

Capturing the Virtual Movement of Paintings: A Game and A Tool

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Abstract—This paper presents a virtual gallery creation game that has been designed for the National Gallery of London, as part of the CrossCult project, with a multi-purpose goal. For visitors, the game allows users to virtually move paintings around, reflecting on their visit through gamification, while creating and curating their own virtual galleries. For National Gallery staff, the application allows them to simply visualise planned exhibitions and to accurately record the positions of paintings when they are moved or re-positioned. This paper describes the game’s underlying structure, designed to serve both as an expert tool and as a game, and discusses the results obtained from initial experiments with end-users. Some preliminary conclusions can be drawn regarding the extent to which the application allows the end users to reflect on the National Gallery collection while creating and curating their own virtual galleries.

Index Terms—mobile application, user interface, game, gallery

I. INTRODUCTION

Over the last twenty years, computer games have grown from a niche market targeting young adults to an important player in the global economy, engaging millions of people [1]. Nowadays, games are being played on a multitude of devices, including personal computers, dedicated gaming consoles, mobile phones, tablets and virtual reality devices. The themes, aesthetics and types of gameplay in modern digital games vary greatly, from combat-oriented competitive games to social quiz games among friends, and from casual games requiring little daily involvement to massive on-line games with millions of interacting players. The diversity of target devices, the broad variety of game themes and a recent tendency towards free games have resulted in a broad player base with a diverse range of ages, genders and cultural backgrounds.

The CrossCult project (www.crosscult.eu) aims to change the way European citizens appraise History, fostering the re-interpretation and reflection upon what they may learn in the light of cross-border interconnections among pieces of cultural heritage, other citizens’ viewpoints and physical venues. Within the CrossCult framework, we developed a range of different games for the four pilots implemented in the project, which can be categorised as quiz games, hybrid puzzle-quiz games, creation games, location-based games and playful interactions that create personal souvenirs. The expansive playerbase and breadth of modern digital games represents a

strategic opportunity for the CrossCult framework to maximise user engagement and enhance the cultural heritage experience through the development of different types of serious games.

We present here the virtual “Gallery Creation” game application that we designed and developed for a CrossCult pilot (Pilot 1). Pilot 1 takes place in the National Gallery (NG) in London, UK, which is a large multi-thematic venue. Its goal is to use the broad collection of a single large institution to illustrate the connections between paintings, painters, places and events across European history, through art. The processes and technologies included in this Pilot aim to demonstrate new approaches to improve the accessibility and experience of European cultural heritage, by increasing the visibility and exploitation of the complex and diverse connections that exist between works of art. The pilot facilitates user reflections and interpretation associated with, for example, the relationships between painters, schools, periods, materials and places. The game application allows users to virtually move paintings around, reflecting on their visit through gamification, while they create and curate their own virtual galleries.

Technological advancements that facilitate location tracking, such as i-beacon devices, allow us to track objects within a building if and when they move. At the NG, paintings move from one location to another, to serve the needs of exhibitions, to receive treatment or for the needs of rehanging and changing the objects displayed in a specific location within the building. Although the record of an object’s location is part of its provenance, the time for recording detailed location-based information is limited. An application that allows the end user to move paintings and record their positions, on a given wall within a virtual space can be used to quickly capture a more precise location for paintings. This application will be a useful tool for museum expert such as the National Gallery’s curators, as well as visitors who wish to play a game.

After a brief overview of related work in Section II, Section III presents the design of the virtual gallery creation game. We designed and developed the game to serve both as an expert tool and as an application for the end user: Section IV highlights the game’s underlying structure to capture and store the location-based information and the features of the application’s interface involved in reflection triggering. Section V presents a first user study; Section VI discusses our preliminary results

on how reflection is triggered and future work is identified. The paper concludes in Section VII.

II. RELATED WORK

The success of commercial digital games has motivated the integration of several patterns of gameplay into other tasks such as training [2], advertisement [3], rehabilitation [4], [5] and learning [6]. Gamification and the idea of serious games have attracted substantial academic and commercial interest in recent years for their ability to involve users in solving problems and to increase their engagement [7]. Studies in gamification [8] have identified play patterns such as autotelic experience, clear goals, immediate feedback, control and skill-level balance that are salient dimensions of flow in gamification. This leads to the conclusion that goal-oriented features provide a firmer basis for prolonging the user’s interaction.

On the other hand, Nicholson [9] argues against gamification which primarily uses extrinsic reward motivators, relying on operant conditioning (rewards, points, limited meaning). In addition, studies in the field of human creativity suggest that extrinsic motivators lower the potential for fostering creativity [10]. Games and playful experiences in CrossCult therefore needed to be designed carefully in order to reap the benefits of gamification (prolonged interaction and self-motivation) while minimising the importance of elements such as extrinsic reward motivators. It was important to ensure that the games implemented in the CrossCult pilots serve the main user requirement: to enable reflection and (re)interpretation of the historic themes, topics and threads central to the pilots.

III. THE DESIGN OF THE CROSSCULT PILOT 1 APPLICATION

Game design is paramount to the creation of any digital game. It defines the way in which players interact with the system, including the motivations and the conditions in which this interaction is brought to an end (e.g. win or loss conditions). A game’s design is therefore comprised of the following elements: the narrative (e.g. themes or specific in-game text), the visuals (including the user interface), audio and possibly different levels [11]. Game design relies on a formal vocabulary, which is useful for understanding the underlying structures of games [12]. For the purposes of describing the game developed in the CrossCult Pilot 1, the formal game design concepts of goals, loops and rewards are introduced in Table I. The game has a goal, which describes the intended gameplay experience: gameplay is formally defined as “one or more causally linked series of challenges in a simulated environment” [13]. The game’s goal is accomplished through the game loop, which can be described as the primary set of actions that players must learn in order to become skilled [14].

The actions that players need to perform as part of a gameplay loop are known as game mechanics, formally defined as “methods invoked by agents, designed for interaction with the game state” [15], where agents can be human players or computer-controlled opponents. Thus, the game mechanics in the gameplay loop for the player are described as verbs in

TABLE I: Overview of the Gallery Creation game and its core gameplay loop.

Theme	Virtual gallery creation
Goal	Fill in an empty virtual room with paintings, based on cues and reflection topics
Core loop	Select virtual walls from NG rooms, move paintings to match NG setup or create a novel setup, receive reward
Rewards	Badges, peer assessment, reflection

Table I. As noted above, the causal chain of the gameplay loop requires that players’ actions are performed in a sequence which ends with a feedback mechanism (receive reward). For the CrossCult Pilot 1 game the functional feedback loop is based on receiving rewards, as the direct consequences of the player’s choices [16]. The table includes extrinsic (badges) and intrinsic (peer assessment, reflection) rewards for players.

Since game design traditionally follows an iterative process of play testing and refining of the game’s rules and mechanics, these goals and core gameplay loops are expected to be refined during the process of development and evaluation of the Pilot. For the first version of the Pilot 1 game application, we have focused on defining its high-level goal, the core gameplay loop and the intrinsic reward mechanisms that we will use to spark sustained gameplay and thus reflection and interaction with the relevant cultural heritage content and experience.

IV. THE PILOT 1 CROSSCULT APPLICATION AS A GAME AND A TOOL FOR THE NATIONAL GALLERY

Pilot 1 allows users with differing levels of experience and knowledge to interact with the NG collection. Users are able to engage and reflect on the information presented and the diverse works of art in the collection based on their own knowledge, choices and experience rather than being forced along a more traditional single choreographed route through the Gallery. The current version of the Pilot 1 game application fulfills two complementary purposes:

- The “Gallery Creation” as a game that can be used by the end users before, during or after the visit to familiarise themselves with the paintings in the collection; a virtual world where a visitor can rearrange the paintings to create a fully personalised exhibit.
- The “Moving Paintings” as a standalone administrative tool to assist museum staff to accurately record the positions of paintings when they are moved or re-positioned.

A. The application’s interface

This section provides a quick overview of the game’s version that has been tested during the controlled experiments the results of which we present in this paper as a user study (see Section V). The ‘Gallery Creation’ game showcases the exhibits of the NG giving players the opportunity to create and curate their own virtual gallery. This game is primarily an autotelic creation game, where the reward is intrinsic in the aesthetically pleasing and personalised arrangement of paintings on a virtual wall. The player’s main goal is to rearrange the paintings in an existing room or to fill an empty



Fig. 1: The intro screen provides easy access to the main modes of interaction with the app, as well as some helpful information on how to use the app.

room with paintings (see Table I). The game is played in landscape mode on mobile devices. In the current prototype, one sample wall is provided with sample NG paintings.

There is also a complementary web version that has been created to facilitate the off-site/remote experiments (<http://research.ng-london.org.uk/scientific/ccgame/>). The web version is also intended to be the basis of the 'Moving Paintings' standalone administrative tool and will be tested in a future user study with experts such as curators and museum staff.

The game consists of the following screens:

1) *Welcome screen*: the welcome screen (Fig. 1) displays instructions on how to use the game:

Do you have what it takes to be a gallery curator? In this game, you will fill a blank wall with paintings from the National Gallery's collection. You can fill a wall with all your favourite paintings, or try and match them to the same theme. Submit your wall to unlock secret badges!

Three buttons at the bottom of the screen allow the player to start with a empty wall (Start button), to view their previously created walls (Gallery button) or to see the Tutorial screens.

2) *Main Creation/Edit screen*: this screen (Fig. 2) features the core gameplay loop, i.e. the creation of the player's wall.

The screen is split into two sections: the Collection and the Wall. When starting an empty wall, all paintings available to the player are placed in the Collection, on the left, in multiple rows of two columns. Paintings in the Collection are automatically scaled in order to fill their allocated space, avoiding any

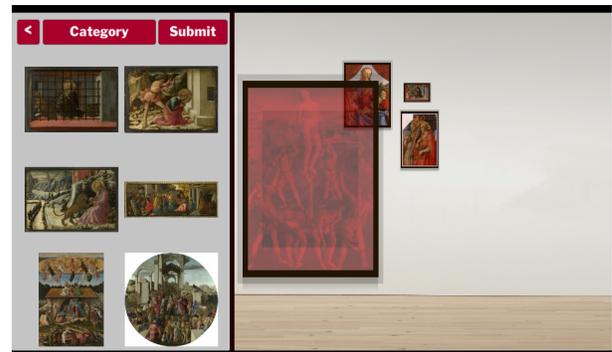
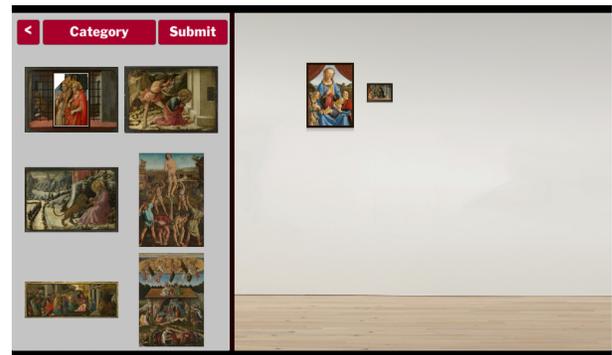


Fig. 2: Edit screen during play. A player adds a painting by first tapping on it in the collection, which 'pops' it out and scales it to the correct relative dimensions (top). Cues for collision (bottom) which show where a painting can not be moved to.

overlapping issues. The collection section features two buttons at the top, which allow the player to filter the paintings based on expert-provided categories (Category button), and to submit their wall and finish the editing process. The Wall section, to the right, is where paintings from the collection are placed. The wall in this prototype stretches left and right, and players can scroll to the left or right by dragging on the wall's empty space (i.e. areas not covered by paintings).

Paintings can be moved from the Collection to the Wall by tapping on a painting once to select it (Fig. 2). The selected painting is then scaled to its correct dimensions, relative to the wall, and is left hovering over the other paintings in the Collection. The resized selected painting can then be dragged across to the Wall and dropped in place. As it is being dragged, the painting will be highlighted in red when its position would be invalid or overlap an existing painting. Dropping paintings in invalid positions returns them to their previous position, back in the Collection or on the Wall (Fig. 2). Different groups of paintings can be displayed in the Collection by selecting different categories. Submitting or finishing the editing process takes the user to the Vanity screen.

3) *The Vanity screen*: this screen (Fig. 3) shows a larger version of the wall after the user has finished editing it. It also notifies the user of any achievement badges collected as a pop-up menu. Four buttons allow the user to view previous creations (Gallery button), start again (New button), navigate

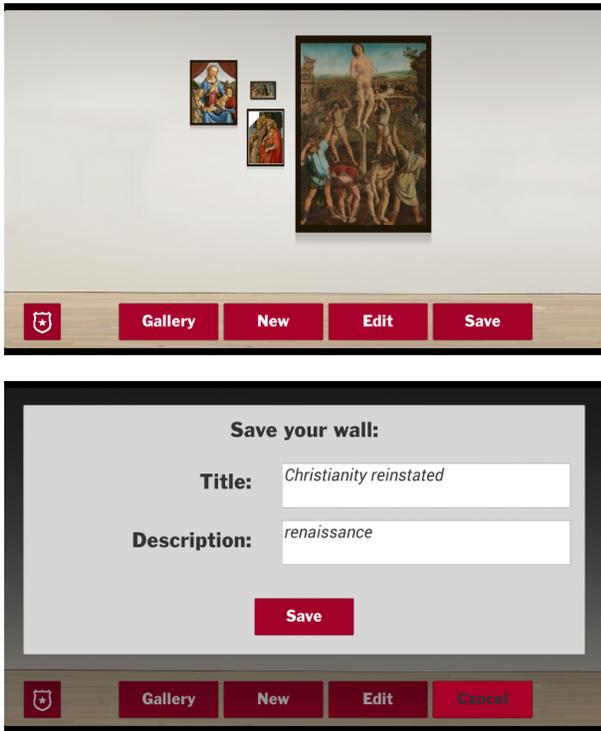


Fig. 3: Vanity screen (top) and the pop-up for saving the player's wall to the gallery (bottom).

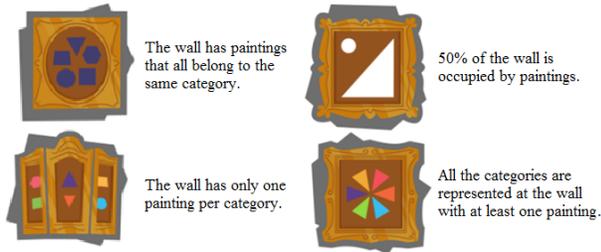


Fig. 4: The Gallery Creation game achievement badges.

back to the edit screen (Edit button), or save the wall to the user's Gallery (Save button). The vanity screen is also shown for walls saved in the gallery: in that case, the "new" option is replaced with an option for the user to "delete" that entry from the Gallery.

The player receives 'rewards' in the form of badges (Figure 4) for completing specific challenges associated with each badge. The badges button, off to the left in Figure 3, shows which badges (if any) the player has collected for this wall. Currently badges feature a few challenges such as covering at least 50% of the wall, having paintings from all categories, or having paintings from the same category.

Finally, the save button creates a pop-up window where the player can give a title and a short description to their wall, using the device's keyboard and auto-correct elements (Fig. 3). Giving a title is intended to prompt reflection from the user to identify (and verbalise in a concise way) what criteria they used to associate paintings on the wall, generally or spatially

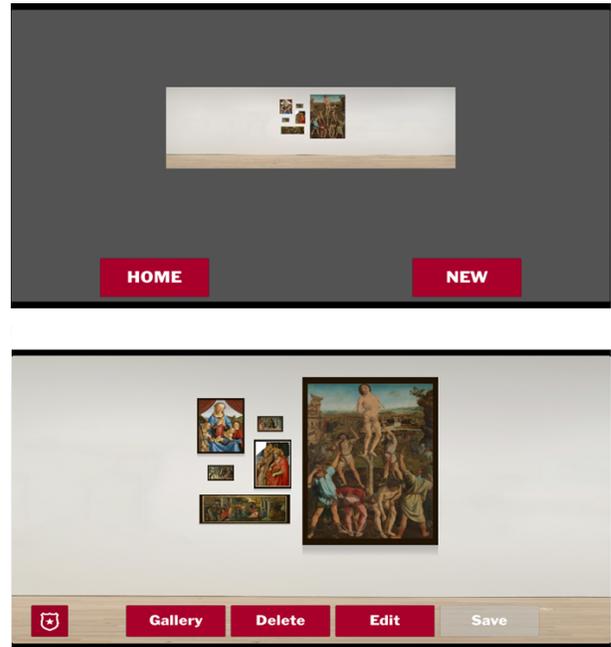


Fig. 5: The Gallery screen with one saved wall (top) and that wall loaded into the vanity screen (bottom).

(e.g. which painting is next to which). This is an unstructured reflective process, which is not mandatory but recorded data will be tested for the quality of titles collected and used to assess reflection based on the evaluation protocol. At this time it is not possible to view the recorded titles and descriptions, but this functionality will be added in future versions.

4) *The Gallery screen*: The Gallery screen (Figure 5) shows a list of the walls created by the user of this device. The gallery contains rows of two columns, showing the screenshot of the full wall for each session. Tapping on the screenshot takes the player to a variant of the vanity screen above, which allows them to see the badges rewarded for this wall, return to Gallery, delete the wall, or edit the wall. The user can only save the wall again after they have edited it.

B. Underlying Technology and Data Structure

The application is developed in *Unity 3D* (Unity Technologies 2005), a top-class game engine which allows the game to be exported in a broad variety of devices and platforms. Currently, the game can be played on a webpage (in HTML format) and as an Android application (for Android 5.1x+). When a user saves their wall (in the Vanity screen described in Section IV-A3), a local file is created which is stored in the user's device (for Android mobile devices) or as cookies on the user's browser (for HTML web versions). Simultaneously, a copy of the saved wall is sent to an external persistent database which stores all users' saved walls; currently this persistent database is used for logging and internal use, although an interface for players or the broader public to view others' walls is under consideration to facilitate peer evaluation. The data saved include the title and description of the wall, an image of

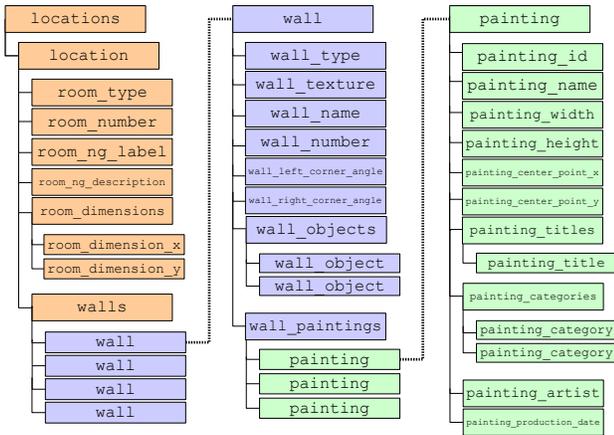


Fig. 6: Outline of the XML structure used to load paintings and their categories into the application.

the wall and metadata on the positions and types of paintings included in the wall. This data can be processed in the future either to assess reflection in end-users or to capture and store curators’ positioning of paintings as an administrative tool.

In order for the application to use NG resources (images, room information, etc.) a specific data structure needed to be used. The system uses an XML structure (see Figure 6) which is automatically generated from the National Gallery ontology, where metadata of rooms (and their contents), walls (and their dimensions), paintings (and their images), artists and categories are stored. In the presented prototype, the application consumes the XML structure of a room and its paintings, and downloads images of these paintings to integrate into the application. This XML structure allows us to build a game for any room in the NG database; moreover, walls created and saved in the game can be re-formatted into the same XML structure and update the NG database with up-to-date painting positions in the case of the expert user tool.

This is currently done during development, resulting in a “static” application, where all paintings and content are pre-baked into the application. This allows the Android version to be playable without internet connection, although the user’s walls will not be stored in the persistent online database in that case. However, future iterations will load rooms’ paintings and other content dynamically, which allows the application to be updated on-the-fly with the most recent room layouts. The list of categories, which the player can use to filter paintings based on theme (see Section IV-A2), is generated based on the paintings contained in the room: each painting belongs to a set of categories which is included in the XML consumed by the application. Therefore, different rooms may result in a different number of categories.

V. USER STUDY

The evaluation of the Pilot 1 application as a game was split into two phases comprising the preliminary evaluation (phase 1a) which investigated both technical issues and user issues to identify development priorities. Following this evaluation

we moved into the next phase (1b), undertaking a formative evaluation during the Spring 2018. This phase included user controlled experiments conducted in Athens with undergraduate students from the University of West Attica (formerly Athens University of Applied Sciences) which are presented here as our user study.

The purpose of the user study is to evaluate the user experience and usability of the ‘Gallery Creation’ game application, testing its features and functionalities. We also wish to understand if the user’s reflection process has been triggered by the interaction of grouping paintings, labeling and adding descriptions to walls. Thus, the tested prototype acts as a demonstrator of the functional properties of the game, evaluating primarily:

- 1) the usability of the application on mobile devices, on and off-site
- 2) the rewarding mechanism (badges) and its effect on player motivation
- 3) the expressive range in terms of player-created content
- 4) the user reflections captured within user-provided titles and descriptions for each wall

A. Experimental Protocol

The experiments carried out as part of the user study were split into two groups (one using the app on a mobile device, and the other using the web version), following the same experimental protocol. Both versions of the game featured exclusively paintings from Room 57 in the Sainsbury Wing of the National Gallery, which were on display in March 2018.

- *Step 1 - Preparation:* the participants were collectively given a short 10 minute introduction about the CrossCut project. The terms and conditions of the application were printed out and distributed, including the consent form, which had to be read and signed by the participants. During this process, the participants were also told they could withdraw from the experiments at any time and request modifications or deletion of their data and that they were free to contact us via email.
- *Step 2 - Preparation:* participants of the first group were then asked to either install the application on their own Android smartphone or use one of the Android test smartphones available. Participants of the second group were asked to open Firefox on their desktop screens and type in the web address of the game experiments (<http://research.ng-london.org.uk/scientific/ccgame/>).
- *Step 3 - Main experiment:* the experiment was initiated by asking all participants to open the NG website (<https://www.nationalgallery.org.uk/>) on their browser and imagine that they would start a visit. They were also asked to think about a possible objective of their visit and what to expect from it. To facilitate this remote experience, the participants were then directed to the following webpage of the NG website (<https://www.nationalgallery.org.uk/visiting/virtual-tours/sainsbury-wing-vr-tour>) where they could experience a virtual reality tour of the Sainsbury

Wing, immersing themselves in the National Gallery’s world-class collection of Early Renaissance paintings from 1200 to 1500. The objective of this virtual visit was for all participants to ‘explore’ the thematic of the paintings on display at the Sainsbury Wing and to step into the NG collection of Early Renaissance paintings for the purpose of the experiment. Participants browsed the 360 tour on their desktop screens for 15 minutes.

- *Step 4 - Main experiment:* after this exploration the participants engaged in a short 5 minutes virtual painting hunt game trying to locate the number of the room where one specific painting, *Tobias and the Angel* (Workshop of Andrea del Verrocchio, approx. 1435-1488) was on display. The painting was located in room 57 together with 10 more paintings. The objective of the virtual painting hunt game was for participants to familiarise with the Sainsbury Wing and in particular with the paintings of room 57, which also feature in the ‘Gallery Creation’ game that they would test later on. The purpose of virtually visiting the Sainsbury Wing was to evaluate how the additional experience influences reflection, relative to simply accessing digital content through the application.
- *Step 5 - Main experiment:* after completing the virtual visit available on the NG website, the participants then played freely the ‘Gallery Creation’ game for 20 minutes using either the installed application on the smartphones or the HTML web version.
- *Step 6 - Post experiment:* finally for the last 20 minutes the participants were asked to complete the post-experiment questionnaire giving us their feedback.

B. Data Collection and Evaluation Methodology

The post-experiment questionnaire was divided into four sections and asked participants about their: (1) basic demographic data (e.g. age group, gender, educational attainment, residential status and nationality), experience (e.g. command of the English language, involvement in and knowledge of Art, use of recommender systems), visiting preferences (e.g. frequency of museums visits, use of audio guides, objectives and motivations) and mobile habits (use of mobile apps, use of museum mobile apps); (2) general thoughts about the app (whether they recommend the app and why); (3) overall user experience, the ease of learning, features assessment and learning outcomes (see Table II) and (4) final thoughts.

Concerning reflection, we consider four constructs that stimulate and contribute to reflection processes in our pilots, including influences from our prior learning processes [17], our personal experiences [18], our emotional responses [19] to both the app and its content as well as our personal interpretation of the content based on a user’s world view [20]. Reflection involves linking a current personal experience to the acquisition of information and knowledge from new or existing learning and is driven by the process of combining cognitive and emotional information from different sources. It is a process that occurs when we act upon different information to synthesise and evaluate it. In order to understand more about

how and if the game stimulates reflection and to evaluate the reflection triggers, we have included a small set of questions, categorised according to Bloom’s taxonomy [21]; a short open question and to express their agreement or disagreement with the two statements using a 6-point Likert scale:

- Open Give us the title and the description for one of the Gallery’s you have created playing the Game [Indicator subcategory-Create Knowledge]
- Scalar The paintings in the collection pane (left) are all part of a coherent whole [Indicator subcategory-Evaluate/View points]
- Scalar The paintings in the collection pane (left) are diverse [Indicator subcategory-Evaluate/View points]

We aggregated results from the game app and web version experiments together, having 25 valid questionnaires in total. Of these, 6 respondents identified as male, 17 as female and 2 preferred not to say. All respondents were Greek nationals in the process of studying for an undergraduate degree, and most were aged between 18 to 24 (25% were aged 25 and above). For their mobile device habits, 88% had never downloaded a museum mobile app game before, although 64% of the respondents had previously downloaded game apps in general. 50% of the participants spend between 30 minutes to 1 hour on a typical day playing games on their mobile device while 25% of them did not play games at all.

In terms of museum and art preferences, 60% of the participants visit a museum rarely and the majority of them (88%) had never visited the National Gallery. Their motivations when visiting a museum are to ‘Learn new things’ and ‘Explore’ (52% and 60% of the respondents respectively). 44% of participants described their involvement in Art as ‘studying’ and 48% as ‘none’. One respondent identified as a specialist/expert in terms of describing their knowledge of Art; the majority of participants describe it as ‘General’ (56%) and ‘Little’ or ‘no Knowledge’ (36%).

C. Results

The aggregated results to the post-play questionnaire are summarised in Table II. The average response is given on a 1-6 scale (1 being lowest, 6 being highest), where Likert scales are used as a response type. Moreover, ‘strong disagree’ (1) and ‘disagree’ (2) ratings are shown as negative responses and ‘strong agree’ (6) and ‘agree’ (5) as positive responses. It should be noted that the questions have been slightly edited for readability (e.g. summarising the game’s title or inverting questions). Responses, especially to open-ended questions, are discussed further in the sections below.

1) *Overall user experience:* Throughout the game experiments the feedback from the participants was very positive, with low scores regarding unexpected app behavior or the app looking unfinished (see Table II) and high scores regarding the look and feel of the app. Moreover, the creation and description of new galleries (walls) was highly rated. Finally, the participants’ responses were slightly more mixed on whether the Game felt like visiting the venue with two thirds of them

TABLE II: Questions to participants (reformatted for readability), and their responses to questions on 6-scale Likert scales.

Question	Pos. / Neg.	Avg.
Learnability		
I was able to understand the different badges offered by the game	9 / 5	3.68
All the features worked in the way I expected.	15 / 0	4.72
It quickly learned to orientate and move the paintings on the wall	15 / 0	4.76
It was easy to learn how to use the Game.	20 / 1	5.16
The terminology used in the Game was easy to understand.	18 / 1	4.96
Completing my Gallery of paintings was quick	12 / 3	4.28
Creating my Gallery of paintings was easy	14 / 3	4.36
Positioning the paintings on the wall was obvious.	12 / 2	4.36
I was able to navigate through the Game	18 / 3	4.80
I was able to create my Gallery of paintings	16 / 3	4.52
I was able to save and edit my Gallery of paintings	18 / 3	4.88
I was able to unlock different badges	9 / 4	3.88
It was difficult to remember how to use the Game.	2 / 18	2.16
Overall User Experience		
Using the Game felt like visiting the venue.	10 / 5	3.96
I enjoyed using the Game	13 / 0	4.48
I liked the look and feel of the Game	13 / 1	4.60
The Game was behaving unexpectedly	1 / 13	2.52
Using the Game felt like schooling	9 / 4	3.85
The design of the Game looked unfinished	3 / 11	2.80
The look and feel of the Game was pleasant	16 / 3	4.60
I am satisfied with the variety of badges available to me	10 / 4	3.92
I enjoyed creating my Galleries	17 / 4	4.60
I enjoyed describing my Galleries and creating my own Groups	17 / 4	4.56
What did you like most about the Game and why?	Open	–
What did you dislike most about the Game and why?	Open	–
Reflection		
Give us the title and the description for one of the Galleries you have created playing the Game.	Open	–
The paintings in the collection pane (left) are all part of a coherent whole	10 / 4	3.92
The paintings in the collection pane (left) are diverse	2 / 5	3.39
Value		
I will use this app during my next visit	7 / 5	3.76
Would you recommend the Game to a friend?	Open	–
Using one sentence how would you describe the Game to a friend?	Open	–
What other game features would you like to have available for this Game?	Open	–

supporting the statement positively; on the other hand, a third of testers stated that playing the game felt like schooling.

When asked what they liked most about the game, responses ranged from the availability of the high resolution images (p1, 2, 6, 7, 12) to the game’s purpose (p25: “that i could make my own gallery”, p4: “I liked that a game involves art and personal interaction”, p22: “that you have to make your gallery in a uniform way”, p23: “I liked the fact that it demands organised thinking”). One of the respondents found the game boring. Respondents disliked the lack of more paintings (p11), lack of metadata about the paintings (p22, 19, 17, 9), little variety on the subject of most of the paintings (p7) and lack of more space to work with the paintings (p23, 21, 20). 25% of testers answered that they disliked “nothing” and two testers stated that the game was not close to their interests (p15, 16).

2) *Learnability*: The overall experience in learning to use the app was positive. Participants seemed to agree with most

learnability questions, apart from one on difficulties in remembering how to use the game (which was understandably juxtaposed by high agreement with the statement “it was easy to learn how to use the game”). A statement where most responses were either slight agreements/disagreements (3-4 on the Likert scale) was regarding how easy it was for users to unlock different badges. Indeed, in this version of the game the few badges available were either trivially attainable (e.g. all paintings belonging to the same category if the users used the category lists in a clever way) or very difficult to get due to the plethora of categories (e.g. all categories represented).

3) *Reflection*: In terms of the three questions pertaining to reflection, results were mixed. On the one hand, many participants agreed that the paintings felt like “part of a coherent whole”; this is not surprising, since the paintings were all curated to be part of the same room (room 57 of the Sainsbury wing) due to similar themes (religious art, primarily) and style. On the other hand, most participants did not have strong feelings either for or against the diversity of the paintings in the collection, with 36% slightly agreeing with the statement “The paintings in the collection pane (left) are diverse”; only one participant strongly disagreed with this statement, and no participants strongly agreed. In terms of the titles and descriptions, the results are insightful. Unsurprisingly, 44% of participants did not give titles or could not remember them, or were mock titles such as “HD gallery” (p15). However, 20% of participants gave titles relating to religion (and Christianity in particular) such as “Gender and Christianity” (p4), 8% relating to life/death, and 12% relating to both with titles such as “reBirth - religion” (p15) and “Born to Die: Living, teaching Christianity, dying. The hard living of Jesus” (p6). Finally, 2 participants gave titles related to animals, and one participant simply gave the title “ART”.

4) *Usefulness and perceived value*: The value and the positive perceptions of the application was recognised by the participants, as nine of them stated that they would recommend the game to their friends and had fairly high agreement with the statement “I will use this app during my next visit”. The attitudes of the participants towards the application indicated its creativity (p6, 7, 13), its interesting features (8 out of 25 respondents) although it can be quite content-specific at the same time (p20: “Rather interesting if you are into museums”, p21: “Very creative but really boring”) and its “educative and entertaining” characteristics (p5). When asked why they might recommend the game to a friend, participants gave a variety of answers ranging from “interesting” (p1, 2, 3) to the opportunity to “develop the ability to create” (p7), but mostly “because it was fun” (p11, 21, 23, 8), “exciting” (p13) and because “it’s fun to try making your own gallery” (p25).

VI. DISCUSSION

Our preliminary user study with 25 participants demonstrated that the virtual “Gallery Creation” game is both stable and usable, and prompted some form of reflection. Notably, users had no problem interacting with the tool, understanding how to use all its features, although some ‘gamification’

additions (such as badges) were harder to grasp. Users had mixed feelings about the perceived usefulness of the game, since they were almost equally likely to use it as to not use it in a next visit to the National Gallery; moreover, several users considered the interaction boring as there was no explicit motivation to create new walls. Reflections of users showed that they were able to identify that paintings in room 57 were part of the same whole (unsurprisingly, since they originate from the same curated NG room) but did not have strong feelings regarding their diverse nature.

While this preliminary user study was vital in helping identify the state of the game’s design and implementation, it is important to note a number of limitations. An important limitation was the fact that the study took place in Athens, far from the site of the National Gallery of London. While extensive care was taken to introduce participants to the NG collection (through the virtual tour and a painting hunt game, i.e. steps 3 and 4 of the Main Experiment), it is clear that the users’ experience would not be the same if the test took place within the Sainsbury wing of the NG building. The small, homogeneous sample (all participants were Greek students, most were aged 18-25) also limits the generality of the conclusions drawn from this user study. Finally, this paper focused solely on questionnaire responses while other important insights may be gleaned from parsing the interaction logs or analysing the virtual walls created by the participants.

Despite these limitations, some of the most promising and generalizable results pertain to the functionality and ease-of-use of the game application. Future developments in the game app will attempt to improve responsiveness, variety in the paintings included in the game, and improve engagement to address some of users’ comments regarding a “boring” experience. Future user studies will also be performed within the National Gallery and compared with this paper’s and future user studies made off-site. Since the game app is only a small component in a larger app ecosystem within CrossCult (including apps specific to a NG visit), future user studies will test the game in conjunction with other apps. Tests with expert users (such as NG curators) are planned as well to assess the usefulness of the app as a tool for monitoring changes in paintings’ positions in the National Gallery; we expect that curators will have different concerns or expectations in terms of an “engaging” experience. Finally, we intend to perform a deeper analysis on the question of reflection as well as an in-depth analysis of the virtual walls (and their titles) created during this and future user studies.

VII. CONCLUSION

This paper introduced a game for constructing gallery rooms in a virtual space (currently allowing re-arrangement of paintings on a single wall), which can also be used by experts to record the movement of paintings in the National Gallery of London. The game design was geared towards an easy-to-use, simple interaction paradigm where paintings are moved from an abstract collection onto a virtual wall and vice versa; personal touches were allowed through the addition of a title

and description, while gamification elements were introduced in the form of badges as extrinsic rewards. A user study held off-site showed that the game prototype was indeed easy to use and stable, while future work will test how the same or newer iterations of the game will prompt reflection and personalized gallery rooms when played in the National Gallery or off-site.

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REFERENCES

- [1] Entertainment Software Association, “Essential facts about the computer and video game industry report,” http://www.theesa.com/wp-content/uploads/2018/05/EF2018_FINAL.pdf, 2018, accessed: 20 August 2018.
- [2] N. W. John, S. R. Pop, T. W. Day, P. D. Ritsos, and C. J. Headland, “The implementation and validation of a virtual environment for training powered wheelchair manoeuvres,” *IEEE Transactions on Visualization and Computer Graphics*, vol. 24, no. 5, pp. 1867–1878, 2018.
- [3] G. Zichermann and J. Linder, *Game-Based Marketing: Inspire Customer Loyalty Through Rewards, Challenges, and Contests*. John Wiley & Sons, 2010.
- [4] C. Holmgård, G. N. Yannakakis, and R. Khaled, “The games for health prototype,” in *Proceedings of the 8th Conference on the Foundations of Digital Games*, 2013.
- [5] A. Rizzo, J. G. Buckwalter, E. Forbell, C. Reist, J. Difede, B. O. Rothbaum, B. Lange, S. Koenig, and T. Talbot, “Virtual Reality Applications to Address the Wounds of War,” *Psychiatric Annals*, vol. 43, no. 3, pp. 123–138, 2013.
- [6] A. Liapis, A. K. Hoover, G. N. Yannakakis, C. Alexopoulos, and E. V. Dimaraki, “Motivating visual interpretations in iconoscope: Designing a game for fostering creativity,” in *Proceedings of the 10th Conference on the Foundations of Digital Games*, 2015.
- [7] S. Deterding, D. Dixon, R. Khaled, and L. Nacke, “From game design elements to gamefulness: Defining “gamification,”” in *Proceedings of the International Academic MindTrek Conference*. ACM, 2011.
- [8] J. Hamari and J. Koivisto, “Measuring flow in gamification: Dispositional Flow Scale-2,” *Journal of Computers in Human Behavior*, volume=40, pages=133–143, 2014.
- [9] S. Nicholson, “A user-centered theoretical framework for meaningful gamification,” in *Games+Learning+Society 8.0*, 2012.
- [10] T. M. Amabile, “How to kill creativity,” *Harvard Business Review*, vol. 76, no. 5, p. 7687, 1998.
- [11] A. Liapis, G. N. Yannakakis, and J. Togelius, “Computational game creativity,” in *Proceedings of the Fifth International Conference on Computational Creativity*, 2014.
- [12] M. Sicart, “Loops and metagames: Understanding game design structures,” in *Proceedings of the 10th Conference on the Foundations of Digital Games*, 2015.
- [13] A. Rollings and E. Adams, *Andrew Rollings and Ernest Adams on Game Design*. New Riders, 2003.
- [14] J. Momoda, “The importance of core game loops - part 1 of 2,” <http://jerrymomoda.com/the-core-loop-key-to-an-engaging-game/>, 2013, accessed 20 August 2018.
- [15] M. Sicart, “Defining game mechanics,” *Game Studies*, vol. 8, 2008.
- [16] T. Fullerton, *Game Design Workshop: A Playcentric Approach to Creating Innovative Games*. CRC Press, 2008.
- [17] S. Tobias, “Interest, prior knowledge, and learning,” *Review of Educational Research*, vol. 64, no. 1, pp. 37–54, 1994.
- [18] D. Boud, R. Cohen, and D. Walker, *Using experience for learning*. McGraw-Hill Education, 1993.
- [19] A. Antoniou, J. O’Brien, T. Bardon, A. Barnes, and D. Virk, “Micro-augmentations: situated calibration of a novel non-tactile, peripheral museum technology,” in *Proceedings of the 19th Panhellenic Conference on Informatics*. ACM, 2015.
- [20] Y. B. Kafai and M. Resnick, *Constructionism in Practice: Designing, Thinking, and Learning in A Digital World*. Routledge, 1996.
- [21] L. W. Anderson, B. S. Bloom, and D. R. Krathwohl, *A taxonomy for learning, teaching, and assessing*. Longman, 2000.