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Abstract:

Mubil, is a 3D laboratory established in 2012 by the University Library of the Norwegian University of Science and Technology in Trondheim (NTNU UB) in collaboration with the Percro lab of the University of Santa Anna in Pisa. The project focused first at the development of a consistent methodology for the use of Virtual Environments as a metaphor to present manuscripts and books. Then the project team developed a 3D game with context from the particular books and invited school classes to test it. Two school classes participated in our workshops and interacted with the 3D products in our 3D lab. The activity was organized as a field trip in collaboration with the subject teachers. The students worked in groups and they were observed, filmed and answered survey questions. A focus group was selected and interviewed. The present study has been using qualitative analysis to examine the user behavior and performance in such an environment. We present here the applications and some preliminary results of user performance analysis. Survey data and content analysis has shown that while the students participate in a group activity solving a task they tend to use their tacit knowledge of gaming in a 3D metaphor of the real world and thus share knowledge with each other. This creates a paradigm shift on how libraries and archives can communicate knowledge from their historical collections to young users through the use of technology. Our study can have a universal value added to the dissemination strategy discourse on designing solutions to attract younger audiences to archives and libraries.

1. Introduction

Libraries and archives have a long tradition in adapting new technological methods in disseminating the content of their collections [1]. Archive collections materialize a new existence through the digitalization process [2] and have become virtual destinations [3] in our technologically rich age. The digitization of collections is used also as a preservation method [4] and libraries have been engaging in emerging technologies as augmented reality [5] to make information content more attractive and accessible to a broader public.

As new technologies emerge and create a challenge for the traditional notions of how cultural heritage is presented and interpreted by todays contemporary professionals [6] more research is needed especially when it comes to manuscripts or printed books that are considered as fragile not to be handled. The main question this paper wishes to draw on is, whether the introduction of virtual and immersive technologies in disseminating the contents of a library-archive collection can enrich the contemporary perception about libraries. Our hypothesis is that the use of such technology can allow a wider access to such heritage items. Libraries seem to have been adjusting to new dissemination methods in presenting their material to younger audiences and allow them to interact with it in a way that does not damage the objects but allows knowledge appropriation [2, 7]. In our study, books and manuscripts are presented to users as digital representation supplemented by the use of augmented reality with 3D models and a 3D game. [8] The experience of reading a book becomes in our case, a type of social interaction in a computer mediated environment [8]. Our overarching goal in this experiment has been to advance the current practice of book digitalization through the use of 3D technology and see how this can support learning in a workshop environment. In the present study we seek to assess user experience in 3D immersive environments and report on our work in progress.

2. Research Aims and Evaluation Issues

Material things present themselves in relation to human beings [18] either physical or virtual. They materialize themselves in the cognitive process of the learning intention [19] that the user carries when he enters the meaning-sphere of the object to be handled. In our case the library has provided a set of digitized content from the historical collections that is books, manuscripts and background narratives to a team of technical experts. Museums, libraries and ICT academy partners were involved in order to develop a consistent methodology enabling the use of Virtual Environments as a metaphor to present manuscripts content through the paradigms of interaction and immersion [20], evaluating different possible alternatives. The main focus of this interdisciplinary collaboration was to create a new learning space at the library where books as digital objects can be seen and read differently. A virtual interaction space was thus established as a 3D laboratory in our venue.

The idea of applying 3D technology for promoting the collections of archives and libraries is not new [10] and the investigation of its influence on the user experience has created new possibilities for books to be handled as digital representations rather than physical fragile objects [9]. Research in the field has been borrowing ethnographic and phenomenological tools or usability analysis methods [11] to evaluate the learning outcome of the visitor experience in immersive environments. A series of projects claim that most computer applications create digital involvement by active participation, and enhance learning through a cognitive dialogue with the user [12]. According to the knowledge creation theory [13] an individual learns when tacit knowledge meets explicit knowledge in a socialization context. An individual that participates in a group task contributes his/her knowledge to the group and learning occurs in participation. The goal of an immersive simulation is to create an illusion of the real world. When an individual enters in a computer mediated environment the experience of presence becomes perceived through the feeling of being there [14]. A few empirical studies have demonstrated that collaborative learning in computer mediated environments can support learning [15]. The Mubil project borrowed ideas from workshops designed for adolescents that allows them to work collaboratively in the real physical world and transferred it into the immersive virtual world. Our approach builds on the research result gained from the idea that the metaphor of a real world game to a virtual one creates increased engagement, motivation and integration of knowledge. [14] Further on the use of 3D technology and the possibility of interaction with virtual objects leads to a better conceptual understanding of the content [16] and if it includes virtually performed tasks, it may then offer greater opportunities of improved contextualization of learning as compared to 2D alternatives [17]. "From the technological point of view the project deepens in the theoretical and practical aspects of virtual reality implemented in educational activities. This applies to the design of the concepts and storyboards but also to the different metaphors of visualization and interaction.

3. The Interface and Workshop Design

Two books were chosen for this experiment. The first one is a printed book from 1569 by Adam Lonicer called "Kreuterbuch". The book has many drawings and is a treatise on distillation of medicinal plants containing valuable information about the history of distillation. The second one is a manuscript about a travel of a noble Norwegian in 1668. Both books were chosen by the MUBIL-project because of their value appreciated by scholars and other users. The books were first scanned and digitized and their texts were transcribed and interpreted by subject-experts. Two teams were working throughout a period of two years to develop two 3D books using different platforms a 3D laboratory game and a workshop concept for school classes.

In 2013 our 3D lab invited a school-class of adolescents at the age of 15 to test the first 3D prototypes of books and the game produced by Mubil. The students were introduced to the subject of Alchemy by their teacher in advance and participated to a field experiment at our library. The experiment established two stations, a physical one and the virtual reconstruction of it. The class was divided in two. The first group was introduced to an experiment from 1569 as that was described in the book that we used in our study. They were called to participate in a physical reconstruction of a chemical experiment described in the book and presented by our Chemistry expert and participated in seeking knowledge about the roots of chemistry by physical activities. That is sketching and touching the physical elements and tools to be used, asking questions and introduced to the virtual experiment lab. The same experiment was to be performed with elements and tools rendered virtually for them and they worked in groups while one person was in charge of the mouse in order to perform the experiment. The second group had a short introduction about the aims of our study on whether the introduction of 3D technology can support learning and were then allowed to freely interact with the 3d books and game and seek knowledge. All groups passed through both stations one after the other and answered the same survey questionnaires. Both worked in smaller groups of five students of mixed gender. One of the smaller groups volunteered as our experts and was interviewed after they completed both tasks. Ethical issues of visitor participation have been cleared up in advance with all the participants so that a protocol has been signed by all as to the use of the material for research purposes.

Figure 1. Lonicer's augmented book.

The manuscripts were presented in the form of an interactive 3D book (*augmented book*) which preserved the physical shape of the book. The 3D environment was basically an ancient desk on top of which the 3D model of the book (fig.1) was placed. The book could be browsed with natural gestures (different interaction devices, ranging from traditional mouse/joystick to touch-screens or Kinect are supported). On each page a set of relevant hotspots, commonly spatially referenced in correspondence to the illustrations, are placed and can be interactively selected. Upon selection, a 3D model of the related object pops-up from the book and floats above it, with an accompanying audio narration explaining the tool and its functionalities. Although the user can access this application also on normal PCs/notebooks, the students experienced through immersive stereoscopic visualization on a Power-wall. Additional layers of information related to transcriptions and translations of the original text, explanatory labels, audio, sounds, movies and real-time 3D animations.

The framework has been also prepared in order to allow the insertion of narrative content, both in terms of videos (for instance the first book illustration was transposed into 3D through a series of depth layers on top of which a movie was produced where a specific narration synced with the 3D exploration of the resulting environment described the place, the characters, the facts etc.) and of 3D animations (fig.2). This feature, in particular, was conceived in order to increase the application appeal especially to young users.

Figure 2. 3D pop-up animation on Lonicer's book.

Figure 3. The virtual laboratory.

Another interaction level is represented by the Virtual Laboratory (fig.3), an application meant to connect the previous levels and allow the students to exploit the knowledge acquired in the previous levels. The user becomes an apprentice alchemist that must perform a real experiment based on the distillation notions acquired from the Lonicer treatise. The process of distilling has been interpreted by Fredrik Kirkemo, a Chemistry student, that has dedicated his master thesis on that particular treatise of medicinal distillations. Thus the game proposed here is based on facts and scientific research. The point-and-click interaction metaphor that is used at the virtual-lab enables players to discover information, combine objects and perform all the operations involved in the distillation of a herb to

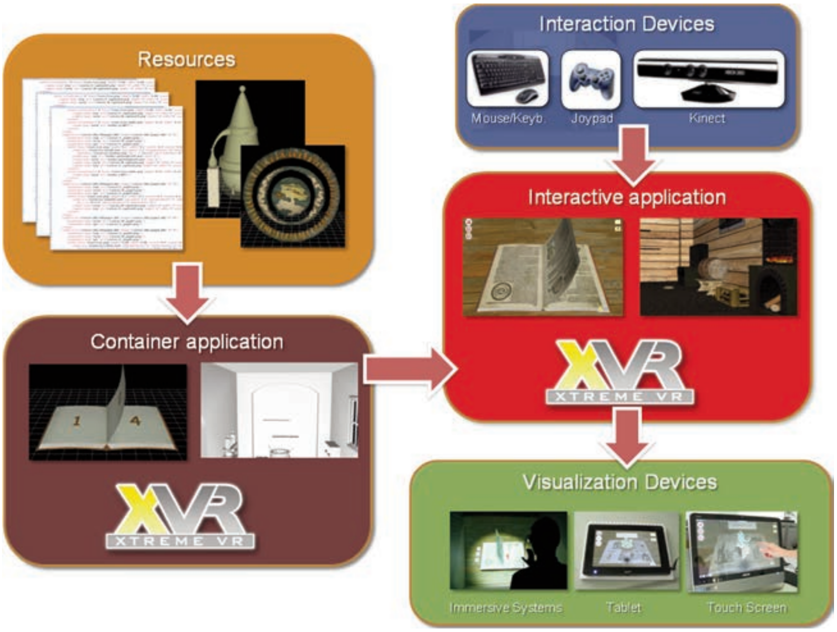

Figure 4. The MUBIL architecture.

produce a medicine. Extracts of the original book are available as a step-by-step help to the player so as to strengthen the link with the previous levels.

Several interaction metaphors have been implemented based on different devices (mouse, joystick, Microsoft Kinect etc.); all of these devices can be used to move a virtual pointer on the scene and execute actions of different types. Thanks to the flexibility of the architecture (fig.4) and of the XVR [21] underlying technology, all the applications have been realized as *blank* container applications which can load a set of resources (XML schemas describing the application flow, textures, 3D models, videos, audios, music) in order to implement different books (in the case of augmented books) or to different experiments (in the case of the virtual lab). All the relevant objects in the virtual scenario have been modeled in 3D based on Lonicer's illustrations and, whenever not present, based on the overall feeling of the book.

Many possible actions have been implemented including mistakes that, however, are always reversible. Every time a step is wrongly applied the voice of the alchemist will give feedback to the player so that he will have to perform the same task again. By introducing a help voice the interaction between the player and the game is more alive. Obviously, however, errors have an impact on the final score. While the students were performing the tasks in the 3D lab they were observed by the instructor and their teacher and filmed. At the end of the day they answered surveys and collected answers to open-end questions that were prepared by their teacher. The overall effort was graded by the teacher.

A second prototype was also presented to a different group of students a few months later. These students participated in an art workshop organized by our library and were introduced to both our 3D books as a free activity while working with sketching techniques and old illustrations from books we have in our library. Virtual worlds are not just a simulation of the real ones, they create new objects transposed in virtual reality and articulated in many levels of abstraction. Thus the represented environments can range from realistic to totally abstract digital scenarios. Among the latest, Information Landscapes [22] are worth to mention. The term "Information Landscape" has been coined by Muriel Cooper in 1994 [23]. IL systems are considered as virtual environments where a set of information entities (text, sounds, images, 3D models etc.) are represented in the 3D space with a well determined spatial organization and opportune connections. The aim if ILs is to not represent reality but rather abstract worlds where the user can seek knowledge through different type of tasks. Inside an IL, information is presented in a layout, commonly designed to present semantic significance, allowing the user for an immediate interpretation of the presented concept. IL systems are thus conceived to bring all kinds of users directly inside information, so that their learning can originate from the exploration of these worlds. User interaction within this particular app is completely free or can take place through a guided navigation. This allows the users to follow a pre-defined interpretation of the logical structure of the content. The guided navigation mode exploits the mechanism of links. IL system links are very similar to hyperlinks, as they connect two information entities. The main difference is that this connection is not instantaneous: IL links are implemented by means of viewpoint animation designed by the landscape author. This may bring additional semantic significance, as following an IL link is not just a teleportation but rather a travel. Another difference with traditional hyper-texts is that IL systems allow to constantly keep the vision of the context where a specific information is placed and, through the free navigation metaphor, they enable a real "non-sequential" rather than a "multi-sequence" approach. This concept has been applied to a second manuscript of the Gunnerus Library collection, a travel journal by Lilienskiold (fig. 5).

The derived IL has been centered on the metaphor of the trip to Italy and in particular to Pisa, acting as an ideal bridge between the two countries involved in the MUBIL project. Section of the texts are

Figure 5. Lilienskiold information landscape.

distributed onto a Virtual Environment representing a stylized 3D map of Pisa, loosely based on the one realized in [24] where the major monuments, described by the author, are visually highlighted. Other information layers are represented by audio narration, explanatory movies and a glossary. The students were allowed to click freely in the map and read or hear the text and navigate around the virtual landscape as if they were actually visiting Pisa in 1670. The students were only observed while interaction and answered some satisfaction and motivation measuring questions at the end of the workshop. This material needs further analysis and only some preliminary observations can be presented here.

Also in this case many different interaction metaphors have been enabled. The same applies to visualization metaphors; this means that the 3D environment can be visualized on a simple flat screen, on a stereo screen or on a system of screens, therefore adapting to touch computers (fig.6, top), tablets, notebooks, and even immersive visualization systems such as CAVE (fig.6, bottom).

4. Experential Learning Results

These applications have been used in an experimental workshop concept presented for new user groups at our library (fig. 7). Our target group was at the age of 13 to 17 years old and we invited two classes, to emerge into our lab and work with the applications so that we could observe them, videotape them and also use them for feedback and interview rounds. We chose this age group since this generation suits better our model of experiential learning as a form of educational success according to previous research [25]. Our purpose was to evaluate the satisfaction level of the students and their learning

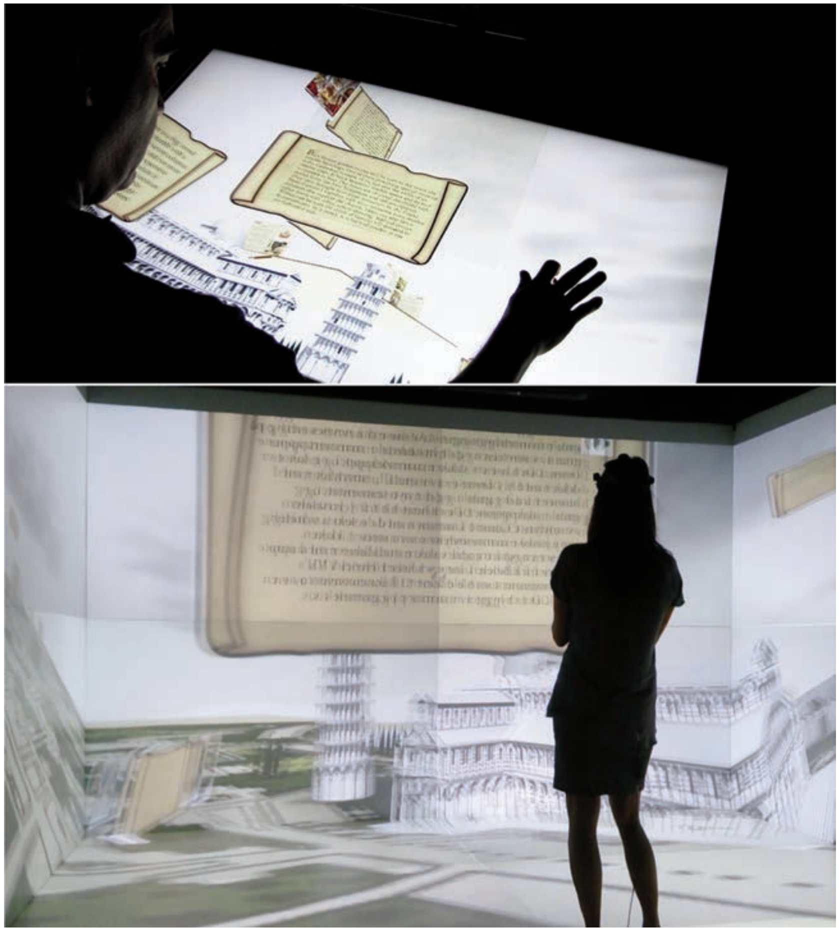

Figure 6. Touch (top) and CAVE (bottom) interaction with the apps.

outcomes [26]. Our research method included all of the above and surveys with both open-ended questions and multiple choice ones. We used the 3D lab with the content from the books as an "experiential space" where students could perform tasks and look for answers. We employed the experimental [26] research method involving an experimental group and a control group to determine whether the use of virtual worlds and 3D models helped them learn as opposed to just reading a book. What we learned through the surveys and the interviews was that the students liked using the virtual 3D-models and the lab because of the fact that they had the ability to actually learn while doing. The fact that this kind of 3D technology was used to augment the book experience increased the motivation [17] for learning as a 13 year old student told at a random interview done by the local newspaper. As our survey showed 90% of the users that participated in our experimental workshop felt that they could move around the lab freely, understand easily the sequence of tasks to be performed and enjoyed the game. The teacher of both classes participated in the planning and the overall design of the activity and prepared chemistry assignments. Their answers to the assignment scored pretty high on knowledge questions. We selected also a focus group that we interviewed to get a deeper understanding of the elements that supported learning through such an experimental frame ([27–28]).

A visit in such an archive environment seemed to be a rich learning experience said the students in their interviews and they wished to learn more about the subject. It was apparent by both the answers and the interviews that experiential learning and task collaboration was appreciated by students and teachers.

The second book that was presented in a different workshop frame with no certain assignments or a virtual task connected to it did not seem to appeal to the students as much. They seemed to be browsing through the book and the map of the town and reported that they like the interface and the design, but the time they would interact with the book was very limited. It was clear to us that the book had to be presented in an educational frame or tasks connected to that. That is part of the further research we intend to conduct in 2014.

Several drawbacks have to be mentioned here as well. We need to further investigate our design and take into considerations biases created by the involvement of the people that develop the concept and the technological platform of an idea into the testing and collecting the data. This kind of involvement being direct and personal [31] is a drawback to be considered.

Figure 7. Users interacting with the apps.

On the other side the software chosen has a number of limitations, with not many possibilities of enrichment in its implementation. The fact that this is a 3D tool which was not tailored for complex interactive design carries unpredictable technical implementation problems that appear along the way. That has given reports of dissatisfaction as to the technical performance of computers that are not robust enough to cope with multiple and random clicking by the users. The 3D lab applications were also tested by random younger users in a public library where the age of the kids-visitors was under the age 10 years old and the level of satisfaction and performance was much lower according to the feedback given from the librarians working there. This material needs further investigation. Hopefully, solving these kinds of technological challenges, will contribute to new knowledge and will allow us to have an insight in the development of such tools.

5. Conclusions and Future Research

In our paper we presented the idea of applying 3D technology for promoting ([17], [32], [33]) the collections of archives and libraries. We discussed several new aspects added to the experience of "reading a book" if it becomes part of an educational activity in 3D. Through our research we tried to investigate how the use of 3D technology can facilitate learning. We presented here the preliminary results of our experimental study in a 3D lab, where users interact with 3D virtual images of physical objects, as old manuscripts and books and their content, in a learning frame. In addition our study suggests also that the practical engagement of free choice in tasks of interactive character in an immersive environment increases the motivation of the young generation of learners. It seems that the ability that 3D technologies provide of visual or sensory realism which is consistent with the real world can affect the learning experience [17]. The introduction of novel technological tools in archive outreach activities creates a room for active participatory interaction. 3D technology evolves in a very rapid rhythm and new open source software as Unity and Oculus technology have already been adapted to MUBIL. Using 3D tools for such a purpose is not easy because besides visualization devices to showcase 3D content, we need to develop conceptual models of using the game tools so that we can explore, challenge and foster social participation. In order to examine the impact of such lab design the project will be evaluated by other neutral partners and random young users during 2014.

Our inquiry on the use of such technology in archive dissemination strategies, will also hopefully add a new dimension to the dialogue between memory institutions and the individual visitor. The challenge will be to trigger the visitor's interest and investigate what modifies his learning.

We plan in testing further these applications by random school groups in order to collect more answers and to test further our hypotheses. In the future we also intend to improve the final applications and look into the details of communication and social interaction. We also need to work further on the development of computer-supported learning tools that use 3D technology in collaboration with teachers and educators as to add real value to our study and 3D lab.

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