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Virtual Environments for Children and Teens

Jamshid Beheshti

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1. Introduction

Today's children and teens are technology savvy. Information and communication technology (ICT) is the prevalent mode of communication among them, with 75 percent of 12 to 17 year olds owning cell phones, and text messaging at an incredible rate of more than 3000 messages per month [1]. This new generation is referred to as 'net savvy' youth [2], Google generation [3], and generation M, for Media, MySpace, or the Millenials [4] among other titles. The most common term, however, is the *digital natives*; those born after 1989, who may process information "different from their predecessors" [5]. The digital natives do much more than text messaging; they *live* in the digital world. Whereas most adults are attached to their physical material artifacts, cherishing their hardcopy books and DVDs, the digital natives live in digital worlds where they own virtual artifacts, which are more than just digital music and streaming movies. They use social networks (SNS) to create personal spaces to store artifacts such as currency and familial possession as a means of self-expression [6].

Digital natives often are well versed in using computer games, most of which now take the form of simulations, such as those designed for the X-Box 360 and the Nintendo Wii. According to a UK survey, teens' reliance on the gaming console to surf the web has increased significantly [7]. Recent reports also suggest that virtual environments or worlds are one of the most popular modes of interaction on the web [8]. The total number of users registered for virtual world sites is now more than one billion, of which the largest demographic group is between the ages of 10 and 15 [9]. The young generation uses the gaming console to access the internet and social networks, and therefore is most likely to want to use the virtual reality technology for more than gaming.

Computer simulations can take various technological forms, including virtual reality, augmented reality, and virtual environments. In the taxonomy of virtual reality, Milgram and Kishino [10] identify a continuum that connects real environments to virtual environments. They define augmented reality as a display where real environments are

augmented with virtual objects. VEs provide a computer-generated experience obtained by and through an interface that engages one or more of the user's senses, and almost always includes the visual sense [11].

By far the vast majority of VEs have been developed for entertainment and gaming. *World of Warcraft* is perhaps the best known and most used VE designed for adult gamers, while Habbo Hotel (www.habbo.com) is one of the most subscribed among the more than 250 virtual worlds constructed for teens. Habbo Hotel founded in 2000, is an example of a thriving VE, boasting to be the "world's largest online community" with more than 200 million registered characters. Other examples of gaming virtual environments for children and teens include Club penguin, (http://www.clubpenguin.com/), which is the most popular virtual world among children aged 7 to 10 in Europe [12], Pet Society (http://www.petsociety.com/), Secret Builder (http://secretbuilders.com/home.html), and Whyville (http://www.whyville.net/smmk/nice). Beals and Bers mention many other VEs for children and provide detailed statistics of their usage [13]. Many corporations have combined their virtual worlds with real children's toys to increase their traffic and therefore their revenues, such as Webkinz, Bratz dolls and Barbie dolls. Beals and Bers conclude that to some extent, parents may perceive these virtual spaces as safer havens than real brick and mortar buildings and encourage their children to use them.

The focus of this chapter is on the design and application of virtual environments (VEs) for children and teenagers by reviewing examples of current systems in education, health, and information settings, design methodologies, and engagement.

2. Education

Virtual environments can provide an interactive, stimulating learning environment beyond gaming. These environments sometimes referred to as virtual learning environment (VLE) [14], or Educational Virtual Environments (EVE) [15] have increasingly gained recognition among educators. Although the application of computer simulations in an educational context has raised some controversy, especially from those educators and developmental psychologists who have questioned the appropriateness of "virtual" experiences for children [see for example 16], a MediaWise report summarizing the findings of a number of research studies, states: "Video games are natural teachers. Children find them highly motivating; by virtue of their interactive nature, children are actively engaged with them; they provide repeated practice; and they include rewards for skilful play. These facts make it likely that video games could have large effects, some of which are intended by game designers, and some of which may not be intended." [17]. Roussos et al [18] point to evidence that immersion and presence can have a strong motivational impact on the users. As Mumtaz [19] argues, young people like computer applications, which often produce engagement and delight in learning. VEs present opportunities "to experience environments which, for reasons of time, distance, scale, and safety, would not otherwise be available to many young children …" [18, p.247]. Students who performed poorly in the classroom seem to benefit most from VEs [20]. Educational simulations can produce engagement through elements

such as "embodiment, cultural embedding, personalised maps, interactive artifacts, dynamic environments, mood, and contextual tasks." [21]. Dalgarno & Lee [22] outline the potential learning benefits of VLEs by identifying the unique characteristics of the 3D environment that may impact students in an educational setting. Immersive technologies and particularly immersive presence are shown to enhance education by allowing multiple perspectives or points of view, through 'situated experience', i.e., simulated field and laboratory work, and transfer of real world experiences [23].

Findings in cognitive research also point to the potential of educational simulations. Drawing upon recent research, theorists have advanced the notion of "constructionism" (a term coined by Papert in [24], and closely connected to Piaget's "constructivism"), contending that knowledge is not deposited by the teacher into the student – what Freire [25] termed "banking" – but rather constructed in the mind of the learner. The use of technology and particularly games in education is important in integrating new materials in a formal learning environment, as gaming is the preferred activity of children in the age range of four to seven [26]. Such activity seems to increase self-esteem [27] and perhaps motivation towards learning.

As Gee [28] has shown, VEs are especially effective in allowing students to experience new worlds where they can develop resources for problem solving and, ultimately, view the environment as a design space that can be engaged and changed. Or as Bass [29] put it, researchers should search for "the critical and productive affinities" between "materials, methods, and epistemology on the one hand, and the inherent structure and capabilities of interactive technologies, on the other." Mikropoulos and Natsis conducted a ten-year review of empirical research on virtual environments in education [15]. They surmised that constructivism is the hallmark of virtual learning environments, and includes seven principles:

"1. Provide multiple representations of reality – avoid oversimplification of instruction by representing the natural complexity of the world
2. Focus on knowledge construction not reproduction
3. Present authentic tasks (contextualizing rather than abstracting instruction)
4. Provide real world, case based learning environments, rather than predetermined instructional sequences
5. Foster reflective practice
6. Enable context, and content, dependent knowledge construction
7. Support collaborative construction of knowledge through social negotiation, not competition among learners for recognition." (p. 771)

In general, education-focused virtual environments support learning in a variety of fields such as architecture, language training, and archaeology. However, the application of VEs in learning is becoming increasingly prevalent, particularly in science and mathematics education. Mikropoulos and Natsis investigated 53 studies on the application of VEs in education, of which 40 referred to science and mathematics [15]. More recent studies include the Mediterranean Sea, for example, which is modeled to teach students about

ecology in an interactive setting [30]. A total of 48 students from two grade six classes were assigned randomly to two groups, 'traditional' and 'virtual' classes, in the Mediterranean Sea experiment. While the results of the experiment did not show a significant difference between the two classes in the learning outcome as measured in the limited pre and post tests, significant results were observed in the students' evaluations of engagement and 'enjoyment' for the VE 'class'. To teach geographical concepts, Tuzun et al [31] created an environment, whereby students collaborate to collect artifacts in different continents. The researchers used quantitative and qualitative methods including pre and post tests, observations, interviews, and open-ended questions to gather data on 24 students divided equally with 12 boys and 12 girls from fourth and fifth grades. Data consisted of achievement and motivation test scores as well as open-ended questions on students' knowledge of the subject matter. All the results showed statistically significant gains by students, which prompted the researcher to conclude that the virtual game-like environment supports learning in geography, whilst increasing students' motivation and makes learning 'fun'.

VEs have been also successfully utilized to represent 3D models of chemical compounds in chemistry classes [32], where the researchers used inexpensive webcams and open-source software to develop their system. They conducted a survey after using the system in a classroom, the results of which showed improved performance when solving problems related to 3D chemical structures. Virtual reality has been applied in mathematics education (for example see [33]). Another technology related to virtual environments is Augmented Reality (AR), which is a promising tool for schools to teach students about a variety of experiential subjects including material science [34].

The use of multi-user virtual environments (MUVEs) in education has been gaining momentum in recent years, with increased number of practical implementations that are reaching classrooms and students [35]. One of the few MUVEs designed for a wide range of purposes is the well-known Second Life (SL), launched in 2003 and intended for users 16 years and older. It has now about one million active followers. Communication in the SL virtual worlds is conducted through avatars, characters that can take the shape of human, animal, vegetable, or mineral. SL has been the subject of much research in education (for example see [36]). Summarizing the results of research, Hew and Cheung [37] conclude that in K-12 and higher education, virtual worlds are utilized to facilitate communication among students for simulation of real world trials and procedures, and for experiential enactments.

3. Health

VEs have been used in behavior modification and intervention. Reviewing the literature, Riva concludes that virtual reality has been used to "induce an illusory perception" of various body parts, as well as improve body image in patients with obesity and eating disorders[38]. Merry et al [39] reports on an experiment using a VE system, SPARX, as a self-help intervention agent to decrease and alleviate depression among young people. The software, designed by Metia Interactive (http://www.metia.co.nz/), utilizes a 3D fantasy

game environment to teach skills to manage symptoms of depression. Young users can customise their avatars to travel to one or more of the seven Provinces, where they learn about 'hope', 'being active', 'dealing with emotions', and so on. In the experiment, the researchers allocated 85 volunteers to SPARX, and 85 to conventional treatment, with a follow up after three months. The volunteers' average age was 15.6 years. The results of the study showed that remission rates were significantly higher in the SPARX group than the conventional group, as measured on various psychological metrics.

Virtual reality and VEs have been used successfully to engage young people in behavior change to manage their weight, to encourage physical activity, and in rehabilitation settings. Exergaming is the term used for those applications that utilize sensory surface for exercising and active video gaming such as *Konami's Dance Dance Revolution* and other arcade games. Exergaming has been studied to quantify energy cost associated with playing active games and increase activities. In a recent study, researchers randomly assigned 108 students between the ages of 10 and 15 years to one of the three experimental groups [40]. The first group used the "Jackie Chan Studio Fitness Action Run", an exergaming environment produced by XaviX; the second group was assigned to the 1-mile run/walk, and the third group utilized the Progressive Aerobic Cardiovascular Endurance Run program. The rate of perceived exertion (RPE), which is measured by a word scale, where zero means 'not tired', and nine means 'very, very tired', was used as a metric. RPE has been shown to correlate strongly with oxygen uptake and heart rate. The results show that the RPE for 'Jackie Chan' exergame group was significantly lower than the RPE for the other groups. The researchers conclude that the exergame can be a potential substitute for other types of physical activities, where space and facilities are limited, and they may also encourage children and teens to participate in aerobic fitness programs, regardless of their body mass index (BMI). Other applications of VEs in health care include brain injuries, pediatric oncology, for assessing attention deficit disorder, and for autism (see for example [41], [42]).

4. Information retrieval

Teens use the Internet for online shopping, downloading music, and sharing their personal information and artifacts. However, 62 percent reported that they surf the Web for finding and retrieving news and information about current events, and 31 percent reported that they search for health, dieting, or physical fitness information [43]. Despite all their online activities, a panel of experts, meeting to discuss the information behavior and needs of the new generation of users, concluded that a research agenda is urgently required to investigate the "characteristics and preferences of this tech savvy group that surprisingly lacks basic skills in information evaluation and retrieval" [44]. A growing body of research shows that children and young adults when seeking information under imposed tasks such as school projects encounter many problems and challenges. In a comprehensive review of the literature Large [45] concludes that children encounter problems in selecting appropriate search terms, move too quickly through the web pages while spending little time reading the materials, and have difficulty judging the relevance of the retrieved pages. These are just a few challenges among scores of obstacles facing today's teenagers, who for most part may

be information illiterate. In fact, studies show that when the youth enter institutions of higher education, they lack information seeking, retrieval and evaluation skills [46].

Rowland et al [3] observed that the new generation is "hungry for highly digested content," and their "information seeking behaviour can be characterised as being horizontal, bouncing, checking and viewing in nature." By horizontal they refer to the skimming activities of the youth, so prevalent in their information seeking, be it at home or at school. Nicholas et al [47] imposed four tasks (pre-piloted questions) on 138 participants, whose age ranged from children to adults. The results show that while the younger generation was faster in searching and retrieving the results, they viewed fewer pages and websites, and conducted fewer searches, resulting in less confidence in their answers to the task questions. One potential inference from many of these studies is that while the young generation is confident in its technology abilities, it lacks information and media literacy skills to make informed judgment on searching, selecting, authenticating, retrieving, organizing, synthesizing, and applying the information to create new knowledge.

In response to the youth's technological skills, and their inadequate competencies in information literacy, librarians have investigated ways to use virtual environments to assist young people in their information seeking behavior. Among the few VEs, Second Life is used in informational settings, with an archipelago allocated to Cybrary City, where more than 40 virtual libraries are situated. Second Life is also the most studied VE among researchers (for example [48]). In addition to Cybrary City, librarian avatars residing on Info Islands formed the Community Virtual Library in April 2006. Within a year of its launch, more than 6,500 virtual reference questions were answered by the Community [49]. Citing statistics by *Gartner Inc* that by 2011 some 80 percent of Internet users will be in virtual worlds [50], several public libraries purchased islands in Second Life to serve their younger clients [51].

Buckland [52] reports on two pilot studies in two Canadian universities, which acquired space on Cybrary City in Second Life. The purpose of the studies was to explore: a) the efficacy of virtual reference service, b) resources and training to offer the service, and c) the need for the service. The staff and volunteers were trained, and virtual reference services with avatars were implemented in Cybrary City for both universities. The result of the pilot studies showed that while Second Life residents could use Google for finding information to fulfill their needs, they preferred to ask librarian-avatars for assistance.

4.1. A virtual information environment

Beheshti and Large [53] designed and tested a virtual information environment for children, which embodies many of the concepts discussed in this chapter. The impetus for the project may be summed up as:

- Obstacles: Researchers have concluded that children and youth lack appropriate training and skills to transfer their information needs to effective search strategies (see for example [54]). The new generation spends little time evaluating the retrieved information, and expects instant gratification with the search results. Younger children

also face spelling and typing challenges that add more obstacles to their information seeking process.

- Browsing: Research suggests that browsing may be a viable alternative to keyword searching for younger users, who might otherwise have problems in seeking information from the web, and whose behavior consists of skimming activities. Studies also suggest that browsing may be the preferred mode of searching, considering that both searching and browsing may produce equally valid and efficient results [55]. Children have a tendency to explore, and view a digital library as "a place to wander about looking for different kinds of information" [56]. Browsing can also produce valuable serendipitous discoveries.

- Visualization: Browsing is primarily a visual activity, and visual-based exploratory interfaces support search activities for learning and investigating [57].

- Metaphors: Many systems have incorporated familiar metaphors in their interfaces, such as the shopping cart and notebook metaphors. These everyday metaphors have made interfaces more "comprehensible and fun" [58]. A familiar metaphor takes advantage of artifacts and context affordances for a more natural and intuitive interaction [59]. Visual interfaces designed for children should be based on familiar metaphors.

- Libraries: Although young people are increasingly using digital information, they are still well acquainted with traditional libraries. The library metaphor has been used in experimental projects (see for example [60]). The book metaphor has also been used in online information systems, as a recognized artifact to assist users in search and navigation (see for example [61]). The Bookhouse project was an innovative retrieval system for fictional work in a public library, which used the library and bookshelf metaphor. Subjective evaluation by the users showed that the new interface was preferred to conventional means of retrieving fiction [62]. In another example a realistic virtual environment of an existing library building was built and user acceptance tests were performed. The authors reported that high school and university users quickly learned how to navigate in the virtual environment without any assistance, showed high user engagement, and expressed positive first impressions [63].

The library virtual environment was constructed using the metaphor of a physical library with rooms, bookcases and books. The user, just as in a physical library, can walk around the library, move among the bookcases, scan the titles of books that are arranged on the bookshelves, select individual books, and open them. Once the prototype was constructed, a combination of Bonded Design and Informant Design (see next section on *Spectrum of Design Methodologies*) was used to obtain feedback from children and young adults on the library.

After the initial construct and testing, the methodology was repeated for a second iteration. The system was tested again, the results of which led to the third iteration. Each iteration yielded feedback from children, which paved the way to new insights and recommendations. At each step, children made a number of recommendations for improving the system: navigational maps, search workstations, classification of 'books', limited personalization (for example color of walls and floors), and limited application of sound for a more realistic setting. Perhaps the most interesting recommendation was

children's desire for presence of avatars, particularly a 'librarian', who would provide help and assistance on demand.
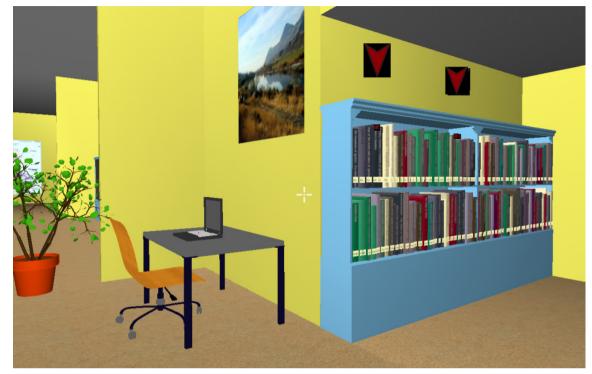

Figure 1. The Library virtual environment

The final product (Figure 1) was the library virtual environment, which was developed as an alternative interface for children's web portals. In this environment, users can utilize *search stations* situated in different locations of the library to conduct conventional keyword and term searches, the results of which are displayed as red dots on a plan of the library. The library contains about 1500 links to English-language websites on Canadian history deemed to be appropriate in content and language for elementary students. The database of links was initially created for *History Trek* (http://www.historytrek.ca), a children's portal on Canadian history [64]. Based on one of the suggestions made by children, all the websites were classified by the Dewey Decimal Classification (DDC) system to organize the collection similar to a typical public or school library.

Three focus group studies were conducted to evaluate and assess the efficacies of the library virtual environment. In the first study [65], eight children and teens between the ages of 11 and 16 participated in two focus groups to assess and evaluate the library virtual environment. In order to encourage the evaluation of the interface, participants completed four tasks, which were used in previous studies with a conventional interface. Similar qualitative methodologies were used in two other focus group studies [66, 67]. The results of these studies showed that the library virtual environment was an engaging alternative to conventional searching. Children reported that the virtual environment was much more 'fun'. The word "cool" was repeatedly used by all the children in the studies, regardless of their gender or age. One child stated: "If I have an option between Google and this [the

library], I would use this. Lots more fun…it is different." Another youngster suggested that the library "would always be more interesting than Google." Children participating in the studies seemed to have a positive first impression, which is one of the crucial factors in measuring satisfaction and the desire of the user to continue working with the application. Norman [59] outlines three levels of design: visceral, behavioral and reflective. The visceral level is about the initial feelings a new product provokes, which may be independent of culture or experience and may have a significant impact on the success of the subsequent interactions. The library seems to be a fun and engaging virtual environment, where children and teens can spend time exploring, browsing, and scanning the digital information, the outcome of which may lead to more successful learning.

5. Spectrum of design methodologies

Although much has been written about the design criteria for technical aspects of virtual reality and virtual environments, only recently researchers have discussed other aspects of design such as content, aesthetics, and behavior. For example, Messinger et al [68] suggest that the "fundamental technical preconditions for a world to support education appear to be (a) realistic rendering, (b) expressive and behaviorally rich avatars, (c) high performance, and (d) easy-to-use tools for education providers to develop the materials necessary for their objectives." Bers [69] divides the design criteria for virtual worlds by age group: early childhood, elementary years, and high school age. She proposes the Positive Technological Development theoretical framework within which systems that can promote "engaging a young person in a good, healthy, and productive development trajectory" can be built. This framework consists of three components: Assets, such as caring, contribution, competence, etc.; Behaviors, which includes communication, collaboration, creativity, and content creation; and Context of practice. Technological tools bridge the gap between Assets and Behaviors, and learning culture, routines, and values may determine the Context of practice.

Until recently, research was conducted by adults with little input from the target audience, children and youth. As Hanna and her colleagues at Microsoft's Hardware Ergonomics and Usability Department commented: "Usability research with children has often been considered either too difficult to carry out with unruly subjects or not necessary for an audience that is satisfied with gratuitous animations and funny noises." [70] In the mid 1990s, a paradigm shift in usability studies began to take shape, when researchers began focusing on young users' participation in the actual design process with the hope that the resulting information retrieval systems meet their needs. As more researchers involved children in the system design process, a need for adopting conceptual models for children as designers arose [71]. There is no doubt that the role of children is critical in the design process as users of the system, as testers in usability studies, as informants in the design process, and as partners [72].

Depending on the role of the users, the models or methodologies applied in the design process may be divided into seven broad categories [71], from the least amount of user involvement to the most participation. Based on this spectrum, the user-centered design is at lowest level

involvement, followed by Contextual Design, which utilizes ethnographic methods to determine how users work; Learner-Centered design, which is based on learning theories and assumes that everyone is a learner, and that learning cannot be detached from practice; Participatory Design, which utilizes the principle that users know how to improve their work and they are qualified to contribute to the development of new systems through their perceptions of technology; Informant Design, which views children (and students) as much more informed of learning practices than researchers; and Cooperative Inquiry methodology, which is developed for the design process involving younger participants, and where children are treated as equal partners in an intergenerational design team.

Large and his colleagues [73] adapted and incorporated a modified version of Cooperative Inquiry in their research. The new methodology was called Bonded Design, because of a natural bond between adults as design experts, and children as experts on being children. Large and his colleagues successfully utilized the Bonded Design methodology to create a portal on Canadian history for Grade 6 students [64].

6. Engagement

One of the most important factors for success of the gaming industry is engagement. For children and teens, engagement is a vital component of user experience (UX), which describes the totality of experience of the user and includes how easy a system is to learn, its efficiency, memorability, error management, user satisfaction [59], as well as holistic, aesthetic and hedonic factors, emotion and affect factors, and an experiential factors [74]. Laurel [75] defines engagement as a first-person experience involving playfulness, fun, and sensory integration that sustains a user's attention. Peters et al [76] suggest that engagement is perhaps the most important concept in human-computer interaction for the design of intelligent interfaces that are capable of adapting to users. For children and teens, engagement show "sustained behavioural involvement in learning activities accompanied by positive emotional tone." [77] On the other hand, youth may become bored, passive, and anxious in the learning environment when systems are not engaging. User engagement is a complex phenomenon which describes "how and why applications attract people to use them within a session and make interaction exciting and fun…" [78]

Among the many factors that make up user engagement is presence, which for children and youth is portrayed in virtual environments as a 2D virtual character or a 3D avatar. A primary concept of presence, aesthetics may be more influential in user preferences than is usability [59], and plays a crucial role in technology's overall attractiveness and its initial usage [79]. There is no doubt that interfaces with highly rated aesthetical appeal provide high overall user satisfaction [80]. Ngo et al [81] identified measures for aesthetic design, including: balance, 'the distribution of optical weight'; equilibrium, 'a midway centre of suspension'; symmetry, the 'axial duplication'; sequence, "arrangement of objects in a layout in a way that facilitates the movement of the eye through the information displayed" (p. 30); unity, the 'totality of elements that is visually all one piece'; simplicity, 'directness'; economy, careful use of display elements; and rhythm, 'regular patterns of changes'. In one

of the few studies on visualizations for children, Large et al [82] found that many of these criteria were present in children's drawings of an ideal interface, suggesting that perhaps young people gravitate naturally to the principles of aesthetical design.

Aesthetics is correlated with the use of metaphors and with 'fun', which is a significant criterion in designing systems for children and teens [78]. Fun has been defined for system designers as: what is expected of the system and whether the system disappoints or satisfies, engagement in terms of time spent on the system, and endurability – what is remembered about the system and the desire to return to the system [83]. Virtual environments designed for children and youth, therefore, should adhere to basic principles of user experience and particularly user engagement.

7. Conclusion

Many systems have been developed for the technology savvy generation. Most of these systems are designed for entertainment, utilizing the affordances of virtual reality to entice the new generation, who live in the digital world. More recently, the application of computer simulation and virtual reality has gained momentum in education, particularly in science, mathematics, geography, architecture and archaeology, where students can delve in the virtual environments for experiential enactment. Multi-user virtual environments such as Second Life have been an appealing teaching and learning tool for both the educators and students. In health care, several systems have been designed to help young patients cope with and alleviate their symptoms, such as pain, distress, and obesity.

Digital information regardless of the format, whether it is text, images, audio or video, plays a crucial role in the young generation's lives. Yet, very few virtual reality applications are available for distributing this information. While children and teens utilize mobile technology and social networks for their everyday life information transfer they still depend heavily on Google and other search engines to find and retrieve information. In so doing, they encounter obstacles and face difficulties in expressing their needs in keywords and expressions, upon which the systems can efficiently and effectively act. In other words, although technology savvy, the young generation lacks certain information literacy skills.

The youth's reliance on technology for consuming and producing information requires the development of new tools for knowledge and information transfer. These tools may be developed by using methodologies that involve and include children and teens as equal partners on the design teams. Their input is invaluable; they are experts at being children and can contribute significantly to the design process. As one example, the library virtual environment was created through a combination of different methodologies as an alternative information retrieval technique for a children's portal.

The vast majority of studies on the application of VEs in education, health, and information retrieval, however, have observed one crucial factor: engagement. Today's new generation is conditioned and accustomed to active participation both in consumption and production of information and knowledge. Participation means engagement. Designing and developing

any virtual environment must be engaging for children and youth to realize the full potential of the technology.

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