost 400,000 Allied and Turkish casualties (HistoryLearningSite, 2012).

The AE2 (Figure 2) was the first Allied submarine to successfully penetrate an area of the Strait known as ‘the Narrows’. Over a period of five days, it harassed Turkish shipping – disrupting the delivery of reinforcements and sea operations in support of Turkish land forces fighting invading Allied forces on the Gallipoli Peninsula. The AE2 encountered various challenges – traversing a minefield, coming under fire, attempted ramming by torpedo boats and two groundings. After being holed in battle by the Turkish torpedo boat Sultan Hissar, AE2 was scuttled by her crew in the Sea of Marmara on 30 April 1915. Today, AE2 is a protected wreck. The wreck of AE2 was located in 1998 by Turkish marine archaeologist Selçuk Kolay (Smith, 2000).



**Figure 2 – In game view of the AE2 submarine**

Within an action based role play game context, *AE2 Commander* introduces players to the history of the campaign, its larger significance in the Great War and the AE2 mission itself. Original source records are introduced as graphic images, via a ‘plan table’ that mimics the real chart table found in a submarine of the World War I era. The document library of archives and manuscripts accessible via the table, is progressively unlocked as the mission unfolds, providing essential intelligence for completion of the next stage of the game. (Figure 3)



**Figure 3 - AE2 Document Table ingame view**

Within a constructivist learning environment, *AE2 Commander* creates opportunities for experience based learning encompassing history, navigation and submarine physics. For example, via crew manuscript accounts of the submarine, the player researches the concepts of trim and buoyancy and how submarine features such as ballast and hydroplanes are used to dive and control trim. The player must also devise a successful strategy for negotiating a mine field, involving the scanning of documents for information on optimal depth for the passage, the maximum safe operating depth of the submarine, optimal speed for the passage and constraints such as endurance under water. Constraints within the game are authentic, based on factors such as the submerged endurance of real AE2 under battery power, maximum operating depth and speed.

Successful computer games rely upon combinations of challenge, control and fantasy (Ritterfeld, Cody & Vorderer, 2009). All of these elements are represented in *AE2 Commander*. The mission of AE2 is undertaken as a sequence of quests based on the

historical record, beginning with progression of the submarine, in darkness, under enemy surveillance and fire to the point of minefield entry. Each quest requires information gathering from digitized sources from NAA and AWM collections, in order to formulate a successful game strategy. Incorrect strategy and failure to consult digitized copy of original sources can result in losing the game. Problem solving is complex involving the knowledge domains of submarine physics and the historical record of the mission as defined by digital reproductions of source records. Control of the submarine involves knowledge and skill in the use of hydroplanes and ballast. Relying on authentic reconstruction of the submarine, Turkish fortifications and warships, fantasy in game play is compelling.

### 3. E-LEARNING AND ENGAGEMENT

AE2 Commander was developed for school years 11 to 12 and for an adult audience. In what is a quasi-experimental research design, digitized copy of historical sources records are provided to users via a 2-D website and 3-D docugame. In addition to the mission task, five scripted learning tasks were prepared, that in principal, could be undertaken and completed using digitized records, narratives and environments found in either deliverable. Problem solving in AE2 Commander is authentic, replicating many problems experienced by AE2's crew in 1915. For example, once submerged, navigation relied upon a gyrocompass, that could be rendered useless by the concussion of torpedo firing or explosions. Using this primitive aid, players must devise a navigational strategy for the Dardanelles Strait while submerged.

Learning tasks were specified with reference to Bloom's taxonomy of cognitive behaviors such as knowledge (recall), comprehension (understanding), application (applying), analysis (analyzing), synthesis (evaluating), evaluation (creating). Two of the five tasks involved lower level learning behaviors involving recall and understanding. For example, users were asked to select statements that accurately described the war situation in 1915, a question that could be answered from the mission narratives and digitized sources available in either the 2-D or 3-D game deliverables. Other tasks sought to measure user attainment of higher level learning outcomes. For example, users were asked to derive the optimal strategy for navigating the minefield. This task could be satisfied via exploratory learning in the 3-D gaming environment, where various strategies could be tested using the submarine avatar involving analysis and synthesis. Essential intelligence (for example the maximum safe operating depth of the submarine and endurance underwater) was also supplied in digitized copy of historical source records, viewed via the mission document table. To provide for reliability in inference testing, user prior learning about AE2 and the Dardanelles campaign of 1915 was also captured.

Exploratory learning is required to carry out the principal task assigned to the player – to devise a strategy to progress the submarine to Chanak with good vitality and health, without detection by Turkish forces. Problem solving involves scanning documents for information on optimal depth for the passage, the maximum safe operating depth of the submarine, optimal speed for the passage and constraints such as endurance under water. Incorrect strategy can result in losing the game.

To master submarine controls, the player must recall instrument and control detail, understand its function, then synthesize and apply this knowledge to dive, surface, navigate and maintain submarine trim. The primary sources here are the Kinder and Wheat diaries held by the Australian War Memorial. For example, the Kinder diary describes in detail the operation of the hydroplanes and their role in surfacing and diving: ‘When the boat submerges, the bow hydroplanes force her under to the required depth and the stern hydroplanes keep the boat level’ (AWM/PR01466, p.7). The Wheat diary describes the maximum safe operating depth of the submarine, a parameter variable for the game (AWM/3DRL/2965). Knowledge garnered from archives and manuscripts is also analyzed, evaluated and synthesized to come up with a mission strategy. Effectiveness of the strategy is evaluated through feedback via alerts, a vitality meter and onscreen action. The archival texts once again are primarily supplied by the official report on the mission compiled by Lt Cmdr Stoker, and the diaries of AE2 crew members Kinder and Wheat.

#### 4. RESEARCH QUESTIONS

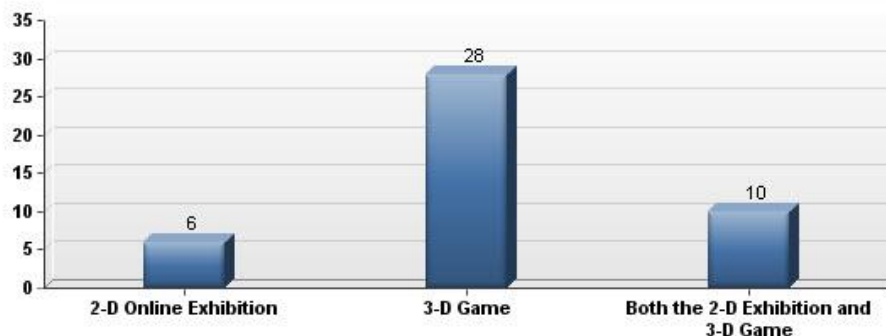
The project achieved alpha release in April 2011. Subsequently, via embedded scripts and a survey, data was collected describing user interaction with the game. Sixty (60) students describing a *pilot study group* drawn from ICT and cultural heritage graduate and undergraduate courses participated in the study. The following research questions were adopted:

- RQ1. For a scripted set of learning tasks, did users prefer the 3-D game, 2-D Web site deliverable or some combination of both?
- RQ2. Were learner object preferences related to independent variables such as age and gaming habits?
- RQ3. Were learning outcomes significantly different between users preferring 3-D and 2-D learning environments?
- RQ4. Was the game successful at promoting exploratory learning?
- RQ5. Within the 3-D space, what evidence existed of user engagement with digitized copy of archival sources?
- RQ6. As measured by rated user satisfaction, was the docugame a success?

#### 5. DATA ANALYSIS: LEARNER PREFERENCES FOR 2-D & 3-D (RQ1-RQ3)

The aim of RQ1 was to measure user preference for 2-D and or 3-D deliverables in undertaking the sequence of learning tasks. Figure 2 shows the basic statistics in terms of user utilization of the deliverables (n=44):





**Figure 2 - Object preferences (2-D v. 3-D deliverables)**

The descriptive statistics show a clear preference for problem solving using the 3-D game. A 1-tailed correlation test with Spearman's Rho showed a weak negative relationship between age and preference for 3-D format ( $n=42$ ,  $\rho=-0.299$ ,  $p=0.027$ ). Another 1-tailed correlation test with Spearman's Rho showed a moderate negative relationship between age and frequency of playing computer games ( $n=41$ ,  $\rho=-0.521$ ,  $p=0.000^3$ ). However, chi-square testing revealed no significant relationships between *correct solutions* to any of the five learning tasks and learning object preferences (2-D v. 3-D) at the weaker confidence level. ( $\alpha = 0.05$ )

## 6. DATA ANALYSIS: EXPLORATORY LEARNING (RQ4)

A significant body of literature exists that purports to demonstrate superior learning outcomes with well-constructed computer games (Ritterfeld et al., 2009; Bulger et al., 2008; Donlinger, 2007). To promote effective learning, game designers have developed a repertoire of learning strategies (Filho and Latham, 2006) including self direction, engagement, interactivity, multimodality, adaptation and real time feedback. Another way of understanding learning and exploratory user behavior in games, is provided by the concept of cognitive flow. Killi and Lainema's (2008) cognitive flow model describes factors (antecedents) in cognitive behaviour that result in learning and exploratory behavior. According to Killi and Lainema, where a game is well designed, the flow state of the user involves elevated concentration, autotelic experience (the extent to which users become so immersed in a game that they experience a loss of self-consciousness), time distortion and a sense of control. Antecedents or necessary conditions for inducing flow states include feedback, goal clarity, gamefulness and playability.

Factors from the Filho and Latham (2006) and Killi and Lainema's (2008) studies were operationalized in a survey tool that players completed during or after sessions with the 3-D and 2-D deliverables. Analysis of the data gathered with the survey tool showed that many necessary conditions for user engagement and learning according to the Killi and Lainema (2008) model were *not* satisfied in the alpha release of AE2 Commander. Specifically, similar percentage agreement and disagreement across factors of *goal orientation, feedback and interface design* were observed. In regard to these factors, the

<sup>3</sup> In SPSS,  $p$  values  $< 0.0005$  are rounded in output to  $p = 0.000$ .

data were unequivocal in the need for further iteration and testing of the design. Free text comments made by players indicated issues in user interface design with implementation of controls for the hydroplanes and rudder. The need for a tutorial or practice mission undertaken in day light was also highlighted in free text feedback.

Results with time distortion (q.40) were more encouraging with 53% (r=21) reporting their perception of time passing as different from normal. The experience of time distortion was also shown to be moderately positively associated with rated satisfaction with the game overall (n=38, rho=0.432,  $\rho = 0.007$ ). Players who experienced total immersion in the game also appreciated it for its authenticity (n=36, rho=0.452,  $\rho = 0.006$ ).

In terms of exploratory behavior, 70% of players (r=37) reported that they engaged with new features, when observed. As might be expected, exploratory behavior was positively correlated with immersion (n=37, rho=0.593,  $\rho = 0.000$ ) and a sense of time distortion (n=37, rho=0.550,  $\rho = 0.000$ ).

## 7. DATA ANALYSIS: ENGAGEMENT WITH DOCUGAMES (RQ5&RQ6)

A priori, regular game players would be expected to be more comfortable with a game of this kind. Chi square testing demonstrated this, with rated overall satisfaction and frequency of game play shown to be significantly related at the  $\alpha = 0.01$  confidence level (n=40,  $\rho = 0.000$ ). However, rated overall satisfaction with the game (RQ5) was mixed with 51% (n=20) of users agreeing or strongly agreeing that they enjoyed the playing experience and 36% (n=14) disagreeing or strongly disagreeing with this statement (q.21, r=39). As noted, factors in interface design and design more generally pointed towards the need for further iteration aimed at improving playability.

Importantly, player reaction to the embedding of digitized copy of historical sources was positive, with 66% (q.21) of players agreeing that the embedding of digitized copy of historical sources made for a more interesting game. Almost half 48% (q.36) claimed to have developed their game strategy with reference to the document library. A 1-tailed test of association with Spearman's Rho showed rated overall satisfaction with the game was moderately associated with a sense that digitized copy of historical sources had been successfully integrated into the game (n=39, rho=0.349,  $\rho = 0.040$ ). Further, rated enjoyment of the AE2 experience also displayed moderately significant association with a sense that the docugame format would be important in the future of digital heritage collections online (n=39, rho=0.349,  $\rho = 0.040$ ). A test of partial correlation controlling for the sense of the game being 'too hard', had the effect of strengthening the correlation (n=32, rho=0.429,  $\rho = 0.011$ ). Results on acceptance of the docugame format were therefore encouraging with the pilot study group.

Rated overall satisfaction was also shown to be moderately associated with a sense of the game being authentic (n=35, rho=0.406,  $\rho = 0.015$ ). Would multi-modality in the delivery of historical source documents improve the player experience? Seventy seven percent (77%) (q.52, r=35) of respondents agreed that actor narration of historical sources would add to the game experience. This was not achieved in the April 2011, alpha release of the game.

Game metrics in the form of successful episode completions, provide feedback on whether tasks were appropriately defined, too easy or too difficult. Review of the game metrics showed that only three users were successful in completing all episodes in the game (Table 1):

**Table 1 - Episode completions**

	Prologue	Episode 1	Episode 2	Episode 3	Episode 4	Episode 5
# of times completed	132	116	17	12	3	3

In this alpha iteration, evidence in the form of episode completions, suggests the need for re-design to improve playability.

## 8. CONCLUSION

Issues with playability and the small number of participants in the study, suggest that no plausible claim arising from this study can be made about the docugame format as a superior learning platform. Analysis of data gathered from the pilot study group suggests that further iteration is required to fulfil all antecedent requirements for a rich immersive learning environment according to Killi and Lainema’s (2008) cognitive flow model. Playability, as measured by survey responses, did not meet player expectations. Subject to the same limitation in terms of sample size, analysis of data gathered concerning user interaction with digitized copy of archival sources was basically encouraging in terms of the docugame format. Review of the game metrics showed that 14% of overall playing time was spent reviewing documents connected with the game narrative. Two thirds of players felt that inclusion of digital reproductions of documents from the Australian War Memorial and National Archives had the effect of making the game more interesting and almost half referred to the document library in developing a mission strategy. Adjusted for playability via partial correlation, rated enjoyment of the AE2 experience also displayed moderately significant association with a sense that the docugame format would be important in the future of digital heritage collections online (n=32, rho=0.429, p=0.011).

On the basis of their experience, players who enjoyed the game were prepared to back the importance of the format. The data analysis was therefore encouraging in suggesting the potential of the docugame format as a new method for promoting engagement with cultural heritage collections.

Work on the AE2 project, has also taken the concept of the docugame in a different direction from that originally conceived by Grace (2011). Since emulation would likely be required in the long term for games to work as a digital preservation strategy, docugames are not an affordable nor scalable method of digital preservation. Docugames are, however, a new and exciting way of connecting users with important cultural heritage in digital format. Current work has merely scratched the surface of what might be possible with docugames and how they might transform the user experience of cultural heritage online.

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