Workshop Proceedings of the 9th International Conference on Intelligent Environments
J.A. Botía and D. Charitos (Eds.)

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doi:10.3233/978-1-61499-286-8-519

Playing in museums by constructing your game

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Abstract. In this paper we present MagMAR, a system for supporting museums visits recognizing the different needs of educators and students. MagMAR combines a Mobile Augmented Reality game (targeted towards young visitors) and a Web interface (targeted towards educators). The Web interface lets educators shape and guide the learning process, while the game is intended to engage students during the visit. A first evaluation was performed asking 9 students and a teacher from a high school class to test a MagMAR in a contemporary art museum in Milan. Results show that the form game was very successful from the sociability and fun points of view, and also guided the students in the retrieval and usage of information for the quiz game. Further improvements are on the other hand due to make the game more integrated in the context and push the students to pay more attention to their surroundings.

Keywords. Serious Games, Augmented Reality, Young people

1. Introduction

Along the years, access to culture has changed forms. Starting from the '60ies in parallel with classic channels and institutions we have seen the emergence of youth culture channels (see e.g., [1] for a detailed analysis on the topic). These channels are dynamic and often informal, and many times do not enjoy official recognition (for example in the case of street art) [2]. In addition, the way young people accumulate, analyse, and disseminate information and knowledge today is strongly connected to new technologies [5]. Opportunities for young people to enlarge their cultural and creative expressions and development - in or outside of school - can thus pass through the usage of technologies.

Within the museum and culture research literature, there has been some emerging focus on how digital devices improve engagement to enhance the visitor's experience. For example, [6] tested a prototype handheld device that delivered descriptions of artefacts in a historic house to multiple users simultaneously, and found that conversations around exhibits increased. In another study, increased engagement and interest was also found with young students when they were given RFID sensors that could detect exhibit locations and unlock virtual information to extend their interactions [7]. Along similar engagement lines, other studies have examined how Augmented Reality (AR) can improve access to information and increase exhibit functionality. For example, [8] investigated the functionality of an AR-enabled mobile multimedia museum guide implemented in a fine arts museum in France. They found,

among other things, that using AR to enhance the museum experience could serve as a viable alternative to traditional text guides in retrieving information, which has potential to attract new audiences.

In this paper we present MagMAR, a system for supporting museums visits recognizing the different needs of educators (e.g., teachers and museums' guides) and students. MagMAR combines a Mobile Augmented Reality game (targeted towards young visitors) and a Web interface (targeted towards educators). The usage of MagMAR in museums and other cultural heritage settings is expected to enhance the fruition experience and reconnect young people to cultural heritage, letting nevertheless the educators able to monitor the learning cycle. The rest of this paper is structured as follow. Next Section and Section 3 describe respectively the motivations and the design principles that guided us towards the creation of MagMAR. Section 4 drafts a short state of the art while Section 5 and 6 describe the MagMAR design and a first evaluation we held with teenagers in a museum setting.

2. Motivations

In [4] the authors narrate an ancient anecdote. When the Spanish galleons arrived for the first time off the coast of the islands in Central America the Indians were not able to see them, as they were objects so far beyond their experience and their ability of understanding to make them in all respects "invisible". Only after a prolonged (and traumatic) contact with the new culture galleons finally became visible and could be integrated into patterns of behaviour, language, and in everyday experience. For many citizens local heritage (museums but also other structures) sometimes seems to enjoy features of invisibility comparable to those of the galleons of the story [4]. In line with [2] the authors of this paper believe that non-formal arts education approaches can be profitably used together with other types of formal approaches to reconnect people - and in particular young people - to culture, making cultural heritage visible to them. In addition, in a recent EU document[15]educators are asked to teach the students strategies and methods to be applied independently from school (the "know how"). This approach urges teachers to lead students outside the classroom, going to museums, on excavation and construction sites, investing time to put students "in situation" and enabling them to "learn by doing"[16]. Creating these possibilities takes time, tools, resources, interdisciplinary connections, and methodological experimentation. Among other things, this approach requires teachers to acquire skills that transcend the role assigned to them by the school until today. These skills, if already present, were acquired in most cases through "informal and non-formal" paths [16].

The two scenarios we described suggest the need to integrate informal learning in formal settings at two levels, the students' and the teacher's one. The approach we propose in this paper, MagMAR, is composed by an augmented reality game targeting young people and a web application targeting educators. These two elements are strictly linked together, enabling the usage of informal learning at both levels.

3. Design for Young People Access to Culture

In this section we describe some additional considerations which drove us in the creation of the MagMAR application.

3.1. It's all about the form: the invisible museum and its non-public

The youth population is, according to the cliché, a *non-public* for the cultural offer, or at least an audience motivationally weak and discontinuous. In study [8] the authors analysed the perceived image of museums targeting teenagers. What emerges is their generally negative connotation. The most used adjective in the conducted survey is *old-fashioned*, and the museum image is linked to the concepts of closure, normativity, distance. What is interesting in this study is that many of the factors that create this connotation are completely unrelated to the content but related to the *form* of the museum. Quality of the experience as a whole, rules of conduct and explicitly didactic value, but also lack of communication or inadequate equipment, are equally if not more important than the content of the collections in forming the judgment of young people towards the experience related to the museum.

3.2. It's all about emotions 1: sense of belonging and sociability

A second study targeted at teenagers [3], has clearly highlighted that young people perceive a great distance between the so-called "high" culture and the youth culture which is considered to be "popular". The most successful initiatives at the level of youth culture proposed by traditional cultural institutions are those in which this distinction is not marked. Moreover, the most vivid, positive, and persistent memories of the museum are those attributable to strong emotions felt during a visit (the emotional dimension is predominant with respect to the cognitive in determining the value of the experience). More specifically what emerges is the deep need for comparison and relationship with others, a dominant socio-relational behaviour that informs the processes of choice, the formation of tastes, and the evaluation of the experience. While the typical adult visitor of museums gives the museum a value in itself (intrinsic dimension), is self-referential (in the sense that the visitor's experience is individual)[9] and tends to a have a reactive attitude towards the objects on display, for the interviewees seem to play a significant role the ensemble of environmental, socio-relational, and emotional factors more than the actual contents.

3.3. It's all about emotions 2: ownership and content

Recent technology, and especially the Web 2.0, offers people the possibility to become involved in activities that are called End-User Development (EUD), i.e. activities that range from simple parameter customization to modification and assembling of components, and even to the creation of new software artefacts [10],[11],[12]. Today, users are no longer passive consumers of computer tools, but they are more and more information and software producers. These new roles of end users blur the distinction between design time and use time in the life cycle of an interactive system. In addition, in [17]the authors highlight that the learning potential in the field of technology enhanced learning is not only linked to game play but also to game design and development (see also [13] [14]).

To summarize, form, ownership and sociability seem to be factors of engagement in exploring cultural heritage and in particular museums.

4. State of the Art: Games for Cultural Experience

Previous section clearly states that the form is an important factor for the engagement of the young population. In this section we describe why we opted for an augmented reality game as an alternative form of exploration in the museum setting.

Games, learning and cultural heritage

Recent studies have shown that the introduction of games has the potential to help young visitors to use the information gained during a cultural tour in a more meaningful way [21] as it obliges the young visitors to use the collected information right away to complete some tasks or answer some questions. In addition, young visitors are most likely used to play video games and are familiar with multiple platforms to play them on. Introduction of a video game in the cultural setting might thus provide a natural environment for the young visitors [22]. Indeed, game play is not a new practice for museums. Through the years a lot of (non-technological enhanced) educational games have been created for museum or other cultural settings. The main idea behind these games was to make the experience for the young visitors more interesting creating an environment where they could learn through interactivity. One typical example of these games is the "treasure hunt", where participants are asked to find in the museum different items and answer a couple of questions about the same by filling in a paper form. The team who answers in the right way and fastest wins.

Augmented Reality

For the game described in this paper we decided to focus on the usage of *Mobile* Augmented Reality (MAR). The main advantage of the AR technology is that it is created to supplement the real world with virtual objects that appear to coexist with the real world. By providing more intuitive and natural means of interaction AR has the potential to further blur the line between computer generated content (for example pc games) and the real world. In addition, the field of AR applications for culture has grown a lot in recent years due to rapid development in handheld devices technology, resulting in a new sub field of augmented reality called Mobile Augmented Reality(MAR) [18]. MAR's popularity today is tightly linked to the availability of smartphones that can exploit its capabilities and enhance user experience while remaining relatively cheap. Researches were conducted also about the usefulness of augmented reality to enhance visitor experience in the museum setting as MAR has the potential to give users more visual information about the items in the museums or even augment the items themselves [19]. However, current widespread applications are mainly targeted at tourism, creating interactive guides for the city or visual augmentation for exhibitions (i.e. to show how a site looked long time ago or how an item was used). Finally, from a learning point of view [20] findings suggest that the usage of AR in a cultural setting might have an impact on conceptual knowledge.

Augmented Reality and Games in Museum Settings

The introduction of digital technologies in cultural settings resulted in revisiting more in general the idea of game play/storytelling in museums (for a detailed presentation and overview see [23]). For this paper, however, we will focus only on the

attempts to bring mobile *augmentation* into the museum setting for educational purposes. In [24] the game itself is an implementation of a classical "Scavenger Hunt" game. A Scavenger Hunt is a game in which the organizers prepare a list defining specific items. The participants seek to gather all items on the list, or perform tasks, or take photographs of the items, as specified. The goal is usually to be the first to complete the list, although in a variation on the game players can also be challenged to complete the tasks on the list in the most creative manner. In [24] users played the game by answering the questions provided by the system. To find the correct answers, they had to explore the museum and find relevant information about one of the items found in the museum. The project was strongly influenced by the technological difficulties that the PDA's provided (by that time handheld PDA's had almost no processing power and little to no memory). However, despite the slow hardware, participant interviews indicate that players enjoyed the experience which proved to be not only entertaining but also educational.

Other studies indicate that the usage of MAR has various advantages over using Virtual Reality simulations for educational purposes mainly due to human perception of our surroundings and the ability to relate to the content of the application [19]. This research supports the idea that by moving around the museum, trying to find the items using the mobile phone camera instead of just getting a list of questions might improve user engagement. Another research on the usefulness of educational games was conducted by [21]. By implementing interactive games in museum setting for PDA's and observing how people interacted with them, the researchers concluded that when children can use the information gained in the museum immediately to play a game the museum experience can be both educational and entertaining.

Finally, the most recent and relevant attempt we can describe is the Mobile Augmented Reality Quest [25]. MARQ is a team-oriented game to provide an AR museum tour. It is targeted at young visitors (age 12-16), who have to explore the museum by solving interactive 3D AR puzzles to reveal parts of the story. The game uses interactive visual and audio augmentation to make the visitors experience as rich as possible. This game supports multiple user interaction by sharing the collected items between players and tracking the position of the players.

5. The MagMar Design

MagMAR combines a mobile game (targeted towards young visitors) and a Web interface (targeted towards teachers). The Web interface lets teachers shape and guide the learning process, while the game is intended to engage students during the visit.

During the visit, students divide into teams to play the game, while teachers can monitor the progress. After the visit, the information is available to students and teachers to reflect about the museum experience. The actual game consists in a digital implementation of a Treasure Hunt game which replaces the pen and paper with an Android device and a Mobile Augmented Reality (MAR) application developed through the Qualcomm Vuforia framework.

One of the main elements which differentiates MagMAR from the games illustrated in the state of the art is the usage of user generated content not only before the beginning of the game for a set up phase, but also during the actual game session. In the first phase, the educator can decide which information will be available to

students as starting point, taking into account e.g., the learning objectives of the visit and the knowledge level of the students. In the second one, students will create contents in form of questions for the game. The main idea behind this design choice is to use the emotional element of ownership which is typically linked to hand-made objects [26] (the questions are valuable because they are created by the members of the team) also for engaging the students in the museum exploration.

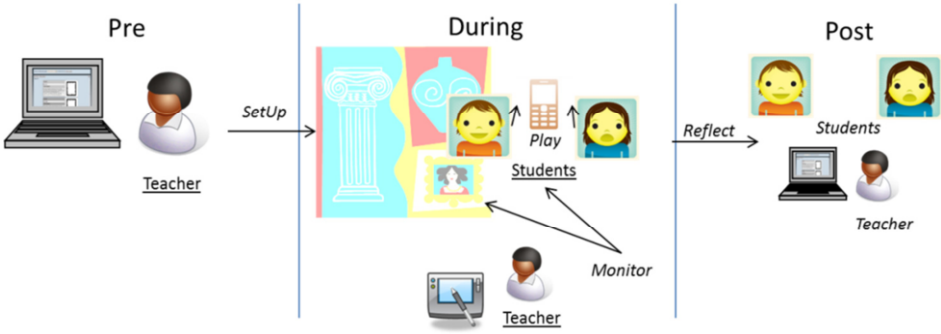

Figure 1. An overview of MagMAR intended usage

In the following we explain the three phases more in details, referring to the current implementation of the system.

Phase 1: The set up

The educators use a Web interface to specify the objects of the game on which they want to focus during the visit and provide related information (Fig. 2). The number of items to be used in each game is flexible as it can be influenced by the size of the museum or other limitations as time or item relevance. The teachers can not only decide which elements are relevant but also the given amount of information, which can vary from a short item description - only sufficient to identify the item – to a more complex description providing some generally known facts about the item (author, when it was created etc.).

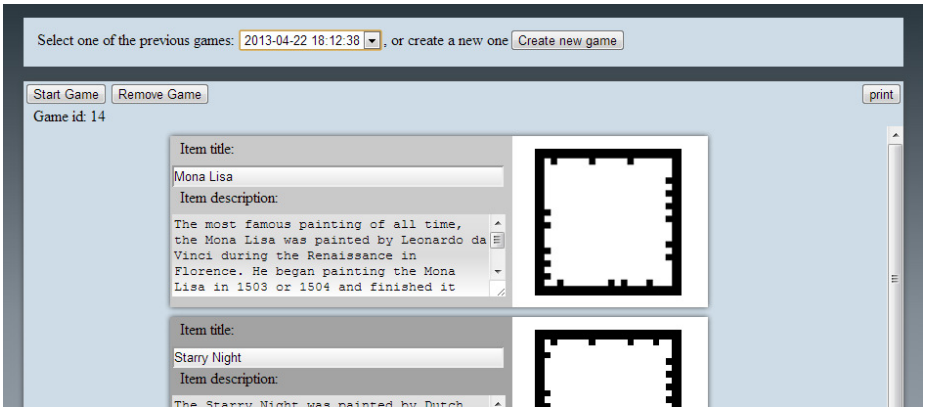

Figure 2. Web interface

For each item, the system generates a physical marker, a small unique pre-programmed picture that is used to identify an item in the physical world and access the related information. Once this phase is over the educator will print out the markers, cut

them out, and head with the class to the museum. Before the actual game session the educators have to manually put all the markers in the vicinity of the corresponding museum items (see Fig.3). In case this is not possible they can simply print out the images associated to the markers and use them while going around in the museum. The information entered by the educator in the Web interface is visible through the MAR application installed on the mobiles (see Fig.3). The visual augmentation is used to create an anchor between the physical item and the augmented dynamic information (firstly the one created by the supervisor, in a second moment the questions created by the students).

Phase 2-a: The game session: Supervising the visit

Once the preparation is over, the game can start. To start the game the educators open anew the Web interface on their personal device, select the previously created game, and start it. The system goes then into a listening mode and waits for the players to join the game. The Web interface allows also for real time game monitoring. This means that during the game session the educator can view in real time the questions created by the players, which provides an overview of the game progress. If the supervisors are not happy with the questions created they might ask the players e.g., to try harder and create the question again.

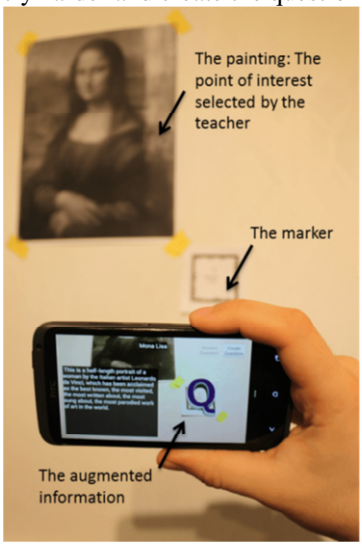

Figure 3. Interacting with markers

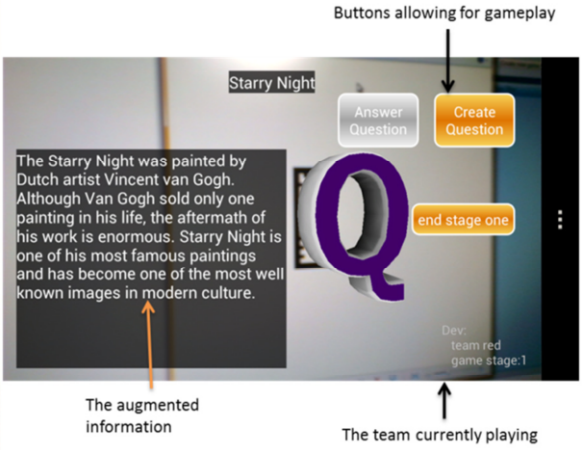

Figure 4. The question/answer process

Phase 2-b: The game session: Creating questions

The main goal of the game is to create difficult - but answerable questions - so that the opposing team will not be able to gain points. When joining the game the teams are assigned a colour (*Team Red* and *Team Blue* in our example). When a player from *Team Red* approaches the first item and points the device - so that the paper marker placed by the educator is visible on the device - the MAR application shows the additional information about the item. This action also makes the *Create Question* button active. Now each team has then to create a question, associated to a particular item, and provide three possible answers, only one of which is correct. The system creates no restrictions about information gathering. In order to create the questions the

players could for example browse the internet to find interesting facts linked to the items. If the teacher considers it more useful, the players can be "forced" to explore the museum exhibits and gain some new knowledge about its artefacts. And so on. This kind of game dynamic require also for good cooperation within the team.

Phase 2-c: The game session: Answering questions

When both teams have finished the questions creation, the answering phase starts (Fig. 4). All the items that were inserted in the game by the supervisor have now questions linked to them. The players from *Team Blue* are now in front of the same marker and are reading the question created by the *Team Red.* At the same time the *Team Red* is answering to the questions created by the *Team Blue*. Once all the teams have found all the items and answered all the questions, information on the supervisor screen gets updated (Fig.5). The supervisor is then able to see the list of the questions, the chosen answers for both teams, and their final score. These results can then be used for further briefing.

MagMAR is not conceived for a specific museum. Instead the design focuses on flexibility and on the possibility to deploy and play the game at any location (museums but also workshops, small galleries, and local exhibitions).

The setting up phase allows denoting any physical object the educators want the students to create questions for. The starting information is also provided by the teacher and it does not require any involvement of the museum, though it does not exclude it. Finally, associating information to the physical object with small markers and accessing it through augmented reality requires minimal impact on the physical area of the museum.

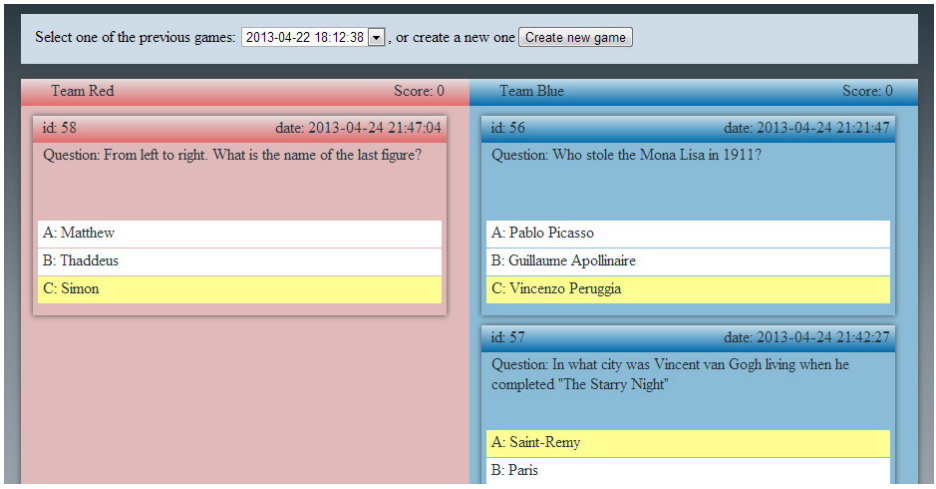

Figure 5. Game monitoring

Phase 3: Reflection after the game

In the current prototype this phase is not explicitly supported, for example through a specific web interface. However at the end of the game the educator can still see the questions created and the results of the teams. The educator can thus use them to (i)

discuss with the students about the game session; (ii) use them to identify e.g., knowledge gaps, interesting points for further discussion, and so on.

6. Testing MagMAR in a museum: initial results and future works

An initial experimentation of MagMar was conducted with 9 students (average age 18) from a high school class and their young, but experienced teacher. The experimentation was held in a contemporary art museum in Milan, Italy. We asked the students and the teacher to use MagMAR for a part of the museum visit, while using a classical guided visit for the rest of the time. Before the visit the teacher inserted in the system information on 11 artistic artefacts she planned to focus on during the visit. Due to time constraints and some technical problems with the prototype, students were asked to create questions only for the first two items, and the global visiting experience involved only 5 artistic artefacts. For the first item, the students created the questions while sitting on the floor in a room nearby the one where the painting of interest was located. For the second item, the students created and answered their questions while standing in the room where the painting was located, together with other works from the same period. While playing the game, the students were given not only a mobile phone with the MagMAR game, but also a museum guide, an Ipad with Internet connection, and they could use the content already displayed in the museum or ask the teacher in order to create and answer the questions.

Hereafter we briefly describe our findings summarizing the results from the observation held during the experimentation and the results of a survey we conducted after the visit. The survey was constructed around a set of quantitative questions - asking to rate from 1 to 5 some affirmations (1= strongly disagree; 5=strongly agree) - and other more qualitative questions to let the students and the teacher free to express more complex statements.

The evaluation of the game was very positive. Not only the students declared they had fun (4.2 average rate) but we observed they were strongly engaged during the game, discussing about the best strategy to use in creating the questions in order to win. Sociability was also important during the game. Students reported that collaborating with the others helped them to learn more about the museum items (average 4.1), even if collaborating was more fun (4.9) than helpful (3.8). Challenging the others was considered the factor that made the game experience more compelling (4.8). The game also worked as stimulus for information retrieval as the students used all the instruments at their disposal to create complicated questions. It is interesting to note that while for the first item they remained seated and only consulted the provided book and the Internet, for the second item they walked around trying to find content for possible answers also in the information exposed in the exhibit (in the specific case, the name of painters contemporary to the one of the focal painting). Though this is clearly not sufficient to draw any general conclusion, it was still interesting to see how the game could actually motivate an exploration of the museum and how a relatively small change of the playing conditions might have impacted on the type of questions that were formulated. Creating and answering questions was considered to help in learning something more about the museum items (3.9 and 4.2 respectively). In addition when asked what they remembered from the museum visit, the students answered with the content of the questions they created. From the observations we can add that one of the groups used the teacher as shortcut to answer the questions. As students were proud of

the questions they created (4.4) this could be an indicator that creating the questions was funnier than answering them. However this is a topic that needs to be investigated further.

On the overall, being involved in first person in the creation of the questions made the experience more interesting. For example, one of the students wrote that "*During the game I was much more interested in the paintings as I was directly involved in the researches about the paintings*." Another one added that "*During the game, being involved in first person in the painting explanation,… I enjoyed it very much and I learned things that I still have in mind*".

Another interesting point is linked to the museum exploration. From the teacher and observers point of view the game distracted the students from the interaction with the museum as their focus was directed towards the game and not the surroundings (the paintings). The situation seemed to reverse while doing the guided tour with the teacher. However students stated that the game encouraged them to explore the museum in a new way (4.6) while some of them (3) reported that they got somehow distracted after the game session. However, though the game on the overall was not perceived as a distraction, the use of augmented reality was more problematic. The current game is not able to exploit the full potential of augmented reality, it distracted the students and as a matter of fact none of them read the content previously inserted by the teacher.

In addition both the teacher and the students stated that a previous explanation of the paintings could have improved the experience.

Finally, a separate discussion should be done about the monitoring phase. The teacher gave the maximum rate (5) to the possibility to monitor the students while playing the game. This leads to think about the importance of this monitoring phase which should be further investigated. Given the positive results from the initial evaluation and because of the flexibility of the application (i.e., its possibility to be applied in different settings), during the next school year we will involve other classes in a more extensive trial.

Acknowledgements

The work is co-funded by NFR-VERDIKT 176841/SIO FABULA (http://teseolab.org). The authors want to thank the teachers and the students of the "Scuola della Comunità Ebraica di Milano" and the "Museo del '900" in Milan, Italy for their availability and kindness.

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