

Using the Blended Spaces Framework to design Heritage Stories with Schoolchildren

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ABSTRACT

Blended spaces are spaces where a physical space is deliberately integrated in a close-knit way with a digital space. Blended spaces may take the form of a carefully designed meeting room, for example, that integrates collaborative media with the design of the physical space. Another type of blended space integrates some digital content with a physical location to create a new, unified user experience (UX). Blended spaces aim to produce a more harmonized UX of a place by considering the correspondences between physical and digital spaces and by considering the movement through these spaces. We have developed a framework for the design of blended spaces that focuses on four principal constructs; ontology, topology, agency and volatility. This framework has proved useful for designing heritage stories in previous work. In this paper we describe how we have used the framework with a group of grade 5 schoolchildren as a participative co-design method to help them develop a digital tourism experience for a living-history village and museum. We describe how the framework was used to guide four design workshops with schoolchildren. The evaluation of a heritage story designed and acted out by the schoolchildren themselves and evaluated by another group of schoolchildren provides evidence that the experience was enjoyed. The outcomes of all four workshops gave us insights towards how to not only design blended spaces with and for schoolchildren, but also how to teach complex theoretical design methodologies that enable schoolchildren to become the designers of blended spaces.

Author Keywords

Design, Tourism, Blended Spaces, User Experience, Co-design, Participative design and children

ACM Classification Keywords

H.5.1 Multimedia Information Systems

1. INTRODUCTION

Blended spaces are spaces where the physical space is deliberately integrated in a close-knit way with a digital space [3]. Blended spaces go beyond simple mixed reality [20], [1] and conceptually are closer to tangible interactions [17] where the physical and digital are completely coupled. The term has been used by a number of authors recently to characterize this close integration of physical and digital spaces. O’Hara, Kjelsko and Paay [21] refer to the distributed spaces linked by very high quality video-conferencing systems such as Halo as blended spaces because of the apparently seamless joining of remote sites. Jetter, Geyer, Schwarz and Reiterer [18] discuss blended interaction with respect to the development of advanced interaction spaces. Like Benyon and Mival [4] they are concerned with the close integration of hardware, software and room design to create new interactive spaces for creativity.

In addition to these examples of room environments, Hoshi and Waterworth [15] discuss blended reality spaces that mix the real with the digital to create ‘tangible presence’. Benyon [5] also discusses blended spaces in the wider sense of a tight coupling of the physical and digital space and how this leads to new forms of presence, something also addressed by Wagner and his colleagues [27].

The aim of this paper is to illustrate how we used the concept of a blended space in the context of digital tourism and more particularly as the foundation for a participative design approach for grade 5 (aged 9 or 10 years) children. Tourism is ideally suited to linking physical spaces with digital content and there are many examples of tourist apps that provide information through augmented reality (AR), often making use of the global positioning system (GPS) to provide context-specific information in museums [22], [24], to university campus visitors [7], [23] or to tourists on phones or tablets [9] [10], [11]. In these experiences there are various points of interest (POI) for tourists that are connected to, or anchored to, digital content. Such systems may provide other forms of context-aware interaction [19] such as personalization of information based on previous places visited by the tourists, or other attributes such as what content people are interested in [24], [25], [26].

All these user experiences for tourists, museums and so on face some common problems. The central issue for location-based information is that people need to be made aware that there is some digital content that they can access. Since people cannot see digital content without some display device, they will be unaware that any exists, or the extent or type of content until they are alerted to it. People need to be guided to the physical location where digital content can be consumed. This is no trivial task. In some situations there may be lots of digital content related to a small physical space and perhaps of interest to different people. In other circumstances there may be only a few pieces of content, but spread over a very large area. If the tourist is walking, then the content can be delivered at one pace, whereas if the tourist is driving, delivering the appropriate content at the appropriate location can be very difficult indeed. Another issue concerns the size of the physical location where the content is relevant and how to control the content delivery if the person walks outside the area. For example, Blythe, Reid, Wright and Geelhoed [8] note that people got quite annoyed when they walked out of the geo-tagged space and hence lost the content they were engaged with in their mixed-reality presentation of riots in Bristol, UK.

The blended spaces framework aims to provide a compelling design methodology for the creation of mixed reality experiences as it provides design guidance on how the digital and physical spaces should be integrated. Designers look for the correspondences between the digital and physical spaces in order to provide visitors with an experience that maximizes the integration of digital content with physical locations. We have previously used this framework to develop heritage stories at the Genesee Country Village & Museum (GCVM), a large living museum in New York state, aimed at year 5 school children [22]. This experience led us to speculate that the blended spaces framework could be used by the children themselves to co-create heritage stories. In the spirit of cooperative inquiry developed by Alison Druin over a number of years [12], [14], we were interested in using blended spaces as the basis of a design partnership between designers and children.

We wanted to exploit the unique physical context of GCVM to explore whether school children could create engaging heritage stories. We felt that the concept of a blended space provided a sound basis for developing a new co-design method that could be used with primary school children. In this paper we describe the method, the heritage story experiences that were created and the evaluation of one of those stories by children from another school. In doing so we explore questions concerning how a deep theoretical framework such as conceptual integration can be adapted for children and adopted in co-design.

This paper presents a brief introduction to the simple but powerful idea of conceptual integration, or blending theory [13], that forms the foundation of the concept of a blended space. This leads to the blended spaces framework. Section 3 describes how the framework was used by designers and children in a series of workshops to create a visitor experience, aimed at children in a living-history village and museum. We highlight the goals and objective of each workshop and how the blended spaces framework led workshop discussions, the concept and physical design of the experience and its formative evaluation. Section 4 describes a summative evaluation of the design by 16 children from another school that provides evidence on the effectiveness of the framework for the design process. A brief discussion and conclusion follows.

2. THE BLENDED SPACES FRAMEWORK FOR HERITAGE STORYTELLING

Fauconnier and Turner, introduced their ideas on the creative process called conceptual integration, or blending theory, arguing that cognition can be understood in terms of mental spaces or domains [13]. They recognize the existence of two input spaces that share some structure with a more generic space. Cognition involves bringing together elements from the domains and blending them to create a new domain that has its own structure. In [13] Fauconnier and Turner explore many examples of conceptual blending in the context of linguistics and creative thinking. Imaz and Benyon [16] applied the ideas of conceptual blending to software engineering and Human-Computer Interaction (HCI). They explored the development of these disciplines and how the concepts that have been used to think about HCI have changed over the years.

Benyon [3], [5] subsequently brought blending theory together with the design of mixed reality spaces by looking at the relationship between digital and physical spaces as a blend. He argues that for the purpose of developing mixed reality experiences, physical and digital spaces can be conceptualized in terms of four key characteristics; ontology, topology, agency and volatility [3], [5].

We have applied this framework to the design of the Genesee Country Village & Museum (GCVM) as illustrated in Figure 1. GCVM is a large outdoor museum in New York state populated by historic buildings that have been transported from different locations to create a vision of life in 18th and 19th century USA. Seen in terms of the blended spaces framework, the ontology of spaces is concerned about places or POIs at a particular destination. The topology of spaces is concerned with how the POIs are related to one another in terms of distance and direction. The agency of spaces is concerned with people and the artificial agents that are in the space and the opportunities that exist for action. The volatility of spaces is concerned with how change affects digital content and physical interaction and vice versa, over time.

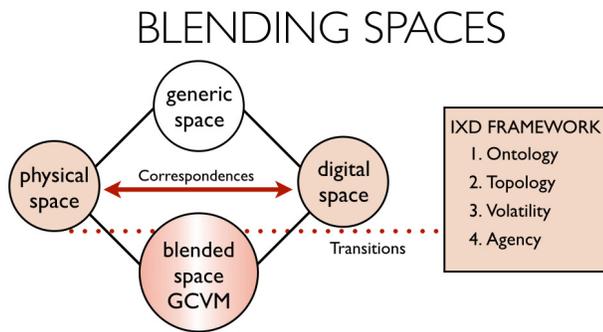


Figure 1. Blended Spaces Framework

The goal of developing a blended space is to provide a good user experience by bringing the digital and physical spaces together in a thoughtful and harmonized way, rather than bolting on digital content to a physical space. In blended spaces, people should feel present in the blended space and be able to maintain their sense of presence through smooth transitions between the spaces [4]. For example, Benyon, Quigley, O’Keefe and Riva [7] envision a design scenario at the home of Edgar Allan Poe. Visitors are lead through the poet’s home by using themes from ‘The Tell Tale Heart’. On the mobile device the visitor receives a series of odd text messages, an ever-increasing vibration and finally an augmented bloody heart pounding beneath the floorboards. This scenario envisions how a well designed blended space delivers a sense of presence for the tourist or visitor through the emergent properties of a well designed blend.

In GCVM human actors are positioned at some of the locations telling rich stories about how people lived in the 19th century. We utilized this approach and converted it into a blended method to deliver historical stories, or what we called, heritage storytelling. A heritage story delivers digital content through video characters (digital agents), relevant to the POI where the visitor is standing. The story links the POIs together creating continuity from POI to POI at a historical destination [22]. Heritage stories use the blended spaces framework in the following way.

1. *Ontology*

A collection of themed POIs that is designed to be attractive to a particular visitor demographic (e.g. a schoolchild may be interested in blacksmithing toy heritage),

2. *Topology*

A reason for two or more POIs to be related (e.g. a visitor has to go to the schoolhouse after finding clues to some mystery at the farm shed),

3. *Agency*

A digital character provides motivation to navigate from one POI to another (e.g. a digital agent, has been missing for days and pleads with the visitor for help).

4. *Volatility*

This construct concerns changes in the digital and/or physical space and the speed of those changes. In the case of heritage stories at GCVM, changes occur between seasons, but remain stable for several months.

This framework has been used by designers to design a visitor experience at GCVM [6], [22] and has proved useful in focusing the design on getting a good relationship between the physical and the digital space. The blended spaces framework sensitizes designers to the key constructs that need to be designed in this context and to the relationships between them. In the work reported here we were keen to see how successful the framework could be in helping school age children to design their own heritage stories. The construct of volatility of blended spaces was not required in this context as the stories were developed for a particular time and purpose that was not subject to change.

3. BLENDED SPACES WORKSHOPS

The Mobile Experiences for Tourism Project, funded by New York Council of the Arts, aimed at creating fun interactive mobile experiences for schoolchildren on fieldtrips. Evaluation data highlighted that schoolchildren were eager to create their own heritage stories at GCVM.

The workshops were held at Allendale Columbia School¹ in Rochester, NY. A class of sixteen grade 5 schoolchildren participated in the workshops spanning from January - May 2014. Faculty from Rochester Institute of Technology (RIT) and

¹ <http://allendalecolumbia.org>

Allendale Columbia coordinated the workshops, while masters level HCI students from RIT helped lead the smaller student groups. Curators from GCVI also participated to advise on 19th century culture and lend artifacts to further understand the historical context of the heritage location.

The schoolchildren were mainly tasked with creating a single heritage story over the four workshops. Student groups were required to generate their own story (identifying the main POIs, ontology), the agents (agency) and the rationale behind why a visitor would go from POI to POI (topology). The students were broken down into five groups each consisting of 3-4 students. The goals of the workshops were for schoolchildren to:

1. **Investigate Spaces** (*Workshop 1*) The Schoolchildren learned how to explore the Blended Spaces Framework by contextualizing, generic, digital and physical spaces.
2. **Create Heritage Stories** (*Workshop 2*) The Schoolchildren curated physical locations with digital content by making design decisions based on the ontology, topology and agency of digital and physical spaces.
3. **Perform Augmented Agency** (*Workshop 3*) The schoolchildren performed their heritage stories as digital agents in front of a green screen. Their digital agents were later allocated to POIs based on the context of the heritage story.
4. **Pilot Test Heritage Story** (*workshop 4*) The Schoolchildren pilot tested, “truancy” a heritage story in preparation for a larger evaluation with public schoolchildren. Schoolchildren were responsible for documenting bugs in the digital space against the context of their physical surroundings.

3.1 WORKSHOP 1: INVESTIGATE SPACES

During the Investigation Workshop, RIT students and faculty brainstormed with schoolchildren to uncover what is of interest during a fieldtrip. The workshop introduced basic concepts relating to the blended interaction framework and began organizing content in generic, digital and physical spaces. The groups were given coloured post-it notes and white boards to lay out the concepts. The goal of the workshop was for each group to have at least one basic heritage story concept that they could present to all workshop participants.

The school children had an integral role in ideation during workshop one. The masters students and faculty introduced the general goals and concepts. The RIT faculty demonstrated how all workshop activities were to be conducted by the school students. During workshop one, the school students worked within the framework and ideation process, while the school teachers of the class made sure the students were in line and did not get off task. The school students did 80% of the ideation, while the RIT faculty and staff spent 20% of their time going over the objectives. The RIT masters students and faculty helped refine the ideas throughout all four workshops. The goal of the first workshop was to generate ideas at a very high level. It was not to identify specific places that the children were interested in. This happened in Workshop 2

Generic Space

The students wrote and posted everything that came to mind from past school fieldtrip experiences. Curators from GCVI brought museum artifacts to demo, inspire and share with the students. The students were able to hold and interact with 19th century items, while the curators explained how a butter churn would operate and what tasks a child would have to perform in order to properly make butter for the family or for trade.

The students used their post-it notes to document artifacts such as, wagons, baseball, molten led, sheep shears, etc., places such as the tinsmith, the school house, inn etc., and people, such as teachers, peers and period actors. The schoolchildren began to organize the post-its into physical and digital container with the aid of a heritage storyboard, see Figure 2.

Heritage storyboarding: Physical & Digital Spaces

A heritage storyboard is a template to layout the generic space while thinking about how visitors could move between digital and physical spaces. The heritage storyboard template comprised of a series of empty containers e.g. “Character”, “Place” and “Character Action”. These correspond to the constructs of agency, ontology and topology (how to get from one POI to another POI) in the blended spaces framework, but are easier for schoolchildren to understand. The template starts with the container “character” (digital agent) and immediately followed by a second container “place” (physical location and artifacts). The “character action” container held the interactions and transition between the visitor and the digital agent.

For example, a visitor could meet digital agent X, while in physical location Y. Then the visitor could be driven by the digital character to do action Z. In the context of a heritage story a schoolchild may meet a digital character named Alice at the physical location of the tollbooth. The digital character could inform the visitor that her brother is missing and that she needs the visitor’s help to find him. The digital character asks the visitor to quickly go to her home to speak with her father. This pattern would repeat at every location till the heritage story reaches a conclusion. The summation of these post-its is read from left to right as a narrative.

Workshop 1 Outcomes

The result of the workshops gave researchers insights towards what is important to a schoolchild, and what is not.

For example, when the heritage stories were developed, it was clear that schoolchildren did not focus on historical facts such as,

“The Altay Store was built about 1848 when new owners took over the business. The structure's deep frieze, heavy cornice and pilasters declare its debt to the Greek Revival style.”²

Instead, the schoolchildren were interested in the store's 19th century toys and candy. They also found the building structure interesting, not for its “Greek Revival Style”, but for its unique back yard hiding places. Each student group performed their heritage storyboard in front of the class (figure 3). This enabled the students to narrate their stories and receive feedback from all other workshop participants.



Figure 2: Work-in-Progress heritage storyboard template

The heritage storyboards were aimed to be temporary to allow for iteration and refinement. Photos of different storyboard interactions were taken to create more formal heritage stories in the next workshop.

3.2 WORKSHOP 2: CREATE HERITAGE STORIES

The second workshop was about formalizing the topology, ontology and agency of the blended spaces framework in terms of different stories that would be interesting to schoolchildren. RIT faculty and MS HCI students introduced the framework by getting the schoolchildren to think about three particular questions:

1. *What were the POIs and what did they contain? (ontology)*
2. *What were the potential relationships between POIs? (topology)*
3. *With whom could the visitor interact? (agency)*

The GCVM curator was also invited to provide guidance on culture, norms, lifestyle and artifacts that were used in 19th century New York. Also, the faculty at Allendale Columbia School guided the schoolchildren to have an educational premise and moral to each Heritage Story.

Ontology: What were the POIs and what did they contain?

Schoolchildren started by investigating common experiences at individual POIs. GCVM has rich history and stories associated with each POI. They were able to ask questions concerning what kinds of activities would happen at the farm shed, what the backstory of the unfinished floorboards of the Campbell house was, or where did 19th century children buy toys. Through this process, schoolchildren defined what topics and POIs they were interested in and what POIs had less interest.

Schoolchildren also explored the contents of individual POIs to develop a richer heritage story. For example, were there any physical artifacts such as tools (hammers), simple machines (butter churns), toys (marbles), etc., that could be used to further educate visitors about 19th century living. Depending on the POI, a location may have many opportunities to use physical artifacts to create more compelling stories. There could be a scenario where the visitor is driven inside the schoolhouse to find a small chalkboard tablet “left behind” by the digital agent. The implications of this interaction could change the course of the heritage story if the visitor finds and reads the message on the chalkboard or not.

² <http://www.gcv.org/InteractiveMap/Details.aspx?id=30>

Topology: What were the potential relationships between POIs?

Schoolchildren began to define their heritage stories by paying closer attention to how their storyboard ideas mapped onto maps of GCVM. With the GCVM map, students were able to trace a visitor's potential walking trajectory going from POI to POI. They began asking themselves and the GCVM curator questions about life in the 19th century such as why a blacksmith would collaborate with a farmer, what kinds of responsibilities would a 10 year-old girl have at home or what did children do for fun at a potter's shop. Through uncovering the answers to these types of questions, the schoolchildren began to create reasons towards why a visitor would go from POI to POI and hence develop the topology of the heritage story.

The schoolchildren would evaluate the topology of POIs by looking at a map. They could ask questions concerning any physical barriers such as fences between two POIs. They could also critique historical accuracy that could impact integrity of the museum and visitor experience. Depending on how the POIs related to the map, a visitor experiencing the pioneer settlement could incorrectly receive information if the visitor was forced to walk through the Victorian village while on a pioneer heritage story. Also, RIT students could give feedback if there were some technical aspects of the topology of the digital space that needed to be considered. For example if POIs were too close together e.g. within 15 feet, our GPS technology would not be able to properly deliver proper digital agents to the visitor.

Agency: With whom, could the visitor interact?

The schoolchildren began to create digital agents that would aid in guiding a visitor from POI to POI. These agents were designed to deliver content in an appropriate manner for school children, while building another level of experience for a visitor exploring a heritage destination. Agents were displayed on a smartphone in front of the user when the context of the location matches the content of the heritage story.

Agents could play either a major or minor role. We created two distinct types of agents, "Leading Agents" and "Supporting Agents". "Leading Agents" are concerned with being the subject of the main heritage story. They often introduce themselves, ask for assistance and give the user direct guidance or goals. Leading Agents were essential to the heritage story. The visitor must interact with all Leading Agents to make sense of and complete a particular tour. "Supporting Agents", on the other hand, are concerned with giving subtle clues to maintain visitor's walking trajectory [3] if they wander off course. Overall these agents are designed to add another layer of supporting information to the heritage story. The visitor does not have to interact with Supporting Agents to gain the essential message of the heritage story. Since Supporting Agents are not a mandatory component of the heritage story experience, not all groups employed them.

Workshop 2 Outcomes



Figure 3. Presenting heritage stories

The results of the workshop were five story concepts and rough storyboards each of which represented a heritage story. Each group presented their heritage story in front of a large projected map of GCVM, see Figure 3. Each story mapped out the collective POI rational (ontology), why a visitor would go to and from POIs (topology), and who would guide a visitor (agency). The heritage stories were:

“Missing Schoolchildren” (Group A) *Premise:* A brother and sister are not at school but are missing from school. *Moral of the Story:* Helping the community came before education.

“Truancy” (Group B) *Premise:* Circumstances keep a boy from getting the most out of his school day. *Moral of the Story:* Children valued and desired the opportunity to get an education.

“A Birthday Surprise” (Group C) *Premise:* A girl is kept busy looking for her little brother who, it turns out was busy preparing a birthday surprise for her. *Story Moral -* Don't rush to conclusions!

“Albert's Missing Marbles” (Group D) *Premise:* A comic 19th century to 21st pun on “losing your marbles”. *Moral of the Story:* Don't go crazy looking for something.

“A Reward for Helpfulness” (Group E) Premise: A girl runs several difficult errands for her mother.
Moral of the Story: Children can have extreme responsibilities.

All groups created their heritage stories in a series of hand drawn sketches and short notes. Home assignments were given to the schoolchildren whereby each student had to select a section of a storyboard and write a script for the digital agent. The Allendale Columbia teachers assisted in shaping, correcting and polishing the scripts. This exercise helped to set a stage for the following workshop, which required students to have the scripts somewhat memorized and ready for video production workshop.

3.3 WORKSHOP 3: PERFORM AUGMENTED AGENCY

The third workshop focused around agency of the Blended Spaces Framework. Since there were five heritage stories, this workshop took two schooldays to produce. The purpose of the workshop was to teach the schoolchildren how to think of themselves as digital agents at each POI.

Each child was provided with a 19th century costume provided by GCVI, to fit his/her role in the story. GCVI curators helped to coach schoolchildren to use proper 19th century vernacular. The video director coached each schoolchild to deliver emotion and energy suitable for each character agent such as the angry school teacher or the heckling classmate. Script lengths need to be short, around 30-60 seconds, due to both the limited 3G/4G services at GCVI and the visitor’s video watching attention span whilst standing at a heritage location. We also needed to ensure that what was actually said was historically accurate, and delivered interesting information.

In front of a green screen, see Figure 4, schoolchildren were the agents of their own heritage stories and had to act out their character scripts. This activity forced the schoolchildren to evaluate their script, their messaging in context to their character in real time. The schoolchildren had to think hard about how they envision their digital selves curated the physical POIs at a heritage location.



Figure 4. Schoolchildren Performing Augmented Agents

The schoolchildren had to create a script that not only included topological information such as what to do next but also included elements of historical content. For example, a schoolchild acted out the town’s Potter (Albert’s Father); from the heritage story “*Albert’s Missing Marbles*”:

Potter: “So, you’re looking for my son, Albert? I think he went to the Altay store. When I have bits of leftover clay, I let Albert make marbles after he loses his. I am trying to get him to learn about clay and glazes. He was just here collecting the batch that came out of the kiln this morning. I’m not sure if he was going to play with them or barter with Mr Altay. All the boys in town sure do like playing marbles, even though they lose their marbles all the time. I suppose if you want to find Albert, I suggest going to the Altay Store.”

This example of acted agency, describes how the visitor could learn about what to do next while learning a bit about 19th marbles; they were clay, and fired in a kiln. Also, the visitor can learn that marbles was a very popular toy in the 19th century. The script also tries to tie in some humour that only 21st century visitors could understand; they (boys) lose their marbles all the time. Although the metaphor of *losing one’s marbles* was not known in the 19th century, this metaphor is used throughout the story of “*Albert’s Missing Marbles*”.

Workshop 3 Outcomes

The results of the two video production sessions were five heritage stories with 5-10 schoolchildren agents in each story, see figure 5. After the videos and audio files were produced and exported for mobile streaming, RIT students uploaded the

content into our content management system (CMS). The RIT students created geo-fences at GCVN and assigned each video to trigger at each corresponding POI.



Figure 5. Schoolchildren as augmented agents

3.4 WORKSHOP 4: PILOT TEST HERITAGE STORY

The fourth workshop focused on preparing for the evaluation. The workshop was broken down into three sessions. The first session was piloting the prototype with the heritage story. The second was a general debugging discussion session. The third session was a Likert survey creation session. The formal evaluation, discussed in section 4, will describe how public school children responded to the heritage stories created by the students from Allendale Columbia school.

Although there were five heritage stories to choose from, we only had time to pilot test and evaluate one story. The purpose of the workshop was to give schoolchildren experiences in evaluating their design choices as they curated physical locations within themselves as digital agents. Furthermore, the workshop intended to work out any technical bugs and evaluate if each digital agent triggered in the right sequence and at the correct POI within the context of their heritage story. We choose the Heritage Story “*Truancy*” from Group B.

Pilot Testing “*Truancy*”

The premise of the story revolves around the daily responsibilities that kept a boy from getting the most out of his school day. In the 19th century, children valued and desired the opportunity to get an education, while the social expectation for schooling was 6th grade for girls and 8th grade for boys. The story puts the visitor in the shoes of a 19th century schoolchild. The visitor must first go to Jimmy’s house so that they can go to the schoolhouse together. The visitor finds out that Jimmy has already left his home and the visitor must find his way alone. The visitor is directed from one POI to the next POI by a compass in the user interface that shows direction and distance of the next POI. As soon as the visitor enters the geo-location surrounding a POI their smartphone vibrates. Lifting the smartphone into the vertical position should display the relevant video or audio content associated with that POI. Along the way, the visitor becomes distracted, heckled and learns that the social norms around a 19th century education are very different than those of today. We choose this heritage story for educational content and for its method of using agency to influence the topological trajectory of walking visitors, see Figure 6.

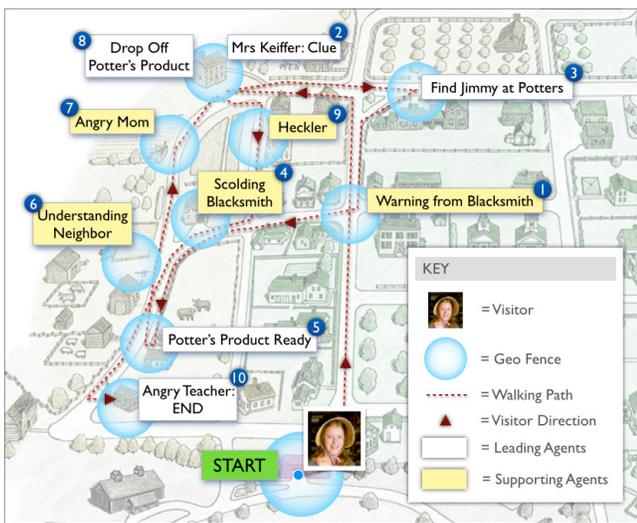


Figure 6. Map visualization of “truancy”

Each number in the list below correlates to the number on the map above, see figure 6. Each number below calls out the agent type, the agent character, where the visitor is and what kind of general comment is provided by the agent.

1. Supporting Agent = Blacksmith | Place = Street | Comment = You are late for school!
2. Leading Agent = Mrs Keiffer | Place = Keiffer House | Character Action = Find Jimmy
3. Leading Agent = Jimmy | Place = Potters | Character Action = Lets go to school
4. Supporting Agent = Blacksmith | Place = Blacksmith | Comment = Hey! Get to school!
5. Leading Agent = Alice | Place = Street near school | Character Action = Run an Errand.
6. Supporting Agent = Farmer | Place = Pioneer House | Comment = Do your chores
7. Supporting Agent = Mom | Place = Street | Comment = Why aren't you in School?
8. Leading Agent = Mrs Keiffer | Place = Keiffer House | Character Action = Chore Done
9. Supporting Agent = Heckling Kid | Place = Street | Comment = Yes, skipping school!
10. Leading Agent = Mrs Crabapple | Place = Schoolhouse | Character Action = Get in!

Six schoolchildren from group B participated in the formative evaluation, or pilot study, see Figure 7. The schoolchildren were tasked with using the mobile prototype to select their heritage story and walk through GCV. When they arrived at a POI, and crossed a geo-fence, the mobile device vibrated to inform them that an agent was present and ready to give them information. Although all video files were correctly triggered at their respective geo-locations, none of videos successfully loaded on the screen. The audio of the video was the only media element that was loaded while at a geo-location. The schoolchildren were at first frustrated, however, they realized their experience was typical of prototyping and evaluating designs in the field.



Figure 7: Schoolchildren pilot testing their heritage story

After the heritage story was completed, we had a session devoted to discussing bugs. We held a focus group to allow the schoolchildren to share their experiences, including identifying problems and ways of solving them. The schoolchildren were keen to try to understand why their heritage story only had audio at each POI.

Workshop 4 Outcomes

We used the 19th century schoolhouse as a schoolhouse, see figure 8. The schoolchildren sat with their tablets (hand held chalk boards) while faculty began to explain the notion of geo-fences and why we may be running into problems.



Figure 8: Debugging apps with 19th century tablets

We uncovered a number of reasons why our video content was not playing with our hand-held chalkboards. We proposed a list of potential bugs that could be related to 4G video streaming issues including the distance from 4G towers, servers may have been slow, the GPS coordinate was off by 15-20 feet, problems with the iOS code, a geo-fence was too small or the video mp4 format could be corrupted.

After collecting these possibilities we began to discuss them in more detail and the students concluded that problems may be around 4G video streaming, 4G quality and problems with iOS code. The conclusions were brought to our development team and they confirmed that the biggest problem was with the iOS code. The development teams fixed the bugs and tweaked other issues that were uncovered including some geo-fences that needed to be placed more accurately, smaller MP4s led to better video streaming and portrait formatted videos played better in our UI compared to horizontally formatted videos. The overall results of the pilot test gave schoolchildren first hand experiences debugging mobile user experiences at heritage locations.

3.5 CREATING EVALUATION MATERIALS

After the debugging session, faculty led a session around creating high-level survey materials for a formal blended spaces evaluation the following week. We categorized our survey based on the blended spaces framework, heritage story (ontology), digital characters (agency) and navigation (topology). The blended spaces framework can guide the evaluation but does not prescribe a series of questions. As with other aspects of the design, the survey was developed in the spirit of co-design. Thus it was felt that we did not want to focus specifically on the appropriateness of the POIs, but wanted to focused on the overall experience of the heritage story, the elements of the story itself and the blended spaces experience. We also focused on aspects of the user interface, particularly the compass as a navigation method. We wrote a series of statements for a Likert survey (Strongly Agree, Agree, Neutral, Disagree and Strongly Disagree) using a mixture of positive and negative statements.

We evaluated ontology as the overarching heritage story or “digital story”. We choose “digital story” for the survey because it was quickly understandable by the participants as compared to “heritage story”. After some interactions with the schoolchildren and RIT students and faculty we created the following statements relating to the ontology of the story as a whole.

- A. The digital story helped me learn about how life would have been like in the 19th century.
- B. I would prefer a museum map instead of interactive digital story.
- C. I would prefer a human tour guide instead of interactive digital story.
- D. The digital story was fun and engaging.
- E. The digital story was too long.

We evaluated topology as the movement and navigation between POIs. After some interactions with the schoolchildren and RIT students and faculty we created the following statements relating to topology.

- A. The compass helped me move from place to place.
- B. I was constantly looking at the mobile device.
- C. I would have preferred a map to a mobile compass for navigation.
- D. I felt as if I was part of the village.
- E. The blacksmith directed me to go to school.
- F. After meeting the character by the drugstore, I felt rushed to return to school.

We evaluated agency through the digital agents that the visitor could meet at each POI. In this study the private schoolchildren were the participants of a heritage story created by RIT students and faculty. After some interactions with the schoolchildren and RIT students and faculty we created the following statements relating to agency.

- A. The Digital character helped me understand life in the 19th century.
- B. I thought digital characters were fun and engaging.
- C. Digital characters gave me enough information to move from location to location.
- D. I felt as if digital characters were in front of me and were a part of the location.
- E. I felt concerned about Jimmy at some point.
- F. I felt rushed to go back to school by the Blacksmith.

- G. The farmer sympathised with me regarding school and my chores.
- H. At the tollbooth entrance, I felt there was an urgent need to go to Jimmy’s house.
- I. At the drugstore I was reminded of the importance of going to school on time.

3.6 SUMMARY

The schoolchildren of Allendale Columbia School became the designers of their own mobile experiences by participating in four interaction design workshops modeled after the blended spaces framework. The fifth grade class was tasked to design blended mobile experiences for other public school children, which forced them to think carefully about how to curate physical locations with their own digital augmented characters. We recorded the schoolchildren in front of a green screen so that they could tell their own heritage stories as a visitor moves from location to location at Genesee Country Village and Museum. The outcomes of all four workshops gave us insights towards how to not only design blended spaces with and for schoolchildren, but also how to teach complex theoretical design methodologies that enable schoolchildren to become the designers of blended spaces. The experience of prototyping and evaluating technology in the field gave them a unique insight into the range of issues that designers and implementers face. The fact that year 5 students can discuss issues surrounding 4G streaming video says much about digital literacy in the 21st century.

4. EVALUATING BLENDED SPACES

The summative evaluation consisted of 16 schoolchildren participants averaging ten years-of-age from a public school in Syracuse, NY. Eight of the schoolchildren had visited GCVM previously. When asked about their knowledge using a smartphone, ten schoolchildren had experience of using one, while six students owned an iPhone.

Upon arrival, the participants were directed to a ‘reporting desk’ where all the evaluation materials were collected. Each participant handed in a signed parental consent form. Participants were organized into groups of three and were assigned a timeslot. Each evaluation session encompassed; signing a consent form, responding to a pre-survey, giving a prototype tutorial, testing the prototype (~25 minutes) and responding to a post-survey on a tablet device. The entire evaluation session took about an hour.

After timeslot assignment, the 1st group started the evaluation session, while other groups continued on their other GCVM activities scheduled for the day. Teachers had the public schoolchildren report to the desk according to their given timeslots. While the participants used the prototype, we had one researcher shadow the group for observational study. After completing the post-survey each participant received a \$10 GCVM gift certificate.

Evaluating Ontology

We evaluated ontology using a high level Likert scale survey that looked at the relationship between the heritage story and other high level discussion topics such as maps, human tour guides and overall learning as described in Section 3.5. Figure 9 shows the results for the five questions concerning ontology.

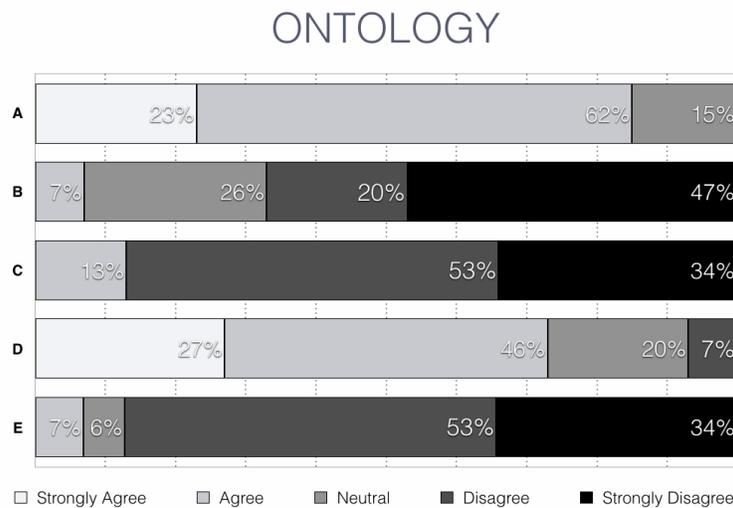


Figure 9. Results from ontology questions

Results

Question A focused on the effectiveness of the heritage story and 85% either agreed or strongly agreed that the digital story helped them learn about 19th century life, while 15% were neutral. The majority were also in favour of a museum map over an interactive digital story (question B), though one of the participants disagreed. Similarly the great majority (87%) indicated that they would not have preferred a human guide (question C) to the app and that the overall experience was fun and engaging question D. The response to question E indicated that the experience was not too long for the majority (87%) of participants.

Evaluating Topology

We evaluated Topology using a Likert scale to look at how schoolchildren were able to navigate from one POI to another. We wanted to know more about how participants viewed themselves by experiencing heritage stories and how they interacted with the device. The results are presented in Figure 10.

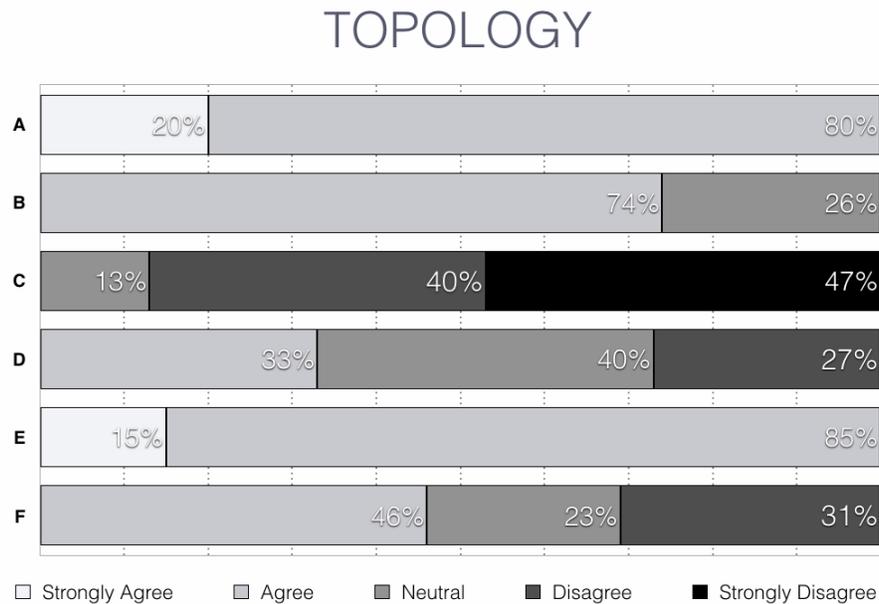


Figure 10. Results from topology questions

Results

All the participants agreed that the compass helped them move from place to place (question A), though this meant that felt that they were constantly looking at the mobile device (question B). However, question C indicated that the app and the compass interface was preferred to a traditional map. The sense of presence in the village was explored in question D and provided mixed results with no strong feelings. In terms of the characters, the Blacksmith directed them to go to school (question E) but the digital character by the drugstore was less effective as a character (question F).

Evaluating Agency

We evaluated agency using a Likert scale to look at how schoolchildren engaged with the characters in the story. We wanted to know more about how participants viewed themselves by experiencing Heritage Stories and how interacted with the device. Figure 11 shows the results.

AGENCY

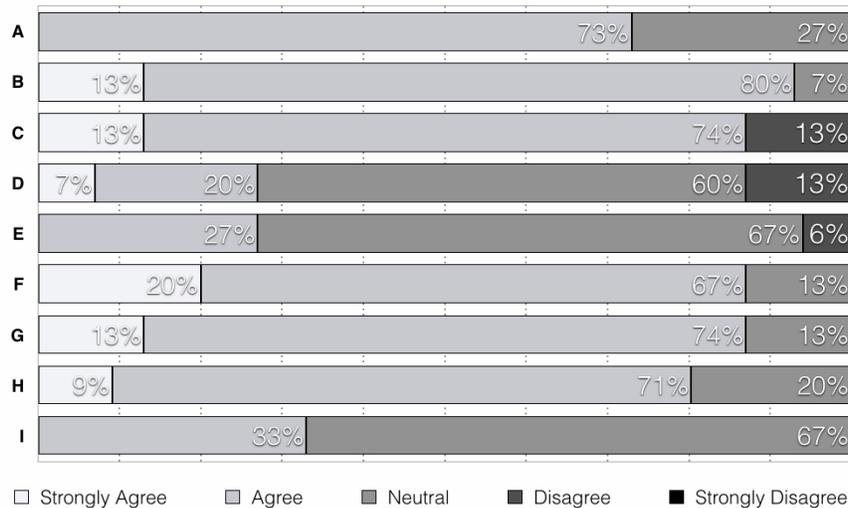


Figure 12. Results from agency questions

Results

A good majority (73%) agreed that digital characters played an important part into understanding of life in 19th century, and 15 out of the 16 agreed that the digital characters were fun and engaging with 87% supporting the statement (question C) that the digital characters gave them enough information to move from POI to POI, while 13% disagreed. Again the sense of presence evoked by the characters were less convincing with 60% responding in a neutral fashion to question D that asked if the digital characters were in front of the participants and a part of the location. In terms of the specific characters, question E asked if they were concerned about the digital character Jimmy and 67% remained neutral however, once again the great majority (87%) they felt rushed to go back to school by the Blacksmith. Questions G and H indicated that these characters were well received, but the overall moral of the story - the importance of going to school on time – was not widely understood, with 67% remaining neutral to question I.

5. DISCUSSION

The experience of using the blended spaces framework as a cooperative design technique has clearly proved effective. Schoolchildren aged just 10 years old are able to conceptualize, design, create and evaluate a blended space experience that other children clearly think is really quite good and better than traditional, non-interactive approaches to learning whilst on a school fieldtrip. The final evaluation suggests that the concepts in the blended spaces framework are useful and effective in focusing attention on key aspects of the tourism experience, namely the POIs, the navigation between them and the digital characters augmenting the physical space. The evaluation also demonstrates that the framework has helped the schoolchildren to frame their own ideas into an appropriate structure for heritage storytelling.

Schoolchildren at Allendale Columbia School received hands on experiences moving through the blended spaces framework from conception to experiencing their own blended spaces. This engagement with real world activities such as the design and implementation of heritage stories is an important part of their approach to ‘authentic learning’. This is the idea that learning should be embedded in real world activities and that children should engage in social learning across other communities. Designing experiences for children from other schools demonstrates exactly this mix of cooperative learning in an authentic environment.

The blended spaces framework has also helped to structure an approach to co-design and collaborative design. Druin [12] originally proposed a co-design approach to working with children in 1999, called cooperative inquiry and over the years this and varieties of the approach have been successfully applied in many circumstances [14]. Clearly school children are capable of co-design and of understanding and engaging with the design process. The analysis in [14] points to some of the many reasons why children should be involved in design. Our experiences confirm this with many ideas coming from the children that would be unlikely to be suggested by adults. One of the young co-designers reported in [14] says of working with adults “You just have to be patient with them, since they only know what adults know.” The blended spaces framework adds a structure to a general co-design method such as cooperative inquiry that is focused on delivering mixed reality experiences.

In more general terms the blended spaces framework helps designers to understand the correspondences between physical and digital spaces and on where the anchor points [3] between the two should be. At GCVM the anchor points that brought the physical and digital spaces together were provided by geo-fences, though as we have seen making these an appropriate size is important for providing a good UX. Focusing on the anchor will suggest unobtrusive ways in which the transition between physical and digital can be made, that in turn provides a good trajectory through the overall space [2]. Taken with the principles of designing with blends in general [16] leads to an effective, reflective approach to designing mixed reality experiences.

In more general terms designers should think about the overall experience of the blended space that they are trying to achieve and decide on the activities and content that will enable people to experience the blended space. They need to decide on the digital content and its relationship with the physical space in terms of the ontology, topology, volatility and agency of the digital and physical spaces. They need to do the physical design of the digital and physical spaces, considering the user interfaces and individual interactions, the social interactions (that combine people, practices, values and technologies within a local environment), the flow (movement through the blended space) and the physical environment [3]. In the case of heritage stories for children at GCVM the blended space aimed at achieving an enjoyable experience that taught students about life in the 19th century and that included some moral message. The experience aimed to be a suitable length for the visitors and to be engaging and the evaluation suggested that this was broadly achieved.

Designers need to consider how to make people aware that there is digital content nearby, how to help people navigate in both physical and digital worlds; how to navigate to the portals that link the spaces. In the GCVM setting the smartphone vibrated to indicate the existence of content, lifting it into a vertical position displayed the content and returning it to a horizontal position displayed the compass interface to direct them to the next POI. Designers should design to avoid sudden jumps or abrupt changes as these will cause a break in presence, or the overall flow of the experience. Designers should aim at creating narratives to steer people through the blended space and to effortlessly access and interact with content. Importantly they should aim at designing at the human scale rather than the technological scale to provide the multi-layered and multimedia experience that weave the digital and physical spaces together. In the case of heritage stories at GCVM we used geo-fences to trigger and deliver content relevant to a particular POI and a compass user interface that directed visitors from one POI to the next.

CONCLUSION

The concept of blended space offers a simple, but powerful way into developing the new swathe of mixed reality experiences that interaction designers will be developing. Blended spaces mean that people have an extended presence; from their physical location into digital worlds. The examples we have explored here make use of traditional digital content such as audio and video, but soon we will be taking people into highly realistic digital spaces when it becomes difficult to tell real from digital. The blended spaces framework aims to characterize the correspondences between physical and digital spaces so that designers can consider their relationships and design for an experience of the blended space itself. Here we have seen how this framework also can be used to structure co-design workshops, making it possible for schoolchildren to conceptualize a blended space experience.

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REFERENCES

1. Benford, C. Greenhalgh, G. Reynard and B. Kolva Understanding and constructing shared spaces with mixed-reality boundaries *Transactions on Computer-Human Interaction (TOCHI)* , Volume 5 Issue 3 1998
2. Benford, G. Giannachi, B. Kolva and T. Rodden. From interaction to trajectories: designing coherent journeys through user experiences. In *Proc. CHI 2009*. ACM Press 2009, pp. 709-718.
3. Benyon, D. R. *Spaces of Interaction, Places for Experience*. Morgan and Claypool. 2014
4. Benyon, D. R. and Mival, O. Designing Blended Spaces. In *Proceedings of Designing Collaborative interactive Spaces*. AVI Workshop, Capri, May 2012
5. Benyon, D. R., Presence in Blended Spaces. *Interacting with Computers* 24 (4) 2012, pp. 219 - 226
6. Benyon, D., O'Keefe, B., & Mival, O. A Blended Space for Tourism: Genesee Country Village & Museum. *Proceedings CHI 2013 Blend13 Workshop*, 2013.
7. Benyon, D., Quigley, A., O'Keefe, B., & Riva, G. Presence and Digital Tourism. *AI & Society* 29, 2014, pp. 521 - 529
8. Blythe M., Reid, J., Wright, P. and Geelhoed, E. Interdisciplinary Criticism: Analysing the Experience of Riot! A Location-Sensitive Digital Narrative, *Behaviour and Information Technology*, vol. 25, no. 2, 2006, pp. 127-139.

9. Cabrera, J. S., Frutos, H. M., Stoica, A. G., Avouris, N., Dimitriadis, Y., Fiotakis, G., and Liveri, K. D. Mystery in the museum: collaborative learning activities using handheld devices. In *Proc. MobileHCI 2005*. ACM Press (2005), 315-318
10. Cheverst, K. Mitchell, K. & Davies, N. 2002. Exploring Context-aware Information Push. *Personal Ubiquitous Comput.* 6, 4, January 2002, 276-281
11. Cheverst, K., Davies, N., Mitchell, K., Friday, A., & Efstratiou, C. (2000). Developing Context-Aware Electronic Tourist Guide: Some Issues and Experiences. 17-24. CHI 2000
12. Druin, A., Cooperative inquiry: developing new technologies for children with children, in: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems: The CHI is the Limit*, 1999, pp. 592–599..
13. Fauconnier, G. and Turner, M. *The Way We Think*. Basic Books, NY, USA, 2002.
14. Guha, M. L., Druin, A. and Fails, J. A. Cooperative Inquiry revisited: Reflections of the past and guidelines for the future of intergenerational co-design. *International Journal of Child Computer interaction* vol 1 no 1 2013 pp. 14 - 23
15. Hoshi, K. and J. Waterworth, J. Designing Blended Reality Space: Conceptual Foundations and Applications. *Proceedings of British HCI conference HCI2011*, 2011
16. Imaz M. and Benyon, D. *Designing with Blends*. MIT Press, Cambridge, MA, USA, 2005.
17. Ishii, H. and Ulmer, Tangible Bits: towards seamless interfaces between people, bits and atoms. *Proceedings of CHI 97 conference* Atlanta ACM Press, New York. 234-241 . (1997)
18. Jetter, H-C, Geyer, F., Schwarz, T., Reiterer, H. Blended Interaction – Toward a Framework for the Design of Interactive Spaces In *Proceedings of Designing Collaborative interactive Spaces*. AVI Workshop, Capri, May, 2012
19. Lieberman, H. and Selker, T. Out of Context: *IBM Systems Journal* 39 (3, 4), 2000
20. Milgram, P. and Kishino, F.. A taxonomy of mixed reality visual displays. *IEICE Trans. Inf. Syst. E77-D*, 12 1994
21. O’Hara, K., Kjelsko J., and Paay J., Blended Interaction Spaces for Distributed Team Collaboration *ACM Transactions on Computer-Human Interaction*, Vol. 18, No. 1, 2011
22. O’Keefe, B., Benyon, D., Chandwani, G., Menon, D., Duke, R. A Blended Space for Heritage Storytelling. In *Proc BritishHCI 2014*. BCS Press 2014, pp. 1-10.
23. O’Keefe, B., Slutsky, B., Iuliucci, N., Nalbandian, A., Thanedar, A., Mokey, S., and Mival, O. Mobile Experiences for Tourism: Brick City Tours. *Ext. Abstracts CHI 2013*. ACM Press 2013, pp. 1413-1418.
24. Rocchi, C., Stock O., Zancanaro, M., Kruppa, M., and Krüger, A. The museum visit: generating seamless personalized presentations on multiple devices. In *Proc. IUI 2004*. ACM Press 2004, pp. 316-318
25. Schering, A., Dueffer, M., Finger, A. and Bruder, I. A mobile tourist assistance and recommendation system based on complex networks. In *Proc. CNIKM 2009*. ACM Press 2009, pp. 81-84.
26. Stenton, S. P., R. Hull, P. M. Goddi, J. E. Reid, B. J. Clayton, T. J. Melamed and S. Wee Mediascapes: Context-Aware Multimedia Experiences. *IEEE Multimedia* 14(3), 2007, pp. 98 - 105.
27. Wagner, W. Broll, G. Jacucci, K. Kuutii, R. McCall, A. Morrison, D. Schmalstieg, J. Terrin On the role of Presence in Mixed Reality. *Presence: Teleoperators and Virtual Environments*, 18(9), 249 - 276. (2009)