Συνέδρια της Ελληνικής Επιστημονικής Ένωσης Τεχνολογιών Πληροφορίας & Επικοινωνιών στην Εκπαίδευση

Τόμ. 1 (2010)

7ο Πανελλήνιο Συνέδριο ΕΤΠΕ «Οι ΤΠΕ στην Εκπαίδευση»

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Abstract

Children generally find it traumatic to change schools. They fear losing their way or arriving late at classes as a result of their not knowing the spatial layout of the new school campus. Spatial disorientation is a source of anxiety and probably delays their academic progress. This may be especially so for children with motoric or cognitive disabilities, or children who are temperamentally unsuited to coping with change. There is great potential for the use of virtual environments to provide groups of children with the opportunity to explore the school environment before they arrive. Each "VE" child will be provided with a virtual version of their new school which they can navigate at ease within their own home, as many times as they like, prior to the start of their first term. Previous studies have confirmed that children (including pupils with disabilities) do acquire extremely good "cognitive spatial maps" of schools from virtual exposure alone. Following VE exposure, children will be tested for their spatial knowledge in school, emotional responses to school attendance, speed of settling-in, attitudes to teachers and other pupils, feelings of confidence, and anxiety level, also the speed with which they make academic progress in the first weeks at the new school. The VE-trained children will be compared with equivalent control groups given either a tour of the real campus, or no prior exposure. Subgroups of children might particularly benefit from virtual spatial pre-training, including children with disabilities or having poor directional sense.

Keywords: virtual reality, school familiarisation

Introduction

Children generally find it traumatic to change schools, when moving for practical reasons (eg. parental job relocation) or when moving to a new educational level (infant to junior, junior to middle, or middle to upper school). In particular they fear losing their way or arriving late at classes as a result of their not knowing the spatial layout of the new school campus. Spatial disorientation is a source of anxiety and adds to other anxieties related to the prospect of having new class mates, school regime and teachers. Probably spatial disorientation slows their adaptation to a new school and delays their academic progress. This may be especially so for children with motoric or cognitive disabilities, or children who are temperamentally unsuited to coping with change. Although some schools organise "trail" tasks, to familiarise new pupils with their new school environment, these tasks may not be undertaken well or successfully by disabled or anxious pupils, since they are not paced according to each individual's ability. All children may benefit from advance information about the layout of a school to which they are about to transfer, and especially if this can be provided in an "empty" school environment, devoid of other pupils and associated distractions. The present study aims to use virtual environments of schools at 3 levels (infant, junior and upper), to provide groups of children with the opportunity to explore the school environment before they arrive. Each "VE" child will be provided with a virtual version of their new school which they can navigate at ease within their own home, as many times as they like, prior to the start of their first term. Previous studies have confirmed that children (including pupils with disabilities) do acquire extremely good "cognitive spatial maps" of schools from virtual exposure alone. Following VE exposure, children will be tested for their spatial knowledge in school, emotional responses to school attendance, speed of settling-in, attitudes to teachers and other pupils, feelings of confidence, and anxiety level, also the speed with which they make academic progress in the first weeks at the new school. Suitable assessments will be used for each age group. The VE-trained children will be compared with equivalent control groups given either a tour of the real campus, or no prior exposure. A further purpose of the research is to attempt to identify subgroups of children who might particularly benefit from virtual spatial pre-training, for example those with spatial anxiety, with poor directional sense or who find it difficult emotionally to accommodate to new environments.

Background: Virtual environments (VEs) in educational spatial training

Virtual environments (VEs) have been used in a variety of educational contexts, as experimental tools and training media (Rose & Foreman, 1999; see Foreman, 2000, 2007 for reviews), in spatial contexts in particular (Arthur et al., 1997; Regian et al., 1992), often directed toward rehabilitation and taking advantage of their uniquely spatial features (Riva & Wiederhold, 1998; Stanney, 2002; Stanton et al., 1998; Wilson et al., 1997). VEs consist of computer-generated environments which appear 3-dimensional, so that travel within a virtual world gives many of the same subjective experiences and perceptual affordances as real world exploration (for example, objects increasing or decreasing in size as the user approaches or recedes from them, cf. Gibson, 1966; 1979). The exploration is conducted in pseudo-real time, displacements within a desk-top display being controlled via the use of an input device such as a joystick or mouse (see Wilson, 1997). Moreover, a VE, while having high ecological validity, also has a high degree of flexibility, such that changes can be made that are not possible in a real environment (Foreman, 2007). This has implications for VE use in the behavioural sciences generally, but in spatial cognitive research especially (Rose & Foreman, 1999; Foreman, 2007). VE flexibility can be usefully applied to the assessment of spatial skills in particular populations, since input control can be tailored to the abilities and limitations of specific groups and environmental cues can be selectively moved or made unavailable in particular experimental conditions, testing a participant's reliance upon them. Augmented reality (for example the selective highlighting of just the accessible routes in a building) can be used in the future to conduct focused remedial training. For an individual whose physical mobility is limited, moving themselves virtually in a simulated 3-D space may be one of the few opportunities that they have to experience self-initiated, autonomous exploration of a large area. Examples of VEs created with Virtools software are shown in Figures 1 and 2.

VEs have been shown to impart similar spatial knowledge to real exploration (Foreman et al., 2003; Foreman et al., 2000; Rossano et al., 1999), and the advantage of real over virtual exploration of the same environment is relatively small (Wilson et al., 1997; Witmer et al., 1996) or absent (McComas et al., 1998). Learning can transfer to model small-scale environments (Sandamas & Foreman, 2007). VR therefore lends itself to many training and educational contexts (Foreman, 2010). Clinical therapy using VE-based protocols involves transfer of at least some aspects of virtual experience to real environments, even when the virtual environment does not accurately or completely represent the real-world situation (North et al., 1997). An individual's skill in spatial learning, demonstrated in a VE, reflects their spatial learning skill in real environments (Richardson et al., 1999; Waller, 2000). The use of VEs enables a wider range of environments to be used for assessment and training than in reality, and complex VEs have been used to access human navigational skills in larger environments such as buildings and towns (Foster et al., 1998; Maguire et al., 1998).

Figure 1. Interior of a school computing laboratory created with Virtools software

Figure 2: Corridor created with Virtools software

Although the benefit of using a VE for a motorically disabled person appears to be the independence and active choice that it confers, much research has pointed, paradoxically, to the absence of consistent activity benefits. When acquiring spatial information from virtual spaces, active participants have occasionally been reported to acquire more information about spatial layouts than passives who view the computer screen over the shoulder of a yoked active counterpart (Brooks et al., 1999) or watch a pre-programmed route (Peruch et al., 1995). However, in many cases actives were no better than passives (Gaunet et al., 2001; Peruch & Gaunet, 1998; Wilson, 1999; see Wilson & Peruch 2002) and passives may outperform actives on some spatial measures (Sandamas & Foreman, 2007; Williams et al., 1996). Rossano et al. (1999) used passive exploration in a VE but obtained effective spatial learning.

That self-initiated exploratory activity is apparently not crucial for the acquisition of spatial information in a VE is important when considering special populations, since participants who are unable to operate input devices can nevertheless be trained effectively (Wilson et al., 1997a,b). However, the phenomenon provides a caveat to the assumption that cognitive processing in a VE is equivalent to real-world performance. For example, the use of an interface device such as a joystick or mouse with a desk-top VE has implications. Waller (2000) and Sandamas et al. (2009) found that interface familiarity increased spatial learning from a VE. This is understandable since interfaces arguably occupy some visual-spatial working memory (VSWM) capacity which can potentially reduce the amount of available short-term spatial storage (Sandamas et al., 2009). Indeed, the operation of an input device is motorically similar to tasks such as systematic key pressing on an invisible calculator, which has been shown to interfere with spatial imagery (Moar, 1978). Garden et al. (2002) have shown that spatial tapping particularly disrupted map route recognition, and hindered the learning of a complex route in a real town, though only in high spatial ability participants. Using a dual task situation, Sandamas and Foreman (submitted) have found that either spatial card sorting, or shadowing of viewed screen movements via key presses significantly reduced the information acquired about room object locations from VE exploration, while 5 minutes of practice with a joystick interface device restored the active superiority in children performing in a virtual version of the Herman (1980) small town reconstruction task (Sandamas et al., 2008). Although a superiority of passive over active participants has been observed in some studies (see above) the effect is selective and not always predictable (Wilson & Peruch, 2002 Experiment 1). If the absence of consistent active-passive differences in a VE does occur due to the additional burden of interacting with the VE that is placed upon an active participant when using an interface device, this has implications for populations who may be motorically challenged or who have working memory limitations. In those cases "accompanied" exploration might indeed be most suitable, with explicit instructions (see Wilson & Peruch, 2002).

Some studies suggest that route-learning in a VE may be more successfully trained than configurational [survey map] learning (e.g. Witmer et al., 1996). However, in many studies, configurational information is also acquired, judging from successful pointing, map-drawing and map-placement performance (Sandamas & Foreman, 2007; Stanton et al., 1996; Wilson et al., 1997) Where routes have been learned more rapidly, this may be because route learning is easier. Patients whose allocentric mapping skills are impaired or destroyed following brain damage can acquire procedural route information (of the form "turn left at the red door, turn right at the statue") (Brooks et al., 1999).

From the above studies it is clear that a high quality of spatial information can be obtained from navigation of a VE, a phenomenon that has been successfully demonstrated in a school environment (Foreman et al., 2003). Children who have navigated a large complex VE for a period of approximately 2 hours (across 3-4 days) can acquire a good "cognitive spatial map", enabling them to identify locations by pointing when they are obscured from view, by taking shortest routes between designated targets.

Children's response to changing schools

Children moving from school to school report feelings of anxiety and apprehension, particularly because they fear getting lost on the school premises, resulting in their arriving at lessons late, and attracting the displeasure of school staff. Teachers report that children vary substantially in the time it takes to feel comfortable and locate themselves reliably. This is probably an accepted phenomenon, but there is no reason to assume that it is inevitable. Ideally, children need to feel reassured, in advance, that they can access strategic locations successfully such as the Head Teacher's office, staff room, music room, toilets, dinner room, play areas and gymnasium, also perhaps (for disabled pupils) special needs facilities and nurse's office. The importance of attempting to overcome these obstacles via spatial "training" of disabled pupils by support staff has been emphasised previously (Foreman & Gell, 1990). However, it is unreasonable to expect that non-teaching support staff will themselves risk the disapproval of teaching staff by allowing a child to take wrong routes, despite the fact that such experiences, in the life of an able-bodied child, are a rich source of spatial training experience. (The situation is similar to the driver who is angry at taking a wrong turn, despite this requiring an educative re-finding of the correct one, since the detour wastes time and invokes disapproval from passengers). There may be more serious strategic aspects to learning routes and locations in a school environment: fire drills may be especially difficult when children first arrive in a school, since they do not know in advance where are fire exits, wall-mounted alarms, and fire equipment. They cannot find the muster area in which they are meant to congregate if a fire breaks out. This would be especially so for a disabled individual whose mobility is limited or for whom a special emergency safety location may have been allocated; without the assistance of non-teaching staff they would find this difficult, and in any case, their lack of mobility is likely to lead to prolonged spatial disorientation compared with able-bodied pupils (Foreman & Gell, 1990; Foreman et al., 1989). Other groups of children who might suffer include those having a poor sense of direction, as indicated by low scores on instruments devised for this purpose such as the Good Sense of Direction (GSOD) Questionnaire (Kato & Takeuchi, 2003), or if they score high on spatial anxiety or state-trait anxiety questionnaires.

Remediation: The present study

It is common in UK schools for some spatial training and environmental familiarisation to be provided for newly-arrived pupils via activities in the form of games. They may be required, individually or in groups, to search particular locations for clues which lead them on a prescribed sequential trail around the school campus. Although this may be appropriate for some pupils, those with poor directional abilities, or disabilities, or who are shy and anxious, may find it hard to work in a group, may lag behind the rest, not finish the trail, and may thus feel less confident after the exercise than before it. The presence of other pupils in the school might prevent them from moving freely from place to place. Clearly what is required is a means by which all pupils can explore the new school environment (a) autonomously, (b) when the school is empty, (c) at their own chosen speed, and (d) as many times as necessary to acquire a good "cognitive spatial map" of it. They would ideally obtain such experience in the vacation preceding their joining the school, but conventionally this would not be possible because schools are closed. In the present studies it is proposed to attempt to provide such training in virtual form to three age groups of pupils as they join new schools, and to assess the impact that having high quality spatial information about the school campus has on their general level of anxiety and emotionality, personal relationship development (with staff and other pupils), and on the speed at which they settle into the school and begin to make good academic progress. These studies will be conducted with able-bodied pupils. Where possible, disabled pupils will be included, though since the benefits of VE training are expected to apply to all pupils, the collection of data from disabled pupils per se is not necessary to demonstrate the principle. Clearly, the availability of a VE for future children who use wheelchairs or who have either cognitive or motor disabilities, would be beneficial in the wider sense. Virtual training has been shown to be beneficial for children introduced to wheelchairs (Harrison et al., 2002; Hasdai et al., 1998). Training regimes may need to be adapted according to the gender of participants, since females have been reported to use more cue-based than survey representations (Choi & Silverman, 2003; Prestopnik & Roskos-Ewoldsen, 2000); this will be explored in pilot studies.

Research design and procedure

The present studies will be conducted in 6 schools, 3 in the UK and 3 in Greece. For each school, a VE will be created of the main buildings, corridors and target locations as in a previous study (Foreman et al., 2003). The VEs will be created by an experienced technician, using the Virtools 3-D construction package, using a floor plan of the school (which can be provided by the school or education authority), and a videotaped route, which illustrates features such as door and window design, colour scheme, floor surfaces, and static pieces of furniture. The authenticity of the VE can be checked by taking a tour of the real building while viewing a laptop representation on the screen. Volunteers including school staff can advise on any changes to improve authenticity. The studies will be conducted at the start of the academic year in the autumn of 2011. Informed parental consent will be obtained in advance for each child's participation. All of one year's intake of pupils (and their parents) will be involved, divided into classes given different treatment conditions. We are considering two options: One will be to provide participants in the VE exploration group with a stand-alone VE of the school, sent as an e-mail attachment or on a CD, usable with a free down-loadable browser, one week prior to the child's arrival for day 1 of the first term. They will be requested to use their home computer to log a total of 2 hours exploring the VE and noting strategic places which will be pointed out to them and highlighted within the VE. A second option is to use Second Life software and create an accessible environment, also representing the buildings of the school they are about to join.

Test protocols

For older children, testing will be conducted both within the VE and within the real equivalent environment, where spatial transfer will be assessed (cf. Foreman et al., 2003). They will be introduced to the VE in the form of a game (visiting the school you are about to join, so that you will know where everything is when you go there) and will be provided with self-assessment measures that assess how well they understand the layout, which they will use to test themselves immediately after the final session (so after a total of 2 hours exploration). The test protocols will require them to take shortest routes, identify important locations in the school which they will frequently need to access (toilets, dinner room, head teacher's office, for example), make detours between strategic locations (measured by completion time, plus trajectory pointing estimates; cf. Stanton et al., 1996), and make pointing judgements to distant (currently obscured) target locations. A number of previous studies have demonstrated children's ability to perform these tasks (Foreman et al., 2003 and above). Poor performance on these tasks will indicate a need for further training. Advice will be provided to parents, as to how to motivate and encourage children without actually performing the tasks for them. On arrival at the school, on alternate days for the first 6 teaching days, the older children will be given questionnaires to complete indicating their subjective feelings about the school, about relationships with staff and fellow pupils, and academic progress. Staff will also complete ratings for individuals within their classes. On each test day the pupils will also replicate the tests used following VE exploration at home, and make equivalent judgements within the real school environment, i.e., taking shortest routes, making detours, and making pointing judgements to obscured distant campus targets. Older children will, during break and play times, be given questionnaires to complete that measure temperament, spatial skills such as sense of direction, and state and trait anxiety. Some elements of the present study may qualify as curriculum-related and might be conducted in the course of Geography or other academic lessons.

Younger children will also be introduced to the VE as the school which they are about to join, and encouraged to explore (as above). Middle school children will be given more support than the older children and simpler protocols will be developed, so that they can complete the tasks without difficulty. Parents will be involved in the testing of environmental knowledge. For the youngest group, the emphasis will be on parents' use of the VE to teach the children about the spatial layout. A protocol will be developed for parents, eliciting information on time spent with their children and their ability to employ the suggested strategies to familiarise children with the school environment. On arrival at the school, tests will be conducted as above, but for younger children these will involve individual questioning using brief questionnaires administered by a member of staff or a research assistant. Directional pointing and way-finding will be assessed as for older children. Testing will be conducted in such a way as not to interfere with the school day, for example before school, at break or lunch times, or after school.

Control groups will be given either an introduction to the school campus prior to arrival at school, in small groups, or no specific spatial introductory training. Booklets will be provided, illustrating the various areas of the school campus and providing textual information about rooms that are featured in the virtual form. Testing will occur as above, but without the VE element. The groups will be compared on all of the variables tested behaviourally and via questionnaires (as indicated above). Teacher ratings of all pupils will also be recorded, indicating the degree to which children are relaxed, confident, spatially aware, the degree to which they get lost on the school campus, interaction with other pupils, and interaction with staff. Overall teacher ratings of the class will feature, particularly if it is not possible to use individual interviews for data collection.

Particular attention will be devoted to gender differences in responses, and the benefits or otherwise of using VEs with children who have disabilities or mobility or intellectual limitations.

Future benefits

When the study finishes, electronic versions of each of the VEs will be left with the schools, for future use as they wish. We will debrief schools about future uses of these environments with particular groups of pupil (eg. anxious, shy, pupils with disabilities including wheelchair users). A further group of children who might especially benefit from greater linkage between home and school are those suffering from selective mutism (having age-appropriate speech at home but not speaking to teachers or other pupils in school; see Sluckin, 1999); the school environment can be used in future with reluctant speakers in an extension of the above study, as such children join the school, to determine whether virtual pre-exposure can reduce anxiety and encourage speaking in school.

Benefits are likely in a more general sense, in education in general. The impact of this research could be considerable. Since many people will in future have access to fast broadband media, it is likely that, if the benefits of this training can be demonstrated, all schools will in future send their new intakes of children VEs of the school as a matter of routine. This would reduce stress on the part of children when joining/changing schools, and speed their accommodation to a new educational environment. It might be especially beneficial for children such as those with disabilities, who might find it especially difficult and traumatic to join a school or change schools.

It is worth noting that the exploration of a VE does not require the use of language; it is an effective way of conveying spatial information to any group of individuals who might be visiting a new school for the first time, including visitors to another country. Although not a specific aim of the current study, it would be possible to tailor an environment so that visitors to a school outside their own country and language community could familiarise themselves with vocabulary and terminology via the inclusion of labels that appear following suitable mouse clicks. It is possible that international student exchanges could also use VEs, facilitating successful exchanges between institutions and countries.

Conclusions

Since past studies have shown that children are able to acquire good quality cognitive "maps" of a school environment via virtual exploration, the present study will apply this knowledge to school familiarisation. It is hypothesised that those children given prior familiarisation of a school which they are about to join will be more confident and spatially aware in their new environment and will make more rapid academic progress in the initial period after joining. We expect children to be more positive emotionally, more relaxed in school and better positioned to make friends. We expect to find benefits for children, parents and teachers. We expect that in the future it will become routine for children changing schools to be provided with an on-line 3-D model of the school which they are about to join.

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