Exploring Methodologies for Designing a Virtual Reality Library for Children

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Abstract
Various methodologies have been proposed to design technologies for children in partnership with children. In this paper, we investigate the degree of involvement of children in designing a novel virtual reality application. During the course of three iterations, we involved children in the design process using Informant Design and Informant-Bonded Design methodologies. We conclude that in the case of a novel application, children's participation may be limited at the initial stages of the design process, but their input is invaluable at the later stages, using mixed methodologies.

1. Introduction

Designing any type of computer interface for children and young adults is challenging. Traditionally, software developers have involved end-users in various stages of the design process, using a variety of methodologies. Involving children in the design process, however, has proven controversial. A number of researchers, nevertheless, have worked in partnership with children to develop new software or web portals (see for example, Bilal & Wang, 2005, Druin, 2002, Hanna et al., 1999, Large et al., 2004).

Designing a virtual reality[*] environment is demanding, particularly one aimed at children and young adults. While researchers have proposed several methodologies for creating software and web applications for children in collaboration with children (see Section 2 for details), none has reported or discussed any participatory methodologies aimed at designing a VR environment for this group of users. We report here on the design methodology used to develop the VRLibrary, an alternative interface for children's web portals. The objective of the VRLibrary is to assist children and young adults in browsing information available on the web for educational projects. The application of a virtual reality system for retrieval purposes is based on the assumption that a

[*] Throughout this paper, Virtual Reality (VR) refers to desktop-based virtual reality applications, where the environment is projected on a monitor screen, and the environment is none immersive.

novel interface can create an *engaging* and motivating environment, where children can retrieve information effectively.

In the following sections, we describe briefly several methodologies reported in the literature, and then proceed to describe the methodologies that were utilized in designing the VRLibrary. The last section includes a discussion of the methodologies, our conclusions and recommendation for future research in this area.

2. Spectrum of Methodologies

Over the last decade or so, several different methodologies have been proposed and tested for involving children in the interface and system design process. Figure 1 shows the spectrum of the methodologies, classified from the lowest to the highest degree of user participation (Large et al, 2006; Nesset & Large, 2004).

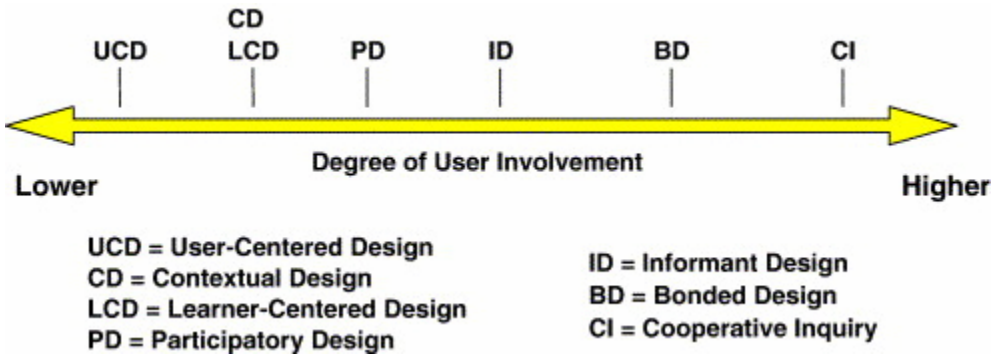

Figure 1. Design methodology spectrum

Seven methodologies have been identified:

i. User-Centered Design: the most conventional approach, user-centered design involves users at the very last stage of the process, where it attempts to measure the impact of technology on users. Observation, transaction logs, surveys, and interviews are used to record users' reactions. Since users have very limited involvement in the design process, technology can be developed relatively quickly, making this methodology advantageous for the producers.

ii. Contextual Design: researchers collect data in the field, by observing and recording the real, everyday activities of the users. These data are then utilized to construct low-tech prototypes, in most cases on paper, which are tested with users through an iteration process.

iii. Learner-centered Design: the main focus of this methodology is to adapt the design to the interests and knowledge of the learners. It is assumed that everyone is a learner, professional and students alike, and the design is to motivate and support them in learning.

iv. Participatory Design: low-tech prototypes are developed based on user input as peer co-designers (Fleming, 1998). Users participating in this methodology are viewed to be the best qualified to determine the role of technology in improving their work.

v. Informant Design attempts to maximize participants' input at various stages of the design process (Scaife & Rogers, 1999). Participants are viewed as informants, who can help researchers fill their knowledge gaps. Whereas in the User-Centered Design, participants are involved only as evaluators, and in the Participatory Design they are viewed as equal partners as professional, Informant Design allows interjections by the users at crucial stages of the design process.

vi. Bonded Design was first proposed by Large et al (2006) and was used in the design and development of *History Trek* (http://www.historytrek.ca), and subsequently several other applications. It follows a model that is related to Cooperative Inquiry (see below) and where the adults provide expertise in human-computer interaction and the children provide expertise on the cognitive, physical and affective states of children. The methodology emphasizes an intergenerational partnership in working towards a common goal. It suggest that children should play an active role in design rather than merely being evaluators or testers at the end of the design process. It does question, however, the nature of the cooperation between adults and children within the team. In this respect it shares some of Scaife and his colleagues' reservations concerning the extent to which true equality can exist within an intergenerational team.

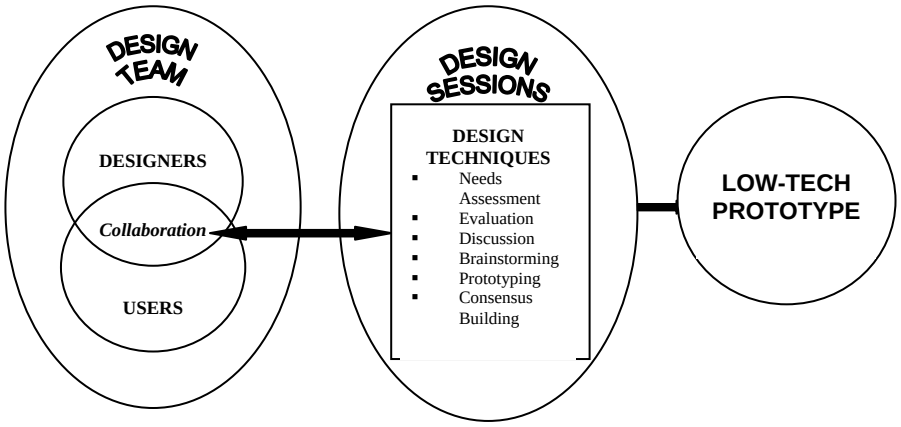

Figure 2. Bonded Design Model

vii. Cooperative Inquiry, developed by Druin (1999), combines various techniques and involves children as equal partners in an intergenerational team. The design team uses contextual inquiry methods to capture users' tasks, roles, and

design ideas. The team begins with simple low-tech design of everyday objects to make children comfortable in participating as critics, designers and inventors.

Involving children in the design team is a recent phenomenon, which is now beginning to be accepted (Nesset & Large, 2004). While most methods including User-Centered, Contextual, Informant, and Learner-Centered use children only when their input is needed, Bonded Design and Cooperative Inquire involve children from the first stages of the design to testing the final product.

3. Designing the VRLibrary

The VRLibrary is related to another project, the objective of which was to design and develop a portal for grade-six elementary school students to help them find information for their class assignments and projects (Large et al, 2004). The topic of the portal is Canadian history. An intergenerational team using the Bonded Design methodology as its framework was formed to conceive the portal. The portal originally designed on paper, was later modified and developed into an operational portal: *History Trek*. A database of approximately 2500 links to web sites in English, French or both, deemed to be appropriate in content and language for elementary students and on Canadian history was created. The portal is aimed mainly at grade-six students who are interested in finding web-based information about Canadian history.

During one of the sessions conducted during the design of History Trek, the idea of designing a novel, desktop-based VR interface based primarily on first-person VR computer games was discussed by the team of adults and children. Based on earlier research on the use of familiar metaphors, browsing, and visualization techniques, we were primarily interested in provoking the students to engage in debate and brainstorming on a different and non-conventional approach to designing a portal for children. All but one student were extremely enthusiastic about such an approach. All agreed, however, that in order to meet the needs and requirements of all users the VR interface should complement rather than replace any conventional portal interfaces. During this session, and following the same Bonded Design procedures as used in the other sessions during which *History Trek was created*, we asked the children to express through drawings *their* ideas for a new interface in a VR-like environment . Figures 3 and 4 are two sample drawings that emerged from this process.

Figure 3. Sample drawing of one of the participants

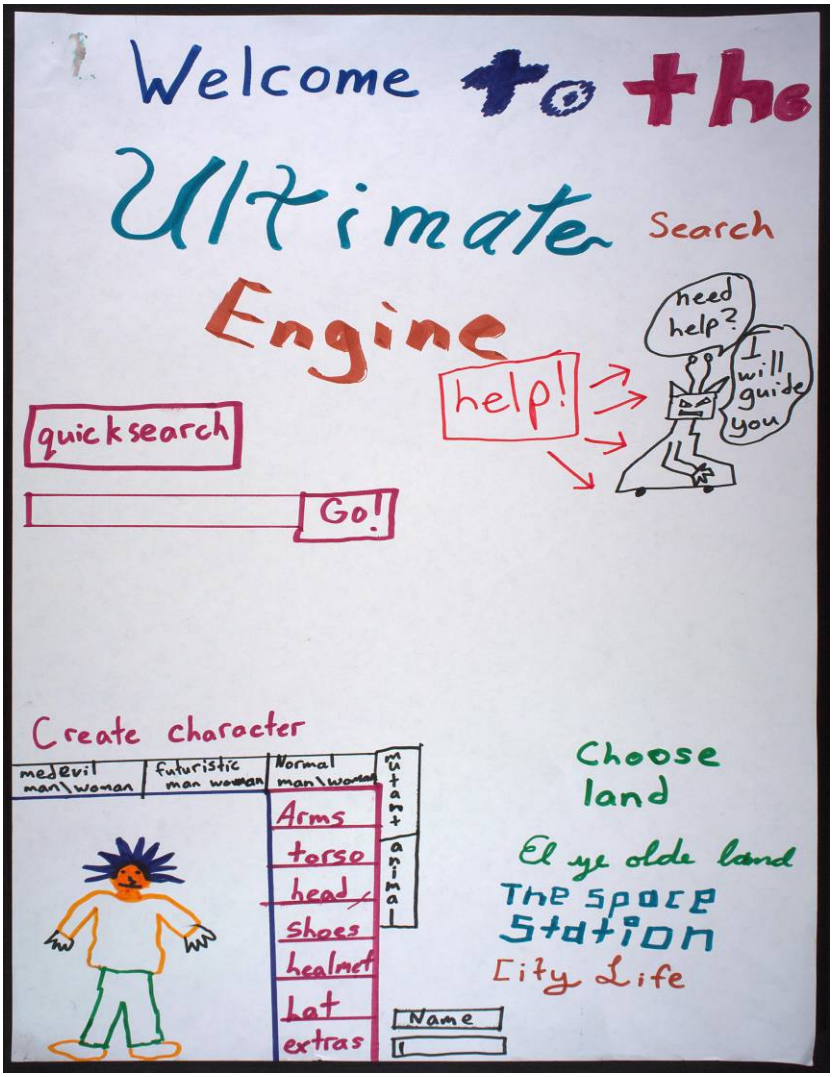

Figure 4. Sample drawing of one of the participants

As Figures 3 and 4 show, children were imaginative. Each drawing contains elements of a conventional portal, for example email and chat rooms, a help feature, and keyword or alphabetic searching. In addition, both drawings contain elements that are not normally associated with a conventional web portal, such as an option for the user to search for categorized information, based on a timeline of 'past', 'present', and 'future' explicitly as in Figure 3, or implicitly as in Figure 4 ('Choose Land', 'Space Station'). The first drawing also alludes to a 'Library' the purpose of which was not made clear by the child. The second drawing introduces a new element: the Avatar. The user can choose and personalize an avatar character.

While all the drawings were creative, the children could not fully envisage the concept of applying a VR interface to navigate the web in search of information. In the VR interface, rather as in a computer game, users would explore the web by moving through virtual space. In fact, adults may have difficulty with the same concept, as very few examples of VR applications for retrieval purposes exist, and those mainly are designed for specific domains. (see for example: Polys & Bowman, 2004) It is generally understood that neither children nor adults can contribute to, or evaluate an innovation since this requires them to imagine something they have not experienced (Norman, 2004, p71). Since the children could not contribute effectively to the design process using the Bonded Design methodology, we began exploring other methodologies for developing a VR interface.

As the first step, we designed a VR library prototype, referred to as VRLibrary, based on previous research on the presentation of books and bookshelves in a 2D environment (Beheshti, 1992; Beheshti, Large, Bialek, 1996). The VRLibrary was constructed using the metaphor of a physical library with rooms, bookcases and books (Figure 5). The user, just as in a physical library, can walk around the library, move from room to room, move among the bookcases, scan the titles of books that are arranged on the bookshelves, select individual books, and open them. The difference is that the library and its rooms are virtual, and the books actually represent websites; when a book is "opened" it displays the contents of the web site in a window on the computer screen. We chose the library metaphor because young people are acquainted with traditional libraries, and we could capitalize on the navigational affordances of recognized artefacts (Beheshti, Large & Julian, 2005).

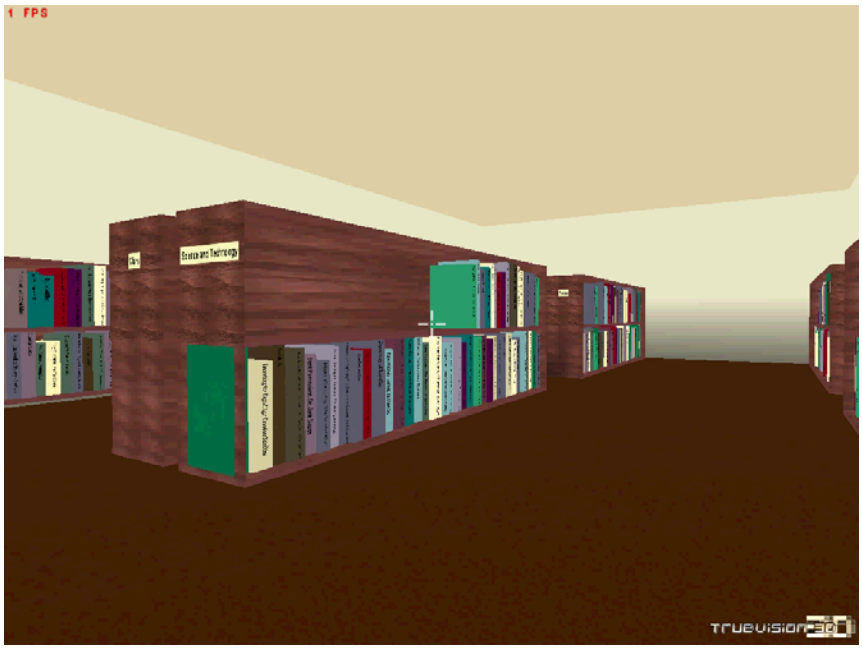

Figure 5. Original VRLibrary room and bookcases

4. Methodologies

i. First Iteration: Informant method

Once the prototype was constructed, we organized two gender-neutral groups to obtain feedback from children and young adults on the VRLibrary. The first group comprised students between 15 and 16 years old, while the second group consisted of children aged 11 and 12. Although this is not a random sample and may not represent these particular age group populations, we felt their profile would offer a 'best practice' or more critical evaluation of the technology.

A group checklist was used by the facilitator to encourage the children to verbalize their mental processes as opposed to guiding them through the product features. We aimed for each participant to freely voice his/her impressions while preventing too much vacillation. Through these groups we hoped to verify a number of assumptions, such as that children would recognize the virtual environment as analogous to a library, they would be able to navigate easily through the environment, they would understand that each book represents a web site without a physical counterpart, and finally they would understand the single level classification employed in VRLibrary, and find a specific book with ease. In an attempt to use the *Informant Design* methodology, we were encouraging the participants to intervene with constructive suggestions for improvement and modification of the VRLibrary.

Although the children were familiar with keyword searching and possibly hierarchal classification, we did not expect them to have ever used a VR library to browse and select web sites. In practice this meant that current features could be discussed and improvements suggested but design alternatives or features not shown would be difficult for the children to judge and comment on in a group study. As well, a novelty effect was expected since this was a new way of finding web sites – would extended familiarity with the interface change in any way users' perceptions?.

The children were encouraged to explore the environment freely and verbalize their impressions anytime they wished. They were given a set of tasks to perform, which included searching for specific open and closed topics. After the participants performed their assigned tasks the facilitator initiated discussions concerning general aspects of the interface and future development directions. The outcome was a number of suggestions for improving the system, including a map or similar tools to guide the user (Figure 6); keyword searching to assist the user initiate browsing; minimum gaming features to avoid distraction; in-context help, and perhaps inclusion of avatars to depict librarians, who would provide in-context assistants when needed.

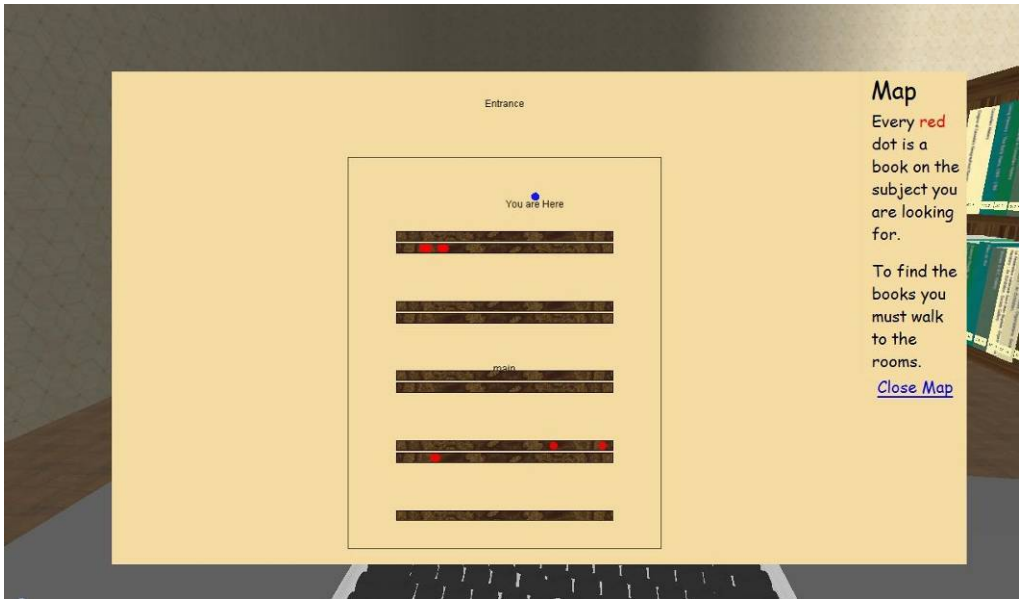

Figure 6. First iteration: the Map

ii. Second Iteration: Informant – Bonded mixed method

Many issues were raised during the first iteration, the answers to which required a conceptual approach to designing a new version of the VRLibrary. It was deemed necessary in the second iteration to bring together adults with expertise in human-computer interaction and children who are experts in being children in an intergenerational design team. Four volunteer students, aged 10 to 12, were recruited to participate in the study, and along with four adults formed an intergenerational team. Four sessions were held, two per week, each lasting about 50 minutes. Each session was planned with a set of objectives, tasks, discussions, consensus building, and low-tech prototyping. In this phase of the project, we used a mixed Informant-Bonded Design methodology. All the children participated in the conceptual design and modification of the system, using similar tools and procedures as in Bonded Design. The children, however, were not involved in designing the original concepts of the VRLibrary, and therefore the methodology cannot be considered purely Bonded Design, but rather a mixture of the latter's techniques with elements of Informant Design.

In each session children made suggestions and recommendations, including the classification of the entire "book" collection using the Dewey Decimal Classification (DDC), labelling of the bookshelves (Figure 7), and the addition of search stations (Figure 8) to permit searching in addition to shelf browsing. Each book is labelled with a DDC number. A menu on the Search Station has five items from which children can choose. Arrows are placed on each book that the user has found through a search. These arrows appear in every room, where relevant websites (books) have been retrieved, and remain in that position until the next search. Another idea that emerged from these sessions was that each retrieved book could be "kept" for future use: when a book is opened, an icon allows the user to store the book, in which case it is not placed back on the shelf. The children's interventions, part of the Informant Design methodology, resulted therefore in a more complex and enhanced environment in VRLibrary.

Figure 7. Second iteration: Labeled bookcases

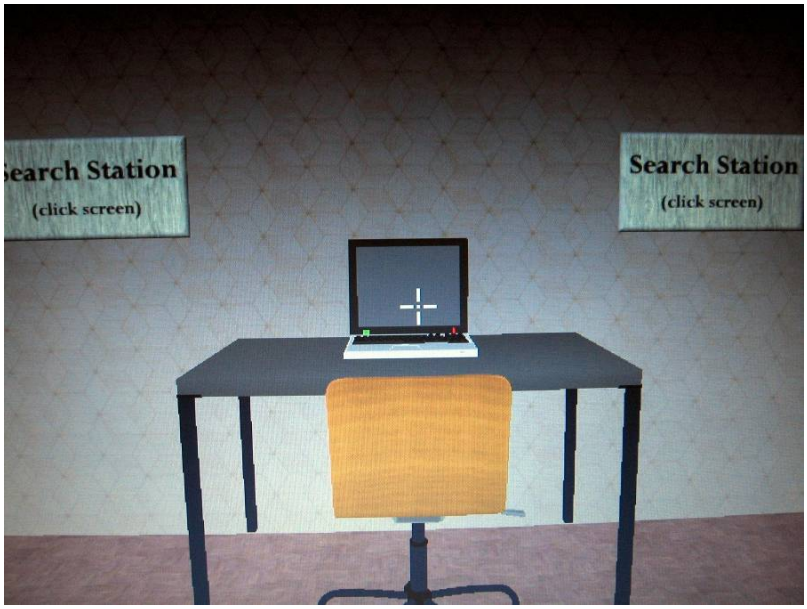

Figure 8. Second iteration: Search station

iii. Third Iteration: Informant method

The version of the VRLibrary that had been generated in the second iteration still required further direct intervention and feedback by children, through another round of Informant Design. The same procedure as in the first iteration was followed: four children volunteered to provide feedback on the VRLibrary (Beheshti et al., 2007). They explored the environment, performed pre-defined tasks, and provided their judgements on the interface. Observation techniques and interviews were utilized by the researchers in this iteration. One keen participant said that the system was "perfect", while others suggested two areas for improvement: expand the content to include many other topics such as the history of the U.S., and in the areas of science and technology; and more personalization options for changing the colour of the library's walls and floors. Both suggestions are straightforward, albeit time consuming, to implement.

iv. Fourth Iteration: Informant – Bonded method

The result of the third iteration demonstrated that the development of the system had reached a plateau, and further progress without large-scale testing would have been futile. The VRLibrary was therefore tested (along with History Trek) by 43 grade-six elementary school students using experimental methods. While the preliminary results show that both systems performed equally well, several key limitations in the VRLibrary system emerged. A fourth iteration is required to address the identified shortcomings and limitations. The fourth iteration will consist of a mixed Informant-Bonded Design methodology, similar to that used in the second iteration, to address some of the conceptual as well as more pragmatic and technical challenges. Four to six children will be recruited to form an intergenerational team with four adults to examine the latest version of VRLibrary, and through brainstorming, low-tech prototyping, and consensus building provide feedback on the system.

5. Discussion and Conclusions

Virtual reality interfaces can be engaging for children, but challenging to design. The methodologies used for designing conventional information retrieval systems and interfaces for children may or may not be applicable in designing virtual reality systems. The objective of this study is to design a VR system for children as an alternative navigational tool to the conventional searching mechanisms available in web portals. Designing any technology for children requires their expertise on cognitive and affective states of children. Various methodologies have been proposed to include children in the design process in a meaningful way. These range from User-Centered, which involves the user only at the last stage of technology development, to Cooperative Inquiry, where children are equal partners with the adult experts in the design team.

Our study showed that the novelty of the VRLibrary did not allow extensive involvement by children in the initial stages of design. Lack of experience, not lack of imagination, prevented children from contributing in consequential way to the conceptual design of the VR environment. Children had to be prompted and the adults had to intervene more frequently than in the previous project on designing a conventional web portal. After the initial prototype VR system was developed, we began an iteration process to involve the children in design. The first iteration was based on Informative design, allowing children to explore, test, and provide feedback on the strengths and weakness of the system. Since the system was already built, on the 'involvement scale' (Figure 1) we could not involve the children any more than the Informative Design methodology allowed . A second round of iteration was deemed necessary based on the children's recommendations, as well as many design and interaction issues, which had been raised and observed during the first iteration:

- Sizes: How big should the books be? How many shelves should be in each bookcase? How tall should the Target be compared with objects in the scene?
- Spines: What font-size and font-style? What colors?
- Movement: Limited to the XZ-plane? Or do we allow "flying" or maybe jumping?
- Velocity: Forward/Backward, Strafe Left/Right, Rotation? Faster or slower than current implementation?
- Movement Interface: Direction set by mouse movement (need not be the case)? How do the children want to do Forward, Backward, and Strafe?
- On Screen Display: Do we need it? When does it display (mouse-over or click)? Where should it be placed on the screen? What font/size/color? What information is displayed?
- Web-Browser: Embedded in an open "book" or not? Which features of a browser: Forward/Back/History/URL box? Do we make an effort to limit navigation to other sites through links etc…?
- Textures: What texture should wallpaper, flooring, doors, book covers and shelves (i.e. wood) have? Do we allow customizable texturing?
- Books: Should the books be "book"-like? Is the current model in the program acceptable?
- Extras: Should we have the sky-lights and windows? Should the external world be seen? Do we need other items in the library, for example desks, computers, lamps, art?
- Book Selection: Do we use the cross-hairs, or should we have a pointer that can be used to grab books anywhere on the screen? What should be done to actually open a book versus just viewing its description?

- Other Characters: Do we need to have other characters using the library?
- Map: What should the map look like? Should the map be something that the user has on their person or something that has a fixed location in the library? Should search results be displayed on the map?
- Menu: Should there be a menu screen? Is it a collection of buttons? How do we navigate the menu (up/down arrows or mouse)? How do we get to the menu?
- Search: How do we search? How do we display the results?
- Layout: How do we divide the library into rooms? How big are the rooms? What about entrance, floors, outside, etc…?

The extent and nature of these issues necessitated more involvement by children in the design process. Therefore a mixed Informative-Bonded Design methodology was used during the second iteration. We utilized various techniques recommend in the Bonded Design methodology to include the children in the design process in order to obtain as many answers to the design questions as possible.

Once the VRLibrary was revised, based on the outcome of the second iteration, we employed the Informant methodology for a third iteration. It was deemed sufficient to engage the children as 'informants' and not at a higher level of participation on the 'involvement scale'. After large-scale testing, the preliminary results show that new issues and questions still have to be addressed, again requiring more involvement of children in the design process. We plan to undertake this using the mixed Informant-Bonded Design approach, as in the second iteration.

One possible conclusion from this study may be that when constructing a novel system, children's initial participation may be more limited than the Bonded Design methodology requires. Perhaps in this context, other less user-involved methodologies like Informant Design are more appropriate for including children in the development process. Once the process is underway, however, a mixture of various methodologies should be considered, depending on the nature and number of issues, questions and concerns, which require children's input. Regardless of the level of input required, and the methodologies used, children's input is invaluable and indispensable in any technology design process.

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References

Beheshti, Jamshid. 1992. Browsing through public access catalogs. *Information Technology and Libraries* 11, no. 3: 220-228.

Beheshti, J., Large, Valerie, & Mary Bialek. 1996. Public Access Catalogue Extension (PACE): A Browsable Graphical Interface. *Information Technology and Libraries* 15, no. 4: 231-240.

Beheshti, J., Large, A., and C-A. Julien. 2005. Designing A Virtual Reality Interface for Children's Web Portals. *Data, Information, and Knowledge in a Networked World. Canadian Association for Information Science 2005 Annual Conference, June 2-4.* The University of Western Ontario, London, Ontario.

Beheshti, J., Large, A., Clement, I. & Tabatabaei, N. 2007. Evaluating the Usability of a Virtual Reality Information System for Children. Proceedings of the Annual Conference of the Canadian Association for Information Science, Montreal, 10-12 May 2007.

Bilal, D. and Wang, P. 2005. Children's conceptual structures of science categories and the design of web directories. *Journal of the American Society for Information Science and Technology* 56: 1303-1313.

Druin, A. 1999. Cooperative inquiry: Developing new technologies for children with children. In M. Williams & M. Altom (Chairpersons), *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 592–599). New York: ACM Press.

Druin, A. 2002. The role of children in the design of new technology. *Behaviour and*

Information Technology. 21, 1-25.

Fleming, J. 1998. *Web navigation: designing the user experience*. Sebastopol, CA: O'Reilly.

Hanna, L., Risden, K., Czerwinski, M., & Alexander, D. 1999. The role of usability research in designing children's computer products. In A. Druin (Ed.), *The design of children's technology* (pp. 4–26). San Francisco: Kaufmann.

Large, A., Beheshti, J., Nesset, V., & Bowler, L. 2004. Designing web portals in intergenerational teams: Two prototype portals for elementary school students. *Journal of the American Society for Information Science and Technology* 55, 1140-1154.

Large, A., Nesset, V., Beheshti, J. & Bowler, L. 2006. 'Bonded Design': A novel approach to intergenerational information technology design. *Library and Information Science Research* 28 (1), 64-82.

Nesset, V., & Large, A. 2004. Children in the information technology design process: A review of theories and their applications. *Library and Information Science Research*, 26(2), 140-161.

Norman, D. A. 2004. *Emotional design : why we love (or hate) everyday things*. Basic Books, New York, NY.

Polys, N. F. & Bowman, D.A. 2004. Design and display of enhancing information in desktop information-rich virtual environments: challenges and techniques. *Virtual Reality*, 8(1): 41-54.

Scaife, M., & Rogers, Y. 1999. Kids as informants: Telling us what we didn't know or confirming what we knew already. In A. Druin (Ed.), *The design of children's technology* (pp.27–50). San Francisco: Kaufmann.