VIRTUAL ENVIRONMENTS: COMPLEMENTARY, EDUCATIONAL TOOLS IN THE MUSEUM INDUSTRY

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Abstract. *By preserving and displaying cultural and historical heritage, the museum is an important educational asset for primary school pupils. Alas, rapid changes in technology has changed visitor behaviour, demanding active participation and interactive attractions. Museums all over the world are developing new strategies to create innovative, technological exhibitions. It is unclear what academic impact the traditional museum and these new communicative methods have on a younger audience.*
Through prototyping and usability testing we have investigated whether a virtual environment can affect children's understanding of historical artifacts, and if this approach has a positive effect on the overall user experience. Through the methods 3D scanning, reconstruction and modelling, the traditional museum exhibition is merged with core elements from gamification, creating a new communicative method where children are active participants in their own learning process.

1. INTRODUCTION

Multimedia has changed how people perceive and interpret their surrounding environment. This has affected the museum industry, where we over the past 60 years have seen a change in visitor behaviour (Bradburne, 2001). Where the traditional museum had a steady stream of visitors, rapid changes in technology and the impact it had on society altered the way people expected to experience different attractions. Where the traditional museum based its exhibition on interpretation through observation, rising technology demanded flexibility and interactivity. Visitors no longer viewed themselves as static observers, rather it became important to participate - the visitor had become an active user of the attractions. This called for a development of dynamic interactions where the user became a functional part of the museum exhibition. Interactive objects worked as complementary tools for interpreting the attraction, whether it be art, architecture or historical artifacts. Museums all over the world are now developing strategies to create new, innovative exhibitions. At the core lies concepts like the Internet of Things (IoT), makerspaces and gamification. Gamification describes an application that uses game design elements in a non-game context (Deterding, Dixon, Khaled, & Nacke, 2011). Within the field of human-computer interactions (HCI), gamification focuses on engagement and the improvement of user experience. This technology creates new ways of communicating historical events and objects, thus giving museums the opportunity to work as a bridge between education and entertainment.

Within the field of gamification, education and learning, a concept worth exploring is virtual environments where physical objects are reconstructed and visualized in a three-dimensional space. Not to be confused with virtual reality, a virtual environment uses a computer monitor, displaying a three-dimensional scene where the user can explore and interact with virtual elements. By capturing and reconstructing real, historical artifacts the visitors can get enhanced insights in culture, tradition and craftsmanship. Most museum objects are too fragile and valuable for active exploration. Also, a better part of the archaeological

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artifacts are fragmented or in some way damaged due to time and weathering. By using techniques like 3D-scanning and 3D-modelling we can reconstruct and conserve historical objects. The technology allows the audience to look at the artifacts in the physical world, and then explore the virtual model of the same object.

2. RESEARCH QUESTION

In accordance to The cultural rucksack, an initiative where pupils are to experience and gain knowledge of cultural heritage, all pupils are to visit local museums during their fourth year in primary school. In the light of this, we ask the following research questions:

1. Can virtualization technology amplify children's knowledge about historical artifacts?
2. Can virtual environments function as a new channel of communication for primary school pupils, mediating local history in the museum?

This paper will present an approach on how 3D visualization of historical objects can be implemented as an interactive exhibition at the museum Borgarssysel in Sarpsborg. We will explore the process behind virtual reconstruction and visualization of physical objects using the technology behind Sense 3D scanner, Autodesk Maya and Unity. The main goal is to discover whether a virtual exhibition can work as a complementary tool for the pupils participating in The cultural rucksack, and if this experience yields greater knowledge about medieval artifacts. This is acquired through a literature study of similar projects, quantitative and qualitative studies, and usability testing. A prototype will be developed to accurately measure the gain and user comprehension of the system.

3. RELATED WORKS

The impact a virtual, communicating environment has on a specific audience is still under investigation. Similar systems have previously been used in video games, simulation or training of personnel working in safety critical sectors, like the mining industry or healthcare (Hodgetts, 2013; Thompson, et al., 2010). Further research is needed to uncover the benefits, goals and requirements of this technology when used as a communicational and educational tool in the museum industry. Studies performed using virtual reality systems and digital reconstructions of historical artifacts has found that the method improved engagement, perception and knowledge of the artifacts (Di Franco, Camporesi, Galeazzi, & Kallmann, 2015). Therefore, Franco et al. (2015) considers the value of these technologies relevant and important when perceiving our past. Digital, virtual tools cannot reproduce or replace the perception that the visitors would have when manipulating physical objects, but the existing technologies produce excitement and engagement, it encourages curiosity and a desire for knowledge about past material culture (Di Franco et al., 2015, p. 260).

Kiourt et al. (2017) considers gamification and virtual scenes an effective approach when wanting to blend domain specific activities like education and cultural heritage (Kiourt, Pavlidis, Koutsoudis, & Kalles, 2017). In their paper about realistic simulations of cultural heritage, they investigate the technological requirements and design elements necessary for a realistic immersion. Even though they don't provide any research evidence on how a realistic environment will effect a target audience, they suggest that the level of user participation will enforce concentration in the activity at hand and at the same time encourage the user's self-improvement.

Mortara et al. (2014) suggests that the usage of such an environment motivates visitors to generate their own knowledge rather than passively receive the information (Mortara, et al., 2014). In their study of serious games, Mortara et al. explored how virtual exhibitions with element from the gaming industry (e.g. task-specific activities) could engage the large public into being active contributors to their own cultural knowledge. Digitally reconstruction of past events and artifacts can deliver knowledge and enrich the user experience by adding historically correct details. Since most museum objects are valuable, fragile and must be kept behind display cases, much information about the artifacts are lost. A virtual environment where the visitors can indulge in active exploration of the scenery and the historical objects, creates the possibility to grasp the objects' material and sensorially perceptible characteristic (Dudley, 2010). Dudley argues that the presentation and interpretation of objects are rendered incomplete and useless without a provision of associated information around the objects. A virtual environment will generate contextual data around each individual object, thus supporting and extending the knowledge obtained about said object.

In the light of cultural learning in virtual environments, a study performed by Ibrahim, Mohamad and Faezah (2015) investigated virtual heritage in the form of virtual environments displaying historical architecture (Ibrahim, Mohamad , & Faezah, 2015). The main goal was to identify design features and requirements needed to mediate efficient information for cultural learning, like navigation, graphic quality and user's freedom and control.

Based on the findings in this literature study, there is a general agreement that immersive, virtual experiences create the opportunity for first person exploration of remote historical sites and situations. This supports the audience to become active participants in their own learning. However, findings during this literature study are concerned with the technical difficulties with developing and implementing virtual environments (Komianos, Kavvadia, & Oikonomou, 2014; Ibrahim, Mohamad , & Faezah, 2015; Kiourt, Pavlidis, Koutsoudis, & Kalles, 2017), virtual museums and tourism (Sylaiou, et al., 2017), virtual reality, serious games, and their impact on the *larger public*. It is not to our knowledge sufficient research related to educational simulations for raising heritage awareness with children and how this technology influences learning effectiveness with primary school pupils. Further research is needed on whether virtual environments could be implemented into the history curriculum, like with The cultural rucksack program, where museum exhibitions mediate local cultural heritage.

4. METHOD

Subsection [3.1] describes the requirements needed to build a complete prototype for later user testing. This includes the process of creating a three-dimensional model and the scanning and reconstruction of historical artifacts. Next, we investigate the engine in which the result from the first two methods are merged in to a virtual environment. At this point we will have a functional prototype which is used to test the reaction and learning effect of the virtual environment on the target group. This is further described in subsection [3.2].

3.1 Technical implementation

High-fidelity, interactive environments based on real places and objects will enhance the users sense of realism, presence and overall experience (Dalgarno & Lee, 2010; Kiourt, Pavlidis, Koutsoudis, & Kalles, 2017). For the model to be as authentic as possible it was verified by museum conservator Lindermo at Borgarsyssel Museum during the entire process. The museum provided historically correct drawings to be used as references, which illustrated medieval households, towns and interior. Information about architecture and interior was further obtained studying Scandinavian vernacular architecture (Grindkåsa, 2007), and through correspondence with communication manager Hasle at Mjøsmuseet in Gjøvik. Using these references about medieval architecture and interior we create an authentic household. The 3D model was built in Autodesk Maya, and later imported in the game development software Unity.

For the purpose of digitally displaying historical artifacts within the virtual environment we use a noncontact 3D laser scanner. 3D scanning is the process of digitally capturing and transferring the characteristics of a physical object into a computer program. Considered a cheap and capable source of 3D data (Remondino, 2011), the scanner emits a laser beam which generates a point map based on the surface information of the target object. For this project we have used the Sense 3D Scanner made by 3D Systems Inc, which is a low cost, commercially available scanner. The device is small and portable, which was important as the objects were scanned in the museum facility; transferring fragile, historical objects to a remote scanning facility was not an option. The following table 1 and figure 2 is a list of the historical objects chosen for scanning.

Object	**Function**	**Scanning level**
1. Plumb line	A small, heavy object used when weaving	Easy
2. Spindle whorl	A small, heavy ring maintaining rotation	Easy
3. Button mold	Used to mold buttons	Medium
4. Kole	Medieval oil lamp	Easy
5. Comb	Used for untangling hair and prevent lice	Hard
6. Ax head	Chopping wood	Hard
7. Whetstone	Used for sharpening tools	Easy

Table 1: Historical objects chosen for scanning.

Figure 1: Objects for scanning.

Figure 2: Reconstructed scanning of ax head.

As with the 3D model, the digitally reconstructed objects were imported into Unity game engine. This is where we create the virtual experience where the user functions as a dynamic element of a 3D environment. Unity is a low cost, cross-platform engine and a popular platform for the development of Indie games, applications and simulations. Using nVidia PhysX engine and an implementation of Microsoft's open source .NET library, Mono (De Luca, Meo, Mongelli, Vecchino, & De Paolis, 2016; Craighead, Burke, & Murphy, 2008), Unity is a diverse developer tool previously used in studies like urban design, healthcare application and as a science tool within primary education (Indraprastha & Shinozaki, 2009; Kumar, Hedrick, Wiacek, & Messner, 2011; Christel, et al., 2012). It was in Unity that we assembled the 3D models, 3D scanned reconstructions and implemented rules for user interaction, merging the different components to a virtual simulation of a medieval household.

Figure 3: Virtual scene.

Figure 4: Virtual scene.

The scene was now an operational prototype ready for usability testing. The players were able to move around and explore the interior of the medieval house. The 3D reconstructed objects are placed at multiple locations within the scene; at the worktable, beside and on the chest, in the entry hall and by the fireplace.

3.2 User testing

Testing the prototype on a target audience would uncover if the virtual exhibition could work as a complementary tool, and whether it could be used to support said audience to gain greater knowledge about medieval artifacts. This was accomplished by several tests where the participants were to explore the physical museum and the virtual prototype.

3.2.1 Data gathering

We will approach the gathering and analysis of data using the principals of Kirkpatrick's Four Levels of Evaluation; reaction, learning, behaviour and result (Kirkpatrick, 1975). The model was originally developed for evaluating the effectiveness of training programs. Capturing how participants feel and react to new technological systems is important when wanting to understand 1) how the system is received by users, and 2) the user experience of the application. By measuring the learning effect, we gained insight in whether the virtual environment affected the participants knowledge about the historical artifacts. Analysing behaviour pointed to how participants used the new information they were given. In this test, behaviour was measured by analysing how well participants could describe historical objects after encountering them inside the virtual environment. The fourth level, results, measured the final outcome of the user tests.

The test group were divided in two, where one group was confined to the traditional exhibition, and the other performed the test using both the traditional and the virtual model. When gathering data, we use the methods direct observation, focus group, questionnaire and assignment.

Direct observation of the participants was used to investigate how well the traditional exhibition and the virtual environment supported the user's tasks and goals (Sharp, Rogers, & Preece, 2011). We registrated how the participants reacted to the textual information from both the physical display cases and the assignment paper. It was interesting to see how they used the virtual model, if the interactions were systematic or explorational, and how they identified the objects from the assignment paper.

After the test, the participants took part in a focus group, with both open and closed questions. A focus group is a form of group interview or discussion which raises diverse issues and conflicts that otherwise could be missed (Sharp et al., 2011). The focus group allowed us to gather qualitative data from the tests, and the participants expressed their opinions about the user experience. The tests and focus groups are video recorded and transcribed for further analysis.

Questionnaires gathered quantitative information about the user experience, and were filled out by the participants after the test was finished. Two different types of questionnaires was created; one for the participants exploring the physical museum exhibition and one for the group that used both the physical exhibition and virtual prototype. The questions were created to reflect one another so that they could be compared in later analysis. The survey consisted of three different scales; agreement, frequency and dichotomous scale. The first, also called Likert scale, was used to measure engagement, enjoyment, knowledge and understanding. The second and third gathered background information. The questions were based on Othmans example questionnaires (Othman, 2012). Where the questionnaires measured the participants subjective interpretation of the user experience and the educational value of the exhibition, the assignment was made to measure the direct, objective learning effect.

3.2.2 Participants

The tests were carried out using 45 fourth grade pupils from local primary schools with various backgrounds, ethnicity and with an equal gender distribution. Each participant was informed of anonymity.

The participants were a part of The cultural rucksack and the teacher confirmed that pictures and video recordings of the tests and focus groups for further analysis were permitted.

3.2.3 Location and equipment

The tests were conducted in a controlled environment, at the facility Olavs Hall in Borgarsyssel Museums, Sarpsborg. Here the exhibition "Tusen rike år" ("A thousand rich years") contains the historical artifacts that were used for the 3D scanning. The working prototype was imported onto six computers stationed in the computer lab inside the Hall. The stationary computers had a 2.7 GHz Intel Core i5-6400 processor, 8 GB RAM, 120 GB SSD, and a GeForce GTX 960 graphic card. They were running on Windows 10, and equipped with 24" HP EliteDisplay screens and Logitech MK520 keyboards and mice.

3.2.4 Experiments

Three individual tests were performed; an unofficial pilot test, a test of the traditional exhibition and one using both the traditional exhibition and the virtual model. The pilot test provided useful insight which was used as guidelines for later tests. The 45 participants were divided into two groups; group 1 and 2. Testing in a group simulated a realistic situation true to The cultural rucksack program. Group 1, consisting of 22 participants, was restrained to the physical museum space, exploring the historical artifacts within the display cases. This resembled the traditional museum experience. Group 2, consisting of 23 participants, was first exploring the physical exhibition after which they engaged in open exploration of the virtual model.

Before each test, the participants were given an overview about the content and purpose of the test they were about to perform. Each test lasted for 30 minutes. During the first 15 minutes, the participants were to explore the exhibition or/and the virtual model. They were given an assignment where they were to explain the function of certain objects, see table 2. These objects were presented in the physical exhibition behind display cases and as 3D scanned reconstructions within the virtual environment.

Object	**Difficulty level**
Comb	Easy
Kole	Hard
Plumb line and spindle whorl	Hard
Ax head and whetstone	Medium

Table 2: Assignment objects.

Group 1 was confined to the display cases and textual information about each object when answering the questions. Group 2 was given seven minutes to explore the exhibition with textual information, and then eight minutes to find the same objects within the virtual environment. In the last 15 minutes, the participants were to fill out the questionnaires. The age group made it necessary to explain each question. Therefore, the questions were read out loud by the test facilitator. After, the participants partook in the focus groups where they got to answer, discuss and reflect the user experience of the traditional and virtual exhibition.

For the purpose of accurately comparing the results from group 1 and 2, the tests resembled one another. This uncovered the reaction, learning effect and the distinctions of the different communication environments.

5. RESULTS

In this section, we summarize the test results using data from the observations, focus groups, questionnaires and assignments. The data from the observations and focus groups were gathered during the tests and video transcriptions. The data from the questionnaires created two different dataset, one for each test group, which we classified into two categories; reaction and learning. This way we could compare the results from the traditional exhibition and the exhibition where the virtual environment worked as a complementary tool.

4.1 Observation

Test observations revealed that the participants were more likely to seek the objects that were easy to visually identify, like the comb and ax head. The fact that these objects were located faster does not seem to affect the participants ability to use the information text when trying to explain the different objects. Few of the participants read the text before filling out the assignment paper. Instead they asked the test facilitator for answers. When the facilitator refused to answer questions related to the objects some participants expressed frustration and even resentment. Many participants found it difficult to understand the assignment text, but were still able to infer the functions of the objects. Of the assigned objects, the kole was the hardest to locate. The few participants that found the artifact in the traditional exhibition were not able to perceive its exact function. Some of the participants from group 2 expressed greater understanding when they encountered the same object within the virtual environment. Participants using the virtual environment engaged in open exploration of the medieval household, during which they encountered the objects at random instead of finding the assigned objects in a specific sequence. Unlike group 1, they expressed curiosity about the historical artifacts, architecture and historical interior. Four out of 23 participants expressed difficulties when using the virtual environment. Being unfamiliar with keyboard and mouse interactions, two of these participants required verbal instructions. The last two of these four had not yet read the assignment paper and asked for assistance. The participants using the virtual model were more eager to complete the assignment than the group confined to the traditional exhibition.

4.1 Focus group

The participants in group 1 expressed a variety of opinions about the test, stating that the traditional exhibition yielded an adequate experience and that the information text was difficult to understand. Within group 2 there was a general agreement that the traditional and virtual exhibition was an enjoyable but challenging experience.

4.3 Questionnaire

To accurately comparing the results, the first eleven questions in the questionnaires were similar. The second one also contained five extra questions, inquiring about the virtual environment. The following results were analysed by separating the queries about reaction (table 3) from the queries about learning (table 5). The questions presented in table 3 measured the participants reaction of the traditional and virtual exhibition. The purpose was to gather data about engagement, enjoyment, involvement and motivation.

Question	Measuring
1. I felt engagement with the exhibition.	Direct engagement.
2. I enjoyed the exhibition.	Enjoyment and inspiration.
3. I feel that the exhibition was something I experienced, rather than something I was just visiting.	Involvement.
4. It was easy to navigate through the exhibition/virtual scene.	Action and behaviour.
5. I felt motivated when exploring the exhibition.	Motivation
6. I like to move around freely when exploring the exhibition.	Action and behaviour.
7. I would like to use this type of exhibition again.	Overall reaction.
8. I would like to know more about history after being here.	Involvement and motivation.

Table 3: Questions for measuring reaction.

To effectively interpret and present the results we found the mean value of each question. This was achieved by assigning a point scale, ranging from 1 to 5, to the agreement scale in the questionnaires. Point 1 represented 'strongly disagree', 2 'disagree', 3 'neutral', 4 'agree' and 5 'strongly agree'. The number of answers within each category was multiplied by the category point. The total value was then divided by the number of participants within each group. This way we could compare the average result from each question across the two groups. As seen in table 4, group 1 had an average of 4.09 in question 2. This is higher than the second groups' 3.17, indicating that there was a higher level of agreement from the participants in group 1 than in group 2.

Question	Group 1	Group 2
1.	3.91	3.83
2.	4.09	3.17
3.	4.18	4.44
4.	4.23	4.13
5.	4.27	4.57
6.	4.46	4.52
7.	3.59	4.52
8.	4.59	4.57

Table 4: Reaction. Average answer from group 1 and 2.

The questions in table 5 investigated the learning experience of the tests. These measured overall knowledge, understanding and efficiency. We used the same method to find the mean value of each question (see table 6).

Question	Measuring
1. I feel that the objects in the display cases extended my knowledge about historical artifacts.	Knowledge and understanding
2. The textual information about each artefact was clear and understandable.	Understanding and efficiency
3. I have learned something new.	Knowledge and understanding.

Table 5: Questions for measuring learning.

Question	Group 1	Group 2
1.	4.05	3.39
2.	3.64	3.57
3.	4.59	4.56

Table 6: Learning. Average answer from group 1 and 2.

Investigating the results, we saw that there was a consistency in the answers given by the second group. There was a lower agreement level in question 2 (table 3) and question 1 (tabel 5), the former inquiring about the level of enjoyment when using the traditional exhibition, and the latter the knowledge gained from observing the objects within their display cases. Comparing the results for question 1 (table 5) shows that group 2 found the objects within the display cases less educational than group 1. The following tables 7 and 8 presents questions and results unique for group 2. These investigated the direct reaction and learning of the virtual environment.

Question	Measuring	Average
1. It was easy using the virtual environment.	Reaction and efficiency	4.26
2. I prefer the virtual exhibition over the traditional exhibition.	Direct reaction	3.74
3. I found the information about the virtual environment adequate to perform the actions I wanted.	Reaction, efficiency and and behaviour.	4.26

Table 7: Questions for measuring reaction for group 2.

Question	Measuring	Average
1. I feel that the virtual environment has extended my knowledge about historical artifacts.	Knowledge and understanding.	4
2. I learned more about the objects when experiencing them in the virtual environment than in the traditional museum.	Knowledge and understanding.	4.23

Table 8: Questions for measuring learning for group 2.

A variation of 3.74 and 4.26 on the results unique for group 2 indicated a high level of agreement. Figure 4 compares the agreement levels within the second questions from tables 7 (reaction) and 8 (learning). We saw that while most participants remained neutral when asked if they preferred the virtual to the traditional exhibition, more strongly agreed that the digital environment resulted in greater knowledge about the assigned objects.

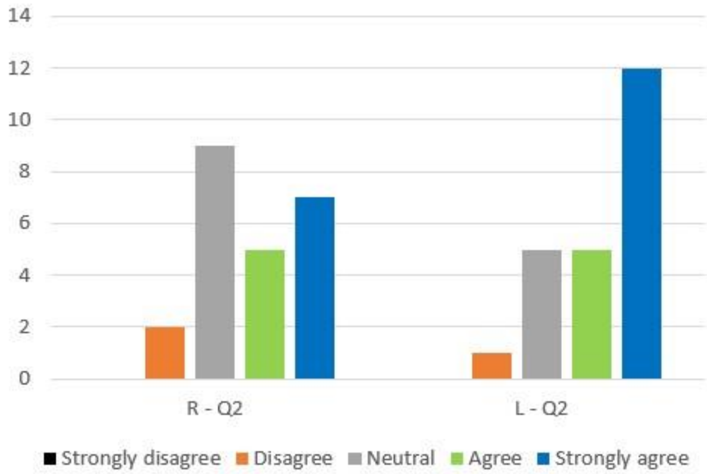

Figure 5: Left: Question 2, measuring reaction. Right: Question 2, measuring learning.

4.3 Assignment

The assignments from group 1 and 2 measured the direct learning effect from the tests, and yielded valuable information about the participants perception of each object. When interpreting the results, each answer was assigned a point ranging from 0 to 3. 0p represented wrong or a lack of answer. 3p were given if the answer reflected the information text in the traditional exhibition and/or the context in the virtual model.

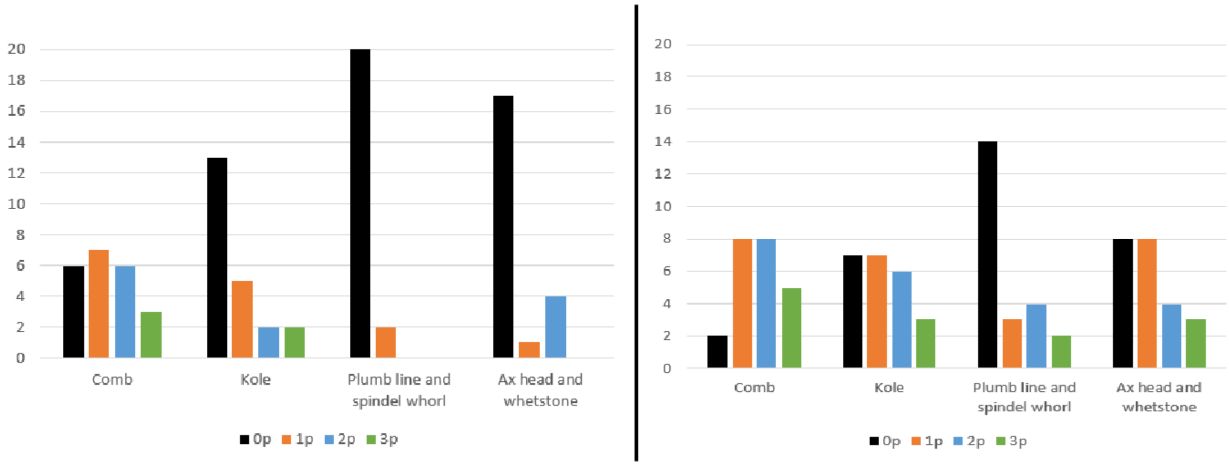

Figure 6: Results from traditional assignment (left) and virtual assignment (right).

The assignment results are presented in figure 5. When using the virtual model in addition to the traditional exhibition the number of 0p decreased and we saw a more even distribution of answers yielding 1p or higher. This corresponded to the findings in table 8 and figure 4; the tests conducted using the virtual model yielded a high average.

6. DISCUSSION

The results expose a difference in children's ability to perceive contextual, textual and visual information. Test observations makes it clear that the participants have little or no interest of reading a long, descriptive text made primarily for a mature audience. This is also seen in the assignment results, where few users could elaborate the functions of the objects. However, interpreting the results from the second question from table 6, many participants agreed or strongly agreed that the information text about each object were clear and understandable. For this result to be accurate, there must be a distinction between what the pupils perceive as visually perspicuous and their ability to interpret the content of the information text; the graphical representation of the information text holds more value than the actual message.

The same table 6 also reveals that the participants in group 2 found the objects within the display cases less educational than group 1. Studying the individual instances shows that while only one participant in group 1 disagreed, six participants in group 2 found the traditional exhibition inadequate as an educational tool. It seems that the virtual model affects the decision making within group 2, decreasing the agreement level.

With an average agreement value of 4.23, participants in group 2 found that they learned more about the objects within the virtual environment than the traditional exhibition. Dudley argues that our ability to perceive an object is affected by associated and contextual data (Dudley, 2010). This becomes clear when comparing the answers from the assignment papers. The participants who got to experience the historical object within its natural setting e.g. the virtual environment, could give a more correct description of the object. During the exploration of the virtual environment the participants discovered the objects at random, instead of finding the assigned artifacts in a specific sequence. This indicates that they recognized the objects from the traditional exhibition. Studying the results from the questionnaires, 17/23 participants found the 3D scanned objects within the 3D-environment to have a higher educational value than the objects inside the display cases. Supporting Dudley's argument, the virtual environment created contextual and associated data, positively affecting the understanding of the participants.

Di Franco et al. (2015) states that an immersive, virtual reality system creates curiosity, engagement and a desire for knowledge. This is transferable to our virtual environment, were the observed level of motivation and engagement increases as participants uses the virtual environment. The results from the questionnaires shows that the engagement level within group 2 lies at an average of 4.44, while group 1 lies at 4.18, supporting the findings of Di Franco et al. When asked whether they would like to use this kind of exhibition again, the average agreement increased from 3.59 (group 1) to 4.52 (group 2), indicating that the virtual environment have a higher impact on the user experience than the traditional exhibition. By blending domain specific activities like education and cultural heritage, with the technology behind computer games and simulations, the pupils experienced their local history through a familiar medium.

For future studies and development, various aspects need to be taken into consideration. Findings in this study reveals that a virtual environment triggers the participants curiosity and engagement, enhances user experience and the knowledge about historical artifacts. It also confirms that the information text alongside the display cases are too mature for a young audience. One solution is to implement a descriptive text suitable for primary school pupils to each object within the virtual environment. This could be solved by using the GUI component in the Unity engine.

Further enhancing the level of interaction and user control within the scene could contribute to enrich the user experience and learning effect. As it is, the user explores the virtual environment but is confined to basic movements. By implementing code that makes it possible to pick up, rotate and zoom in on the scanned objects, the user becomes an even more active contributor to the learning process.

7. CONCLUSION

In this paper, we demonstrate how technologies like 3D modelling and 3D scanning can create a virtual environment true to historical architecture and interior. It is especially interesting how this environment can work as a complementary, educational tool in a real museum setting, and whether it amplifies the knowledge of the children attending The cultural rucksack program.

To obtain information concerning this area, a virtual prototype was created using the 3D modelling program Autodesk Maya, the System 3D Scanner and Unity Game Engine. The virtual environment was tested using participants from The cultural ruck sack. Through direct observation, focus groups, questionnaires and assignments we measured and compared user reactions and the learning effect. This was done by dividing the user group, where one group was confined to the traditional museum exhibition and the other used the traditional exhibition and the virtual prototype.

The results reveal that the traditional museum is too mature for a primary school audience. Being a passive observer, confined to the information texts and the objects within the display cases, has little effect on the children's ability to perceive the function of an object. When introduced to the same object within a virtual environment, the participants showed greater understanding. Active exploration of a medieval household generated contextual data for each object, increasing the educational value of the museum experience. The virtual environment also triggered the participants motivation and engagement, indicating that it has a higher impact level on the user experience than the traditional exhibition.

That being said, we do not suggest that the virtual environment should, or could, replace the traditional exhibition. We propose a combination of the two, merging the museum experiences with new communicative methods. 3D scanning, 3D modelling and gamification have proved capable tools when reaching a younger audience, making the participants from The cultural rucksack active participants of their own learning process.

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