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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[2] *– a docugame released as alpha software in April 2011 by ECU's Research Centre for Transformational Games. Docugames form a genre of serious games that employ digitised copy of historical sources as part of the game narrative. The design and development of* AE2 Commander *began in 2009, when the authors received an Ian MacLean Award*[3] *from the National Archives of Australia (NAA) to build an authentic 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 digitised copy of archival records held by the NAA and to measure the e-learning and engagement outcomes that were achieved with the docugame format*.

In an earlier Archives and Manuscripts *article, the authors introduced the methods and technologies of computer game design and development used to produce* AE2 Commander.[4] *This paper reviews the learning outcomes that have been achieved with the game and the player reaction to the inclusion of authentic digital recreations of historical source records. The topic is significant within the context of e-learning, but also more generally, as many cultural heritage institutions seek new ways of engaging audiences through the leveraging of serious games*.

Keywords: docugames; e-learning; serious games

Nature and origin of docugames

The docugame has emerged as a genre of computer game 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[5] 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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In a case study of 11 docugames, Grace concluded that factors such as the 'non-linearity' of games, the 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'.[6] In the absence of models, Grace argues that developers should employ the heuristics of effective game design. Of the 11 games surveyed, Grace found developers of docugames were fairly equally mixed between educational institutions (four), artistic enterprises (four) and commercial entities (three). Seven games explicitly aimed to realise 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 connections 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 digitised national collections held by major libraries, museums and national and regional archives and records centres. As on-demand and pre-emptive digitisation bring important collections online, opportunities exist to engage new audiences and leverage this activity in ways that are transformative, in terms of public perceptions 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 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 multiple modes, such as images, sound, animation or video, might be used to deliver a text – suggests a solution to the problem of document integration. But this also is not without drawbacks. Avatar animation, in particular, requires lip synchronisation, 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 but a small window into the many decisions that must be made during the design process.

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, which has been 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 reproductions of sections of documents, and a virtual environment that affords interaction and prompts, which guide the audience's construction of the narrative.

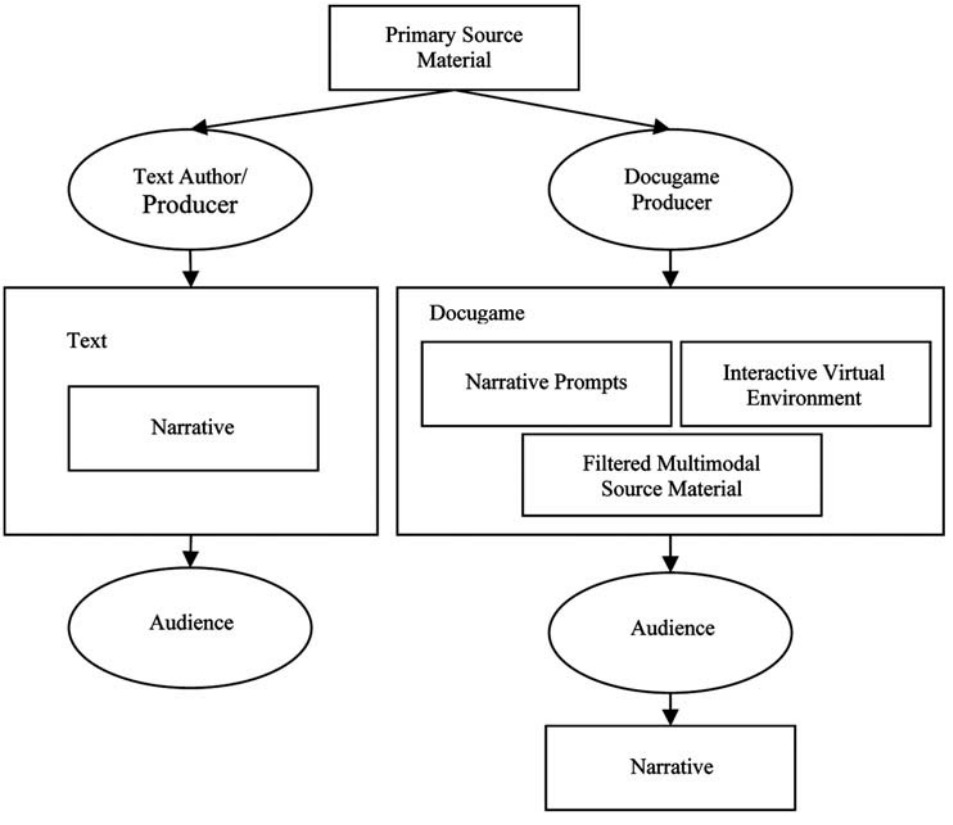

Figure 1. Pathways to narrative: how docugames are different.
Note: The docugame design model is fundamentally different to that of a traditional non-interactive text. In a traditional text, the narrative is constructed by the text author, whereas the audience constructs their own narrative in a docugame,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

This shift in responsibility for construction of the narrative, can be a dilemma. The question arises: if the player constructs the narrative, how can the game be regarded as authentic? The answer is through careful design of the environment and the mechanics of game play. While the player might seem to be acting as a free entity in the game world, he or she is, in fact, 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 retrace the route of a historical mission, as is the case with *AE2*, constructs such as invisible walls confining play to the mission boundaries do not make for satisfying game play. On the other hand, decreasing the chance of mission success through introduced hazards will encourage the player to follow the intended route naturally.

Case study: *AE2 commander*

AE2 Commander is a role-play e-learning docugame that authentically recreates a 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.[7]

The *AE2* (see 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, including traversing a minefield, coming under fire, attempted ramming by torpedo boats and two groundings. After being holed in battle with the Turkish torpedo boat Sultan Hissar, *AE2* was scuttled by her crew into 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.[8]

Within an action-based role-play game context, *AE2 Commander* introduces players to the history of the campaign, its larger significance in World War I and the *AE2* mission itself. Original source records are introduced as graphic images via a 'plan table', which 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 the completion of the next stage of the game (see Figure 3).

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

Figure 2. In-game view of the *AE2* submarine.

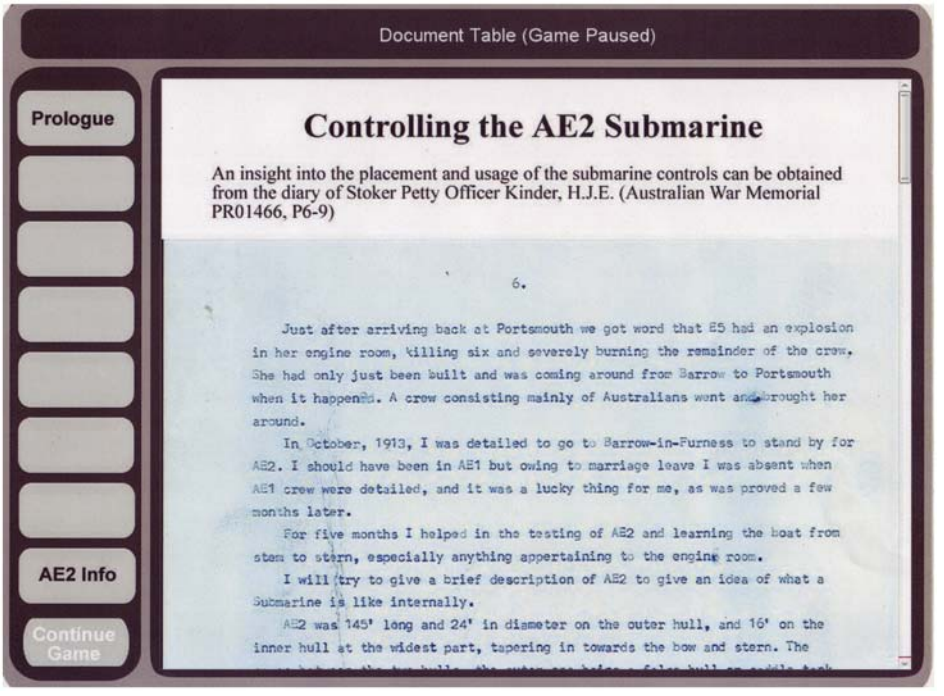

Figure 3. *AE2* document table in-game view.

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 the real *AE2* under battery power and the maximum operating depth and speed.

Successful computer games rely upon combinations of challenge, control and fantasy.[9] 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 the progression of the submarine in darkness, under enemy surveillance and fire to the point of minefield entry. Each quest requires information gathering from digital reproductions of records sourced from the NAA and Australian War Memorial (AWM) collections, in order to formulate a successful game strategy. Incorrect strategy and failure to consult digitised 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 the source records. Control of the submarine involves knowledge and skill in the use of hydroplanes and ballast. Relying on authentic reconstruction of the submarine,[10] Turkish fortifications and warships,[11] fantasy in game play is significantly realised.

E-learning and engagement

AE2 Commander was developed as a resource for upper secondary schools and adult audiences. Digitised copy of historical source records is provided to users, via a 2-D

website as well as the 3-D docugame. In addition to the mission task, five scripted learning tasks were prepared, which, in principal, could be undertaken and completed using digitised records, narratives and environments found in either the 2-D or 3-D deliverable. Problem solving in *AE2 Commander* is authentic, replicating many problems experienced by the crew of the *AE2* in 1915. For example, once submerged, navigation relied upon a gyrocompass, which 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 behaviours, such as knowledge (recall), comprehension (understanding), application (applying), analysis (analysing), synthesis (evaluating) and evaluation (creating). Two of the five tasks include lower level learning behaviours 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 digitised 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 digitised copy of historical source records, viewed via the mission document table. To provide for reliability in inference testing, user's 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, i.e. to devise a strategy to progress the submarine to Chanak in good vitality and health, evading Turkish forces and defences. Problem solving involves scanning documents for information on optimal depth for the passage, establishing the maximum safe operating depth of the submarine, operating at optimal speed for the passage and constraints such as endurance under water. Incorrect strategy can result in losing the game.

To master the submarine controls, the player must recall instrument and control detail, understand its function, then synthesise and apply this knowledge to dive, surface, navigate and maintain submarine trim. The primary sources here are the Kinder[12] and Wheat[13] diaries, which are currently held by the AWM. 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'.[14] The Wheat diary describes the maximum safe operating depth of the submarine – a parameter variable for the game.[15] Knowledge garnered from archives and manuscripts is also analysed, evaluated and synthesised to come up with a mission strategy. The effectiveness of the strategy is evaluated through feedback via alerts, a vitality meter and on-screen action. Once again, the archival texts are primarily supplied by the official report on the mission, as compiled by Lt Cmdr Stoker,[16] and the diaries of *AE2* crew members Kinder and Wheat.

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 students, encompassing 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 website 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 digitised copy of archival sources?
- RQ6: As measured by rated user satisfaction, was the docugame a success?

Data analysis: learner preferences for 2-D and 3-D (RQ1–RQ3)

The aim of RQ1 was to measure user preference for 2-D or 3-D deliverables in undertaking the sequence of learning tasks. Figure 4 shows the basic statistics, in terms of user utilisation of the deliverables (r=44).

The descriptive statistics show a clear preference for problem solving using the 3-D game. A one-tailed correlation test with Spearman's rho showed a weak negative relationship between age and the preference for the 3-D format (n=42, rho=-0.299, ρ=0.027). Another one-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, ρ=0.000).[17] However, chi-square testing revealed no significant relationships between *correct solutions* to any of the five learning tasks and learning object preferences (2-D versus 3-D) at the weaker confidence levels ($\alpha = 0.05$).

Data analysis: exploratory learning (RQ4)

A significant body of literature exists that purports to demonstrate superior learning outcomes with well-constructed computer games. In a review of the literature, Mitgutsch,[18] citing earlier work by Mitchell and Saville-Smith,[19] provides the following factor-based explanation as to why computer games engage learners:

- They represent fantasies and follow a simple principle of winning or losing, with instant outcomes.[20]
- They use aesthetic modelling and recognisable features to engage the learner's attention[21] by stimulating the learner's enjoyment with visual feedback.[22]
- They provide a complete and interactive playing environment and an immersive experience.[23]
- They open up different solutions and ways of solving problems.[24]

According to Filho and Latham,[25] to promote effective learning, game designers have developed a repertoire of learning strategies, including self-direction, engagement, interactivity, multimodality, adaptation and real-time feedback. Another way of understanding learning and exploratory user behaviour in games is provided by the concept of cognitive flow. Killi and Lainema's cognitive flow model[26] describes factors (antecedents) in cognitive behaviour that result in learning and exploratory behaviour. According to Killi and Lainema, when a game is well-designed, the flow state of the

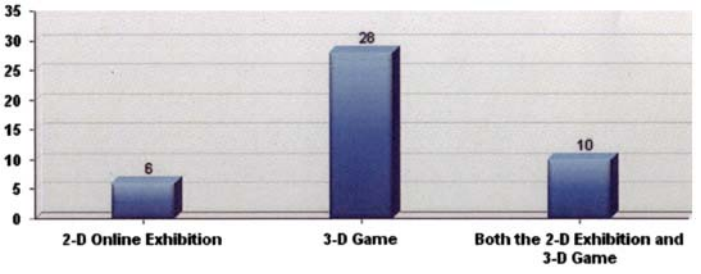

Figure 4. Object preferences (2-D versus 3-D deliverables).

user involves elevated concentration, an 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 both the Filho and Latham, and the Killi and Lainema studies were operationalised in a survey tool that players completed, either 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 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 data was unequivocal in the need for further iteration and testing of the design. Free text comments made by players also indicated issues in user interface implementation of controls for the hydroplanes and rudder. The need for a tutorial or practice mission undertaken in daylight was also highlighted in free text feedback. Any further iteration of the design aimed at progressing the software from alpha to full release would need to logically address these issues.

Results with time distortion (question 40) were more encouraging, with 53 per cent (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, ρ=0.007). Players who experienced total immersion in the game also appreciated it for its authenticity (n=36, rho=0.452, ρ=0.006). In terms of exploratory behaviour, 70 per cent of players (r=37) reported that they engaged with new features, when observed. As might be expected, exploratory behaviour was positively correlated with immersion (n=37, rho=0.593, ρ=0.000) and a sense of time distortion (n=37, rho=0.550, ρ=0.000).

Data analysis: engagement with docugames (RQ5 and 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, ρ=0.000). However, rated overall satisfaction with the game (RQ5) was mixed with 51 per cent (n=20) of users agreeing or strongly agreeing that they enjoyed the playing experience and 36 per cent (n=14) disagreeing or strongly disagreeing with this statement (question 21, r=39). As previously noted, data analysis of user experience with interface design, feedback and playability points towards the need for further iteration of the game to improve playability and overall player satisfaction. Game metrics, in the

form of successful episode completions, provide another source of evidence on player acceptance, engagement and satisfication. Review of the game metrics (Table 1) showed that, during the data gathering period, only three users were successful in completing all episodes in the game, again suggesting the need for tweaking and futher iteration.

Table 1. Episode completions

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

What can be said of player reaction to the docugame concept? Importantly, player reaction to the embedding of digitised copy of historical sources was positive, with 66 per cent (question 21) of players agreeing that the embedding of digitised copy of historical sources made for a more interesting game. Almost half – 48 per cent (question 36) – claimed to have developed their game strategy with reference to the document library. A one-tailed test of association with Spearman's rho showed rated overall satisfaction with the game was moderately associated with a sense that the digitised copy of historical sources had been successfully integrated into the game (n=39, rho=0.349, ρ=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, ρ=0.040). A test of partial correlation, controlling the sense of the game being 'too hard', had the effect of strengthening the correlation (n=32, rho=0.429, ρ=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, ρ=0.015). Would multimodality in the delivery of historical source documents improve the player experience? Seventy-seven per cent (question 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, due to budgetary constraints. There was simply no money for lip-synchronised avatar narration of archival sources.

Conclusion

No evidence-based claim can be made from this study about docugames as a superior learning platform. Analysis of data gathered from the pilot study group suggests that further iteration is required to fulfill all antecedent requirements for a rich and immersive learning environment, according to Killi and Lainema's (2008) cognitive flow model. Playability, as measured by survey responses, did not meet player expectations in the alpha release version of the game. However, subject to the qualification that the sample size was small, the analysis of data gathered concerning user interaction with digitised copy of archival sources was encouraging. A review of the game metrics showed that 14 per cent of overall playing time was spent reviewing documents connected with the game narrative. Two-thirds of players felt that the inclusion of digital reproductions of documents from the AWM and NAA had the effect of making the game more interesting and almost half referred to the document library in developing a mission strategy. When adjusted for playability via partial correlation, the rated enjoyment of the *AE2* game also displayed moderately significant associations, with a

sense that the docugame format would be important in the future of digital heritage collections online (n=32, rho=0.429, ρ=0.011).

On the basis of their experience, players who enjoyed the game were prepared to back the importance of the genre. The data analysis was therefore encouraging in suggesting the potential of docugames 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. 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 documents in digital formats. Current work has merely scratched the surface of what might be possible with docugames and how the genre might transform the user experience of cultural heritage online.

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