USE OF VIRTUAL REALITY ENVIRONMENTS TO IMPROVE THE LEARNING OF HISTORICAL CHRONOLOGY

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Abstract

Past evidence suggest that people acquire poor understanding of chronology during their education, and studies such as that of Masterman and Rogers (Instructional Science, 30, 2002) have suggested that technology might be employed to improve history teaching. The difficulty that children have with the concepts of time and chronology arise probably because of their abstract nature, and teachers indicated in questionnaire responses that they would welcome the availability of effective history teaching paradigms. A pioneering attempt was made to exploit a new paradigm, Virtual Environment (VE) technology that ought to engage high-capacity spatial memory, to improve participants' learning of chronology. Three age groups (undergraduates, middle school, and primary school children) were trained in virtual space to learn sequences of events, visited successively as though travelling in a time machine. Controls saw the same events but as paper text/pictures or as PowerPoint slides. In the initial part of the project one nine-item time line was used. Undergraduates remembered more when tested immediately after training with a VE, especially when challenged to remember each up-coming event. Primary school children in UK, and Ukraine, (with, and without, regular computer experience) also did so, when provided with adequate pre-training with the medium. Only middle school children persistently failed to benefit from VE training, despite the use of a variety of materials and despite repeated training after one month on one occasion. Two and three parallel timelines were employed, depicting music and art history, and the history of psychology, art and general history, respectively. A substantial benefit was seen when undergraduates used a large spatial environment which allowed them to view across three parallel timelines. It was concluded that VEs have potential as a means of imparting better chronological knowledge than other media so long as they are sufficiently challenging. Alternative paradigms need to be developed which improve the longevity of historical learning from VEs.

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"A society at ease with itself"

(Unknown author)

1.1 Introduction

Speak to people about history and many will ask why it is important to know about history at all. They will differ about where history starts, wondering from which moment in time history began. Puzzlement about the content and nature of history is not new (cf. Barbeau-Dubourg, 1753). For many centuries people have been trying to understand what it means to be a part of history and how and why particular people become historically important figures. The impact of history is equally obscure. How could it help ordinary citizens, living ordinary lives, to understand why and how history has determined the way they live? What has happened in the past to make them live in such a way, and how would their lives be different now if historical events had turned out differently? In some respects, this relates to human achievement and potential; Collingwood (1994) commented that history was the only clue to what [humans] can do and what [humans] have done. History has thus been acknowledged as having a broader content than just events and dates. Each event, either historical or political, can potentially create a strong precedent that determines the further course of history, a process that is continuous and applies to current events. Although some events are so prominent as to be obvious historical milestones (such as the 9/11 attack on the Twin Towers in New York) in most cases, ordinary individuals are not aware of all the processes taking place in everyday life activities, ones that in future an historian might refer to as "history", as having acknowledged historical significance.

Anecdotally, experiences such as walking through the remains of a Roman bath house in Leicester, UK, or exploring the remains of an amphitheatre found in North Africa, are activities that bring the explorer closer to history, by taking them back to the places where history happened. This is perhaps understood intuitively, explaining the great popularity of television programmes showing archaeological excavations. Although people will always have searched for historical clues, for many observers, it is difficult to comprehend the fact that many centuries ago there were ordinary people, who also had problems, and harboured fears about what the future held for them. Even prior to the evolution of modern homo sapiens, our ancestors were engaged with various domestic activities, such as crafting, hunting, fishing, and arguing with neighbours. Earlier peoples and generations could hardly have imagined that there would be an archaeologist, living many centuries after them, who would spend an entire life searching for objects that they had produced during their lives and used to eat their meals. Could they have been aware of the fact that many years after their physical death, a student from a department of archaeology, full of curiosity and enthusiasm, would search for anything that had been left behind?

The UK media regularly complain that British children have no concept of history and historical personalities. For instance, according to a recent survey one in four children think that wartime Prime Minister Winston Churchill is the name of the nodding dog in insurance adverts. The survey, which sampled 1,000 eight to 11-year-olds, also found that children were more able to recognize television presenters Ant and Dec than Gordon Brown, then Prime Minister. Only 79 per cent could identify the current Prime Minister from a photograph, compared to the 94 per cent that recognized the TV hosts. In a list of the most important people and events in British history compiled for TV's History Channel, Winston Churchill, Queen Victoria, Florence Nightingale and Sir Walter Raleigh were omitted but The Beatles were included. The author remarked that it is hardly surprising that Britain's children do not know much about our historical greats (Leslie, 2008). Poor historical knowledge in children and adults is not a newly discovered phenomenon. Howson (2007) has reported that concern was expressed as early as 1917 when two Texas high school teachers, sampling 668 students, demonstrated a surprising lack of historical knowledge among them. It is arguably necessary to find new strategies that could help students to leave school with a better, broader and more comprehensive understanding of history (Howson, 2007). If history is so popular (see above), why, then does the educational system fail to excite interest in and memory for historical materials? One of the intentions of the present work is to find ways of conveying historical information (content and chronology) in a memorable way and thus pave the way toward methods that enable a more personal, empathic understanding of history, ultimately including phenomena such as cause and effect, though new media may be needed to teach these ideas effectively.

Figure 1. Where is Churchill?

1.2 How effective is the teaching of chronological subjects such as history?

Following from Howson (2007) who previously speculated about how successfully history has been taught as a curriculum subject in school (as reported by teachers and by past pupils), it is important to verify what people remember of taught history, to what extent this information is retained over time, and to what extent members of the public can now place prominent historical events in sequential, chronological order.

1.3 Assessing history teaching and quantifying chronological understanding in the population

Since no studies had previously explored the issues of history teaching and learning, two questionnaire studies were designed specifically to explore history teachers' attitudes towards history and any problems that they felt compromised their teaching of history to children (Questionnaire study one below). The first questionnaire was conducted in the form of a pilot study, consisting of a series of open questions. Following this, a second questionnaire was compiled (in Questionnaire study two below) to examine the attitudes of undergraduate students and members of the general population toward history. Questions were devised, asking what participants thought, retrospectively, about their learning of history in school (Appendix 13.1.1). In particular, for the purposes of the present studies, it was important to discover whether they remembered the learning of history as a pleasant experience, or boring and monotonous, and whether they could relate what they had learned during their education to their current everyday lives.

1.4 Questionnaire study one: History teachers' assessments

The first questionnaire was general, and was distributed to a group of five experienced history teachers from a single mainstream middle school (with children aged 11-13 years). The questions were deliberately chosen to be general and open, exploring issues which they thought to be important, directed at the ways in which they had attempted to overcome problems had evolved to convey historical sequences and how effective these strategies had been. Questions asked about (a) staff experience of teaching history, (b) problems they had encountered, (c) strategies they had developed to attempt to overcome the problems, (d) the success or otherwise of those strategies, and (e) developments that they would welcome in history teaching. The questionnaire was distributed as a pilot exercise among a group of five middle school history teaching staff from a single school. Afterwards the same staff participated in an unstructured group discussion.

The results indicated that teachers felt that most young children had (a) no concept of chronology per se, and that (b) their ability to place events in historical order was generally poor. The children would often confuse present and past dates, failing to realize that there is a distinction between the two. Teachers emphasized that new/challenging ways of teaching should be introduced to engage children with the learning of history and about the content of history. They commented that at present children are left to memorize historical dates that bear no obvious relationship to their present lives. Most schools still rely on presenting history in 2-D formats, though teachers reported using several 2-D media – timelines, chronologies, maps and diagrams. There were positive responses, for example a teacher commented that children enjoyed creating their own representations of time "…because it involved organizing their life". However, the exercise indicated very clearly (a) the degree of disappointment of history teachers with the teaching techniques available, and (b) their desire to see improvements in the way that history is taught.

1.5 Questionnaire study two: Memories of learning history and chronological competence in undergraduate students and the general population

A further questionnaire study was designed, based on the information obtained from the teachers' responses, to test historical knowledge and understanding of chronology amongst undergraduate students and other adults [without specialist history training]. It was designed to explore participants' attitudes towards their experiences of learning history in school, after which a brief test examined their actual chronological knowledge, using twelve very prominent historical landmark events. The list was selected from the internet and from history books, using events that were assumed to be known by all students (from their general knowledge) regardless of educational and ethnic backgrounds. The events were as follows: (see Appendix 13.1.1 with dates inscribed)

The fall of the Berlin Wall

The Battle of Hastings

The French Revolution

The Russian Revolution

The Roman invasion of Britain

The death of Socrates

The Great Fire of London

The plague in London

The Opium wars with China

Introduction of votes for women in the UK

The ending of the Vietnam war

The Invention of the telephone

(The items are listed above in the same order as they were listed in the actual Questionnaire Study).

1.6 Participants

One hundred (78F, 22M) people participated in the questionnaire between October 2007 and March 2008. One objective of the research was to investigate participants' chronological understanding of history, to which end they were given the above list of 12 prominent historical events in random order, which they had to place in correct chronological sequence. Some questionnaires were distributed among students before university psychology lectures (N=70), after prior permission had been gained from the teaching staff. Some members of teaching/library/security staff (N=15) also volunteered to participate, and some questionnaires were distributed to members of the general public (N=15). Each participant spent approximately 10-15 minutes completing the questionnaire and chronology task. Participants were selected randomly from within their groups (opportunity samples), regardless of their age and cultural and educational backgrounds. Although all resident in the UK, people from a range of backgrounds and cultures were recruited, since it was of interest to know more about differences/similarities in learning history in various communities. Data from both sexes, from different age groups and different cultural groups were therefore analyzed separately, following an initial analysis of the full 100 participants.

The variables of interest were:

The attitude towards learning history at school (how positively or negatively rated), summed across scores for questions examining this issue, and the amount of historical information that participants could remember, i.e., the number of historical items they placed correctly in chronological sequence, at least some of which is likely to have been gained from their school history learning experience.

Independent variables were

1. Gender
2. Age
3. National origin and educational/cultural background

1.7 Results

Taking all the data together, the average number of items placed correctly was only 3.1/12. Perhaps most importantly, some 30 participants were unable to place any items in correct order, and simply spoiled their questionnaire sheets (0 male and 30 females).

Among those who could complete the exercise, thirteen participants achieved respectable scores (arbitrarily, above 7/12) (8 males and 5 females).

Gender differences were analyzed statistically using an independent groups t-test, which showed a significant difference, males out-performing females, making fewer errors when placing historical items in chronological order, $t(98)=3.012$, $p<.003$.

REM (removed) scores were also calculated. This measure was used here in the same way as in experimental studies of virtual historical fly-throughs, i.e., the numerical differences between the placed and the true list position for each item, summed across all (12) items, giving a measure of list coherence and chronological organisation (Foreman et al. 2008; see Chapter four for example calculations). A negative correlation between Age and REM score was found, so that the older the participant, the closer events were placed in the list to their correct list position, $r(100)=-.330$, $p<.001$.

An additional correlation was performed between Age and the raw number of items placed correctly. The results revealed that that there was a positive correlation between these two variables, suggesting that the older participants were, the more knowledge they possessed about historical events in general, $r(100)=.382$, $p<.001$. Further, when two sub-groups (endogenous British vs. those from non-British backgrounds) were compared, the test did not yield any statistical difference, implying that participants performed at equivalent levels regardless of their educational/cultural background, $t(95) =-1.590$, $p>.001$.

1.8 Discussion

1.8.1 Historical knowledge.

Overall, the data showed that most participants experienced problems with chronology (Dawson, 2004; Haydn Arthur and Hunt, 2001; Shuter and Childs, 1987), insofar as they were usually unable to place prominent historical events in correct chronological sequence. However, males were better able to do so than females, and older participants performed better than younger ones. The success of the older participants' performance can perhaps be explained in terms of different teaching styles used in the past and now. For example, the traditional rote learning (a technique that focuses on memorization) (Li, 2006) that was probably more often used in the classroom in the past may have been more effective) – it might have emphasised the "vertical" and ordered sequence, rather than thematic teaching which might be regarded as emphasising the horizontal associations of events, whereby many areas of curriculum are connected together and integrated within a theme (Fogarty, 1997). On the other hand, a more likely explanation relates to the fact that many older participants actually lived through some of the more recent historical events, and they may remember both the content and the relative historical ordering better for this reason.

1.8.2 Attitudes to school history learning.

General attitude towards learning history in school was universally very negative. The comments made suggested that the way history was taught in school was rather "boring, unchallenging and uninteresting". Cultural/educational backgrounds did not yield any differences, in terms of the accuracy of placing events in chronological sequence, nor apparently in terms of attitudes toward teaching and learning, implying that strategies and methods used in teaching history in different countries and cultures might not be very different, or at least that they are equally effective or ineffective. (Note that many of the items related to events that would be internationally and universally known and not purely related to British history). Generally, the problem appeared to lay in the fact that children/adults do have problems with chronology per se. However, there was substantial criticism of the materials used in class room history teaching. The majority of comments expressed in response to the questionnaire suggested that history should ideally be taught in a different way, encouraging more active participation on the part of pupils. Most welcomed the idea of using more advanced technology, integrated into teaching, thus allowing more exposure to learning materials that could subsequently activate children's participation in the learning process (cf. Furness, Winn and Yu, 1997). This can enthuse learners, but also encourage interactive learning in media that are popular with children and with teachers (cf. Underwood, Baguley, Banyard, Dillon, Farrington-Flint, Hayes, Le Geyt, Murphy and Selwood, 2010). Technology has many advantages, but in the history teaching context, it can potentially bring a learner closer to history, and making history personal rather than abstract, so not existing as information "up there" (Caltz and Munro, 2001; Stanton, O'Malley, Hui Ng, Fraser and Benford, 2003).

Statistically, males performed better when placing historical events in order compared to females, a result that is in agreement with those of several studies reported previously in the educational literature (Chan, 2007; Coluccia and Louse, 2007; Sanders, Sinclair and Walsh, 2007; Lachin, Sergi, Ruggiero and Gnisci, 2005).

The results of this study, particularly the low mean scores and large numbers of participants unable to place any historical events, not only emphasize the importance of finding ways of presenting history in a memorable and meaningful way, but they also emphasize how much present generations are likely to suffer as a result of having such a poor grasp of historical events (and, consequently) their inter-relationships. The participants said that they had no idea about historical events that they were asked to place in correct order, although some of those events had taken place during their lifetimes. Some answers were shocking in so far as some participants failed to recognize very obvious facts, e.g., failing to acknowledge a long gap between Socrates and Bell. In fact, some participants claimed that the death of Socrates occurred after the invention of the telephone. Of course, such bizarre responses may reflect a confusion about the identity of the figure (they might have confused Socrates with a footballer) or they may have responded randomly and thoughtlessly. However, such behaviour indicates poor knowledge of (and consequent inability to use and appreciate) what is widely regarded as basic historical material.

Poor knowledge of history among the general population is not a new discovery (Howson, 2007). However, this deficiency has wider implications, for the present situation. The concept of citizenship is promoted by government, yet it is impossible to see how individuals can have a real grasp of social identity and responsibility if they lack the most basic understanding of events and context that have led up to the present national, social and cultural situation which they see around them. It is arguable that one of the broader benefits of improving historical thinking and chronological understanding would be to provide the bases from which social responsibility might improve and develop within society generally.

The present studies represent an attempt to address poor understanding of historical chronology by developing the use of a new technology, virtual environment (VE) technology to enable its use in classrooms to motivate students. It is hoped that VEs may be especially useful in this respect because they can invoke the use of a visual-spatial memory store. It was hypothesised that more would be recalled, in correct order, after experiencing a sequence of events depicted sequentially in a VE, compared with the same materials presented in 2-dimentional media (such as PowerPoint or on paper as text). Second, it was hypothesised that encouraging active anticipation of up-coming events (in a game format) would improve upon passive fly-through VE formats and would result in more material being remembered in correct chronological order. Third, it was hypothesised (non-directional hypotheses) that the benefits or otherwise of using particular media would depend upon children's existing skills and abilities, their usual daily experience of computers, and also the amount of training provided prior to the initiation of the initial training phase with the current chronological materials. Fourth, following the gathering of data related to the above hypotheses, it was further hypothesised that the use of a wider 3-D format, involving multiple timelines, might extend the application of VE technology so that a larger range of materials (in different domains) might be effectively acquired from a VE compared with other formats.

Chapter Two: Different methods used in teaching history to children.

"*What confusion reigns for a long time in the child's little head before he grasps that the ever-moving present turns to-day into yesterday and tomorrow into to-day!*"

William Stern, 1923.

2.1 Introduction

Teaching history presents a number of problems for those who teach and for those who learn. History is not a static discipline that remains unchanged for centuries. Some parts of history have been amended, rewritten, reinterpreted and abolished or lost, indicating a dynamic mutable side to the discipline. A number of factors determine how historical data are presented to learners. Political and ideological influences can play a substantial role in how historical evidence is interpreted, so that history needs to be treated with caution and scepticism if learners are to benefit in the widest sense. 'History …. is a lively, challenging, indeed thrilling subject which deserves -- and indeed I would say has -- to be at the centre of any well-balanced curriculum… the primary purpose of education is to produce well-rounded and sensitive human beings. If that is indeed our belief history must be central in the education of our children' (Davies, 1998, p8). But to what extent are children able to acquire and remember such information?

The question of children's sense of time worries many teachers, who believe that any deficiency in this aspect of development might adversely affect the rest of a child's intellectual development (Chapter one, Questionnaire study one). In particular, time duration and differences among time periods and epochs can be difficult even for adults to comprehend and remember, and children can make apparently bizarre errors, sometimes reversing the ordering of events occurring 500 years and 200 years ago. A questionnaire designed to investigate what problems are most pervasive in teaching history, conducted with primary school teachers (Chapter one, Questionnaire study one), has revealed that pupils have particular difficulties with ordering events, both across recorded history and within a lifetime or generation. They are aware of period labels (e.g. Tudor, Victorian etc,) but they do not know where these fit into the bigger picture (Chapter one, Questionnaire study two; Haydn, 2001; Dobson, 2004). In other words, they fail to view history as a continuum, with all the events that are happening within an historical context, directly or indirectly, related to each other. Haydn (2000) comments that it is important to teach history in such a way that causes pupils to be engaged with the learning process and to make them realize that there is connection between their past, their present and their future. Haydn (2008) stresses that students should understand how historical events relate to each other in a global context.

It has been argued above that young children particularly might find it difficult to comprehend the concepts of time and chronology. Some researchers of history education have suggested that it may be helpful to concentrate less on absolute historical time (that is linear and abstract, and might not relate to children's own lives), but rather to teach children to concentrate more on a chronological understanding of time (order of events, how they are related to each other) (Haydn, 2009; Dawson, 2004). This provides the children with the structure which will be used later on in further development of their historical thinking. Besides, Haydn (2008) argues that chronology can provide pupils with a sense of structure, scaffolding that organize concepts in a more coherent form. Dawson

(2004) has argued that Chronology is not about placing historical events in a correct chronological order, but rather it is to teach children to understand events and a "sense of period" in which these events took place. Children should be able to make connections and draw comparisons between events and thus allow themselves to be thoughtful and objective in understanding cause and effect phenomena. Haydn (2008) suggests that chronology is helpful as long as pupils have a good understanding of relationships among each of the historical events. Haydn (1999) argued that the cultivation of this phenomenon depends on how historical time is taught in schools. In addition, even with the intention of conveying a proper understanding of historical chronology in the school classroom, Haydn (1999) believes that a problem lies in the impossibility of understanding the passage of time other than through living. In particular, some historical events are rather remote from the children's direct experiences and therefore children cannot relate their own experiences with the events that they study in school as they appear to have no relevance to their own lives. Dawson (2004) argues that not much effort has been made to teach children to appreciate chronology. For example, Key Stage 3 textbooks provide few activities that help to develop chronological knowledge or understanding. (Shuter and Childs, 1987). According to the author, teaching is a key tool to help children understand chronology. Teachers should focus more clearly on objectives of their teaching materials and keep reinforcing the understanding of chronology and time. This will eventually be imprinted in pupils' minds and will become a part of their thinking process. In other words, Dawson, in his article "Time for chronology?" (Dawson, 2004), stresses the need for visiting and revisiting materials learnt previously. Students should be encouraged to revisit materials that were learnt previously thus, hopefully, cementing them thoroughly in their memories. More importantly, such activities could enhance further understanding of chronological knowledge. Different strategies and activities have been designed to understand and help students to overcome chronological misunderstandings and confusion. Haydn, Arthur and Hunt (2001) have suggested a framework for teaching and learning about time:

- T1- time – dating systems and conventions and vocabulary
- T2- a framework or map of the past over the time span laid down in the UK National Curriculum
- T3- knowledge of a number of short term frameworks e.g. key events and chronology of the Norman Conquest or World War Two
- T4- deep time: an understanding of the true scale of the past from the formation of the earth onwards

The authors argued that by following these stages, teachers will be able to help students to get more out of learning about history.

2.2 Children's development of the Time concept

The sceptical view, that children have a limited ability to learn chronologically, was first introduced explicitly by Piaget and colleagues (Piaget and Inhelder, 1956), who claimed that children think in fundamentally different ways from adults and older adolescents. Besides, the concept of time is an especially difficult one to define as such since there are two types of concept involved -- relative and subjective. Haydn (2008) claims that it is not children's inability to comprehend time that matters, but rather that time itself does not 'exist'. It is neither a concrete nor an abstract concept – simply, for the child it is not 'there' at all. Haydn (2008) argues that time is 'an illusion' and to get an understanding about time, the analogy of "time" was invented. To get closer to time, people have come up with a simplified version of time that most commonly consists of a linear timeline (Haydn, 2008).

Thornton and Vukelich (1988) identified at least three types of time: clock time, calendar time and historical time. These concepts require depicting a person, place or event in the past using some form of time language. The adult's comprehensive understanding of time combines these three elements with a dependant sense of personal time. Friedman (1982) argued that the understanding of clock and calendar time is a prerequisite for establishing a sense of historical time. Bradley (1947) made a distinction between clock and calendar skills. Bradley (1947) argued that clock time skills develop from small units to larger ones, whereas calendar time skills work in reverse: days, weeks and then months. Oakden and Sturt (1922) identified three components of historical time:

- understanding of time by understanding words, symbols in everyday use
- an ability to form the conception of a universal time scheme, and the ability to use the dates by which such a scheme is symbolised and
- knowledge of the characteristics of definite epochs in the time scheme, and the ability to place these epochs roughly in the correct order

Blyth (1990) points out that that there is no clear cut agreement about what is meant by 'historical concept'. Some time concepts are concerned with recording the passing of time or with changes of time, while others describe the shared characteristics of time such as Victorian, Roman, etc.

Overall, there can be no doubt that a child's knowledge of time and time-related experiences is limited. Age, culture and circumstances also play a significant role in defining the concept of time. Jahoda (1963) suggested that the concepts of time and history are developed in a social climate, and thus they are subjective, not only dependent upon an individual's experience of the passage of time in their lives but also in the context of their culture and milieu. Bernot & Blamcard (1953, cited in Jahoda, 1963) supported this claim by studying how farm labourers in a French village, whose families had lived there for generations, had a perspective which went beyond their personal experiences, whereas, for example, immigrants who had come to that village from elsewhere showed no sense of their past nor the past of their relatives.

From the above study (Bernot & Blamcard, 1953, cited in Jahoda, 1963) it is clear that cultural peculiarities must form a part of the mechanism that helps children to understand historical time. However, increasing age changes the potential for children to form an accurate and comprehensive understanding of the concept of time. Piaget (1962) argued that a child's intellectual development progresses through a number of stages and only when they reach the appropriate stage, at about 12 years old, are they capable of "formal operational thought". He suggested that since the concept of time can only be understood in relation to concepts of speed, movements and space, and since this understanding develops slowly, young children cannot understand, for example, that the concept of time can be measured in equal intervals (Piaget, 1962). On this basis it was argued that school history teachers should help children to learn a body of knowledge about the past (McAleavy, 1998). Similarly, Peel (1967) argues that some young children are limited in their ability to comprehend some abstract concepts in an historical context or the significance of time within it. They may understand that William 1 became King of England, but not the implication of his reign or what he did for the nation. (It is notable that recent programmes broadcast by the British Broadcasting Corporation [BBC] have been given titles such as "What the Romans Did for Us", reflecting the corporation's appreciation of this important aspect of history). Partington (1980) argues that the teaching of isolated dates cannot occur in isolation but rather in a context. Dates per se that are associated with events will be meaningless for children's understanding of time and history unless they can see, and know more about, the events themselves.

However, it would not be accurate to say that even young children live their lives devoid of chronology. For example, Thornton and Vukelich (1988) found that between 4 and 6 years of age, children begin to perceive a daily routine chronologically from early morning until bedtime. Children begin to place events in chronological order by describing the patterns of their personal lives in a story-like manner. Firstly, children should learn more about people, their visual images, clothes, habits, activities. Secondly, mental package or development of a sense of period in which they lived could be introduced so that children make a connection with subjects they are learning about (Dawson, 2004). Oakden and Sturt (1922) argued that children's temporal understanding develops markedly by the age of eight or nine. Further, by this age the children accurately use the terms 'past', 'present' and 'future'. Thus the authors believed that the age of eight–nine years is when a child begins to master historical dates. Prior to this age, Oakden and Sturt (1922) have stated that the labelling of dates and periods has little meaning to children; therefore the teachers should explain labels in more detail, forming relationships between dates. Levstic and Pappas (1981) found that by the age of ten years children used specific descriptions such as "the Incas" to identify time epochs. Between the ages of 12 and 16 years children begin to place dates and events in a correct historical order (Oakden and Sturt, 1922).

Discussion of the transitions that occur between modes of historical thinking have tended to focus on the relationship between the time concept and the perceived importance of events to the individual. Jahoda (1963) and Friedman (1978) suggested that children of about four years old become aware of time through the specific events that are most important to them. However, Jahoda (1963) believed that it was not until the age of 11 that children understand the implication of historical dates, so that the age of 11 years is arguably a crucial turning point in this conceptual development. Friedman (1982), in his classroom studies, claimed that a total and global understanding of time occurs after the age of 11 years, yet some authors (e.g., Flickinger and Rehage, 1949) have suggested that a full understanding of chronology appears to be evident only from the age of 16 years. In particular, the latter authors studied the understanding of historical durations in children between 8 and 15 years. Children were asked to construct two historical intervals from their own knowledge of historical persons to make judgments of their duration and to explain the reason why they came up with such a judgement. First, the child was asked to name any historical person or event, then to work backwards or forward from this anchor point, in one direction at a time. The benefit of using such a protocol, according to the authors, is that the teacher can accurately identify the stage of the child's conceptual development.

West (1981) found that children have more information about the past than that which they have gained in schools. This can help them to sequence events and artefacts confidently. Stow (2000) found that young children's concepts of historical time have become more developed since the introduction of the UK National Curriculum (NC), although it is unclear whether the NC *per se* is responsible since it also depends on factors such as schools' and staffs' teaching strategies that might have become improved or elaborated in the period since the NC was introduced (Cooper, 2004). It is essential, however, to understand that the full comprehension of time depends on children's mastery of language and the terminology used to segment historical sequences and eras. Through language children can refine concepts. Wood (1995) has found that the understanding of the concept of time is closely related to language proficiency. The centrality of language may, indeed, be the main prerequisite for the development of the time concept; a child's understanding of time-related words is dependent on the linguistic forms used to express the temporal reference (Harner, 1982).

Bruner (1960) argued that a key task in the process of education is to learn structure (via 'scaffolding'). The model leans heavily on learning models developed earlier in Russian psychology by such theorists as Vygotsky (1926). The instructor should encourage students to discover principles themselves. This can be achieved through an active discussion between the instructor and learner. More importantly, the instructor should be aware of the learner's cognitive level so that the materials delivered by the instructor suit the learner's cognitive level and lead them into his or her next proximal zone of intellectual understanding. Bruner (1960) believed that language was the most important tool for cognitive development. Parents or teachers should support children's activities by talking to them, by breaking down activities into small steps and simplifying the task that the children should perform, like the provision of a scaffold for a building, designed not to be a product but rather a conduit for, or supporter of, learning. Eventually, after providing support for the child, until he or she is confident enough to continue with the task independently, the educator's role should be gradually removed (Bruner, 1960).

As pointed out in many previous studies, a child's early language is highly restricted and relies on here-and-now sentences (Brown, 1973; Minami, 2002). Adults constitute an effective tool enabling children to use their speech more effectively (Chiung-Chin, 2003). However, in language acquisition, children need to learn to decrease their reliance on contextual support. This helps them to become independent and competent speakers (Chiung-Chin, 2003). Language acquisition studies have reported different results concerning the age in which children can use temporal devices. For instance, some researchers claimed that children learning English start using 'before' much better than 'after' (Clark, 1971, for three year-olds; Feaguns, 1980). On the other hand, other researchers reported no difference in using these two terms (Amidon and Carey, 1972, for five year-olds). The differences in findings can be accounted for by considering the different tests involved, methodologies and sentences used to talk to children, and, more importantly, the age of the participants (Winskel, 2004). Weist (1986) proposed a model for children's progress through sequences of temporal devices. The first category is the speech time system — a here-and-now communication system. The second is the use of tense to mark past/non-past, continuity and non continuity. The third category refers to using temporal adverbs and temporal adverbial clauses. The final stage of children's progress through temporal relationships relies on using the past perfect tense and the temporal prepositions 'before' and 'after'. However, some studies claim that children can actually understand the past tense before they acquire linguistic skills to talk about past events as such (Eisenberg, 1985; Harner, 1982). Others claim that the understanding of the past tense and using the first sequencing conjunctions appears before two years of age, and changes continue into the school years (Ervin-Tripp and Bocaz, 1987). Besides, the development of temporal relationships is rather a slow process. Time perception is more a conceptual idea, compared to spatial perception (Ervin-Tripp and Bocaz, 1987).

Therefore, emphasis should be placed on the development of time-related vocabulary (Cooper, 1995). Harner (1982) suggests that children, by the age of 10-11 years, have mastered the varied linguistic structures related to time, although there must follow a period in which they must learn to apply the terminology correctly. Clearly, relationships between cognitive strategies and structures and classroom performance are of great importance when designing curricula and attempting to find ways of assisting children with the early and rapid acquisition of the time concept. However, since teaching strategies used in the classroom in the past have concentrated upon the learning of semantic information (dates, people and events), this may have limited the opportunity for children to appreciate 'time passing', something that may be conveyed more effectively using other media. This is an issue that will be taken up in the following chapters and experiments.

In summary, the learning of history has traditionally involved the retention of dates and events and their sequential ordering, usually via the study of books and worksheets containing names, dates and events. Many students seem to have difficulties recalling such information, perhaps because of the limitation of verbal-semantic memory stores and the abstract nature of time -- the absence of cues that place events in any intuitive chronological order -- and various solutions have been proposed to overcome this problem (Cooper, 1992, 2000, 2002; Friedman, 1982; Hodkinson, 1995; Hoodless, 1996; O'Hara and O'Hara, 2001; Partington, 1980; Wood and Holden, 1995; Yaxley, 2004; Wood, 1995; Booth and Husbands, 1993).

2.3 Strategies employed in schools to increase understanding and knowledge in chronology.

Various strategies have been employed to attempt to enhance children's chronological thinking skills, both in able-bodied children and those with challenges such as learning difficulties. Clearly, a new approach to the teaching of historical chronology – using engaging technologies -- might potentially benefit children of all abilities, but might be especially beneficial for children who, for example, have difficulty with the English language or who are slow in processing novel information. Children with disabilities appear to have particular difficulty understanding time, chronology and history, though the reasons for this often remain unclear. Turner (1998) used an emotional dimension by having disabled children – many of them having multiple and complex disabilities -- think about 'what it would be like' to have experienced an old sailing ship. This was apparently successful – they concluded that it "must have been awful", suggesting that they had internalised the fact that life there was different from their own. Artefacts can also encourage curiosity and visualisation of abstract concepts, making them more relevant to the children (Hoodless, 1996; O'Hara and O'Hara, 2001; Wood and Holden, 1995; Cooper, 2000). Morris (1992) tried to develop a child's ability to interpret portraits. Some researchers have used pictures as stimuli for discussion about time (West 1981, 1982; Lynn, 1993; Harnett, 1993; Stow, 1998). Blyth (1994) and Cooper (1995) argued that emphasis should always be placed on visual sources, since these improve children's ability to discriminate and thus differentiate between the present and the past. Similarly, Andietti (1993) argued that the use of visual sources stimulates the understanding of chronology. Thus taking children to museums, archaeological trips etc. can be especially beneficial, and these will enable children to develop a sense of a chronological sequence of events having taken place in the past. Alderson and Low (1996) argue that visiting historical sites is a significant part of learning as it helps to gain an understanding of 'historical importance' and subsequently to become a part of historical heritage that helps to develop a sense of personal belonging to a particular historical place.

The use of role play and drama (enacting historical events, or dressing in period costumes, adopting the roles of people from different eras and social classes) can help pupils to make history more personal, more intimate, and this arguably encourages the pupils to take more responsibility for what they are learning. Using drama in school can be an effective way of placing children into the context of past events (though sometimes this can be chaotic, when control cannot be exercised over many aspects of the environment). Nevertheless, when children are asked what they most enjoyed about learning about a particular historical period, they typically say that it was taking a role-playing part in drama (Jones-Nerzic, 2009).

Wood (1995) argued that the collection of items and photographs of the local environment, studying a particular building or street that has changed over time and sequencing and justifying artefacts can also facilitate the understating of time. More importantly, children should be able to actively participate in constructing their own timeline that can arguably help them to gain a better understanding of time (Wood, 1995). Having a discussion group partly supervised by a teacher helps children to understand the concept of time more deeply, assisting them with expressing historical concepts verbally, and thus making the concepts less abstract and remote. Reading stories and discussing the content of the story, introducing the children to the passage of time through the story, writing essays, reading newspapers and writing newspaper reports that might have appeared at the time of a significant event, also inviting grandparents to participate in group discussions, talking about their experiences of being school children, discussing and comparing their old photographs with current ones, undertaking a research project that involves visiting sites, archives and other historical places -- all these bring a child closer to history, to understanding the mechanism involved in creating an historical process, showing that the child himself/herself is a part of the mechanisms that form history.

2.3.1 Two-Dimensional timelines

Some researchers claim that the most beneficial tool to assist children with understanding chronology more effectively is to introduce them to timelines (Hodkinson, 1995; West, 1978, 1981; Hoodless, 1996, Wood, 1995). Questionnaire study one in Chapter one (above) has shown that in order to help children to make history less “kaleidoscopical” and more coherent, teachers tend to adopt the use of timelines. In their responses to the questionnaire they said that children can be encouraged to create their own timelines, in which they can include historical events but also personal events e.g., the dates of birth of their siblings, dates of starting schools etc.

Timelines and charts can vary in type and content (Wood, 1995). Wood (1995) has listed a number of types of timeline:

- simply arranging items in order (e.g. by pinning up pictures in a sequential display)
- locating items within a band representing periods that are named and have outline dates
- using detailed dates
- using long sweeps of time to relate different depth studies to one another;
- providing detail of one study
- placing different aspects against one another on a time line
- going backwards in time from the present, commonly called a "time tunnel" (Wood, 1995, p13).
- involving vocabulary such as before, now, then and after
- Sequencing of lines (often personal/family driven)
- photograph timelines
- themed timelines (for example dress/fashion, transport)
- short timelines such as the 6 wives of Henry VIII
- clocks and diaries
- extended timelines, for example invaders and settlers from the Romans to the Normans (O'Hara and O'Hara, 2001).
- Pupils need to construct their own timelines, which will help them to comprehend a sense of duration. The timelines should be visited and revisited. Different epochs can be coloured in different colours (Dawson, 2004)
- Spatial engagement with timelines, walking along the line that is visual and appealing to pupils. It does not have to be a big period or event that has no relevance to any pupils, but rather to concentrate on an individual that can represent the epoch under investigation. More importantly, using narratives aloud will engage pupils with the

story and will help to organize their memory in a more coherent structure (Dawson, 2004)

Madeley (1921), was more concerned with the mode of use of time charts, claiming that time charts of pictures should be unfolded, with historical events and people placed in a chronological order, thus enabling children to see events in relation to each other. She also argued that time charts should be presented in a simple way with few entries on the time chart to avoid confusion. Madeley (1921) emphasized the necessity to compare the chart in time with a map in space (thus recognizing the important representation of time as a temporal-spatial configuration). It is important to present historical events and historical people in relation to each other with dates, otherwise if there is no relation then the dates will become simple 'telephone numbers'.

Hodkinson (1995) and Wood (1995) claim that children should be allowed to create their own timelines, that they can add to in each year of their study. He concluded that timelines should be created uniquely for each class of pupils. Also, such timelines can be moved with the class as it progresses through the school. It can represent a joint collaborative exercise, one for which a class takes collective ownership and responsibility. Each of the class is an active participant. The teacher should explain the relationship of the units with each other so that children can progressively understand the time line in more and more detail. In other words, if such timelines are constantly available throughout the school, then the children will be constantly bombarded with knowledge relating to historical time (Hodkinson, 1995). There are also opportunities for children to work together on timelines, collecting data and information about the past by using websites, cross-referencing different aspects and discussing causes and effects. Text and images can be placed on timelines, rearranged and modified. This would allow a group of children to work together and share knowledge. Children can explore the sequence of events in relation to their own family history and by talking about family photography and listening to true stories from their parents and grandparents, they can learn to repeat and retell sequences of events, follow a plot, and create images. An important aspect of this way of thinking about time passing is that it emphasizes the cross-referencing among different domains of information; children should not be encouraged to think of time as a single dimension but to appreciate that it consists of different domains (possibly art, science, music, architecture, and world events). This issue will be explored in later chapters below.

The work of John West (West, 1978, 1981) has made a huge contribution to the way in which chronology and timelines are handled in primary schools. West's studies showed that children as early as primary school age were confident in sequencing pictures. He claimed that it is a mistake to assume that one can teach a 'feeling of chronology'. Maintaining the feeling of chronology is, he argued, best developed by encouraging children to actively participate in constructing chronological events (West, 1982; Wood, 1995). West (1982) proposed some practical advice on timelines, suggesting that a uniform wall can be useful for this purpose; at one time, a ten meter wall can illustrate the ten year lifespan of a child, while at another time, it might be used to represent a whole century. With each alteration, an old line should be retained to provide a visual tool for children. Discussion of the construction of the classroom timelines should be encouraged, to accustom children to the dynamic nature of time. West advised that children should work on the timelines as a whole group making it a regular part of their history lessons. The wall can also be replaced by the 'washing line' (a line strung across the classroom like a line of washing) using pegs as markers of the time intervals. Collicot (1990) argued that the timeline should not necessarily be linear, but can be represented in circles, cycles or zigzags. In her view, the timeline is cultural and thus its representation can vary. Diem

(1982) advocates a personalized time chart, making methodological constructs more personalized and concrete (see Table 1, “Personalised Time Chart example”).

Table1. Personalised Time Chart (developed by Diem, 1982).

Day	**Personal events**	**School events**
Sunday	Went to basketball game	No school
Monday	Practised basketball applied for a job after school	Career Day Assembly
Tuesday	Fight with parents because of poor Grades	Went to Counsellor’s Office

Hoodless (1996) recommends that as young as primary school age children may use zigzag books, personal lifelines and even three-dimensional life timelines to accustom them to the concept of chronology. Children can also construct small-scale timelines within periods (epochs) to help sequence events. However, not all researchers agree with the claim that timelines are the main prerequisite for understanding chronology as such.

Thornton and Vukelich (1988) state that when children are asked about their daily routine, they can usually include an orderly chronology of what was done, i.e., beginning with morning activities and ending with bedtime activities, thus indicating that they possess the ability to recognise ‘time distinction’ (Simchowitz, 1995). Despite the widespread use of timelines, children still find it difficult to work with some aspects of history including chronology. It is important to remember that for all forms of 2-D timeline, it is the viewer/observer who has to impose the concept of “time passing” since all of the items in the time line are presented simultaneously, so that a child may have to scan a washing line of events from left to right and appreciate that the movement from left toward right represents the passing of days, or weeks, or years, or centuries.

2.3.2 Modern Technology and Timelines

Modern technology has been used before in an attempt to assist children with the handling and remembering of chronological information. For example, Masterman and Rogers (2002) used a 2-D timeline aimed at bridging the conceptual gap between concrete experience and the abstract concept of the passage of time. The role of multimedia is to facilitate learning, in particular the acquisition and reasoning with abstract concepts through scaffolding (Wood et al. 1976) whereby various learning materials are used to stimulate and encourage children to accomplish problem-solving tasks, nudging them into their next proximal zone of intellectual development. Masterman and Rogers (2002) advocated the use of Interactive multimedia (IMM). The central tenet of the model is to support the learner in helping with specific activities. The learner masters an activity after which they can perform associated tasks without relying on IMM. Masterman and Rogers (2002) believe that IMM can help the learner to explore abstract ideas in a more innovative way. The abstract ideas can become more explicit and can also be visualized. One of the additional benefits of applying IMM is to enable learners to “actively collaborate” with the computer, which helps them to construct new forms of knowledge. The theoretical model used in Masterman and Rogers’ (2002) study is Cognitive Interactivity, initially introduced and developed by Rogers and Scaife (1998). The central paradigm is designed to investigate the process by which new information is integrated with existing knowledge and then represented. Also, this enables the conducting of an investigation, whereby benefits and costs of particular forms of representation could be further explored.

In their experiment, Masterman and Rogers (2002) used a timeline which was depicted in the form of a winding road shown on a computer screen. Pupils could mouse-click pictures spaced out in a temporal-spatial order along the timeline, in order to reveal and view the information presented along the time line. After visiting a particular event or figure they could return to survey the timeline display and select an image at another point in history. In their discussion, the authors argued that these activities helped children understand '… the appropriateness of using different graphical representations to reason about different aspects of chronology' (Masterman and Rogers, 2002). Further, Masterman and Rogers (2002) found that the children who participated in the experiment were able to understand the concepts presented to them. Most importantly, they could apparently order, sequence and understand events, thereby understanding the similarities and differences between past and present. Although the study does show evident benefits from using this protocol, the benefits were not been formally assessed by comparison with other teaching media. To be beneficial as a teaching aid, the technique needs to increase information retention (in correct sequence) compared with traditional classroom methods such as washing-line timelines, or the presentation of information as written text.

The researchers hoped that the problem of the poor chronological ordering of historical events can be dealt with effectively by implementing the idea of scaffolding, progressing from concrete experience to reasoning with more abstract representations. Masterman and Rogers (2002) suggested that children's capacity for reasoning about temporal relationships in the historical past is affected by a number of factors: the children's abilities in terms of the mathematical understanding of history, the understanding of historical numbers and their relations to each other.

This problem may be overcome via the use of a form of timeline that a participant can pass through, so that they move forward as time passes. (For more discussion, Chapter eight).

In conclusion, although various strategies have been used by teachers and educationalists to help children to overcome the problem with sequencing historical facts, none of these has been subjected to proper experimental analysis. Masterman and Rogers (2004) reported that children and teachers were enthusiastic in using 2-D timelines on computer screens but did not show that the use of the technique improved upon other available alternatives. None of the above methods has been compared with any form of control (such as reading from books). The present research poses a question: how can we gauge whether a strategy used in education actually works? Perhaps, teachers would like to think that different timelines in the shape of a circle, or cyclic, or linear are exciting and challenging to children. However, when some students were asked about using timelines, in the course of testing during the current projects, their response was rather negative. They commented that 2-D timelines have their own limitations. The present research is novel insofar as it will use a novel technology experimentally (3-D virtual environment [VE] technology) and it will challenge assumptions, asking directly about the efficacy of this particular technique, using experimental methods, and using control groups for comparison.

Besides, 2-D timelines might not be universally applicable, or for complex representations of historical detail – there is a physical limit to how much can be pasted on a wall at one time and so physical timelines must have their limits. Indeed, some pupils (including some with disabilities) may have physical difficulty scanning along a long timeline. In contrast, with VEs there is no spatial limit; a number of timelines can be presented simultaneously. This issue will be discussed in the forthcoming chapters.

Chapter Three: Using modern technologies in a classroom.

"No History, No Self—Know History, Know Self"`

(Winner of a Best T-shirt competition)

3.1 Introduction

History could potentially benefit from the use of electronic technologies. This has been recognised previously, and attempts have been made to augment classroom teaching, with varied success. The focus of the present discussion will be in the use of a new technology, virtual environments (VEs), which might be thought to be especially beneficial since it might allow historical events and chronology to be depicted in such a way that it can be effectively remembered using a spatial (rather than semantic) memory store. This issue will be discussed below, but the use of alternative and wider forms of technology will be discussed initially.

Haydn (2000) identifies two main principles in using modern technology in this area:

- pupils are asked to work with the information with which they are presented
- this should be some valid historical information that engages students, making them excited about the activities they are involved in rather than simply performing matching exercises

In the recent past it was uncommon to use any technology in the history classroom, and although history teachers appear to recognise the benefits of applying technology, not all seem keen to integrate IT skills in the history classroom and avail themselves of the opportunities afforded (DfE, 1995). Nevertheless, the National Curriculum specifically states that all pupils should be given opportunities where appropriate, to develop and apply their IT capability in their study of history. (DfE, 1995).

A recent report produced by Becta (Underwood, Baguley, Banyard, Dillon, Farringdon-Flint, Hayes, Le Geyt, Murphy and Selwood, 2010) identified challenges and issues in the field of using IT in education. The report shows that considerable progress has been made in recent years, but there are still some signs of slowness in the development of using IT, even advanced colleges feeling that they could do better in terms of employing technology in classrooms. FE colleges are more likely to have projectors and other educational tools in order to deliver teaching in classrooms. One of the most promising findings that the Becta report identified is that there is strong evidence that young people do prefer to use technology where possible. According to the report, fewer than 10 per cent of students are offered use of technology in a core subject at least once a week. The report suggested that the improvement of the use of technology has had a positive impact on learners' experiences. Also it has contributed to finding creative ways of delivering teaching materials. There has been steady improvement since 2003-2004 in the use of learning platforms in FE colleges. Overall, however, there is still room for improvement.

Haydn, Arthur and Hunt (1997) state that the use of IT increases pupil motivation and can improve attitudes to school and pupil behaviour. The government inspection body, the Office for Standards in Education [OFSTED] claimed that the potential of IT is often not fully exploited by history department. (OFSTED History, 1994). Field (1999) argues that the effective implementation of IT will bring fruitful results, will promote the development of interest in historical materials, and will develop knowledge and skills in history, which at the same time will assist teachers in delivering learning materials. In programmes of study for history at Key Stages 1 and 2 it has been argued that the most appropriate ways to use ICT are to help pupils to organize materials in a more coherent way and make it easy to communicate information to other pupils (Cooper, 2000).

Borkowski (2002) claimed that ICT in educational settings allows the exploration of scientific research and the exploration of real phenomena. The learner does not, therefore, simply acquire knowledge manually through reading books (Borkowski, 2002; Eggarxou and Psycharis, 2007).

Field's (1999) argument, that ICT in history is an effective tool in teaching materials to pupils, will be seen as too much of a generalization. He continued by saying that some programmes may serve their function temporarily, making children excited for a short period of time, but fail to deliver the most important aspects – instilling knowledge -- whereas other programmes, which, on the face of it may not appear to be very interesting, lacking sound, not providing a very interesting background, lacking in complexity and sophistication, may nevertheless make a significant contribution to the learning process (Field, 1999). A modern multimedia computer has the potential to offer a great deal (Field, 1999); it brings interactivity (allowing pupils to explore, to investigate materials at their own speed) supported by advanced technological innovations. For example, a CD-Rom that presents text about the outbreak of World War II allows pupils to read out loud (suitable for some pupils with special educational needs), to explain unknown vocabulary, to improve pupils' literacy, as well as improving their knowledge and reasoning. Cut and Paste exercises in Microsoft Word can potentially help students to increase their understanding of chronology. Some research and central planning would appear to be necessary, however, to ensure that all of the materials that are available from the various alternative sources on the world wide web, such as the Viking Network Web, the London Blitz, Victorian Web, are comprehensive materials, optimally suitable for pupils of different abilities and ages. Some teacher guidance is also necessary. Clearly, it is important to ensure best use of time in the classroom and that the use of computer or other technologies do not compromise economical time management (Haydn, 2000; 2008). Of course, technology can also be used to enhance communication and interaction among teachers and pupils.

O' Hara and O' Hara (2001) have described three types of software that are presently used in history teaching:

- Themed software, which provides information to support specific periods such as Viking's CD Rom, and The Third Reich package (providing a unique selection of materials on historical events that may be inaccessible elsewhere). This resource also enables children to appreciate and comprehend other domains such as art, music, and literature from the past (HMI, 1991)
- Open-ended software that is not specifically designed to cover a particular historical period but helps to extend knowledge and children's efforts to communicate and organise materials in a more relevant/appropriate way. An example of this would be the use of Microsoft Word Processing that enables children to replace, organise, edit, and paste historical materials, and which simultaneously allows and frees children to use their creativity (HM1, 1991)
- The Internet offers unlimited facilities for collecting information from various sources that have been hitherto inaccessible. However, some information may not be suitable for children. Therefore, the aim of the teacher (or a 'guide facilitator') is to enhance and build upon this development of learning by effectively utilising all available means and media including information technology capability, resulting in and leading to relevant exciting learning experiences (Fields, 1993). Some schools have even started producing their own websites in which some historical topics are featured: (www.wickham.com).

Other historical websites are as follows:

- Harrappa, which covers the History of South Asia. It has a good section on the Indus Valley, which also includes a visual tour through the valley and provides some information about it
- World Wide Web assists teachers to find interesting documents and resources. Also, pupils can contact and correspond with pupils from other schools on historical projects (The use of new technology in the history classroom)
- The BBC Educational History site that provides an introductory guide to learning history www.bbc.co.uk/education (BBC, 1997)
- The History Zone (www.history – zone.com)
- Research Machines' "Living Library" (http://www.eduweb.co.uk)
- AngliaCampus (http://www.angliacampus.com)
- The Historical Association's "History Online" (http://www.historyonline.co.uk)
- http://schools.channel4.com
- The History Channel (http://www.thehistorychannel.co.uk)
- http://www.spartacus.schoolnet.co.uk/eduwebsites
- http://www.hc.cc.tx.us/library/histnc.htm
- The History Courseware Consortium's Core Resources for Historians
- http://www.e-help.eu. This website is designed to promote the use of ICT in the history classroom. The website presents videos and interactive seminars. The primary goal of e-help is to produce a course for European educator.

In his article, Field (1999) has listed a number of ways in which such ICT can benefit teachers and pupils and enhance learning:

- It can improve pupil motivation and attitude towards learning materials
- It provides an alternative method of teaching

- It can be an accessible medium, usable by all, and it can therefore benefit pupils with special educational needs (who are often reported by special needs staff to find difficulty with appreciating historical chronology)
- It provides a clear account of historical events making them less confusing and disorganised
- It focus pupil's attention on to relevant materials
- It provides pupils with some guidelines that help them to work more effectively when dealing with the vast amount of information available through the internet

Technology has evolved from simple text to the now-familiar two dimensional graphics. In recent years, however, there has been an even more significant advance made in the computing world, in which 2-dimensional environments have been supplemented by 3-dimensional environments. In a 3-D environment participants are presented with an environment in which information can be organised and experienced in three dimensions: screen positions have not only x and y but also z coordinates. So, sequentially and realistically, such a medium allows a visitor, for example, to explore hierarchical information in a 3-dimensional chart, and allows the user to navigate through a space that can represent a hierarchy of knowledge.

Virtual reality is thus an interactive computer technology that employs a 3-dimensional modelling of objects that participants can perceive and manipulate in real or pseudo-real time (Wilson, 1999). Virtual reality (VR) is defined as an artificial world (sometimes a replica of a real world) in which participants employ perceptual-motor and cognitive skills. Also, 3-D graphics software and hardware have advanced to the degree whereby semi-realistic views of real world and abstract ideas/concepts are presented in such a way that they resemble a real environment (Calitz and Munro, 2001)

Computer simulations and virtual reality are potentially powerful learning technologies by themselves, offering teachers a means to concretize abstract concepts for students (National Centre on Assessing the General Curriculum report, 2003).

The user can be presented with new knowledge in such a way that they are permitted to exercise freedom over their movements within the virtual environment, similar to and sometimes greater than the freedom that they have in a real environment. Also it can allow the user, operating a simple keyboard key, mouse or joystick, to fly through and pass historical sequential events, as though the user is travelling in a time machine. It has been argued that experiencing the passage of time by flying in a Virtual Environment (VE) may fix events more clearly in memory, since self-initiated exploratory movement in a VE invokes spatial rather than semantic memory (Foreman, Wilson, Stanton, Duffy and Parnell, 2005). Spatial memory is thought to have unlimited capacity – at least, it is not subject to any identifiable limit (Foreman et al. 2005). Long routes and many landmarks can be easily memorised rather like remembering routes in a familiar town. Specifically, humans acquire spatial knowledge of a new environmental space, even a large spatial environment (a space which is not perceivable from one single point) by travelling through it, especially if they explore it virtually but repeatedly. Besides, spatial cognition is based on the acquisition of a number of landmarks within an environment that at the same time provides participants with an ability to form a structure or representation that defines relationships between the objects within that environment (Wallet, Sauzeon, Prashat and N'kaoua, 2009). The strategy adopted by the participant is also important. Humans can acquire spatial knowledge by using different strategies such as cue-based piloting, path integration, and navigation by cognitive representations (perhaps 'maps') (Foreman and Gillett, 1997; Thorndyke and Goldin, 1983).

O'Keefe and Nadel (1978), after Tolman (1948), argued that the most effective spatial representation involves the construction of a cognitive 'map' that is more elaborative and includes the shape, structure and surfaces (see Kitchin, 1994). This allows the understanding of spatial relationships between multiple cues and landmarks. The latter can be used as a navigational aid that allows the formation of organizational relationships with other points (Jasen-Osmann and Wiedenbauer, 2004). Of course, humans can also rely on other additional strategies that will assist in directing themselves in an unknown environment -- for example the use of olfactory and tactile cues (Loomis, Klatzky, Golledge, Cicinelli, Pellegrion and Fry, 1993), though the most effective modality for acquiring spatial information is arguably vision.

VEs can effectively convey information regarding spatial layout and environmental relationships, allowing route-learning, mapping, and landmark use, of a kind associated with cognitive map formation, and in participants ranging from children to elderly adults (Foreman, Stanton and Wilson, 2003; Ruddle, Payne and Jones, 1998; Stanton, Foreman and Wilson, 1996). However, since time and space are inextricably related, movement through a VE can be regarded both as movement across particular distances, or as displacements in time. This connection, the temporal-spatial dimension of VEs, will be used in the present studies. Encountering events or items successively in a VE conveys the notion that the events are related within a chronological "space".

Locations represented in spatial memory can be encoded in relation to other locations rather than from a particular stand point (Hartley, Trinkler and Burgess, 2004). The spatial relationship between objects is durable and can remain stable over a long period of time (Hartley et al. 2004). This can be demonstrated by referring to the Morris watermaze paradigm (Morris, 1984). The latter was used to study navigation in rats, which were trained to use environmental cue configurations in order to escape from a pool of opaque liquid. The animals were trained to find a platform in a fixed location that was concealed beneath the surface of the water (Morris, Garrud, Rawlins and O'Keefe, 1982). If the rats sustained impairment to the hippocampus, a brain structure located in the temporal lobe, they failed to swim to the correct location '…when the hidden platform was removed on probe trials' (Hartley et al. 2004). This experiment and many others have demonstrated the involvement of the hippocampus in controlling spatial memory (Burgess, Maguire and O'Keefe, 2002).

The same process seems to occur when people explore within virtual space. Participants who are actively involved in memorising materials as a series of places, rather like the memorising a row of familiar shops, via flying through a virtual version of an environment successfully acquire information despite having experienced the environment only virtually (Foreman et al. 2005) because the same perceptual processes are probably engaged (Foreman, 2010; Gibson, 1962; Held and Hein, 1963). The VE allows the user to explore a space equivalent to a large public building, in pseudo-real time (Wilson, 1997; Bliss, Tidwell and Guest, 1997; Foreman, Stanton, Wilson and Duffy, 2003; Foreman et al. 2005; O'Neil, 1992; Ruddle, Payne and Jones, 1997; Rose and Foreman, 1999).

Why is spatial knowledge acquired from simple exploration? This is a question that applies to any spatial situation, but is particularly relevant to the use of VE technology. There are a number of reasons:

1. People may want to learn about an environment and later use experience of an already-known environment to make use of another less familiar environment (Munzer, Zimmer, Schwalm, Baus and Aslan, 2006)
2. Spatial knowledge helps an individual to plan routes that consist of a sequence of places (Munzer et al. 2006)

3. Without spatial knowledge people would be simply lost in an unknown environment (Munzer et al. 2006)

The same appears to apply to virtual spaces. In his article, Wilson (1997) illustrated several potential benefits of using a VE, describing three research areas in which the understanding of space via a VE can be applied: learning and disability; investigating the relative importance of physical and psychological activity in VE use; and memory processes in virtual and real environments. Similarly, Jansen-Osmann and Wiedenbauer (2004) identified additional benefits conferred by the special features of VEs, i.e.,

- spatial relations and environmental features can be changed quickly
- any environment can be simulated and navigation can be measured on-line (see also Goldin and Thorndyke, 1982)
- it gives unlimited control over the visual features and it allows detailed recording of behavioural responses. Besides it allows the manipulation of landmarks and routes that in real life is sometimes impossible (see also Moffat, Zonderman and Resnick, 2001)
- individuals can develop their knowledge about navigation, routes, and they can develop survey knowledge (see also Jansen-Osmann, 2002)
- the flexibility of VEs allows ecologically valid testing in cognitive and neuropsychological studies (see also Rose, Brooks and Rizzo, 2005)
- VEs provide naturalistic settings and behaviour in VEs is similar to that in equivalent real environments (see also Foreman, Pohl, Mandelkow, Lehung, Herzog and Leplow, 2000; Ruddle et al. 1997) but at the same time they allow participants to feel safe within the environment, even in one that in real life can be regarded as dangerous

However, VE use is not universally appropriate; for example, it might cause nausea especially with older female participants (Moffat, Zonderman and Resnick, 2001). The biggest drawback of using VEs (when a desktop system is used) is that it prevents participants from experiencing actual spatial movements (Moffat et al. 2001). Nevertheless, despite the practical limitation of VEs, there is evidence of showing that learning in a virtual environment transfers well into a real environment (Arthur, Hancock and Chrysler, 1997; Foreman et al. 2004).

3.1.1 Virtual Environments and Learning/Physical disabilities.

One of the particular benefits of attempting to adapt virtual environments to classroom use is that it may be beneficial for pupils who do not usually succeed in academic subjects, history among them. Therefore, although the objective of the present studies is to design methods that assist all pupils, it is worth considering whether particular categories of challenged pupils might especially benefit. VEs have been used extensively in the past with groups of children having learning difficulties or physical/mobility limitations.

Cromby, Standen, Newman and Tasker (1996) conducted an experiment which showed effective transfer of training from a virtual to a real situation. A group of students with learning difficulties were given extended experience of a tour in a virtual supermarket. Another group was given the same experience exploring other virtual environments such as a city, a house and ski slope. Afterwards, the group that was trained in the virtual supermarket completed shopping tasks faster compare to other two groups, and they selected more correct items. Also a VE has been used with children suffering from cerebral palsy to train them to drive a motorised wheelchair (Inman, 1994). Turner (1994) argued that VEs provide people, but especially those having some form of disability, with a safer environment within which they can exert independent control.

A project was carried out with participants with learning disabilities travelling on a virtual bus to school (Mowafy, 1995, cited in Wilson, 1997). The virtual travelling allowed the disabled children to familiarize themselves with the environment that under different circumstances would have remained unknown to them. During the virtual trip the disabled children taught themselves about the place where they needed to transfer to other buses and about other alternative routes they may need to use in the future to get to school. In the real world, the mere thought of doing such exercises without any external support might stop the children acting upon them, whereas the virtual tour provides an opportunity for physical disabled children to explore, relatively free from the limitation imposed by their disability (Wilson, 1997).

Other usability studies of VEs have demonstrated that people with learning difficulties can benefit from such environments. For instance, Cooke, Laczny, Brown and Francik (2002) described a virtual courtroom, a virtual reality and multimedia-based training platform that was intended to prepare people with learning difficulties to cope with the courtroom experience. The idea of this project was to introduce people with learning difficulties to different scenarios, for example, in which the person may be required to give evidence in court, potentially making the experience less daunting and improving their performance and confidence.

Passig and Eden (2001) investigated whether or not practice with rotating 3-D objects in a VE would enhance mental rotation in deaf and hard-of–hearing children compared to practice with rotating 2-D objects. They compared an experimental group consisting of 21 deaf and hard-of-hearing children playing with 3-D virtual objects with a control group consisting of 23 deaf and hard-of-hearing children playing with 2-D objects. The results revealed that those who practiced with the VE 3-D objects significantly improved their performances on spatial rotation, which at the same time enhanced their intellectual as well as their language skills compared with the group that practiced with the 2-D objects.

Passig and Eden (2003) conducted a similar study in which they aimed to use VE as a tool for improving structural inductive processes and the flexible thinking with hearing-impaired children. There were three groups involved in this study: an experimental group, which consisted of 21 deaf and hard-of-hearing children, who practiced with a VE 3-D game; a control group, which consisted of 23 deaf and hard-of-hearing children, who practiced with a similar (but not virtual) 2-D game; and a second control group of 16 hearing children who were free of any intervention. The results revealed that those who practised with VE 3-D spatial rotations showed a significant improvement in inductive thinking and flexible thinking.

There is some evidence suggesting the particular effectiveness of using 3-D presentations (Cockburn, 2004). For instance, Tavanti and Lind (2001) reported the effectiveness of using 3-D over 2-D environments, participants in their experiment recalling the location of alphabet letters much better than those who used 2-D. Cockburn (2000) claimed that in no previous studies was it evident that a 3-D environment would invoke spatial memory. Wickens, Olmos, Chudy and Devenport (1997) argued that the benefit of using 3-D is still not explored as the success of 3-D would depend on many factors such as the environment used by participants, the nature of the task, the structure of the information presented to participants and many other factors that might well influence how participants organize and remember information from a 3-D presentation.

Brown, Neale, Cobb and Reynolds (1999) constructed a 3-module Virtual Learning Environment, The Virtual City, consisting of a house, a supermarket and a café, which was used by special needs adults and children to learn some of the life skills needed to live independently. The transfer of some learning skills to the real world was found, although the authors recommended that further studies were needed to assess the benefits of training. Since one benefit of using VEs in the context of teaching historical chronology may be that it is a very suitable medium for children with cognitive and/or physical disabilities (who appear to have special difficulty with retention of chronology), and for children who are weak in history, disability status and educational attainment of children were taken into account in the present series of studies wherever possible.

3.2 Gender differences in learning spatial materials

Gender differences are variable from one VE based study to another (Coluccia, 2004; Chan, 2007). Where significant gender differences occur, these could be explained in terms of at least two theories: evolutionary, and the process-oriented approach. Coluccia's (2004) literature review on gender differences in spatial orientation skills reviewed literature from 1983 to 2003. The author discussed the influence of biological and socio/cultural factors as well as different strategies used to solve orientation tasks, from the evolutionary point of view. Evolutionarily, functions performed by males and females were often different. The Hunter-gatherer theory (Silverma and Eals, 1992) suggests that there are modern day differences between the genders in spatial and cognitive abilities that originated from differentiated prehistoric sex roles. The authors argued that the development of human abilities can be explained in terms of competition between genders and competition to get access to food. Development of females' spatial location depends on their ability to trace offspring and food location (Levin, Mohamed and Platek, 2005). Females tend to focus on local features (for example, using different map learning strategies), which require specific characteristics rather than an appreciation of global features of environments, the latter being more evident in the strategies adopted by males (Coluccia, 2007)

The results of many studies are consistent with the notion of specialized spatial processes in males and females, reflecting division of labour (Coluccia, 2004, Hubona and Shirah, 2006). The evolutionary theory fails to explain what cognitive processes are involved in these activities. It also fails to take into consideration other cognitive aspects that might be equally involved in prioritizing certain tasks for female and male.

The process-oriented approach argues that gender differences arise according to which tasks are performed by males and females: men are better in doing tasks that require active understanding or assimilation of spatial information while women are better in tasks that require passive maintenance of information (Kaufman, 2007; Geary, Saults, Fan Liu, Hoard, 2000; Good, 2002). The approach seems to be a universal explanation of what determined gender differences in the first place, though it does not necessarily explain why men are better in certain spatial tasks, but fail to perform equally well on other tasks. Men perform much better on the tasks that require more overt physical activity in the gathering of information, whereas female are thought to do better in terms of storing this information.

Clark and Paivio (1991) claimed that gender differences are influenced by the dynamic or static nature of the mental images that are required to perform certain tasks. Men do better when manipulating and transforming mental images or object locations in a real three-dimensional environment (Lachini et al. 2005) whereas female do better when they actually work with static images or when they have to deliver visual characteristics of images (Vecchi and Girelli, 1998). Researchers also claimed that verbal tasks that require spatial transformation were performed better by men compared with women (Colom, Juan-Espinosa, Abad and García, 2000). By the same token, women are better than men when it comes to remembering the spatial location of objects (Colom et al. 2000) and outperformed males in resizing objects (Hubona and Gregory, 2006).

Chan (2007) tested a sample of 337 Chinese, gifted students on spatial ability. He found that there were gender differences in spatial ability favouring boys. Other measurements showed modest support for gender differences on other tasks, especially in visual arts experiences, favouring girls. The authors concluded that with an experience which required fostering spatial knowledge, girls could significantly improve their performance in terms of using spatial abilities.

Large gender differences, favouring males, have been reported in a virtual spatial maze navigation task by Astur, Ortiz and Sutherland (1998) though in many other studies, gender differences, where they occurred, were small. Thomas et al. (1999) tested 1,800 participants in a virtual arena task, finding at best that gender differences were variable and inconsistent.

In summary, it is hard to predict, in a particular instance, whether there will be significant gender differences on a spatial task unless it makes extensive use of mental rotation per se. In most spatial and spatial-temporal tasks in VEs, it is likely that males will be found to be superior, but because their use of computers, use of computer games, and familiarity with interface devices will be greater (Waller, 2000). In relation to the studies described in later chapters it is important to note that interface familiarity can influence the acquisition of spatial information from a VE (cf. Sandamas and Foreman, 2007) and that it may be necessary to provide at least modest training with an interface device to overcome any unfamiliarity of participants – particularly female participants -- with the VE medium (Sandamas, Foreman and Coulson, 2009). However, the importance of the gender variable for spatial testing and virtual remediation is unclear. The results of Astur et al. (1998) might suggest that gender will influence the effectiveness of VEs in the context of spatial-temporal learning even in small groups, although others suggest otherwise (Sandamas and

Foreman, 2007), gender will be tested routinely as an independent variable in the present studies.

3.3 Virtual Environment Use in Education

There has been a frequent prediction that VEs will prove to be the most effective medium for use in education in future (Grove, 1996; Johnson, Roussos, Leigh, Vasilakis, Barnes and Moher, 1998; Losike, 2006; Whitelock, Brna and Holland, 1996; Winn, 1993). Furness et al. (1997) suggested that VEs can be successfully applied in an educational environment thus enabling teachers to improve the delivery of complex topics without the need for simplification. VEs have already been widely used as a spatial knowledge training medium, sometimes in educational environments (Foreman et al. 2003, 2005; Waller, 2000).

Eggarxou and Psycharis' (2007) results provided strong support for using 3-D environments in educational settings, enabling pupils to explore the Erechtheum in ancient Athens. Virtual Reality Modelling Language (VRML) can be used to simulate space that enables students to visualize new information in a new way and thus help them to understand abstract concepts more concretely. Generally, as was pointed out earlier, 2-D timelines do not give a sense of spatial relationships between and among historical events; they are rather presented in categories that might not necessarily have any interlinks to each other. According to an influential NCAC report only one single study has investigated applications of VEs in the humanities (NCAC, 2003).

With regard to language learning, Schwienhorst (2002) noted various advantages of using VE technology especially that it can provide self awareness, interactivity and it enables real-time collaboration. Further, VEs give the ability for students to revisit aspects of the environment, thus enabling them to exercise personal, autonomous control over the environment to a greater extent (NCAC, 2003). In his study, Ainge (1996) showed evidence that students who built 3-D solids could recognize 3-D shapes in real life, compared with a control group that constructed 3-D solids by using paper and who failed to perform on the real world 3-D object recognition task.

Space-time dimensions have been exploited in VEs by archaeologists to display changes which have occurred over the years on excavated sites, allowing the users to take a visual journey through the historical past (Barcelo, Forte and Sanders, 2000). In particular, the project named Apfrodisias was initiated and carried out by a group of American archaeologists who aimed to teach students of archaeology, history, and urbanism. The aim of this project was to introduce the students to a virtual environment, which could be used either in a classroom or a museum. It could also be used on-line as a communication tool by archaeologists and students. The virtual environment consisted of reconstructions of the Agora market place of the antique city of Aphrodisias where architectural elements, sculptures, textures, and virtual characters living inside the virtual city of Aphrodisias were incorporated. The archaeologists were mainly concerned with depicting routines, and daily activities of the citizens living in the Agora.

The Norwalk project (based in a public museum in Norwich, Norfolk, UK) called the "Origin" has the same educational objectives. The aim of the project was to introduce children to the diverse culture of the Norwalk Norwich region. The display is aimed at children, who are accompanied by a virtual boy on a skate board skating across the screen which depicts a 3-D virtual scene with converging roads. The boy moves from one stage in history of the region to another. On his way to a particular target he stops at different historical sites explaining to a viewer about the tools used during this period, about traditions, customs, daily routine and the diverse culture of the inhabitants. Although an excellent and engaging display, the sequential and chronological aspects are not explicit because the historical events are not necessarily experienced in a particular order.

A similar project was designed by a group of Russian/Ukrainian web designers, who have been working on the history of Russia based on Karamzin's (1766-1826) interpretation. Nikolai Mikhailovich Karamzin was a Russian author credited with reforming the Russian literary language. He is best remembered for his *History of the Russian State*, a 12-volume national history modelled after the works of Gibbon (1737-1794). Karamzin was a pioneer in trying to organize historical events into a book which could be easily understood by all readers regardless of class, educational background and gender. His main objective was to popularize the history of Russia, to make it more accessible and more available for everyone. The project is timely, since Russian and Eastern European citizens are now learning about historical eras prior to the communist period, which place their countries in a broader historical context. The authors of the project have been working with Karamzin's idea, but trying to implement it using new technologies, helping television viewers to see the subject matter from a different angle: it is innovative, exciting and up-to-date, taking into account the viewer's preferences. The designers of the project claimed that the way history is presented to viewers is usually one-sided, failing to take into consideration alternative explanations, theories on a specific historical argument. In general, history has been segregated, one part is well popularised as it appeals to the public, another part remains unknown to all but the most inquisitive of members of the public, since it is less interesting and exciting. In a nutshell, unpopular history did not exist. Characters depicted in various historical scenarios are depicted as avatars (the soldiers' breath being visible in the cold air), and movements of both people and animals are realistic; thanks, arguably, to the 3-D aspect of the environment, one can feel the presence of the characters, and perhaps imagine how they felt at that particular moment. However, the chronological aspects of the project were not incorporated in the 3-D version; it was rather a depiction of a particular event followed by narrative speech. A chronological aspect was provided but via a 2-D backdrop, showing, as a vertical timeline, the family tree of the Russian royal dynasty. In other words, while some form of 'presence' may be created via the 3-D representations of events and actors, chronology is not incorporated into the 3-dimensionality. The question remains: can a viewer follow and remember chronology from a 2-D sequential line of historical developments?

The Riverside City Project is described as a multi-user virtual environment for learning scientific inquiry and 21st century skill. The virtual environment is a 19th century American town that is affected by disease. Students are supposed to work in teams in order to develop a hypothesis to identify a potential cause of the disease. In the project they have freedom to interview the citizens of the town to identify what they think might contribute to the development of the disease, to be able to read relevant documents, visit hospitals and review the photographs. Also there are some agents available to provide guidance, but the students themselves decide what approaches they want to use to complete their inquiry. This is to encourage the students to learn science concepts and inquiry, the ability to challenge scientific evidence; the ability not to take historical materials for granted but rather to encourage the idea that one should question them, doubt them and, finally, find an answer.

In one study, 700 students who participated in the above project showed greater improvement in their inquiry skills compared to the students who used a paper-based curriculum. Additionally a qualitative study was conducted; the findings also indicated that the students had a better understanding of scientific content (Ketelhut, Dede, Clarke and Nelson, 2006). This is one of the rare studies in which a learning protocol has been assessed empirically using a controlled experimental design.

It is important to note that, similarly to the Aphrodiasia project, and the Norwalk project, the Russian and the American projects were designed specifically to introduce children/viewers, via a 3-D simulation, to stages in history that are usually problematic and less well remembered when the same information is introduced in schools using 2-D materials.

The four projects described above are clearly both interesting and exciting and bring new light into how children/adults learn, or might learn, history. The paramount aspect that unites all these projects is the use of 3-D technologies that allow users to feel a 'sense' of history, to be present there, to experience things as they were and are -- as though travelling through time. In particular, by using an interactive VE, participants can have:

- Active control over the environment
- A feeling of being present at a particular period of time in history
- an appreciation of history as real events
- easy accessibility to some realistic historical materials
- and consequently more understanding of the diversity of history

Learning history via a VE should not be a one-way process. Support from teachers, peer group and time for self-reflection are also important. The discussion with other students or adults that explain difficult concepts is a very important factor not only in the learning process but also in social interaction that can lead to deeper learning (Francis, 2006; Stanton, O'Malley, Fraser, Ng and Benford, 2003).

The study by Stanton et al. (2003) examined the importance of adults' participation in a mixed reality situation. It aimed at aiding children to discover and reflect on historical learning. The study involved a paper-based history hunt in which participants made drawings of a variety of different locations at an historical site. Then the paper versions of clues were transferred electronically and used to interact with a story. When the information was transported electronically, it revealed a 3-D environment of the castle. Data revealed that when using mixed reality, the importance of collaboration between the adult and child is very significant in terms of engaging a child with new materials such that it helps him/her to make connections and new discoveries. The authors supported the idea of using new technologies along with collaborative learning. The main finding was that by developing an immersive environment that facilitated the quality of learning, children and adults could be helped to more effectively communicate historical information. Previously, it had been argued that children who made museum trips with their parents and then later spent time explaining the details of the trip would tend to remember more about the display seen in the museum. The same analogy was employed in the Stanton et al (2003) study, using a collaboration pattern that adults and children employ when reflecting on new historical discoveries that later can be integrated into the experience of mixed reality learning environments. The analysis revealed that adults' role was to structure, drawing attention to information, making connections between historical events. The whole experience of the project revealed that the physical act of exploring using paper helped children to be more involved with the environment, making connections between physical activities and physical environments that at the same time corresponded to past activities and environments.

Despite the fact that the above studies were mainly concerned with history, and the teaching of historical content, they cannot be assumed to teach children effectively about historical events in chronological order. The studies' main objective was to introduce the context of a particular historical epoch, thus failing to focus on the sequence of the events. Needless to say, the core of any successful learning process -- regardless of discipline -- is to make connections between one event and another, to explore cause and effect phenomena. Without this, education in general, and history in particular, can be seen as chaotic.

However, the question arises as to whether a feeling (or illusion) of "presence" is necessary for a participant to fully benefit from the illusory reality of a VE. Furthermore, does the feeling of presence occur reliably, in head-immersion VEs but especially in desk-top VEs? Despite intense interest in this phenomenon, there have been limited attempts to explain why the human beings feel presence when using 3-D media or simulation technologies (Lee, 2004, though see Sadowski and Stanney, 2002). Even though simulation and interaction technology have developed significantly, approaching steadily towards more realistic experiences, there are still some areas that need to be looked at --- the differences between the real and virtual environments. In some cases it is only the visual aspects that are simulated in 3-D (De Kort et al. 2003).

Where a user controls a virtual agent, De Kort and his colleagues (2003) posed the question, whether or not there is correspondence between the physical body and the perceived body on the screen. In view of the absence of the physical body in the simulation, there is no correspondence between '…what the user sees and the movement and position of the body' (p.363). This is important because the sense of presence is said to be the defining experience for Virtual reality (Steuer, 1992).

Another evident difference is that some technical devices that are used make substantial demands while navigation is undertaken through a VE. This in itself can make the user feel unnatural about his/her experiences (De Kort et al. 2003). Besides, the devices used in the VEs may often complicate the movements, which might result in disorientation (Witmer, Bailey, Knerr and Parsons, 1996). Any of these aspects may well contribute to differences seen between real world experience and that in virtual worlds. However, the historical projects described above and the numerous research projects already done in this field have shown that the participants claim that the VE helps them to develop a sense of presence.

A study that used desk-top VEs with some benefits with a group of individuals with disabilities who had difficulty in understanding or remembering chronology was that of Pedley, Camfield and Foreman (2003). Participants were six disabled children who had different forms of cerebral palsy. The participants created personal timelines consisting of visual images of significant events in their lives, which could be re-experienced repeatedly as a ‘fly through’. Prior to the experiment, the participants found it difficult to think of three personal events in a chronological order. However, after completion of the programme they reported that they could easily remember their personal events sequentially. All participants expressed their confidence in being able to remember significant events in the order which they took place originally. All in all the findings showed that these children may have gained better understanding of chronologies as a result of their participation. The authors of the study concluded that “creating VEs allowed the group to explore their own life histories in new ways.” (p.186). Not only did the study demonstrate the benefit of using VEs with disabled children, but also it brought interesting accounts of children’s personal understanding of their disabilities and how disabilities affect their lives. The children had the courage to talk about personal issues openly, without being stigmatised. This study revealed how it is to be a disabled person in an ‘able society’.

Based on the rationale and findings of the earlier study (Pedley et al. 2003), the present studies aimed to incorporate VEs into history teaching that could potentially provide children with a visual fly through of successive eras of national history. Pedley et al. (2003) demonstrated that disabled children, who have particular difficulties with understanding space/time concepts, benefited from using VEs (see also section 3.1 above), and able-bodied participants might also benefit from using VEs, enabling them to better place historical events in chronological order. Using VEs could transform the traditional 2-

D timelines so that the memories for historical events could be encoded and stored within spatial memory; storage could incorporate many events since spatial memory has apparently unlimited capacity. In addition, the present studies will investigate the possible benefits of using VEs in the teaching and learning of various academic disciplines that have strong chronological components, beginning with world history, the history of psychology, and art history.

3.4 Multiple timelines

Chapters 5-7 below explore the application of VEs in educational settings, to convey the concept of chronology, so that children and adults who had training in the VEs, and control groups trained with other media (PowerPoint and Paper conditions), are subsequently tested for their ability to place the depicted series of historical items in their correct sequential order. In these studies just a single timeline is used to train participants to recall nine historical events. In most cases, the materials were selected with teaching staff assistance, to represent materials that teachers required children to learn in class but which were frequently mis-ordered.

The mixed and interesting findings from the studies suggest that VEs do not confer reliable advantages over other media in terms of immediate recall or recall after an interval (with, or without retraining). The introduction of challenge, in a format typical of many competitive computer games, was clearly beneficial in many cases. However, a problem remains, insofar as it cannot be assumed that the earlier studies tapped spatial memory. Participants remembered as series of items laid out in virtual space, but there is no way of telling to what extent participants remembered successive items in the way that they would remember a series of items when, for example, repeatedly walking past shops in a main street.

Later studies (Chapters eight and nine) explore the possibility that there may be greater advantage from using a different type of environment, in which two or three timelines are introduced simultaneously, thus allowing a participant to explore them in parallel, having the facility to switch from one time line to another within the same environment. Participants can either learn both domains simultaneously (as information is always available for each domain) but as a single timeline that incorporated two superimposed domains (Chapter eight), or as separate timelines in parallel (Chapter nine). In the latter case, therefore, the participant can scan across from one time line (domain) to another, thus experiencing events that were simultaneous in historical time at the same points in space in the VE.

The construction of the timelines was based on information selected from various internet links and historical books. For instance, the timeline of the history of the world depicted historical events that occurred in general history from 1879 to 1998; the history of psychology time line introduced major events that shaped psychology and psychological thinking and, finally, the history of art time line presented significant developments that took place in the artistic world, each one covering the same time period (1879-1998).

The rationale for this experimental approach was partly influenced by Kullberg's (1995) environment, in which the history of photography was depicted in a 3-dimensional multiple timeline format. In that instance an explorer had control over their displacements in the environment such that he or she could navigate among photographs, travelling in different directions, and had a choice of either obtaining further information about a selected photograph (by clicking on a relevant icon) or moving on in time to further items. Also, a possible advantage of Kullberg's (1995) format is that the ability to see an overview of the environment (from an elevated virtual viewpoint) makes it potentially easier for the explorer to establish spatial relationships – establish an effective cognitive ‘map’ (O’Keefe and Nadel, 1978) – amongst places/images, and that may subsequently improve recall of the information. It should be noted that Kullberg’s work was not intended to be a significant contribution to educational technology, and perhaps for this reason no attempt was made to evaluate whether the use of the multiple timeline could improve upon a user’s understanding of the history of photography compared with simply reading books about it.

Multiple timelines are not new, insofar as complex representations of multiple domains of history have been depicted in the past in 2-D form. An introduction to the history of such timelines, going back to the earliest recorded centuries, will be provided. This is in order to understand how ancient scholars thought about time and, more importantly, how they thought about presenting time and relative time graphically. Of course, early timelines suffered from various difficulties and incorporated different levels of complexity. For instance, it was not always possible to grasp, from a complex time line, the continuity of time from one era to another. Not only did early scholars have difficulty in representing time in a simultaneous graphical form, but also the use of timelines was rarely tested insofar as the latter were not easily accessible by the general public—it was mainly the privilege of educated scholars to work with timelines. In recent years, however, the improvement in the representation of time has made it possible to use new materials in schools. The following chapters will consider the advances made as a result of employing new technologies (in particular, VEs) to present complex multiple timelines. The main objective of Chapters nine and ten is to determine whether, by using VEs, either or both children and/or adults could improve their performance in remembering items chronologically across domains by being spatially engaged with a large-scale multiple timeline. Anecdotally, people find it difficult to associate one event in living memory with another, even when the events occur at the same time. With advanced technology such as

VEs, and with the knowledge that spatial memory is apparently unlimited, the potential of VEs is enormous for imparting temporal-spatial information about many historical events. In addition, it will arguably allow participants to engage with an environment and gain (potentially unlimited) information from different disciplines presented simultaneously. In future, should the present study prove to be successful, the environment could be expanded via the addition of new timelines such as the history of medicine, history of religion, history of sport etc. This could be very useful, especially for children who might thereby discover a new way of learning about history: hopefully they would not find this a boring and monotonous task, but rather exciting and interesting (like playing a realistic computer game), and useful insofar as the information to be remembered may become more strongly and permanently imprinted in memory. Mixed reality offers potential for making a bridge between now and then, that people often find it difficult to comprehend (Stanton, O'Malley, Hui Ng, Fraser and Benford, 2003; Prangsma, Boxtel, Kanselarr and Kirschner, 2003). If VEs are used in the future in places such as museums, this might improve the experience of visiting and enhance knowledge about the past. In other words, by using new technology, this could act as a bridge between physical and digital worlds (Stanton et al. 2003).

3.4.1 History of complex timelines and time depictions

The Greek word 'chronos' means time and 'logia' means a branch of knowledge. Chronology is the sequencing of events/people in relation to each other and to existing knowledge of other, already known events/people/developments.

Chronology is not an everyday concept, but its importance is widely acknowledged in teaching history (DES, 1985/86/89A/91A, DFG, 1995). 'It is from this fact that Chronology and Geography are often termed the eyes of history ….. Chronology is its very bedrock and foundation: History in its beginnings was no more than a simple Chronicle'. (Barbeu-Dubourg, 1753).

Throughout the centuries people would visualize time as being linear—the line appears as the most conventional way of dealing with time. Recently scholars have found way of presenting chronological historical events on a measured timeline (Rosenberg, 2007).

Timelines are thought to be able to help children and adults learn chronology in more exciting ways. A number of attempts to present time in a visual way can be traced back through recent centuries. For instance, Diderot wrote a descriptive account of the chronological machine invented by Jacques Barbeu-Dubourg that 'imagines a combination of several component charts brought together to form a single large one' (Diderot, cited in Ferguson, 1991). Throughout history, cultures have developed their own way of representing chronological events. For instance, the Persians had their king list, the Greeks produced their table of Olympiads, and so on (Rosenberg, 2007). The most influential timelines produced in the eighteenth century were the Chart of Biography (1765) and New Chart of History (1769) invented by Joseph Priestly (1733-1804) (Rosenberg, 2007).

At the present time given the significant advances made in technology and media, it has become possible to represent timelines, regardless of their complexities, by using various media. The BBC history website has launched a program, in which persecution and Genocide during the Nazi Regime in Germany (1933-1945) was shown, taking a learner through the path of history in a sequential fashion. More importantly, having control over movement within the environment made it possible for the learners to regulate the speed of their movements -- whether to speed up or slow down -- if more or less rapid experience of the information was desired. Speed adjustment was accessed by clicking on a particular screen icon. The time line covered 12 years of Nazi rule and deliberately deprives the learner of the benefit of hindsight or a view of the future, ensuring that they experience historical events in the sequence in which they actually happened to those who lived through them. However, a feature of that program, which is shared with most other attempts to use new media to convey chronology, is that it has never been assessed scientifically to determine whether or not it is effective. That is, whether viewers acquire anything constructive from the presentation that could not be acquired as quickly or effectively from other medium.

The second time line, covering the general history of the 20th century: in art, music, political life, wars, innovations etc., http://www.channel4.com is presented in a linear format in a 2-D version year by year, starting from 1900 to 2000. Clearly the developers hope that it engages a child's interest sufficiently that they would be motivated to follow and remember linear histories of art, music or politics when these are not spatially "connected" with each other. Certainly, the materials included on the web page are highly interesting and informative, giving a sense of history, but in which important and less important events are equally highlighted. Moreover, the information is reasonably condensed. Enough materials are provided to allow a child to think about history in general, allowing the viewer to realize how present day history has been shaped by the past. The only concern that one might raise is not being able to visualize historical events that might have happened in parallel -- not being able to see continuity and interconnectivity. In fact, all domains are presented in different dimensions. To improve that timeline and potentially increase its effectiveness, the information could be presented categorically and spatially so that events can be seen to be interconnected.

A timeline called world history or "hyper-history" time line (http://www.hyperhistory.com) is also available, in which different categories of event are presented including culture, religion, music, politics, and science. They are all presented in a 2-D format. Clicking on an icon on culture takes an observer to view a linear time line having a list of artists, musicians and filmmakers. For those who want to know more about particular events, more information is available in the form of texts or images, e.g., of individual artists' work. The presentation is impressive and well researched, but is presented in a rather chaotic manner with so much information that users could find it difficult to follow. Again, the timeline is categorically divided, placing all artists under subgroups: Classicism, Romanticism and others. No temporal-spatial connection is evident in this time line that relates events according to their chronological positions.

The bakery company, Hovis, which frequently emphasizes its long history and traditional character, has recently produced a commercial video showing a boy, initially in his local bakery, buying a loaf of bread. On his way home he is seen passing through the history of Britain in the 20th century. Along with the changes in the world that the boy observes, his clothes also change to conform to the era depicted, perhaps designed to indicate the breadth of changes that happened in all dimensions of people's lives. At the beginning of the video clip, a poster is seen on an advertising board in the background telling the viewer of the news about the sinking of the Titanic. The next episode shows a demonstration of suffragette women on the streets of London, demanding the right to vote in elections. Then there occurs the outbreak of World War 1 -- soldiers are seen leaving London to fight at the front; an image of destroyed houses during the bombardment attacks in World War 2; a celebration of a royal Jubilee and a demonstration of miners during the government of Prime Minister Margaret Thatcher. Finally the video clip concludes by showing the Millennium fire work display in central London. From an informal discussion with children (not a part of the present research and thus not analyzed as such), it was evident that children enjoyed watching the clip. They expressed their excitement over the video, implying that they thought it combined simplicity and interest in providing clear information about how the history of Britain evolved during the past century (YouTube New Hovis Advert In Full HD Stereo – 12 Sept 2008).

Bamber Gascoigne's website: www.historyworld.net: The work presented on this website, developed by a well-known university quiz show presenter, is fundamental and well-searched. A viewer is presented with various information, including Art, Religion, Literature, technology, wars, performing arts etc., Also there are other links that help to understand a chosen subject in more depth such as a link to *Encyclopedia Brittanica* that lists historical events in alphabetic order, but not in chronological order. Another disadvantage of this link is that all information is presented as one big entity without being categorically subdivided. When a viewer moves forward they are given a timeline scale on the left starting from AD1 moving towards 1975, although other events such as the development of primitive homo sapiens are mentioned before AD1. For instance, c.4m years ago: Apes of a certain kind develop the habit of walking upright on two feet. Next to a very condensed description of the historical facts, there are other links that show other available resources to explore a particular phenomenon. On the left hand side a viewer is presented with an extra button that after clicking it gives more detailed information about the specific event. There are other divisions incorporated in the website, making it easy for a learner to narrow down his or her research by giving options such as Areas—a selection of countries; themes/specific and general. For instance, for the specific theme, the learner could choose a subject such as Empires that is divided into various existing empires: Austrian Empire, German etc. Another positive aspect of the website is it gives an option of time search (www.timesearch.info/timesearch). Overall, the website is very interesting and presents a host of fascinating facts in a short version as well as more detailed versions. It is very easy to navigate through all the information and it is straightforward to find a specific theme that one might be interested in. Perhaps, it is a difficult task to follow a chronology and see what other events happened in parallel as there is no simultaneous visual context. An interesting fact is that, apparently, not many teachers use this website for their lessons (Gascoigne, personal communication, 2009), perhaps due to its complexity and potentially distracting richness of information.

Chapter Four: Methods, measures and protocols adopted in fly-through studies

"History is a series of lies, where we must choose the one that seems closest to the truth"

Jean-Jacques Rousseau (1712-1778)

4.1 Introduction

The present chapter describes the materials and procedures typically and generally used throughout the experimental studies reported in Chapters five--seven, though any deviations will be described in the particular studies. Studies used a nine item paradigm (the upper limit of 7+/-2, the conventional short term memory [STM] limit; see Miller, 1956), in which nine historical events were presented as images in a chronological sequence in three conditions, each condition being experienced by independent experimental groups.

Clearly, the aim of the present set of studies was eventually to engage longer term memory, to enhance the acquisition of relatively large quantities of historical information across longer time intervals, the VEs being studied often and extensively. However, at the outset, initial studies aimed at addressing the benefits of using VEs in a short time period to learn a fixed series of events, and therefore used a number of items that marginally exceeded the amount that could be reliably expected to be remembered from a short term memory store, i.e., 7+2=9 items.

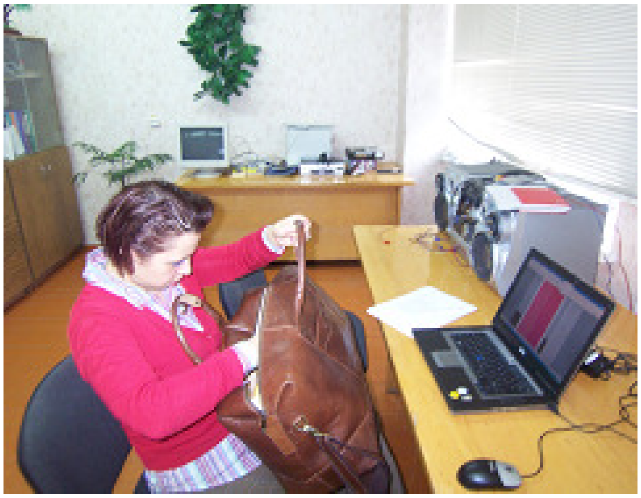

Figure 2. Ukrainian school.

Studies used 1) a VE (a 3-D sequence, with successive panels depicting events, along a line in a virtual space, successive images appearing alternately on the left or right of the line of flight. Two control conditions were mostly used for comparison (apart from Experiment 12,), which could be 2) PowerPoint (successive items presented on a monitor screen as full screen images), 3) Paper: a sequence of printed images on paper, equivalent to those displayed in the VE sequence, containing the same information, 4) Verbal/Text: printed text alone, on successive A4 sheets of paper, or 5) Washing Line: a 2-D sequence of the nine items, on paper sheets strung across the room. The information used to construct the sequence was the same in each condition compared, except that Verbal/Text only conditions did not include the picture images, only equivalent descriptive information (label and date). Where real historical events were featured, these were obtained from classroom materials selected with the assistance of teaching staff, who were asked to select items that children, in their experience, often remembered in wrong chronological order. Testing with undergraduate students used imaginary historical materials – the history of an imaginary planet.

The benefits of using imaginary information was that (a) it ensured that all of the participants were equally unfamiliar with the information prior to the commencement of testing, and (b) that the unequal spacing of historical events [which is probably not an influencing factor] could be overcome totally in an imaginary sequence, since successive events were spaced apart, arbitrarily, by 20 years.

In the case of classroom studies, efforts were made, with the help of teachers, to ensure that the comparison groups were equally capable in terms of their classroom performance in history lessons and thus their experience of the materials depicted (reflected in standard classroom assessments). Although this was a rather ad hoc approach, it is interesting that these measures were found to correlate significantly with pupils' performance on task, for example in Experiments three(a) and four.

Figure 3. Ukrainian Primary school.

In the first part of the research (Chapter five), in VE conditions participants were given limited time to explore the VE or text based materials, which they saw or flew through passively five times, a number that was selected arbitrarily but reflects the fact that anecdotally, one seems to remember the layout of a small high street of shops reasonably well after five successive travels past them. Thus participants encountered and viewed successive events on five occasions, but with no challenge or scoring system incorporated. The data were generally poor for both primary and middle school children (see Chapter five).

Based on the comments made by pupils and the results obtained, some modifications to the environment were made in the second part of the research (Chapters six and seven), introducing challenge and scoring systems (similar to many standard computer games), in which participants were asked to anticipate which picture was going to appear next. For each correct answer, they were given a point that incremented their total, their score being automatically up-dated in a score window located in one corner of the monitor screen.

To examine whether participants would remember VE-taught information over time better than after other forms of presentation, repeat testing was conducted for the three conditions, in some studies, after delays of between two and eight weeks. In a UK study with middle school children the entire training and testing procedure was repeated, in order to examine savings scores in an age group whose performance on initial training and testing had been especially poor.

Figure 4. Testing in a primary school in Ukraine.

4.2 Types of VE, computers, software

Images were displayed on three computers: a 30/25cm monitor, running on a Pentium 3 computer with 128 Mb RAM and equipped with a NVidia Riva TNT2 graphics card, Microsoft Windows XP Professional Version 2002 computer: Intel (R) Core (TM) 2CPU; 6300 @ 1.86GHz, 1.86Hz, 0.99 GB of RAM. Virtools Dev 3.0 educational version software (www.virtools.com) was used to create the virtual fly-through. Virtools Player File was exported from Virtools Dev 3.0.

Figure 5. Testing primary school children in Ukraine.

For the purpose of the present research two types of VE were designed for the presentation of single 9-item timelines. In the first, nine sequential images followed one after another at a distance such that approximately two seconds elapsed between successive images as the participant moved through the fly through. Participants were allowed to move, at a constant forward speed, and only in the forward direction, to explore the content of the environment. A second type of environment was specially designed for school children in the Ukraine; this was necessarily done to accommodate the requests from Ukrainian teaching staff, to make the virtual experience as close as possible to a typical school visit to an exhibition or gallery. The latter consisted of two floors, which were constructed with nine historical images (representing the history of Ukraine) located in each gallery. In total, two floors with four rooms (two on each floor) were visited by children. Additional elements such as manoeuvring and using a lift to move between levels via stairs were also incorporated. Participants were allowed to explore the environment in all directions, although the order of the paintings to be remembered was always followed in correct sequence. For more information, refer to Chapter seven.

After completion of all experiments, feedback was given, explaining all details and possible outcome of the research. Participating schools and teachers were told that the purpose of the research was to attempt to provide media that would assist with history teaching, so that some benefits might accrue to the school (and other schools) in the medium term, also, they were assured that should any publications arise from the research, their participation would be acknowledged and they would automatically be sent a copy.

Figure 6. Primary school children in Ukraine.

4.3 Scoring of Performance

The following measures were used in the course of the studies to examine how well participants had remembered the 9 items – in terms of specific item-order memory (such as COR [correct] scores) and in terms of the overall, general organization of the list (such as REM [removed] scores). Measures were selected according to their significance for each of the studies described below, and selection is justified in the report for each study.

1) REM score (i.e., "REMOVED" score -- how far a picture was placed from its correct position in the sequence; see Foreman et al. 2007). For instance, for a particular picture that ought to be placed in position 3, but was placed in position 6, the REM score would be 6-3=3. Correspondingly, a correctly placed picture would obtain a score of 0. Each list constructed by a child was given an overall REM score by totalling the REM scores for each of the nine items in the list. The REM score was used since recording only the number of items in correct list positions does not adequately describe the participant's success in ordering the materials. For example, placing item 9 in list position 1 but ordering all subsequent materials 1-8 in correct order results in a "correct" score of zero, despite the fact that most of the items were correctly chronologically placed. The REM score therefore gives a more sensitive measure of the participant's overall organization of the list and chronological ordering of events. This measure is used in all experiments.

Figure 7. Art history in a VE. Undergraduate participants, UK.

(2) REM1 the same score as REM, but analyzed after a delay period (variously two to six weeks). This measure was used in Experiments three, four, six, seven, eight and nine.

(3) REM2 was calculated by subtracting from the total Removed Score, the score that was ascribed to the highest–scoring picture. In a nutshell, the difference between REM and REM2 lies in the fact that the former indicates overall accuracy of ordering the pictures, whereas the latter avoids very high scores due to the very bad placement of a single item, despite the overall sequences of the nine pictures being generally well remembered (perhaps all otherwise correctly remembered). This measure was used in Experiments two, three.

(4) Correct order measurement (Cor) (/9) indicated how many of the 9 pictures were placed correctly in their true list positions in the initial testing phase; participants were given 9 slots on a page, as successive dotted lines and labelled 1-9; they therefore placed as many items as possible in the correct numbered slot. This measure was used in all experiments.

(5) Correct order 1 (Cor1), the same as Correct order but measured after delays. This measure was used in Experiments six, seven, eight, nine.

(6) SPE: serial position effects: The number of items correctly remembered and placed in list positions 1-3, 4-6 and 7-9. (See below). This measure was used in Experiments two, three, five, six and seven.

(7) Use of a set of questions in the form "DID X COME BEFORE Y?", although not all studies were designed to explore this variable: Experiments two, three and five.

Measures eight and nine were used when competition was introduced into the protocol:

(8) The number of trials (in some instances referred to Rounds or Passes) that participants required to meet the researcher's criterion of two successive passes without error in the training phase. This measure was used in Experiments six, seven, eight, nine, ten, eleven and twelve.

(9) A total error score, i.e., how many errors were made throughout all passes prior to reaching criterion in the training phase. This measure was used in Experiments six, seven, eight, nine, ten, eleven and twelve.

(10) In Chapter ten, Experiment twelve, where multiple timelines were used in parallel, additional variables were introduced.

In some experiments, all the above measurements were analyzed whereas in others, variables were selected according to the issues under investigation, driven by specific hypotheses.

Figure 8. Training using a VE. Primary school children in Ukraine.

4.4 Remembering the order of items in a list

Some of the earliest work in psychology on memory used the remembering of a list of items, usually words (cf. Ebbinghaus, 1900). In early studies, participants had to match paired associates (RAIN-BAT) in a list, prompted by presentation of the first and having to recall the second. In others they might be asked to learn a list, and were then required to recall all of the list items, in order. The number of passes through the list to achieve perfect performance was used as a measure of learning. Miller (1956) found the short term memory capacity for lists of words to be approximately 7+/- 2 items, so a range of five to nine. In later studies, experimenters such as Murdock (1962); French, (1994); Healy, Havas and Parkour (2000) and Deese and Kaufman (1957) investigated the serial position effect. This term was coined by Hermann Ebbinghaus and refers to the finding that recall accuracy varies as a function of an item's position within a study list (Ebbinghaus, 1900). Moreover, the participants' performance was compared at early primacy effect. The term refers to a cognitive bias that results from disproportionate salience of initial stimuli or observations. For example, participants tend to remember more items/words from a long list of words towards the beginning of the list compared to the words from middle positions. The term "recency effect" refers to the tendency for participants to also recall effectively items presented at the end of the remembered list (Atkinson and Shiffrin, 1968; Glanzer and Cunitz, 1966; Ebbinghaus, 1900). It has been typically found that performance dips in middle list positions, an effect that can be influenced by drugs such as the stimulant caffeine (Barraclough and Foreman, 1997).

Pictorial images were not generally used in such studies, which often used nonsense syllables; items were actively avoided if they had an intrinsic sequence built into them, such as dates and historical order – these would have been regarded as distractions or confounding variables, since each successive item in list-learning studies was intended to be separate and independent of the others, remembered without the assistance of any contextual cues (Glanzer and Cunitz, 1966).

The studies in this thesis included lists of textual items presented as successive items, but these were linked in an historical sequence. In most cases the materials selected as representing historical events were presented as pictures (with dates and captions). It was hoped that the use of VEs would induce spatial memory rather than semantic memory (see above), in particular since spatial memory is not obviously limited in terms of capacity (Foreman et al. 2006). Although participants could remember a simple verbal label for each item, so remembering the sequence as a 9-item list, it was hoped that spatial memory would be employed preferentially. In other studies, for example in which participants experienced rows of shops in a VE, they quickly acquired a good spatial memory for the layout of the shopping mall and for positions of individual shops (Foreman et al. 2005; Tlauka, Donaldson and Wilson, 2008). After a short period exploring a VE, a participant can make spatial judgments that could only be made using a cognitive "map" such as pointing in the direction of currently-not-visible landmarks (Foreman et al. 2003; Sandamas et al. 2008). In the present study, items were not single words but labels and dates representing events in time-space, encouraging a more elaborate encoding than for a simple list of words.

Clearly, semantic and spatial memory have different characteristics in terms of the way in which materials are learned: a list of words has a clear start and finish whereas spatial information such as a line of familiar shops has no single starting or finishing point; items can be sampled in any order, and approached from different directions on different occasions. Nevertheless, it was of interest to know whether, after experiencing a series of locations laid out in a sequence in space, so presented in the form of a spatial list, information would be remembered best (or selectively lost) at the start (primacy) or middle, or end (recency) of the list, and therefore these data were collected and analyzed.

In early work on the serial position curve (Glanzer and Cunitz, 1966) it was assumed that the recency effect for immediately recalled lists resulted from a read-out from short-term storage (STS), since a delay of 30 sec could greatly reduce or abolish recall of the words in later list positions. In that case, a recency effect with delayed recall of items from the present displays would not be expected. However, work subsequent to that of Glanzer and Cunitz (1966), for example Glenberg, Bradley, Kraus and Denzaglia (1983), has demonstrated long-term recency effects indicating that the effect arises from a generally greater tendency for participants to remember late items in a list of information. Long-term recency applies to different kinds of information, including spatial order information, and occurs whether participants are expecting to be tested or not (Nairne & Dutta, 1992). Therefore both primacy and recency effects in the serial position curve would be expected in the current test situations.

4.5 Group sizes in the experiments to be reported

The size of the groups used in the forthcoming experiments ranges from 10 to 20 participants per group. The size of the groups was equivalent to those in previous studies of spatial learning conducted using VEs (Foreman et al. 2005; Pedley, Camfield and Foreman, 2003; Cockburn, 2004; Ruddle et al. 1997). In the studies reported below, null effects are reported for VE use, though these are unlikely to have arisen from low N's being employed. Indeed, in some experiments where there were a large number of participants employed (such as Experiments three and four) children still failed to benefit from the use of VEs. Besides, non-significant results were clearly non-significant and not borderline (eg. middle school results, Experiments three, six and nine) even when groups were combined across experiments to give larger N's. Indeed, where significance was obtained for middle school participants, this indicated a benefit of using PowerPoint, one of the control procedures.

From a practical point of view, conducting experiments using VEs in schools, it is extremely difficult to access larger populations. Working with such environments requires a great deal of time and effort, since each participant is required to spend a considerable amount of time working with the particular environment.

Prior to running the studies below, especially those with children, the researcher contacted schools, making special arrangements to speak to the head teachers and history teachers, explaining the rationale behind the studies. Consent forms had to be signed and returned by parents to conform to ethical requirements. In some experiments (Experiments three, six and seven) the researcher spent a considerable amount of time socializing with children, making them feel comfortable in her presence before training could commence. After completion of the studies, children were presented with a simplified version of the results, making them realize that they had participated in an important study ('a time machine') that could have future benefits for new generations of students. Teachers were also debriefed.

4.6. Issues in the conduct of the research

With regard to the studies conducted in schools in Ukraine, two separate ethical approvals had to be obtained from Middlesex University and from local education authorities in Ukraine. The head teachers of the schools were given a full explanation of the potential benefits of the studies, and the whole procedure was carefully explained. After this, parental consent was sought. In some cases it was rather a difficult task to convince teachers, especially in the Ukraine, that the present studies were innovative and had potential to improve teaching history in classrooms. The Ukrainian teachers had different priorities from UK teachers (see The Ukrainian Teachers' Questionnaire, Chapter seven), their main concern being to have more time devoted to the delivery of teaching rather than the introduction of technology. Occasionally, the fact that the project was funded from a UK source and undertaken by English University staff made them suspicious about possible consequences for the school. They reported that a number of "pseudo-psychologists" had worked in the school previously, collecting data, but after completion of their studies they would write only negatively about the school or would not come back again to talk about the findings. Another obstacle was that, as a part of the studies' protocol, the researcher had to return after two to six weeks to schools to complete the final stage of data collection. Even though teaching staff of all of the schools involved were initially very enthusiastic about participating, the enthusiasm waned after the first phase of testing, despite their having been warned about the repeat testing procedure (designed, as was explained to them, to explore the longevity of any lasting effects of VE use, and whether the impact of using VEs could imprint images for a longer period of time).

Occasionally staff would require deviations from research protocols, where, for example, it was essential to reduce time commitments by having pupils at first work in small groups and then progress to individual testing. After each experiment in both countries, the history teaching staff was invited for an informal talk where results and finding were thoroughly discussed and their advice was sought for future developments of VEs as a teaching and learning resource.

Where the use of 3 parallel timelines was introduced (Chapter 9) to teach the history of psychology, history of art and general history, difficulties in recruiting participants were evident. The task required considerable effort, time and commitment on students' behalf, so that in many cases it was rather difficult to achieve a product. Students were required to work with the environment, ideally spending 20 min. per day over two weeks to learn the content of the VE. Given the fact that the training and testing procedures were separated by two weeks, this added to the commitment, unwelcome particularly at busy times of the academic year. The enthusiasm of participants could not always be guaranteed. Some potential participants declined to take part, and therefore the final sample was somewhat selected, despite the fact that students were rewarded with experimental participation credits. Nevertheless, studies were always completed successfully, despite all obstacles and difficulties, and a notably significant benefit of using a VE was uncovered in the final study reported.

Chapter Five: Using a VE fly-through of historical events as a "time machine" to convey chronology

"*Our ignorance of history makes us label our own time. People have always been like this.*"

Gustave Flaubert (1821-1880)

5.1 Introduction

Historical time and sequences of historical events are usually difficult concepts for children to acquire and comprehend. In schools, children usually learn about such abstract concepts by relying on semantic information most often provided on printed worksheets. To learn dates of events, for example, children have no option but memorize them laboriously by heart, which, in most cases, (unless they are especially interested in history, or revising for examinations) does not bring any results insofar as they have little understanding of meaningful historical relations but only a list of 'labels'. A VE appears to be a promising medium to employ in schools to remedy this problem, since it relies on a participant's acquiring spatial memory rather than semantic memory, spatial memory having no obvious capacity limit, in contrast to semantic memory. In the present chapters a series of experiments is reported using three age groups: primary school children, middle school children and undergraduate students, in which the learning of events in a virtual fly-through (a virtual time-machine) was compared with the learning of equivalent material in other formats that are sequential but lack the spatial element -- such as a computer-based sequence of screens (PowerPoint) or printed pictures/textual material.

Also cross-cultural comparisons were made in an attempt to (a) determine the extent to which virtual fly-throughs might have cross-cultural application, but also (b) relate benefits of VE use to children's frequency of use of computers generally -- children with less computer skill in an environment where computers are less available than in the UK might especially benefit from exploring chronological sequences of historical events in a VE since they might be highly motivated by using a novel medium. Experiments one to seven were therefore conducted in the UK and Experiments eight and nine in Sumy, Ukraine.
The studies in this chapter used virtual fly-throughs, following participants' familiarization with the medium. All participants had to fly through the environment five times and then they moved to a testing stage in which their memory for chronology was tested (cf. Chapter four).

5.2 Experiment one: A comparison of historical chronological learning from three complexities of VE

It was noticed in pilot studies that some children complained that virtual environments used in some experiments were rather unchallenging and too simple to be authentic -- and this factor might have reduced their own motivational level. In this case, it might be expected that an environment having a variety of engaging and realistic features would promote the greatest learning. However, when a more complex environment was used, that included many animations and sounds, primary school children appeared to be distracted and consequently they did not gain as much historical information as expected and, when tested, they showed no significant improvement in retaining information compared to other conditions. (The latter experiment is described below, Experiment four). Since this is an issue that potentially impacts on several studies later in the thesis, in order to clear the ground, and to determine whether environmental complexity could be a factor that had a negative impact on performance, the issue of VE complexity is addressed at this point. The dilemma, therefore is, as to whether, to be effective as a training tool, an environment should consist of exciting and engaging environmental features, or whether simpler characteristics should be preferred. To resolve this issue, a study was conducted, in which three environments of different complexities were compared.

5.2.1Method

5.2.2 Participants

Forty-five participants took part in the experiment (9M, 36F). The participants were selected randomly from within a university student population. Participants were asked to sign a consent form in which they agreed to participate in the experiment and indicated their awareness of their right to withdraw from the experiment at any time, without penalty, should they e.g., experience any discomfort. Participants were asked if they had any eye problems. They were tested wearing glasses (vision corrected to normal) where they usually did so. One participant informed the researcher about an eye condition which was not considered sufficiently serious to warrant exclusion from the experiment. All participants were confirmed as having had no formal art education and they were unfamiliar with most art works presented to them during testing. More importantly, at the outset of the experiment they were confirmed to be unaware of the chronological ordering of the paintings or the specific year when any one was painted. Perhaps surprisingly, the majority of participants had no prior knowledge about the artists and their work presented in the experiment.

5.2.3 Materials

Images were displayed on a computer monitor screen. The set of nine pictures, painted by famous artists, were employed with the same set being used in each experimental condition.

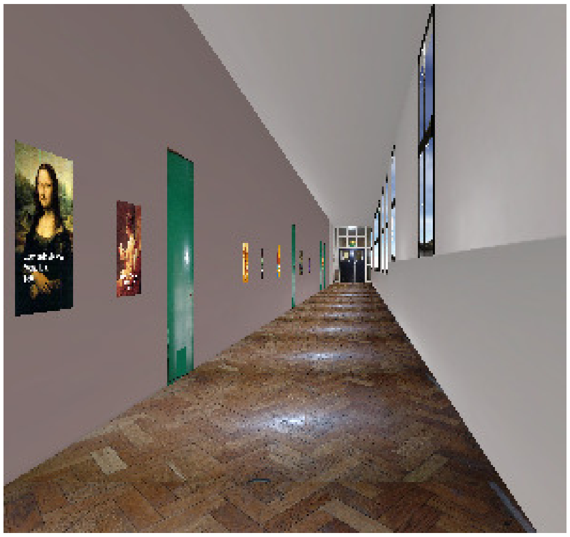

Figure 9. Art history represented in a medium VE (Experiment one)

They were displayed in chronological order (see Appendix 2) with dates inscribed:

Mona Lisa (Leonardo da Vinci),

A young girl reading (Jean-Honore Fragonard)

Sunflowers (Vincent van Gogh)

The old guitarist (Pablo Picasso)

Abstract painting (Elizabeth Bell)

Disintegration of Persistence (Salvador Dali)

Twilight (Vasiliy Kandinsky)

Movements in Squares (Bridget Riley)

A bigger Grand Canyon (David Hockney)

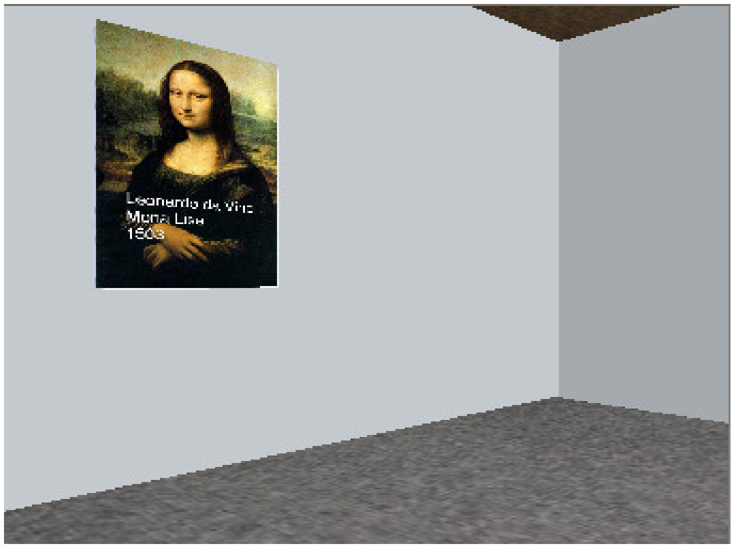

Figure 10. Art history represented in a complex VE (Experiment one).

These were sequentially displayed in 3 VEs, one (basic or low complexity; Figure 9) a featureless corridor, one (medium complexity) consisting of a model of a real corridor with windows and other features, and a third (high complexity; Figure 10) incorporating manoeuvres, i.e., using a lift between floors and going upstairs and downstairs.

5.2.4 Procedure

Participants were recruited and taken to a quiet room. They were randomly allocated to one of the three conditions: high, medium and low environment complexity. They were told that the experiment would take only 10-15 minutes to complete, and were informed about the procedure involved, i.e., that it required remembering a series of paintings that would be presented on the computer screen. The screen was placed at a comfortable distance (approx. 40 cm) in front of them.

Each participant was allowed to pass through the environment with a researcher once by depressing a keyboard key which provided forward movement at a constant velocity (backward and sideways movement keys having been disabled). Each painting was explored thoroughly insofar as participants' speed of movement was such that they could read the name of the artist, the title of the painting, and the year in which it was produced, as they approached each painting. Passing through each VE took typically five to six minutes. Participants' requests were met, if they asked to spend extra time stopping and viewing any particular painting. They passed through the environment five times. After completion of the procedure, participants moved to a test condition, by being given a set of the nine images (but without any text) that they had seen in the environment, printed on A4 sheets of paper. They were asked to place these in the order in which they had seen them on the computer. When they had completed the task, the placed order of pictures was recorded. Feedback was given to all participants, giving details of the reasons for conducting the research.

5.2.5 Results

Two dependent variables were analyzed: The number of pictures placed in their correct positions in the sequence (Number Correct), and REM (removed scores) using a one way independent ANOVA. The result showed that there was no significant difference obtained between the three conditions on either the REM scores (see Figure 11) or the Number Correct variable, $F(2,42) = .388$, $p > .05$ and $F(2,42) = .691$, $p > .05$, respectively. No gender difference was found on REM and Number Correct variables, $t(43) = -.711$, $p > .05$; $t(43) = -2.38$, $p > .05$ although this should be treated with caution since only nine males participated.

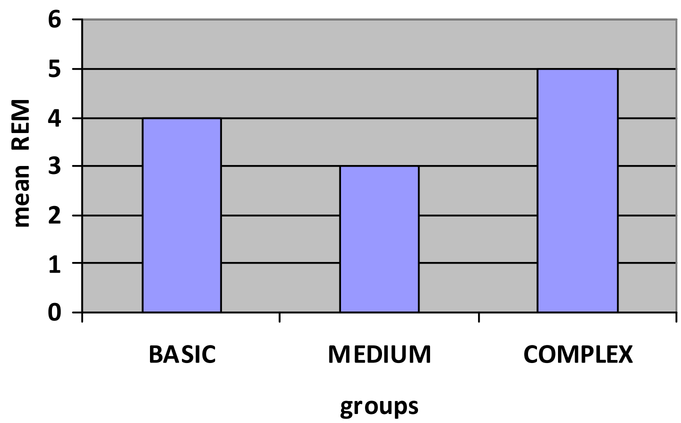

Figure 11. The mean score for the REM (removed score) variable for three environments (Experiment one). The lower the score, the better the performance.

5.2.6 Discussion

The present experiment was designed to address the issue of whether different complexities of VE would produce different results, for example whether basic environments with no animations would produce better recall than environments that used more complex images, environments and potentially distracting effects and manoeuvres. The results showed that the effectiveness of the environment did not depend on its complexity or the inclusion of potentially distracting details. Statistical analysis revealed that participants retained the same amount of information irrespective of the complexity of the environment they experienced. Gender differences were also found to be non-significant, although this should be treated cautiously since not many male participants were tested (cf, Sandamas and Foreman, 2007).

The study has shown that environmental complexity is apparently not an issue in relation to the learning of historical/art information from a VE. In later studies reported below, a relatively simple environment was used, though in some instances it was necessary to use a more complex environment; in those instances, the data supported those of the present study insofar as comparable results were obtained from groups of participants tested with different environmental complexities. The results of the present study, and results in subsequent studies, suggest that the complexity or simplicity of an environment is secondary when considering the effectiveness of using a VE to convey historical information.

In the course of the present thesis, only a limited range of environments was available, though future studies might develop a variety of different complexity environments using such possibilities as moving between successive rooms, each room representing an historical era, or a lift moving up and down, each floor representing different era in history. Complexity in this case was defined according to the ease with which the participant could manoever about the environment in order to encounter all of the historical items; this was in large part determined by the demands made by staff members in participating schools. However, the results of the present study suggest that, within reason, whatever the specific complexities introduced into the VEs, the results would be rather comparable. In particular, the results indicate that VE complexity was not a significant factor in determining performance in the current series of studies.

5.3 Experiment two: Memory for imaginary historical information acquired from a VE, a "washing line", or verbal/text alone in undergraduate students

In this study, undergraduate students were tested using a 9-item series of historical events that depicted the chronological history of an unknown and imaginary planet. Two particular benefits of using such materials are that (1) it can be assumed that no participant has any prior knowledge of the sequence [in contrast to the use of national historical items] and (2) events could be conveniently spaced at 20 year intervals, avoiding any concerns about whether the spacing of events in chronological time ought to reflect the relative time intervals between them. (This issue will be addressed in a later study). A washing line condition was introduced because this is a popular way of conveying chronology in school class rooms, by enthusiastic history teachers (Dawson, 2004; Hodkinson, 1995; West, 1978, 1981; Hoodless, 1996, Wood, 1995). The verbal/text protocol was used because it best reflected the type of instruction that would be given in a conventional classroom in which such materials are being learned. The purpose of this control condition was to provide a baseline, corresponding to what one would expect to be remembered from conventional teaching, relying on the presentation of semantic information alone -- information that may later be required to be related to images of historical events.

5.3.1 Method

5.3.2 Participants

A group of 39 undergraduate students agreed to participate in the experiment (15 male and 24 female, aged 18-22 years old), being randomly chosen from among the university student population. They were randomly allocated to one of three groups, with no specific attention being paid to their prowess in history classes in school. None was a history specialist. For their participation, module credits were available as a reward, although some participants did not require any such inducement. All had normal or corrected-to-normal vision. All provided informed consent for participation and confirmed their awareness of the right to withdraw without penalty if they were to suffer any discomfort.

5.3.3 Materials

A set of nine pictures with images and dates was created, each picture representing an event in the history of an imaginary planet. The images were taken from internet sources, modified using Microsoft Paint. Imaginary dates were ascribed to each picture at 20 year intervals; dates and descriptive captions were added to the pictures. Images were pasted as successive screens into a VE (Appendix 3)). This was a dynamic timeline that could be freely used by the participants, who had full control over the environment by allowing themselves to fly through the environment and learn the events that were represented within it, using forward movement only but with active control over their movement. The VE was created using the same tools as were described in Experiment one. For a 'washing line' control condition, the same pictures (with captions and dates) were used on nine successive A4 sheets, which were pegged along a string across one wall of the room. For the printed verbal/text control condition, the procedure was the same except that captions and dates were printed, three per page, on three successive A4 sheets in portrait orientation.

5.3.4 Procedure

The VE group consisted of 13 participants (four males and nine females), who experienced a fly through of the environment. They were seated comfortably in front of a PC desk-top computer, their eyes approximately 40 cm away from the screen. The forward key was activated enabling the participants to fly through the environment in a forward direction only - the rest of the keys were disabled and thus the participants was not permitted to make movements in any other direction. The researcher asked them if they could imagine that the images they were about to see showed a history of events taking place on an imaginary planet; they were to try to experience the events that were depicted on the screen. The participants were allowed to spend as much time as they needed to view and experience the environment. Upon completion of a fly-through, a message appeared asking whether the participant wanted to go through the environment again from the beginning: “Do you want to go again”, to which a Y(es) response would take them back to the beginning of the sequence. The total time required to complete the fly-through, with the forward key continuously depressed was 67s. They passed through the materials five times. Participants in the washing line condition were allowed to view the pictures presented to them, the dates and captions being printed on each picture. For one “pass”, a participant would be asked to scan slowly along the line from left to right and remember as much as they could about the pictures.

In the verbal/text condition group the same nine pictures plus dates and captions were presented. The participants were asked to familiarize themselves with the successive items of text in A4 format, presented as described above. The instructions to participants were to look at each caption in turn carefully and remember as much as possible.

All participants, in all three conditions, passed through the materials five times, taking roughly the same length of time to complete the exercise. Five passes had been found, in pilot work, to result in participants reporting that they felt comfortably able to remember events, dates and order of occurrence.

After having completed the first part of the task, the testing element of the study was introduced by inviting the participants to answer the questionnaire prepared by the researcher in advance, and then by placing the nine A5 test pictures (without dates or captions) in a line, in their correct chronological order as presented in the training phase. No time limit was imposed but on average, participants did not spend any longer than four to six minutes doing this.

For assessing the participants’ ability to remember the nine events the following measurements were taken:

(1) A questionnaire posed nine questions of the form “Did X come before Y?” requiring true/false responses

(2) Nine test pictures were presented (being the same pictures that were used in VE and washing line conditions, but from which the dates had been removed), randomly scattered face-upward on a desk. The task of the participants was to place the pictures in correct chronological order on a wall, attaching them using Blu-Tack plastic adhesive

5.3.5 Results

For analyzing data, four measurements were recorded for each participant. The first measurement, referred to as “Correct number” was the number of A5 pictures placed in their original places in the one to nine sequence. The second was the number of questions correctly answered (out of nine) on the questionnaire. Later, a third score was derived from the placement order, referred to hereafter as a REM or “Removed” score. This assessed how far each picture was placed from its original position; the numbers were summed across the nine pictures for each participant [see Chapter four for further details]. An additional score, Removed2 or REM2 was used, when testing was repeated after an interval.

In order to examine serial position effects in the data (SPEs), the number of items placed correctly in list positions 1-3, 4-6, and 7-9 were recorded separately for each participant.

Parametric testing was justified for number correct and REM scores, insofar as all data were normally distributed (meeting the main criterion for the use of parametric testing to analyze data). A Group x Gender two-way analysis of variance (ANOVA) for independent groups was used. Post-hoc group comparisons were made using the Least Significant Differences test (with two-tailed probabilities, unless otherwise specified) following the main analysis, when effects were found to be significant.

There was a group significant difference in placing the pictures in their correct position $F(2,33)=4.41$, $p<.05$. Participants in the VE group performed significantly better than participants in the two other groups (either washing line, $p<.05$, or verbal/text, $p<.05$, groups). However, further analysis showed that there was no significant difference found between washing line and verbal/text groups, $p>.05$. As regards the Gender variable, no statistical difference was found $F(1,3)=2.38$, $p>.05$ so male and female participants performed equally well. No significant interaction between Gender x Group was found, $F(2,33)=4.8$, $p<.05$.

For the number of questions answered correctly, the analysis revealed no significant difference, though the result bordered on significance, $F(2,33)=2.99$, $p=.06$. On the surface, mean scores for the VE group indicated that the number of errors committed in this condition was arithmetically less than the numbers of errors made in the other two groups. Regarding the Gender effect, results indicated that there was no statistical significance, though once again the difference (favouring males) was borderline, $F(1,33)=3.59$, $p=.06$. There was no significant Group x Gender interaction, $F(2, 33)=.04$, $p>.05$

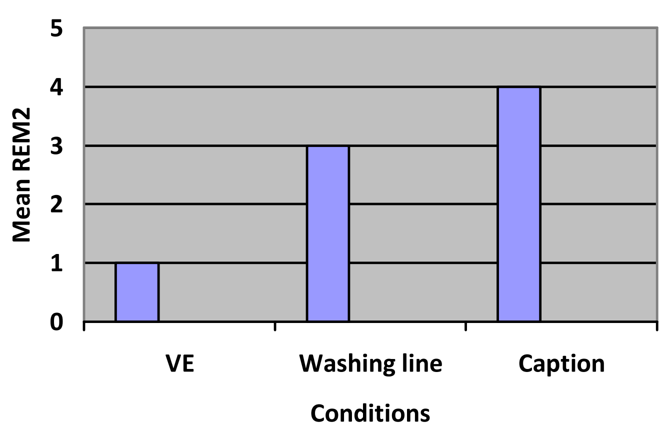

Figure 12. Mean REM2 scores for the three groups (Experiment two).

The third variable that was investigated was Removed scores. There was a highly significant difference among groups, $F(2,33)=5.95$, $p<.05$, and a nearly significant gender difference favouring males, $F(1,33)=3.48$, $p=.07$. The interaction between Gender and Group was found to be non-significant, which suggests that regardless of sex, the participants performed equally across three conditions. Further, the participants in the VE condition performed significantly better than those in the other two groups, washing line and text (p's< .05 and .003 respectively). However, no significance was found between washing line and text groups, $p=.19$. An additional variable that was investigated, referred to as Removed2 scores, revealed the same tendency, ANOVA indicating that the three groups differed, $F=(2, 33)=4.64$, $p<.05$ (Figure 12). The Gender difference almost achieved significance, suggesting that males performed better compared with females, $F(1,33)=3.2$, $p=.08$. The VE group performed significantly better than the washing line and caption/paper groups, p's< .05 and .005 respectively but no significance emerged between the latter groups, $p>.05$.

Since data variances were not homogeneous for the SPE measure, this was analyzed by employing a non-parametric test, the Kruskal-Wallis test, to conduct a one way independent groups' analysis on each successive serial block. Group differences were then examined using the Mann-Whitney U–test. The result showed that there was a group difference in the middle block only (position block 4-6), $X^2(2)=5.91$, $p<.05$. The VE group achieved higher scores compared to the washing line and text/paper groups, $U(13,13)=42$, $p<.05$, although the latter two groups failed to differ significantly.

5.3.6 Discussion

The present study revealed that groups showed significant differences on three out of four measures, and almost reached significance on the fourth, the number of questions answered correctly. Notably, participants who used the VE made fewer errors than those in the other two groups. This suggests that VEs could indeed be an effective medium for teaching sequences in general and the order of a series of historical events in particular, at least in undergraduates, and perhaps more so than traditional 2–D timelines (cf. Cooper, 2000, O'Hara and O' Hara, 2001, Wood and Holden, 1995, Yaxley, 2004; Hodkinson, 1995; West, 1978, 1981; Hoodless, 1996, Wood, 1995). Undergraduate students might, however, be a special group insofar as they may have better knowledge and experience of working with computers than younger, school-age children. Secondly, by this age, participants may have developed a full understanding and conceptualization of the concepts of time and history (Dawson, 2004; Howson, 2007). Further, undergraduates might have more knowledge in appreciating past and present than younger age groups -- they have an ability to detach themselves from the present time and understand historical events [even imaginary events] from a different and more detached perspective. Philosophically, when it comes to defining time, a dilemma arises: where can one draw a line between the past and the present? By adulthood, undergraduate participants have developed significantly their spatial skills due to undertaking activities such as travelling around the country or the world independently and visiting new places and acquiring good knowledge about time. New strategies to remember sequences of events tend to rely on spatial memory, which they may have developed as a consequence of such experience (cf. Foreman et al. 2007).

The present study also showed an almost significant difference between female and male participants on several measures, always favouring the latter. The difference was most evident on two variables (questions answered correctly, and REM). More participants would have been needed to examine gender differences, though it is clear that with the group sizes in the typical history classroom, gender effects are not obvious.

In conclusion, in spite of the popularity of 2-D timelines taught in schools, using timelines and artefacts (Hoodless, 1996; O'Hara and O'Hara, 2001, Wood and Holden, 1995, Blyth, 1994; Dawson, 2004, Haydn et al. 2001) undergraduate students tended to benefit more from the new medium of VE exploration by comparison (Ainge, 1996; Cockburn, 2000, 2004). Encouraged by this result, a VE was used in the next study in an adjunctive way to formal national curriculum teaching in secondary schools, to assess whether middle school pupils would benefit from the use of VEs in learning about medieval history.

5.4 Experiment three: The use of VE fly-throughs as adjuncts to national curriculum history (medieval Britain) at middle school level

The interesting and successful results with undergraduate students (Experiment two) encouraged the experimenter to conduct a series of experiments, in which secondary school children in the UK were tested to see whether their age group would also benefit from the VE exploration and whether a VE format can be an effective medium in teaching history at middle school level in the UK.

5.4.1Method

5.4.2 Participants

Sixty-two children (29 male, 33 female, between 11 and 14 years old) were randomly allocated by class teachers into two groups in Experiment three(a) and three groups in Experiment three(b), (Totals: Paper: N=24, 17F, 7M; VE: N=26, 9F, 17M; PowerPoint: N=13, 7F,6M) in two North London schools. The teachers were asked to equally distribute their children across the groups, taking into account their classroom performance in history. The Experimenter noted instances where particular children were identified by teaching staff as having particular difficulty with history. Prior to commencement of the experiment, parental consent was obtained via letters sent home to parents.

5.4.3 Materials

Before setting up the procedure, the researcher spent a week becoming acquainted with the participants by attending history lessons and helping the teacher with delivering school materials. All materials that were used in the experiments were designed in conjunction with teaching staff, who advised on the materials to be included according to their experience of what children generally had difficulty in remembering in correct chronological order. All materials were based on National Curriculum requirements.

Similar to previous experiments described above, a nine item VE fly-through was constructed, representing a historical chronological sequence. The experimental design was identical to that used in other experiments (Experiments one and two), apart from the fact that in the present experiment significant events in Feudal England were incorporated (see Appendix 4). No dates were ascribed to the pictures as some events did not have specific date identities. For instance, the construction of different styles of castles (first wood and later stone) is not accurately datable. Besides, some events that were depicted in the VE occurred within a single pivotal year, 1066. The same images were used to create two other conditions (PowerPoint and Paper conditions). The same format of presentation used in the previous experiments was duplicated. Regarding the specification of the computer used, this can be found in Experiment one.

In this study, the materials used corresponded with the materials being taught in class in the course of standard history lessons. The Norman conquest of 1066, which was the beginning of what is called the Norman period, was characterized by depicting the construction of wooden castles then followed by a later construction of stone castles covering the period up to 1300. Therefore, prior to the experiment, participants had received training in text format in history lessons. During the experimental period, the participants were asked to come into the computer room in groups of five to spend some time familiarizing themselves with the general procedure. Normally, the participants would work in nearby computer rooms that had been organized by one of the technical support team. The experimenter spent a considerable amount of time with the participants to make sure that the experimental procedure was well understood and followed without any distraction.

The present study consisted of two sub-studies and was carried out in two different schools. Data have been combined. The present study differed from others (above and below) in terms of how participants explored the environment – a consequence of the time constraints associated with working in a class room adjacent to teaching lessons. The participants in the VE condition (N=26, 17M, 9F) were given an opportunity to investigate the environment in a small group initially, participants taking turns to operate the keys. Later, in Experiment 3b, each participant operated the environment and thus explored individually and independently. A criterion was, however, set such that each participant had to experience five passes through the environment. After completing the training stage, the participants were asked to proceed to a testing condition. It should be mentioned that between the two sub-studies, Experiment three(a) and Experiment three(b), the VE environment was slightly improved with the incorporation of some supplementary auditory and 3-D visual cues linked to some of the items in the environment, such as battle sounds, to make the environment more engaging and interesting. Passage through the nine items took 67 seconds; returning to the beginning took 15 seconds.

A PowerPoint condition (N=13; 6M, 7F) was introduced, as a second control variable, into Sub-study two. The visual materials used in Power Point were identical to those used in the other two conditions and introduction to the materials, as a group and then individually, was the same. No supplementary auditory or visual cues could be included in the PowerPoint condition when it was introduced in Sub-study two, or in the Paper condition. Before proceeding with a training stage, the participants were instructed that in order to move on to the next image, a downward directional key should be pressed. At the end of a session of nine images, an additional screen would appear to invite the participants either to continue with the training task by returning to the starting point (the same as in the VE) or to proceed to a testing stage. The time taken to pass through the nine items was paced such that it was similar to that in the VE condition. The Paper Condition (N=24; 7M, 17F) involved the children looking through the images presented by the researcher. The pictures would appear in the predetermined correct order, the time taken to pass through all 9 being similar to that in the VE condition.

The researcher would use narratives to encourage children to make sense of the events, to create a short story that was connected to each event presented in the sequence. The words such as ‘before’, ‘after’ and ‘then’ were often used to emphasise the importance of a chronological context of the present study. All children had to pass through the virtual environment/PowerPoint/Text materials five times, so encountering of the nine events was equated across conditions.

Testing stage:

Each participant was tested individually. The interval time between two stages i.e., training and testing, was 48 hours. The researcher explained the task by showing nine images presented in an A4 format and asking the children to place the nine images in the correct order (i.e., the same order that they were shown in the training stage). The participants were not limited in time, but four to eight minutes were typically taken to complete the task. After this, the children were asked to complete a questionnaire, in which they were required to answer questions of the form “Did X come before Y?” This part took seven to ten minutes to complete.

To test the hypothesis that VE materials have a greater lasting impact and durability compared with the materials used in other conditions, a further test session was carried out, comparing a sample of the Paper Group (13 participants) with a sample of the VE Group (13 participants), two months after the original training and testing was completed. (This sample did not include PowerPoint-trained participants since this condition was introduced only in Sub-study two).

5.4.4 Results

Data were analyzed in the same manner as in the previous experiments. In terms of picture ordering, there was no significant effect of Condition, $F(2,57)=1.12$, $p>.05$. No significant difference was obtained between genders, $F(1,57)=.89$, $p>.05$, and there was no Gender x Condition interaction, $F(2,57)=.19$, $p>.05$. When the number of questions answered correctly was analyzed, the same pattern emerged, there being no significant differences found. Removed and Removed 2 Scores (see Figure 13) (for the calculation, see above in Chapter four) also failed to show any significant result. There was no significant result observed between groups in terms of primacy, middle or recency position blocks, $X^2(2)=1.03$, 1.18 and 1.53 respectively; p’s>.05.

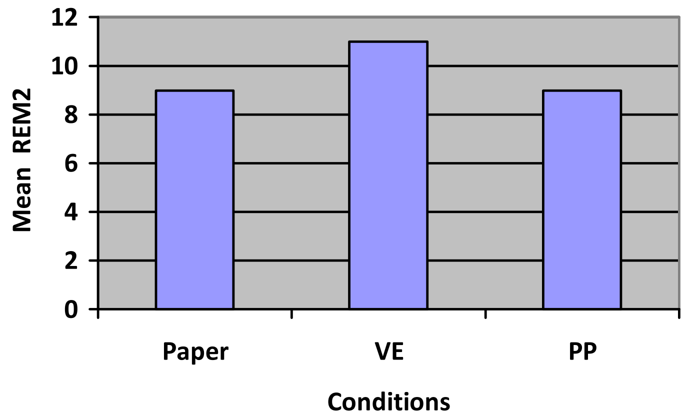

Figure 13. The mean scores for REM2 for the three conditions (Experiment three)

After finishing the experiment, the researcher asked teaching staff to rate the children's ability in history. However, there was no indication of any relationship between teacher ratings and performance variables. In Experiment three (a), it appeared that there was a tendency for students with a poor academic performance in history to show better memory for historical events after experiencing the VE training as opposed to Paper presentation, a result that bordered on statistical significance (p=.052). However, this was not seen in Experiment three (b), where no hint of statistical significance emerged. The effect in this study is likely to be unreliable.

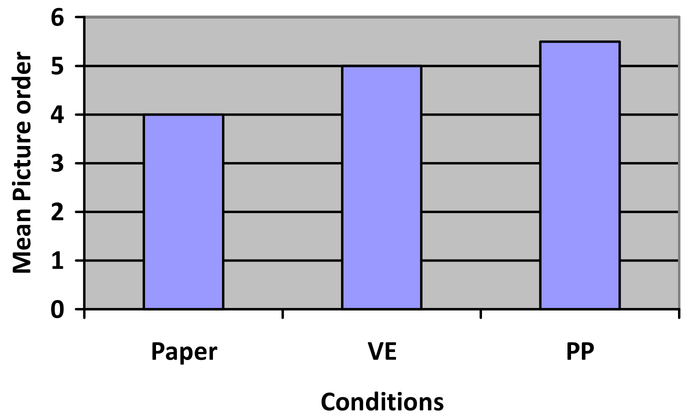

Figure 14. The mean scores for the Picture order variable for the three conditions (Experiment three)

In addition, after a two month interval, there was no difference obtained when two subgroups were compared. Children were not better able to remember the items presented in the training stage after having formerly experienced VE training than those in the Paper condition. However, further analysis revealed that there was a high correlation between the picture ordering score in the first round of testing and in testing after the delay, $r(24)=.7$, $p<.001$, suggesting that the measure used was sensitive and reliable.

5.4.5 Discussion

The results from the present experiment were rather disappointing, insofar as the VE presentation was not successful in promoting good scores (Experiments two and five) as was the case with undergraduate participants in the previous study. Indeed, participants showed no benefit on any measure from using the VE format in learning the sequence of real historical events. In addition, there was no benefit of using a VE in terms of the longevity of memory. In fact, since in this study, the pictures used in the training phase were also those used in the testing stage, this might have been expected to favour the Paper group (Prangsma et al. 2009; Hodkinson, 1995; West, 1978, 1981; Hoodless, 1996; Wood, 1995). In addition, the materials used in this study were rather unchallenging – being limited by the sources available for national curriculum mediaeval history – and this may not have encouraged participants to explore the environment in an excited and active fashion.

A final study employed younger children (primary school participants) who worked with the material that had not yet been taught to them in the classroom. The study used some interesting aspects of eras of history, and this might have been expected to improve recall at test. Therefore, this study also used the encouraging results from undergraduate students (above) and extended the use of VE fly-throughs to a primary level group.

5.5 Experiment four: The use of VEs in the teaching of primary level history

Due to the rather disappointing results from the above study with middle school children, modifications were made to the presentation format for primary children that were expected to engage participants and increase the likelihood of obtaining positive results.

5.5.1Method

5.5.2 Participants

Seventy two primary school children took place in the present experiment (39 male, 33 female). The children were asked to participate in the research on a voluntary basic, 35 children in year 3 (19M, 16F, 7-8 years) and 37 children in year 4 (20M, 17F, 8-9 years). All children had at least some regular classroom experience of manipulating a computer key board. Vision was not formally tested but teachers confirmed that no child was regarded as having other than normal or corrected- to-normal vision. Parents were contacted by teaching staff so that parental consent was obtained for each child to participate in the experiment prior to its commencement. Teachers rated the participants' classroom history abilities by using a 1-3 scale (1—high, 3—low).

5.5.3 Materials

A set of nine images was used, as in the studies above. A new VE format was used, incorporating some animations and sounds such as a French battle cry accompanying the depiction of the battle of Hastings, a rolling Viking boat, and a noisy virtual Hurricane aircraft flying over a depiction of evacuees in World War II (see Appendix 5). This was done to make the environment more appealing for the children. Movement through the environment was controlled by depressing the space bar. The Power Point condition materials were presented as sequences of slides, using the same computer as the VE condition. The same nine images were used in the Paper condition.

5.5.4 Procedure

The participants were divided into three separate groups by their class teacher, who was asked to divide them on an equal basis, with equivalent numbers of boys and girls in each condition and matching the groups as closely as possible on the basis of the abilities of the participants. Due to class room constraints, an initial training phase occurred with small groups of children (within conditions) rather than on an individual level, but each participant then had a chance to use the environment alone, in turn.

In the VE condition (N=24; 13M, 11F) children were asked to travel through the environment by pressing the number "8" key on the keypad on the right hand side of the computer. They were asked to pass through the environment and try to memorize each of the images that they were passing by, as though they were walking past them. At the end of each fly-through they were prompted to go back to the starting point and continue with the training phase. Run time through the environment was 62 sec.; returning to the start and beginning the next fly-through took about 20 seconds.

The Power Point condition (N=23; 12 M, 11F) was run as in Experiment three (b). For the Paper condition, (N=25; 14M, 11M), a set of pictures were given to the children asking them to study each picture carefully, to study the images in order, and to remember as much information from each picture as they could.

In all three conditions the participants were asked to spend about twenty minutes to memorize all information ascribed on the images. They were free to interact with each other. The experimenter and the participants had to read aloud the dates and the description of each pictures. Dates were particularly brought to the participants' attention. The teacher and the experimenter actively assisted the children in completing their task. The participants were unaware that they would be tested later.

Testing took place two days after the training session. Each participant was tested individually and spent about five to seven minutes completing the testing task, depending on how long it took them to answer questions verbally. They were asked to place the nine images in order. After having completed the task, the children were presented with nine questions, relating to their knowledge of chronological order, in the form "Did X come before Y?" Each yes/no answer was scored as correct or incorrect.

5.5.5 Results

The allocation of the pupils to three conditions was found to have been random, since there was no significant intergroup difference in teacher ability ratings, $X^2(4) = 2.77$, $p > .05$. There was no gender difference found in teacher-rated ability, $U(39,33) = 607$, $p > .05$.

With regard to the task in which the participants had to place pictures correctly, ANOVA revealed that the three conditions failed to show any difference, $F(2,66) = 1.38$, $p > .05$. Boys did somewhat better than girls, the difference almost reaching significance; Mean (boys) =6.72; Mean (girls) = 5.58; F(1,66)=3.85, p=.054. The Group x Gender interaction was not found to be significant, F (2,66) =.094; p>.05.

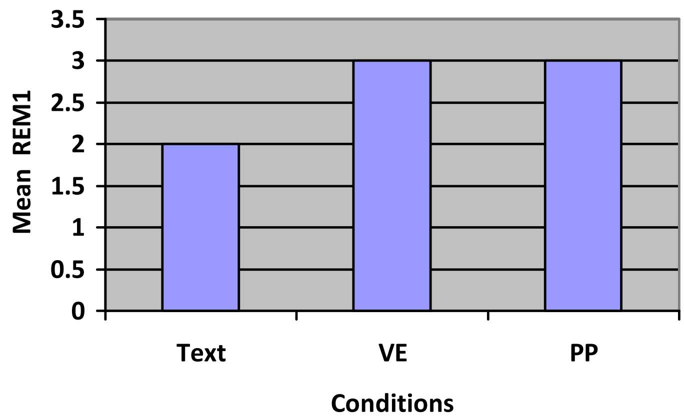

Figure 15. The mean for the REM 1 scores for the three groups (Experiment four).

When data were entered to analyze the number of questions answered correctly, the three conditions differed significantly, F(2,66)=3.86, p<.05. The Paper condition was significantly better compared to two other conditions, Power Point and VE, ps<.05 respectively, although these groups failed to show any significant difference from one another. There was no significant Group x Gender effect, F(2,66)=1.15, p>.05.

Teachers' ability ratings correlated significantly with the number of questions answered correctly (Spearman's rho[N=72]=.22; p [one-tailed] =03).

When the difference between Removed and Removed1 was analyzed statistically, there was no significant difference, F(2,66)=1.8 and 1.4; p's >.05 (Figure 15). The teachers' ability ratings were significantly correlated with the participants' performances on both Removed and Removed1 scores, rho[N=72]=.19 and .20, p's [one-tailed] ≤.05.

Serial order effects were analyzed. The Kruskal-Wallis test showed that there was no significant difference when comparisons were made within individual serial position blocks. When data from the first 2 blocks were combined, however, placement accuracy in these list positions (1-6) was significantly better in the Paper group than in the two computer groups combined, $U(25,47)=423$, $p<.05$. A gender difference was found to be significant: the boys' mean was 2.67 against the girls' mean of 2.18 in primacy position 1-3, $U(39,33)=406$, $p<.05$, though no such superiority was found in recency positions 7-9, $U=581$, $p>.05$.

5.5.6 Discussion

The results of the present study have shown that children trained in a VE showed a disadvantage of using a VE. The detrimental effect was especially evident when scores for items in early/intermediate positions were analyzed. Perhaps, children of this age group were more vulnerable to influences that produce loss of information in early list positions. This result may have been due to the use of an over-exciting element used in the environment, and perhaps sounds and animations might have produced clutter and distracted from the task. Alternatively, or in addition, a lack of familiarization with the environment may have caused children to remember little. Dawson (2004) stresses the importance of visiting and revisiting the materials taught in classroom, especially when chronology is concerned. He argues that over a period of time, the materials taught will become a part of pupils' mind. Perhaps, the same strategy can be said about VEs, when children are required to visit the environment over and over again until they become familiar with the content of the environment, given the fact that VEs are rarely used in classroom, therefore an extra training is required. Children might have employed semantic memory in encoding a series of successive images presented in the environment, as opposed to spatial memory that might have improved recall (cf. Sandamas and Foreman, 2008). An interesting incidental point is that the present study revealed there to be a gender difference in terms of SP, boys showing better recall in early list positions, a phenomenon not reported previously.

5.5.7 Interim conclusion

The above experiments have shown that VEs might not be universally useful and beneficial for the learning of historical chronology, at least not for all age groups. Although undergraduate students seemed to benefit from using the VE format, other age groups did not. Middle school children failed to learn more chronological material from it than from other media. Moreover, primary school children actually performed worse after VE training compared to control conditions. They were perhaps overwhelmed by the animations and sounds used in the VE. Also a lack of engagement with the environment might also affect how much information participants could retrieve when tested (cf. Zinchenko, 1981), since they had experienced it only passively. During the training stage, children did not have as much opportunity to interact with the environment as they would, for example, when playing a competitive computer game (Sandamas and Foreman, 2007). They were given information which they had to memorize afterwards, but since there was no activity involved on their part, they experienced a list of simple historical events presented to them but with no relevance to them and their lives. The selection of historical events to be included in such an environment should be considered carefully; a good environment can be built upon children's personal history that might improve retention when tested (Friedman, 1982).

Additionally, children may benefit from active involvement in the construction of their own environment or their own timelines (Pedley et al. 2003). In the present study, the environment used encouraged a one way learning process which proved to be less beneficial, especially for middle and primary school children. An important conclusion from the present studies can be that, despite the potentially positive influence of technology in classrooms (Smart, 1996; Underwood and Underwood, 1990, Watson, 1993), the use of traditional methods in history teaching such as the use of paper images can well be beneficial and effective for some ages (such as a primary group) but not for middle school children.

Chapter Six: Can the introduction of challenge and pre-training VE experience enhance the learning of chronological sequences?

"*Maybe history repeats itself—but I have to have facts*"

A. Prince Alamut Ambush x111, 1971.

6.1 Experiment five: Does the introduction of challenge enhance the learning of chronological sequences from a VE in undergraduate students?

6.1.1 Introduction

The foregoing studies have generated mixed results regarding the benefit of using VEs in teaching history. Undergraduate students did benefit when learning about a series of imaginary historical events (the history of an unknown planet), compared with their learning of equivalent materials from 2-D displays. They showed a statistically significantly better performance, but they still made some errors in VE conditions. Performance was enhanced but not greatly enhanced. The present experiment was based on the results obtained from the previous study, in which undergraduate students benefited more from virtual 3-D (compared to 2-D) training, but was modified. The paradigm used in this study relied on a game-like format, in which successive screens (paintings, representing epochs of art history) had to be memorized and anticipated during training. As in a computer game, participants' scores were displayed in the upper right corner of the computer screen. The benefit of using art in this context was its unfamiliarity to participants, confirmed by discussion with the participants.

6.1.2 Method

6.1.3 Participants

Thirty six undergraduate students (18M, 18F) were randomly drawn from an undergraduate population. They were aged 18-27 years old. All of them had normal or corrected-to-normal vision.

6.1.4 Materials

Internet Explorer was used to download a browser, enabling the Virtools software to run. The environment used was as in the studies above. The nine pictures were displayed as successive screens with the titles of the pictures, the names of the artists, and the dates of the paintings displayed in the upper right corner of each picture. The positions of the pictures was set 30 virtual units apart and the total distance from the start to the finish of the series of pictures was 1680 virtual units, giving a duration from the first picture to the last of 56 sec. when the forward key was continuously depressed. The user would take about seven seconds to "walk" through the environment from one picture to the next one. The viewpoint was held stationary while participants guessed what the up-coming image would be. For the PowerPoint version, the same procedure was applied as in the previous experiment. The same nine images were displayed as in the VE condition, with names and dates. To move from one picture to another, a forward arrow key located in the corner of the right side of the computer keyboard had to be activated. For the Paper condition, the same information about the pictures (i.e., names and dates) was provided on plain sheets of paper. For information about the pictures see Appendix 6.

6.1.5 Procedure

All participants were trained individually. For the Virtual condition, the participants were instructed to observe the environment carefully while depressing the forward arrow key to move through the environment. They were told to look at the pictures and try to remember the order of the pictures, if necessary using terms such as “blue flowers” as descriptors. No attempt was made to draw their attention to specific information depicted on each picture. The same procedure as in Experiment four was applied. On the second fly through, at each picture, when the picture screen was in prominent view the viewpoint was held stationary. The participant had to describe this picture on the screen, and if correct, the experimenter would click on the screen to display the picture, after which the participant was free to move forward to repeat the procedure with the next image. If the participant described the picture incorrectly, he/she was asked to choose again and an error was recorded. At the beginning of each pass, the screen counter was reset to zero. If the participant guessed a picture correctly, his/her score would increase by one. The experimenter noted all errors and continued until the participant achieved two successive error-free fly throughs. In the PowerPoint condition, the same images were displayed as in the VE condition, using full screen images. For the training procedure with challenge a blank screen was displayed and replaced when the image was correctly anticipated. For the Verbal/Text condition, participants were tested with semantic information provided on each plain sheet of paper only (the artist’s name, as text, the picture’s name and the date it was painted). Following training, after an interval of five min. participants were assessed using three tests:

- The numbers one to nine were listed vertically down a test sheet and they were asked to fill in as much information as they could recall about the nine successive pictures, if possible providing the painter’s name and the picture’s title and date. Then the sheet was removed.
- A list of nine questions about picture order, of the form: “Did Kandinsky come before Matisse?” was then provided, answered with just “yes” or “no”.

- Finally, a set of nine pictures were placed randomly (without names or dates) and participants were asked to order them correctly, i.e., to reproduce the order in which they were shown in the training stage. No time limit was imposed, though on average 8 minutes were spent completing these tasks.

The dependent measures were:

a) For training:

(1) the number of trials (passes) required, excluding the first, in which the pictures/information were displayed to the participants, for them to achieve a criterion of two successive error-free passes

(2) the total number of errors made before criterion was reached

b) For testing:

(1) the amount of information provided correctly in the first test (nine pictures each having three items of information: painter, picture title, date) so possible maximum of 27 items

(2) the number of questions answered correctly out of a total of nine

(3) the number of pictures placed in correct order, calculated using a REM score procedure (see details in Chapter four)

Note that participants in both computer-based conditions had seen the pictures while those in the Verbal/Text condition had not. Clearly, verbal or textual information could also have been provided by computer, but the use of the paper-based control condition was a reflection of what usually happens in a class room, so that the verbal condition here was the most valid as a procedure against which to compare the computer conditions. In post-criterion testing, although the verbal control group had not seen the images, their picture ordering was regarded as a strong control insofar as some participants might have been able to order at least some pictures from their general knowledge of art. The degree to which verbal controls could order images without having viewed them in the training stage thus provided the most valid "chance" baseline against which to compare the computer based conditions.

6.1.6 Results

Trials to criterion (i.e. the number of passes through the materials, excluding the first, required to meet the criterion) were analyzed using the Kruskal-Wallis non-parametric analysis of variance. Groups differed significantly, $X^2(2)=26.85$, $p<0.001$, the Mann-Whitney U-test (corrected for ties) showing that the VE group took significantly fewer trials than either the PowerPoint or the verbal control groups, $U(N1=N2=12)=25.5$, $p<0.001$ and $U=0$, $p<0.001$. For total errors to criterion (i.e. incorrect anticipations of upcoming pictures), data were well distributed and were analyzed parametrically. A one-way ANOVA for independent groups followed by post hoc comparisons (least significant difference test) revealed that three groups different significantly, $F(2,33)=67.6$, $p<0.001$. The VE and PowerPoint groups almost differed, $p=.06$, but the VE group differed significantly from the Verbal/Text condition, $p<0.001$, and the PowerPoint and the Verbal/Text condition differed significantly, $p<0.001$, the latter performing significantly better.

Analysis of error positions was conducted by totalling the number of errors made by each participant in training within three successive list position blocks, representing list position blocks 1-3, 4-6 and 7-9, respectively. Note that the VE condition showed almost error free learning, and therefore median scores for all blocks were zero, while the Power Point group made errors most frequently in the middle list position, and for controls a large number occurred in middle list positions (see Figure 16).

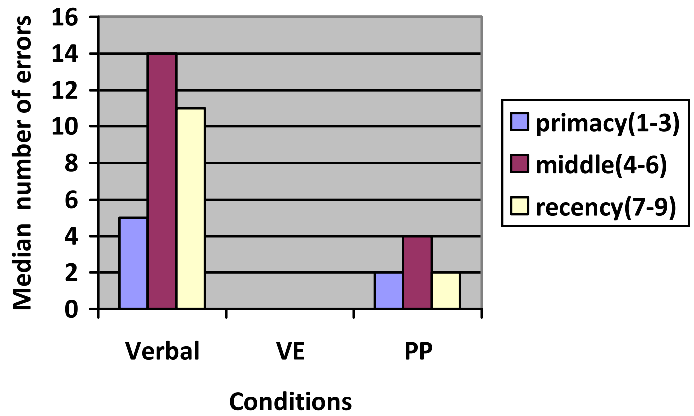

Figure 16. Median number of errors made during the training (Experiment five).

Post-criterion testing

When participants were assessed for their ability to remember information about the pictures, groups differed significantly, $F(2,30)=8.22$, $p<0.001$, the VE group differed significantly both from the PowerPoint and Verbal/Text controls ($p<0.001$) (see Figure 17*)*. However, the latter two conditions failed to differ significantly ($p>.05$). Non-parametric tests were used to analyze other post-criterion measures. When answered questions (of the form "did painter x occur before painter y?"), group differences were sufficiently close to significance, $X^2(2)=5.17$, $p=.07$, that a post-hoc test was conducted, the Mann-Whitney U-test suggesting that the VE condition was superior to PowerPoint and Verbal/Text groups combined, $U(N1=12, N2=24)=85$, $p<05$, and that VE was significantly superior to PowerPoint, $U=35.5$, $p<.05$.

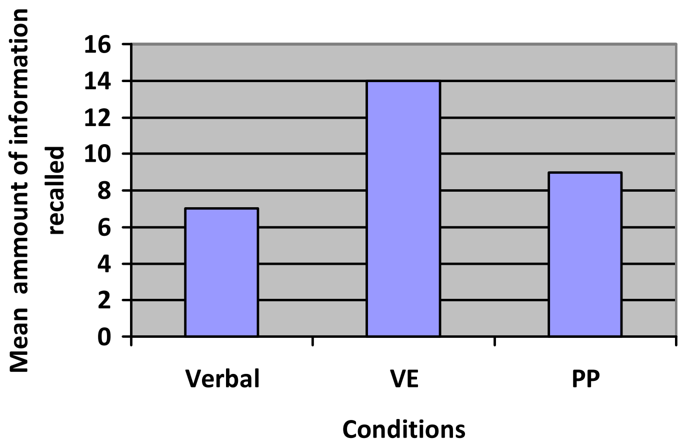

Figure 17. Mean amount of information recalled in Experiment five.

When REM score (reflecting the ability to place the pictures in correct chronological order) was assessed, the VE group's performance was entirely error free. As for the Power Point condition, two participants made two errors each, while 11 out of the 12 controls made between 2 and 4 errors (overall group mean was 2.5 errors). Gender differences were examined as well, but there was no statistically significant difference obtained.

6.1.7 Discussion

The format used in the study closely approximated that with which students would be familiar from their use of computer games. The current study has shown a strong advantage of using a VE format, as opposed to using a PowerPoint condition. The present study reinforced Haydn's scepticism (Haydn, 2000) about the effectiveness of using technology such as PowerPoint in classroom teaching. It would appear that an alternative medium should be adopted to improve children's learning (Haydn, 2001; Dawson, 2004). Interesting data were obtained from the present study, in which participants in the verbal control group performed especially poorly. Also the PowerPoint condition (the simple use of a computer display) gave a very poor performance compared to the VE condition (cf.

Smart 1996; Underwood and Underwood, 1990). During the training procedure, it was evident that participants from the VE condition learned more and more quickly compared to the two control conditions and as a result, participants from the latter two groups also showed poor retention when tested afterwards (c.f., Cockburn, 2004). This is in agreement with the previous study by Hartley et al., (2004), who claimed that the spatial relationship between objects is durable and can remain stable over a long time.

It appears that the verbal control group concentrated more on particular items (the picture name) while the experience of each picture with its accompanying textual information enabled the VE participants to absorb more of all kinds of information provided in the environment (spatial sequential and associated verbal). Interestingly, although the amount of information recalled (out of a maximum of 27 items) far exceeded the 7+/-2 items associated with short term memory (Miller, 1956), suggesting that participants were using a memory store with a limit greater than that traditionally regarded as the short term memory store used for the learning of simple lists of items. On the other hand, the VE group was far from perfect, and their results revealed that they could remember only half of the total information presented. This aspect of the study should be examined further, for example using repetitive learning of lists of different lengths (but see also Experiment 12 below).

The VE participants showed that they could remember all items across different positions. This could be explained in terms of the strategy used to remember the nine items as a series of places within virtual space. This way of thinking could be identical to how people remember the order of a line of familiar shops rather than a simple list of unfamiliar words used in standard memory tests (see Broadbent, 1992; Barraclough and Foreman, 1997).

Hitherto, the benefit of using VE technology (for example, with undergraduates) was assumed to derive from the fact that it arguably relies on spatial memory which can be regarded as having unlimited capacity for remembering new information (Foreman et al. 2007) -- how many separate places can we recall? -- and therefore spatial memory is apparently free of conventional constraints such as a storage buffer size.

6.2 Experiment six: The use of challenge in enhancing learning in primary history teaching

6.2.1 Introduction

In an earlier study (Experiment four above, Chapter five), with primary children, nine sequential images were presented chronologically in a VE, depicting eras of history from ancient Greece to World War II. It was found that children in this primary group did not benefit from exploring historical events in the VE format. In fact, they performed significantly poorer in the VE condition than pupils given the same information sequentially on paper (Paper condition) or as a non-spatial sequence displayed sequentially on a computer monitor (PowerPoint condition). The present experiment was designed to improve upon the earlier study by encouraging children to anticipate what was going to appear next, at each sequential choice point. When they anticipated correctly they scored a point (their score being displayed on the screen). This format, therefore, involved more active participation of children in the task and moderate competition and challenge, rather like many computer games. Besides, children were asked to think carefully about historical events presented to them. Also, the researcher was keen to find out more about whether children knew about certain historical events presented in the environment prior to the experiment. This adapted protocol might also help to overcome another disadvantage. In the previous experiment (Experiment four above), children were apparently overexcited by the animations used in the environment and perhaps concentrated less on the main task as a result of this distraction. By introducing challenge and a competitive element (requiring anticipation, and displaying their score on the screen), children were arguably more concentrated on the main task in this experiment. It was hypothesised that children in this study would perform considerably better than those in the earlier study. Further, the environment itself was designed not to feature any elements that could be considered distracting. It was very simple, easy to understand and easy to follow (see Figure 18).

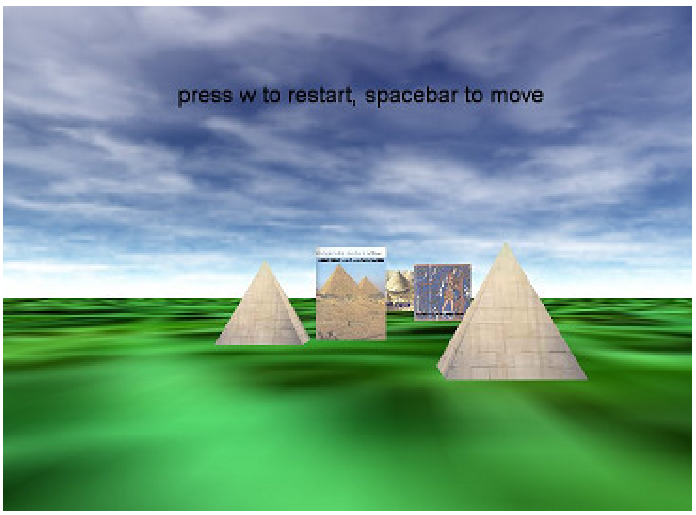

Figure 18. A screen shot showing the beginning of the sequences used with the VE group.

6.2.2 Method

6.2.3 Participants

Participants were 52 children (32M, 20F) drawn from a primary school in North-East London, UK. The children were from a single class, (the rising nine class), the average age being eight years six months at the time of testing. All had normal or corrected-to-normal vision. Teachers signed a consent form, in which they indicated that since the study was deemed part of National Curriculum, parental consent was regarded as unnecessary. However, it was ensured that all children wished to participate and were aware that they could withdraw from the study at any time if they wished. Teachers asked pupils about their typical daily computer use, which averaged 10.5 hours per week.

6.2.4 Materials

The VE was created using Virtools Virtual Reality software running on a Microsoft Windows XP Professional Version 2002 computer. The environment ran in Microsoft Explorer with a Virtools 3-D plug-in.

A set of nine pictures was used, representing historical epochs, being the same set as used in the previous study with primary age children (Experiment four above). Briefly, each picture was dated using a specific date rather than an era (ranging from “3000 BC” to “1939 AD”). A brief description of the picture and what it represented was added to each; for instance, to represent the ancient Egyptian era, a picture was used which depicted pyramids, with “Ancient Egypt” and “3000BC” added conspicuously in white lettering to the upper part of the figure. The Second World War and the evacuation of school children was represented by showing a picture with a train standing stationary at a platform, while children with suitcases and gas masks, accompanied by their relatives, were boarding it. The caption read “Evacuation, second world war” and “1939”. Features were modelled and introduced into the VE to help to make the child feel “located” in space rather than just viewing a picture. For example, models of Egyptian pyramids were located around the picture of pyramids, and a virtual Hurricane aircraft flew overhead as the participant approached the evacuation picture. Backward and sideways movements were disabled so that participants could proceed in a forward direction only, achieved by depressing the space bar. To return to the start and to pass through the environment again, participants were instructed to use the “W” key.

For the Power Point condition the same computer was used, the nine pictures being identical to those in the other conditions. In this condition, in the training phase, the pictures were separated from each other by using a blank Power Point screen. The blank screen was displayed for approximately the same length of time (eight sec.) as participants took to move from one picture to the next in the VE.

In the control Paper condition, the same material was used as above, the pictures being printed on A4 sized sheets and presented to the child in landscape orientation with text added as in other conditions. Intervening blank pages were shown for eight sec. each.

6.2.5 Procedure

Children were randomly divided into three groups on the advice of teaching staff, to encompass a similar range of ability in history in each group. These were a Paper group (N=16; 8M, 8F), a PowerPoint group (N=18; 12M, 6F), and a VE group (N=20; 14M, 6F). Participants in the VE group were introduced to the VE individually and shown how to move forward through the environment by depressing the space bar. All pictures were visible at this stage. The participant was then asked to perform the second, training phase, in which the anticipation (challenge) element was introduced. The researcher asked the participants to anticipate each next picture by asking "Which picture is going to appear next?" Responses (which could be a picture name or a description) were recorded as correct or incorrect. If wrong, the participant had to guess again until correct. The number of times that the participants had to pass through the nine items to reach criterion – two passes without errors -- was recorded, after which they proceeded to the next stage, i.e., the testing stage. On average participants completed four fly-throughs to achieve criterion.

In both the VE and PowerPoint conditions the participants had control of the environments since they operated the spacebar key themselves. In the Text condition, the nine pictures were presented to the participants, one at a time, and they were asked to inform the researcher when they wished to proceed to the next picture. The same anticipation routine was used in all three conditions.

When training was complete, the participant was taken to an adjacent set of desks on which were placed the nine test items, in random order. The participant had up to five min. (in practice, all taking about two min.) to place these in the correct chronological order as seen in the training stage.

6.2.6 Results

Five scores were obtained: during initial training, (1) The number of trials (passes) to criterion and (2) A total error score, summing all errors committed prior to reaching criterion. Two further measures were obtained from the initial post-criterion testing: (3) REM score, or "removed score" [see Chapter four] and (4) Correct order [the number of pictures placed in their correct position in the one to nine sequence]. 5) Serial Order variable (see Chapter four). A further two scores were obtained when testing was repeated three weeks after the original training and testing phases: (5) REM1 [removed score], and (6) Correct order1 scores, measures (5) and (6) being calculated in the same ways as (3) and (4).

Each variable was subjected to an independent measures 3 x 2 Groups x Gender ANOVA (Analysis of Variance). The results showed that there was no significant difference between groups on any measure, though on total errors, a group effect approached significance, $F(54,2)=2.66$, $p=.07$. When further analysis (using the post-hoc Tukey test) was conducted on the total error variable, participants trained in the Text condition were found to have made fewer errors than the PowerPoint group, a result that approached significance, $p>.05$. There was no significant difference detected between other conditions: VE and Text groups and PowerPoint and VE, $ps>.05$. Other non-significant measures were: REM score $F(54,2)=1.390$, $p>.05$ (see Figure 19); Correct order measurement $F(54,2)=1.107$, $p>.05$; Number of Trials $F(54,2)=.322$, $p>.05$; REM1

F(50,2)=1.094, p≤.05; and Correct1 F(50,2)=.088, p>.05. No significant gender differences were found on any measure.

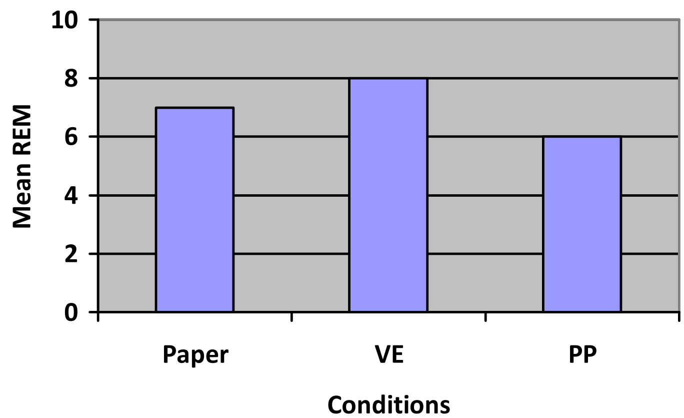

Figure 19. Removed scores for the three groups (Experiment six).

6.2.7 Discussion

The data showed that the introduction of challenge in to a virtual display of historical chronology is not, alone, sufficient to ensure good learning. Indeed, in terms of total errors (number of incorrect anticipation errors committed prior to achieving criterion), there was a suggestion of a group difference that almost reached statistical significance, the group trained in the Text condition making arithmetically fewer errors than those in the PowerPoint condition, but there was no hint of significance between VE and PowerPoint conditions. Other measures showed no significant differences. The results reinforced earlier findings, that PowerPoint seems to be an especially ineffective medium for conveying chronologically sequenced information (Haydn, 2006; see Foreman et al. 2006), and once again indicated that children of primary school age appear not to experience the kind of benefit from using VEs in the history context that characterizes an older, undergraduate sample (Foreman et al. 2006).

The present study failed to support earlier studies which have found sex differences on many spatial measures following VE exploration (Astur et al. 1998; Chan, 2007; Coluccia et al. 2007; Choi and Silverman, 2003), though sex differences can require large numbers of participants for significance to emerge when children use VE based tasks (Sandamas and Foreman, 2007), and so this conclusion must be treated cautiously.

Some children commented that they did not have computers at home and that they found the task rather difficult to perform, and thus the poor results might have arisen from participants' lack of familiarity in using computers generally and/or VEs for educational purposes, specifically. Therefore in Experiment seven, the same basic protocol was used as in the first study, but children were given extra experience with the environment and input device control before full training commenced. Since VE use might arguably be especially useful with children whose performance is initially poor, a subgroup was identified within the class having special educational needs.

6.3 Experiment seven: Challenge and pre-training experience in the use of VEs to teach historical chronology at primary level

6.3.1 Introduction

The same paradigm as described above was adopted, with a further modification, whereby children were given more time to explore the VE. It was hypothesized that by making this modification, ensuring adequate familiarity with the medium, error free learning would be achieved.

6.3.2 Method

6.3.3 Participants

Forty-five primary school children (32M, 13F) were randomly drawn from the population of a school in north-east London by the teaching staff. Children were confirmed by teachers as being normally sighted or corrected-to-normal. Teachers signed a consent form, in which they indicated that since the study was deemed part of National Curriculum, parental consent was regarded as unnecessary. Teachers asked pupils about their typical daily computer use, which averaged 13.8 hours per week.

6.3.4 Materials

The same materials and images were used, as described in Experiments four and six above.

6.3.5 Procedure

The groups were divided into three conditions: a Paper condition (N=15; 11M, 4F), a VE condition (N=15; 10M, 5F) and a PowerPoint condition (N=15; 10M, 5F). The same procedure and design for the study were used as described above, but participants in the VE condition explored the VE for longer. The first time they flew through the environment (with all pictures visible), they did so together with the researcher who pointed out features of the device in controlling movements; the second time, children flew through by themselves but closely observed by the Experimenter. Again, the Experimenter guided them through each event slowly, asking each child to give more information about a certain historical event, and thus encouraging them to think about the historical timeline presented to them (see Experiment six, above). As a result children in this study had approximately five to ten minutes of extra exposure to the input device compared with Experiment six. Children in PowerPoint and Paper conditions were also given an extra pass through the materials which was adjusted to take approximately the same time as the extra VE training. All other procedures were followed as in Experiment six.

6.3.6 Results

Data were initially analyzed for all children in the class. The same six measures were taken as in Experiment six. When the number of rounds/passes to criterion was analyzed using a one-way ANOVA, the result was highly significant, $F(2,42)=9.63$, $p<.001$, showing substantial differences between groups. Post-Hoc tests revealed that participants in the VE condition required fewer trials to meet the criterion than in Paper ($p<.05$) and PowerPoint conditions ($p<.001$) but there was no significant difference between Paper and PowerPoint conditions, $p>.05$. Non-parametric statistical analysis was carried out on REM scores as one of the criteria for parametric analysis was not met: zero error scores which occurred frequently in the VE group caused their distribution to violate the normality requirement. The Kruskal-Wallis Test was used to compare the three conditions, VE, PowerPoint, and Text. The result obtained was significant, $X^2(2) =6.2$, $p<.05$. The Mann-Whitney U-test showed that the VE group was significantly superior to the Paper group on the REM variable, $U(N_1=N_2=15)=64.00$, $p<.05$ (two-tailed) and that VE trained participants performed better than PowerPoint participants $U (N_1=N_2=15)=70.5$, $p<.05$ (two-tailed) but there was no significant difference found between Paper and Power Point groups, $U(N_1=N_2=15)=108.5$, $p>.05$ (two-tailed) (see Figure 20). Clearly from these results, it has shown that using PowerPoint presentation was not as ineffective as suggested by the results of earlier studies (above). The variable "Correct order" was bordering on significance, $F(2,42)=2.73$, $p=.07$, but post-hoc tests failed to reveal significant differences between VE and Paper or VE and PP groups, both p's>.05. Other measures showed no significant group differences.

Serial order effects were analysed by using the non-parametric Kruskal-Wallis test on successive list position blocks. The results revealed no statistical significance in the primacy block (1-3), but significant differences in the middle (4-6), $X^2(2)=6.9$, $p<.05$, and recency (7-9) blocks, $X^2(2)=6.2$, $p\leq.05$. The Mann-Whitney U-test showed that in the primacy block more items were placed correctly in the VE group than in the Paper condition, $U(N1= N2=14)=55.5$, $p<.05$. No significant difference was found between VE/PP and PP/Paper groups. In the middle list position block, more items were placed correctly by the VE group compared with PP, $U(N1=14, N3=15)=64.5$, $p<.05$. In the recency position block, the VE group did better than both Power Point and Paper conditions, $U(N1=14, N2=15)=68.5$, $p<.05$ and $U(N1=N3=14)=55$, $p<.05$, respectively (see Figure 21). No other significances were obtained.

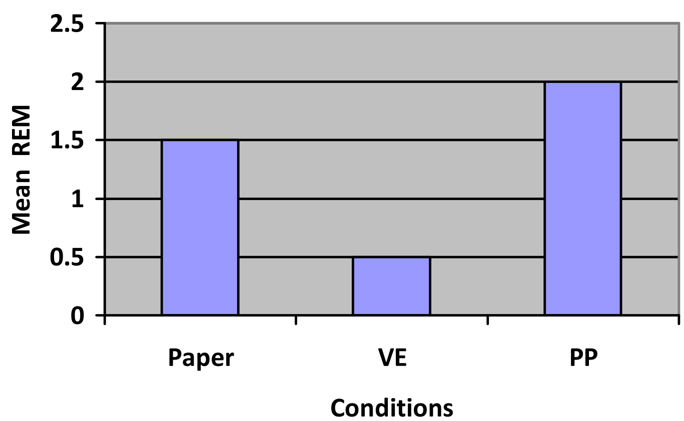

Figure 20. Removed score for the three groups (Experiment seven).

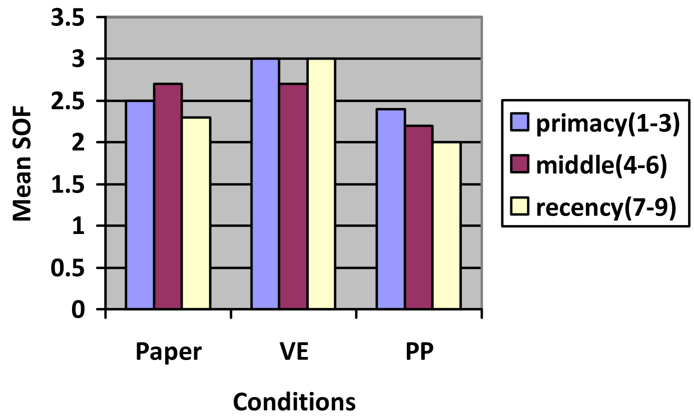

Figure 21. Serial order effect in the three groups (Experiment seven).

The present results were compared with the previous findings from primary school children who did not have challenge incorporated in the protocol, and who performed particularly poorly (Experiment four, Chapter five; Foreman et al. 2008). (Comparability between schools is complicated by differences that may arise from differences in curriculum, computer use and teaching strategies, though this applies equally to all of the experimental conditions in which the children were tested). Control groups (both Paper and PowerPoint) did not differ between the experiments but those in the present study who used VEs did perform significantly better on the REM and Correct Order variables than those using VEs previously. ANOVA was used to compare VE conditions in the two experiments, and the result was highly significant, $F(3,64)=7.64$, $p<.001$; $F(3,64)=9.65$, $p<.001$. Further Post-Hoc revealed that there was a significant difference between the schools p's$<.05$.

6.3.7 Discussion

Compared with the previous study, the addition of extra pre-training for VE participants clearly improved retention of the historical materials. Significantly better learning was reflected in the lower number of trials needed to reach performance criterion in training and then by significantly better Correct order and REM scores at test. Indeed, performance was error free for all VE participants and thus substantially better than for VEs in the previous Experiment six and in the previous paper (Foreman et al. 2007; Cockburn, 2004). The response of the children was positive; they reported enjoying the experience of working with a new medium and were enthusiastic about participating in VE exploration. However, this and previous studies (Foreman et al. 2006) do only relate to the learning of a limited number of items (in this case, nine) and thus are only applicable to situations where a teacher has several items that must be remembered in correct chronological order, rather than for example, understanding historical developments that may depend on the confluence of several contributory events.

Computer familiarity in this case refers not to familiarity with using computers (since many children did this often), but related to familiarity with computers as a medium specifically in the historical chronological context. However, another variable that could influence the effectiveness of the use of VE technology is computer familiarity per se (Sandamas, Foreman and Coulson, 2008). In an earlier study (Foreman et al. 2006; Experiment four, Chapter five) it was felt that primary age children were especially overawed and overexcited by using a VE medium, and this appeared to have been responsible for a particularly poor level of learning in this age group compared with middle school and undergraduate groups. However, general computer familiarity is difficult to assess as an independent variable in the UK context because many children have access at home to computers, and computers are frequently used in the classroom. Therefore to assess whether a lower level of computer familiarity might compromise the ability of pupils to learn historical chronological information from VEs, a final study used the same age group as in the UK studies but in a Ukrainian primary school, where children were altogether less familiar with computers. Challenge was incorporated, as above, by having the children anticipate up-coming images, plus prolonged pre-training, since this combination proved effective in the present experiment. The same comparisons were made among conditions as in UK samples.

Chapter Seven: Can VEs benefit children's learning of historical chronology in a culture where computer experience is more limited?

"I am just saying— what's history, anyhow?"

(Peenish, www.annezook.com)

7.1 Introduction

The studies reported in above chapters were all conducted in schools in a culture, the UK, where most pupils reported using computers on a regular basis and all had very extensive computer experience. This might influence results in at least two ways: computer familiarity might make it easier for pupils to use VEs, and navigate more naturally and freely, leading to good retention of historical materials. On the other hand there was evidence from one study (Experiment four, Chapter five) that primary children (with limited knowledge of computers, on account of their age) were apparently overawed by the computer experience, leading to especially poor retention. Therefore two studies were conducted, in primary and secondary schools in Sumy, Eastern Ukraine, to examine the effects of using VEs in a country where children have much lower levels of computer familiarity. It also provided an opportunity to examine cultural differences in the teaching of history and chronology in class rooms.

7.2 Experiment eight: Use of a VE to enhance the learning of Ukrainian history in a Sumy primary school, in Eastern Ukraine

The present study was conducted to explore an additional dimension, whether children from the Ukraine would benefit from the use of VEs in learning about the history of the Ukraine. Children who have had little or no experience with computers might actually learn more from exploring the materials presented in the VE given the novelty and attraction of the procedure, but the hypothesis was two-tailed insofar as a child naïve to computers might be overawed by the experience and fail to retain historical information as a result.

The present study also had an heuristic element: to see if there is any cultural difference between learning/teaching styles usually adopted by teachers in the two countries, which could have implications for the introduction and benefits of technology. In order to compare teaching styles used in both countries and explore which method was thought by teachers to be the most effective in teaching history in primary and secondary schools, the same short questionnaire as used with UK teachers (see Section 1.4, Questionnaire study one above) was translated and distributed amongst Ukrainian teachers. The analysis revealed that the biggest challenge the Ukrainian teachers faced while teaching history was their inability -- due to time and resources available to them -- to cover historical materials required by their National Curriculum in the given time. The teachers felt that the children also faced the same problem, so that they had limited time in which to acquire new information. Their suggestion was to maximize the number of hours spent on learning history as well as introducing new forms of teaching that required less time (on the part of teachers and pupils) to understand information, and allows pupils to be exposed to some forms of illustration of historical materials (Informal questionnaire used with Ukrainian teachers, 2008). Clearly, the use of VEs might fill this role.

7.2.1 Method

7.2.2 Participants

Thirty pupils (14M, 16F, aged seven to eight years old) from school number N.23 in Sumy in the Eastern part of Ukraine took part in the experiment. Children were randomly selected and equally divided into three conditions by the teachers: PowerPoint (N=10, 4M, 6F), VE (N=10, 5M, 5F) and Paper (N=10, 5M, 5F). Participants' vision was not assessed, but teachers confirmed that all children had been assessed by school authorities and had been confirmed as having normal or corrected-to-normal vision. Teachers asked pupils for details of their typical daily computer use, which was found to be an average of 2.5 hours per week.

7.2.3 Materials

Nine pictures representing significant events in Ukrainian history were selected with the assistance of teachers, based on the materials used to teach history in the classroom to this age group and representing events considered important for children to remember chronologically (Appendix 7). The images were downloaded from Ukrainian history pages on the Internet. A new VE format was designed (based on teachers' requests) that consisted of four gallery rooms located on two floors in a virtual gallery, similar to those that pupils might visit on school excursions. Each floor consisted of two rooms of the same size. On level one a first room contained two pictures, on opposite walls, while another had two on adjacent walls. The same room layout was replicated on a second floor, in which three pictures were placed in one room and two pictures placed in the final room. In order to move from the first to the second floor a child was required to call a lift, from which the participant was required to go along a short corridor, leading to the first of the level two rooms, after which they could pass across the corridor to the final room. In the training stage, all pictures were dated and named. The PowerPoint condition was conducted using the same materials but as a succession of single screen displays with dates and text; the Paper/Text condition used A4 pictures with dates and text, so replicating the conditions used in Experiments six and seven.

Figure 22. Testing in a primary school in Ukraine.

Figure 23. Testing in a primary school in Ukraine.

7.2.4 Procedure

School N. 23 in Sumy, Ukraine, was contacted and invited to participate in the present research. Ethical approval for the study was obtained from both the Ethics committee of Middlesex University Psychology Department UK and the Local Educational Authority in Sumy, prior to the experiment commencing. Two rooms were allocated in order to carry out the procedure. Two children were called from their classroom at a time. Teachers were asked to select the children randomly. When the participants arrived, the researcher asked them whether one of them wanted "to play" with a computer. On this basis, children were assigned to the VE, PowerPoint or Text conditions. Children in the VE group were asked to look at the VE together with the researcher, who showed and explained how the environment worked. The experimenter went through the environment with the participant reading and explaining all information depicted on each picture. They were told to try to remember the order of the pictures, plus dates and titles. Participants and the Researcher went through each historical event together, talking about it, discussing the relevance to the participant's present life. However, the next testing stage of the experiment was not revealed to participants at this point. After having completed a first part of the training, participants were told to explore the environment by themselves until they were comfortable to move to another stage of the training phase. The whole training thus consisted of two successive trials, which were for training/experience only and not analyzed subsequently. At this point challenge was introduced (as in Experiments six and seven, Chapter six) so that participants had to guess which picture would be displayed on each up-coming screen. Errors were recorded and in the case of an error the child had to make further guesses until correct. This procedure was repeated until participants had reached the criterion of two successive error free passes. On average children would typically require two to three passes to reach criterion. The same was conducted with other conditions, moving between PowerPoint slides or between successive sheets of A4 paper with printed images, in all cases having the same labels and dates as displayed in the VE condition. After reaching criterion, all children performed a testing phase i.e., they were required to place the images (provided on A4 sheets, but without dates) in correct chronological order. On average three to four minutes were spent completing this task. Overall, children spent seven to ten minutes carrying out the whole experimental procedure. After a two week interval, the testing condition was repeated to explore which condition was most effective in terms of remembering historical items over a longer time interval. Children were debriefed about the purposes of the experiment following this second test phase.

7.2.5 Results

Six dependent variables (as in Experiments six and seven) were analyzed using ANOVAs which indicated significant or marginally significant group differences on REM, $F(2,27)=3.22$, $p \leq .05$, Total Errors, $F(2,27)=5.26$, $p<.05$, Correct order, $F(2,27)=3.25$, $p \leq .05$, and Correct order1, $F(2,27)=3.3$, $p \leq 05$. Post-hoc Tukey analyses revealed that for Total Errors, the computer groups (VE and PowerPoint) made more errors than the Paper group, p's<.05 On the REM variable the VE group performed much better than the PowerPoint group, $p<.05$, but there was no significant difference between VE and Text groups, $p>.05$ (see Figure 24). On the Correct order variable, the VE group answered more questions correctly than PowerPoint, $p<.05$ but there was no significant difference between VE and Text groups, $p>.05$. On the Correct1 variable (two weeks after initial training and testing), the VE group gave fewer correct answers compared to the Text group, $p \leq .05$.

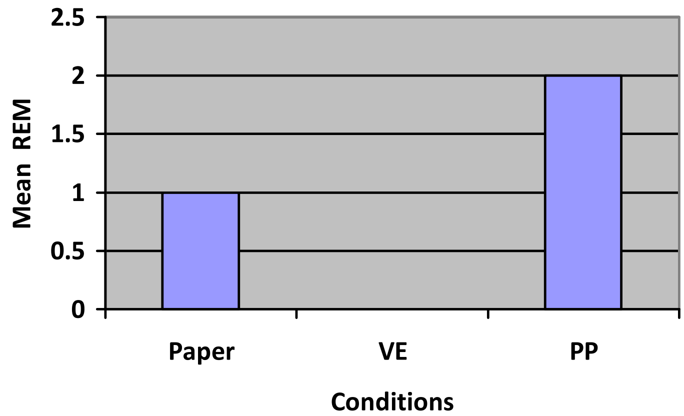

Figure 24. Removed score for the three groups (Experiment eight).

Other variables gave no significant results, including the gender variable $t(28) = -.434$, $p > .05$. A correlation was performed between the Ability scale (rated by teachers) and REM and Correct scores. Data showed that the Ability rating variable correlated positively with how well children performed on the Correct order variable, a result that almost reached significance, $r(29)=.334$, $p=.07$, but when the REM and the ability rating variables were correlated, a negative correlation was revealed which also approached significance $r(29)=-.312$, $p=.09$, suggesting that the higher the ability rating by teachers the lower the error score on REM.

The serial order effect was examined by using the non-parametric Kruskal-Wallis test, applied to each list block in turn (1-3, 4-6, 7-9), revealing that there was a significant group difference only in the middle position $X^2(2)=6.43$, $p<.05$, the Mann-Whitney U-test revealing that VE group placed more items correctly than the PowerPoint group $U(N1=N2=10)=25$, $p<.05$.

7.2.6 Discussion

The main result from this study showed that even among pupils who do not use computers as often as those in the UK, and do not have the same degree of computer familiarity, with challenge incorporated in the VE, there is some benefit in using a VE to acquire historical chronological information. This further reinforces the conclusions from previous studies, showing that with active involvement (Wilson, 1997; Foreman, 2007, Pedley et al. 2003, Wallet et al. 2009), anticipation, challenge and longer time spent on the environment during pre-training, primary school children seemed to benefit from using a VE. This finding is especially important when compared with previous studies in which this age group was found to be apparently overawed or overexcited by using the VE medium (Foreman et al. 2006 and Experiment four, Chapter five), data in those cases being obtained from primary age pupils in studies in which passive fly-throughs were used, or with inadequate prior training with the medium. Interestingly, however, when tested here, children in the VE condition answered fewer questions correctly than in the Paper trained conditions when they were retested after a two week interval, which suggests that there was no benefit of using VE presentations in terms of the longer-term retention of information.

Another controversial aspect of the findings was that participants in the VE group during the training phase made more errors in the course of the trials required to meet the "two successive correct passes" criterion, compared to the Paper condition. This is not consistent with the findings from previous experiments (Experiment six and seven), in which VE participants made fewer errors in the course of training trials. Some aspects need to be investigated further in order to understand a) why children did better in the VE group when tested straight after the training phase, but failed to show any significant effect after two weeks (this is in disagreement with the previous finding (Hartley et al. 2004) who argued that spatial memory remains stable over a long period of time; and b) why participants tended to have more questions answered correctly in the Paper group compared to VE and PowerPoint after 2 weeks? As far as the REM 1 score was concerned, participants in the three conditions performed equally well, in line with Prangsma et al.'s (2009) findings that while visualisation is generally beneficial, combining text and different forms of visualisations did not necessarily enhance history learning.

The present study further indicated that gender was not a significant determinant of how well new materials are learned (consistent with Experiments one to eight; Sandamas and Foreman, 2007; Astur et al. 1998; Chan, 2007; Coluccia et al. 2007; Choi and Silverman, 2003). It is important to mention that the VE used in this study was different from other environments employed throughout the research above (see Chapter five, Experiment one). Despite the complexity of the environment that required additional mental effort (using left/right turns, manoeuvring up and down the lift) primary school children did benefit significantly from the VE experiences, although this advantage was no longer evident at follow-up testing, and so there was no lasting effect. In addition, the correlation tested showed that general performance was correlated negatively with the REM score, so children who were rated highly by teachers and who had higher marks for their classroom achievement tended to perform better in the tests by placing items accurately. Teacher ratings (higher marks) were correlated positively with the Correct order variable, suggesting that the stronger children were in their classroom performance, the more items were placed correctly when tested. This is important because it indicates that the test procedures used had content validity.

Figure 25. Testing primary school children in Ukraine.

Figure 26. An image of learning history in Ukraine. Primary school.

Figure 27. Sofievsky Cathedral presenting in a VE. Ukraine.

Figure 28. A screen shot of one room of a VE used with middle school children in Ukraine.

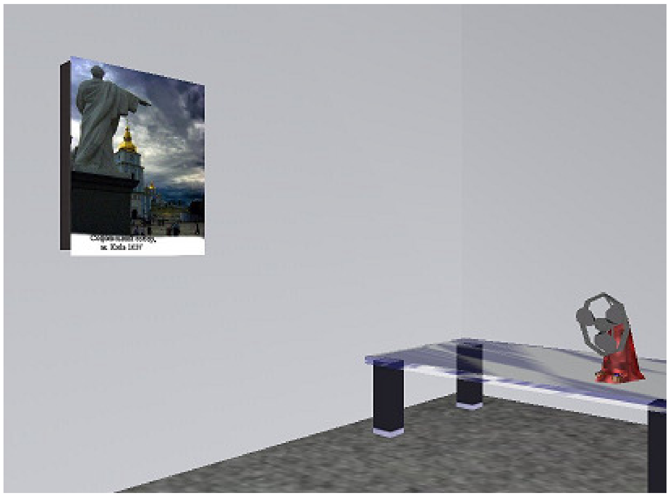

Figure 29. An image of a VE used in learning history in Ukraine.

7.3 Experiment nine: Use of a VE to enhance the learning of Ukrainian history in a Sumy middle school, Eastern Ukraine

Having achieved mixed results from the middle school in the UK, but a significant benefit of using VEs with challenge when children were adequately pre-exposed to the medium, the aim of the present study was to see whether this would apply equally to a group of children of the same age in the Ukraine, having much less experience of computer use. Challenge was again incorporated during training and children were introduced to the VE format individually by the experimenter and given time to explore the environment, to familiarize themselves with the medium prior to beginning the experiment per se (cf. Experiments six and seven above).

7.3.1 Method

7.3.2 Participants

Thirty (15M, 15F) pupils from a Ukrainian middle school were tested in the experiment. The group was a year group, the average age being twelve years. All children were confirmed by teachers as being free of sight-related problems**.** Prior to the experiment, the teachers signed a form, confirming that no parental consent was essential as the materials used in the study were based on National Curriculum requirements and that the study could therefore be regarded as part of the regular curriculum. However, in line with ethical requirements, children were informed that they could withdraw from the study at any time without any penalty. Teachers asked pupils for details of their typical daily computer use, which was found to be an average of 1.5 hours per week. Ten out of thirty participants did not have any access to computers.

7.3.3 Materials

The same materials were used in the experiment as described in the previous study with primary children in Ukraine (Experiment eight). The same VE layout was employed. However, there were three new pictures added to the existing environment to match the learning material covered by teachers in classroom lessons. All pictures were named and dated. The new list of items is shown in Appendix 8. An example is shown in Figure 30.

Figure 30. Grigorij Skovoroda, philosopher and writer. An image used in a VE in the middle school in Ukraine.

7.3.4 Procedure

Children were randomly divided into three groups: a Paper group (N=10; 4M, 6F), a PowerPoint group (N=10; 5M, 5F) and a VE group (N=10; 5M, 5F), on the advice of teaching staff, to encompass a similar range of ability in history in each group. Participants in the VE group were introduced to the VE individually and shown how to move forward through the environment by depressing the space bar. All pictures were visible at this stage. The participant was then asked to perform the second, training phase, in which the challenge/anticipation element was introduced. The researcher asked the participants to anticipate each next picture by asking "Which picture is going to appear next?" Responses (which could be a picture name or a description) were recorded as correct or incorrect. If wrong, the participant had to guess again until correct. The number of times that the participants had to pass through the 9 items to reach criterion – two passes without errors -- was recorded, after which they proceeded to the next stage, i.e., the testing stage. On average, participants completed four fly-throughs to achieve criterion

In both the VE and PowerPoint conditions the participants had control over the environments since they operated the spacebar key themselves. In the Paper condition, the nine pictures were presented to the participants, one at a time, and they were asked to inform the researcher when they wished to proceed to the next picture.

When training was complete, criterion having been reached, the participant was taken to an adjacent set of desks on which were placed the nine test items, in random order (pictures, without text or dates). The participant had up to five min. (in practice, all taking about two min.) to place these in the correct chronological order as seen in the training stage. After the completion of the experiment children were debriefed. On average participants spent five to seven minutes to complete a whole task. After two weeks the same test procedure was administered to investigate which condition was more effective in terms of remembering items in their correct order over a longer period. For their participation, participants were given fruit.

The dependent variables to be measured corresponded with the study described above:

1. The number of correctly placed items
2. The total number of errors made in rounds during the anticipation stage, prior to reaching criterion
3. The number of fly throughs (VE) or passes through the materials required to reach criterion
4. REM (removed) scores
5. REM1 scores at testing after a two-week delay
6. The number of correctly placed items (Correct order1) when tested after a two-week delay
7. Children's general classroom history performance (rated by teachers), based on their grade

7.3.5 Result

An independent one-way ANOVA was used to analyze the variables (Total Error, REM, REM1, Correct order, Correct order1, and Number of Trials.) Although the VE group scored arithmetically higher than others (Figure 31) the three groups showed substantial variability and did not differ significantly.

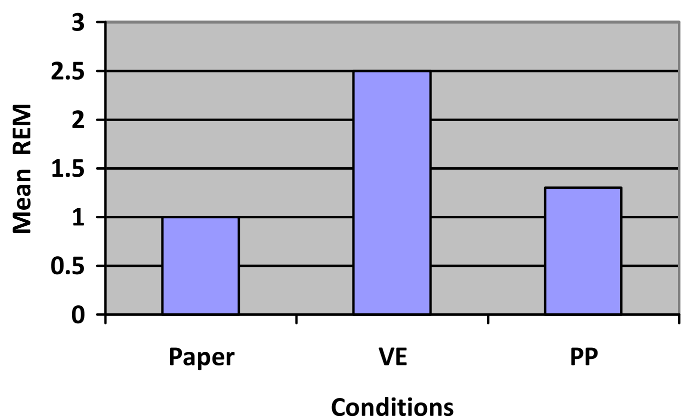

Figure 31. Removed scores for the three groups (Experiment nine).

The Serial order effect was examined by recording the number of pictures placed correctly at the beginning of the list (primacy effect: list positions 1-3), in middle list positions (4-6) and in at the end of the list (recency effect: list positions 7-9). Data were analyzed using a non-parametric Kruskal-Wallis test, but no significance was found.

The Gender difference was found to be non-significant, $t(28)=-.467$, $p>.05$. When a correlation was performed between the Ability variable (teacher's ratings) and Correct order1 (the number of items remembered when the same test was repeated after two weeks), it showed a near-significant negative correlation between these two variables r(28)=-.361, $p \leq .05$. The correlation between the REM and Ability scores was clearly non-significant.

7.3.6 Discussion

The results of the present experiment have shown that VE experiences might not be beneficial in all age groups and that, as in the UK sample (Experiment three) middle school children show no benefit from VE training. Most of the variables that had been explored did not show any significant differences, suggesting that VE environments either should be further improved (Wickens at al. 1997; Cockburn and Makenzie, 2004) or that the use of VEs might, simply, be inappropriate for middle school (11-13 year) pupils. Throughout the research statistical analysis has revealed that participants in the Power Point condition suffered most in terms of remembering events presented in chronological order (Experiments one to eight, Haydn, 2000). The present experiment also supported this claim showing that participants from the PowerPoint group required more trials to go through in order to remember all historical events. Gender difference was also non-significant, suggesting that female and male benefited equally from new technologies when adequate training was provided (Coluccia at al. 2007; Sandamas and Foreman, 2007; Astur et al. 1998; Chan, 2007; Choi and Silverman, 2003).

7.4 Experiment ten: Use of VEs to enhance historical understanding amongst middle school children in the UK

The rationale for introducing an additional second part of training and testing to the next experiment was to expose the participants to the same environment twice, so that "savings" scores could be calculated. In previous middle school studies (Experiment three), VE participants had not performed better than in other conditions but if VEs had been very engaging and images had become "imprinted" more effectively (note: an overexciting environment could distract children's attention from the task; see Experiment four), then middle school children might perform better. Perhaps there is no immediate beneficial effect of using VEs, but such might become more evident when participants revisit the same environment after a two week interval, relearning the same materials again thus reinforcing retention. The environment used in the present experiment was linear. The analogy can be drawn from visiting and revisiting a well known high street—one might not necessarily make any effort to learn a position of shops or their spatial relationship to each other, but nevertheless, one might find it progressively easier to recall the shops and their locations. By introducing extra training and testing sessions, in conjunction with other important factors such as the use of challenge and a scoring system, participants are given maximum opportunity to take any benefit that might arise from using a VE.

The introduction of new materials, selected by teaching staff, in the present experiment might encourage children to be more engaged with the environment. In the previous experiment (Experiment three) with the same age group, where performance was rather poor, this might be thought to have occurred because participants were asked to learn medieval materials that they had been taught about in the classroom, and this might have affected their enthusiasm for the experiment.

7.4.1 Method

7.4.2 Participants

Forty-nine middle school pupils from North London were randomly selected by teaching staff to participate in the experiment (26M, 23F). None had sight-related problems. Prior to the study, a parental consent form was sent to all parents, notifying them about the experimental procedure and objectives of the study. Children were informed that if they felt uncomfortable about the study, they could withdraw at any time without penalty. Teachers asked pupils about their typical computer use, which averaged 6.5 hours per week. All children had access to computers either at home or school.

7.4.3 Materials

Two laptop computers were used in the VE and PP conditions for this study. The VE was created using Virtools 3-D construction software. The nine pictures were imported into the VE environment and the name and date of the event was presented on each of them. The browser version used for the software was Mozilla Firefox, and Internet Explorer as there were two laptops. Although the software was running on two different browsers, no differences were found during the fly throughs in terms of progression speed. PowerPoint slides were created using Microsoft PowerPoint software, and sheets of plain A4 paper were used to print the pictures for the Paper condition. Pictures and labels were the same in all conditions.

As in previous studies in UK samples, a set of nine images was used, in a linear sequence, depicting major universal historical events (Appendix 9). All images were labelled and dated. Images were selected using the internet with the assistance of teaching staff. For instance, it was recommended by the teacher to import a horrific image of the victims of the Holocaust into the environment to represent the Nazi regime and its drastic consequences for the world (Figure 32). The teacher argued that this image should evoke sympathy and engage the eleven to fourteen year-old pupils with the content depicted on the picture to make them think about history not in terms of nine items presented to them, but rather to think in terms of a cause and effect phenomenon. Other images showed main discoveries happening at certain times in history, regarded by history staff as being especially significant. Contrary to Experiment three, where items were selected based on National Curriculum requirements; the present study was based on a random selection of images that was supposed to engage the participants.

Figure 32. The victims of the Holocaust.

The PowerPoint condition had the same images presented to the participants with dates and names ascribed to them. In the training phase, successive pictures were separated by a blank Power Point screen. The blank screen was displayed for approximately the same length of time (eight sec.) as participants took to move from one picture to the next in the VE.

In the control Paper condition, the same material were used as above, the pictures being printed on A4 sized sheets and presented to the child in landscape orientation with text added as in other conditions.

7.4.4 Procedure

Part 1

The same procedure was applied as in Experiment eight. Children were randomly divided into the same three conditions, a Paper condition (N=16; 9M, 7F), a PowerPoint condition (N=15; 7M, 8F) and a VE condition (N=18; 10M, 8F). Participants in the VE and PP conditions were seated approximately 40 cm from the laptop screen and were given time to familiarize themselves with the controls of the laptop before the beginning of the training. In the VE condition, participants were told to use the forward key to fly through the environment. They were able to stop and have a closer look at the pictures when they wanted to and continue from there onwards. Participants for the PP condition were shown full screen pictures without any spatial context. Speed of progression through the materials was roughly equal across the three conditions.

Participants in all of the conditions were told to try to memorize the orders of the pictures and the information on each of the pictures. They were asked to pass through the nine pictures and view each in turn. After they have done that, they were asked to do the same again but with the difference that they had to anticipate "which picture is coming up next" on the blank screens or papers. Once the participants had described the picture or the information correctly, the experimenter would click on the blank screen to reveal the picture on the screen or turn up the page to reveal the picture on paper. If an incorrect answer was given, an error would be recorded and the participant would be asked to try again, and so on, until correct. Participants in the VE condition could see a counter on the top middle part of the screen that showed zero at the start of each pass. After each successive error-free correct answer, one point would be added to the counter. Thus, if the participant correctly anticipated seven out of nine pictures at the first attempt, seven would be displayed by the time the pass was completed, the experimenter resetting to zero before beginning the next pass. All participants were tested immediately after being exposed to the training procedure.

Part 2

After a one month interval the participants were asked to undergo the same experiment, in which they were asked to go through the training followed by the testing stages (exactly the same procedure being applied as in *Part 1* of the experiment).

Upon completion the measurements were taken and the participants were debriefed about the aims of the study.

7.4.5 Results

Part 1

Five variables were analyzed in the initial phase: Total number of trials (number of passes required to meet a criterion), Errors to criterion, REM, Correct order and Serial Order. The Total number of trials variable was analyzed by using an independent one-way ANOVA (since the data met all parametric requirements), which showed that groups differed highly significantly $F(2,46)=10.35$, $p<.001$ (Figure 33). A further Post-Hoc test revealed that participants trained in the VE and PowerPoint conditions required more passes to meet criterion than in the Paper condition (both p's< .001).

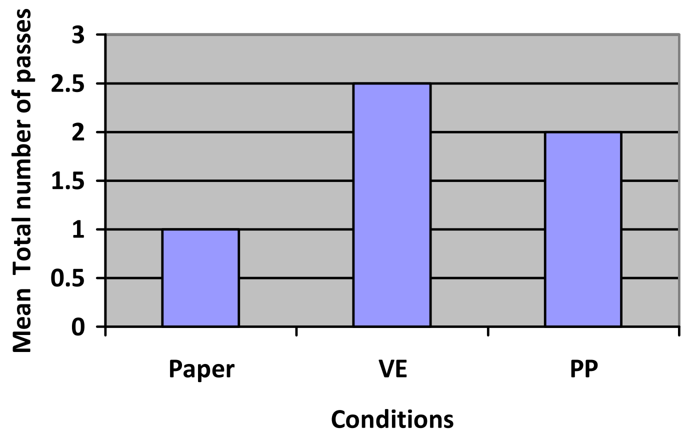

Figure 33. Mean Total number of passes to meet criteria (Experiment ten, Part 1).

The REM variable was analyzed using a non-parametric Kruskal-Wallis test (since data were not normally distributed). The results showed that there was no significant difference observed amongst the three conditions, so participants did equally well in all three groups $X^2(2,49)=4.41$, $p>.05$. The Correct order variable was found to be non-significant also ($X^2(2)= 4.35$, $p\geq .05$).

The Serial Order Effect was investigated by using a non-parametric Kruskal-Wallis test (since data were not normally distributed, failing to meet one of the parametric requirements). The result revealed that there was no statistical difference observed on middle and recency position blocks, although the primacy block was found to be significant $X^2(2)=7.75$, $p<.05$. A further analysis using the Mann-Whitney test showed that the participants placed more items correctly in the PowerPoint condition compared to the Paper condition $U(N=15N; N2=16)=72$, $p<.05$. The Gender variable showed no significance.

Part 2.

The additional measures taken at retraining and retesting were Total errors 1, Total number of trials 1, REM 1, Correct order 1 and Serial order effect 1, the latter recording the number of pictures placed correctly at the beginning of the list (primacy effect 2), in middle list positions (middle 2) and at the end of the list (recency effect 2).

An independent one-way ANOVA was used to analyze the first four variables. The Correct order 2 variable was found to be significant $F(2,45)=3.51$, $p<.05$, participants who were trained in the PowerPoint condition tending to place more items correctly than the participants trained in the VE condition, $p<.05$ (Figure 34). The other three variables did not yield any statistical differences.

The Serial Order Effect was again examined by using a non-parametric Kruskal-Wallis test. No significance was found in the middle 1 or recency 1 positions. However, the result for items placed at the beginning of the list (primacy 1) was found to be significant, $X^2(2)=7.31$, $p<.05$. Further analysis using the Mann-Whitney test showed that the participants who were trained in the VE condition placed more items correctly in first list position block (1- 3) than their PowerPoint counterparts (U=N1=17; N=16)=87, $p<.05$. However, there was no significant difference found between the VE and Paper conditions, nor PowerPoint and Paper conditions.

The gender variable was not significant on most variables, although when a t-test was performed on the primacy 2 positioning, it showed that male participants placed more items correctly than female participants, $t(46)=1.95$, $p< .001$

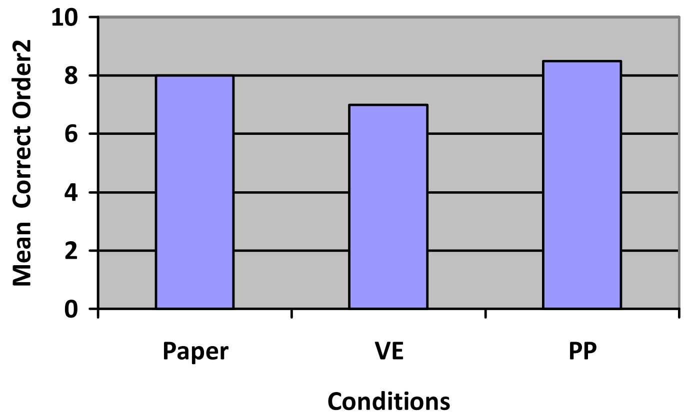

Figure 34. Mean Correct Order 2 items placed correctly after one month interval (Experiment ten, Part 2).

7.4.6 Discussion

The present study provokes further questions about the general use of VEs in educational settings. In fact, the present study found that VE participants, far from benefiting, required more passes through the environment to meet the experimental criterion. The Correct order 2 variable showed an interesting feature, insofar as participants who were trained in the Power Point condition did (contrary to the previous findings above, in which the PowerPoint failed to deliver effective learning) place significantly more items correctly than VE participants. On the other hand, the Serial Order Effect, when further analyzed, showed that the participants who were trained in the VE condition placed more items correctly in the early list positions 1-3 than their counterparts in the PowerPoint condition. Despite the fact that the participants were exposed to the same training and testing stages twice, so that there was plenty of opportunity for any benefits of VEs to emerge, the results did not show any such effect, and thus it remains obscure why middle school children did not benefit from the VE environments as did other age groups (c.f., Prangsma at al. 2008; Cockburn and McKenzie, 2001). Perhaps, children of this age are not developmentally ready to accommodate extra information, due to developmental changes that occur around this age from eleven to fourteen years old (Flickinger and Rehage, 1949; Jahoda, 1963; Friedman, 1982; see below). Perhaps at this stage children's spatial memory is still in the process of developing, and therefore the spatial memory overload might cause children's inability to take full advantages of the potential that VE s might offer. (This and other possible explanations are further elaborated below).

It is also important to note that the materials used in this study were rather different from those used in others above, for example containing provocative and arguably more memorable materials (such as a holocaust image). On the other hand, there was no evidence of a ceiling effect across all training conditions. The use of materials, as in other studies above, was based on recommendations from teachers, who wanted children to learn materials of the kind that they would encounter during national curriculum teaching sessions. However, it has to be noted that throughout all of the above studies with middle school pupils, using different materials, different formats and with different nationalities, the absence of any advantage from using VEs (with or without challenge) was consistent and repeated, in contrast to the benefits that were observed with other age groups when equivalent training procedures were adopted.

7.5 General discussion

The foregoing studies produced interesting data insofar as they demonstrated that VEs might not be effective as learning media for chronological materials for all age groups, and especially not with middle school children (c.f., Prangsma at al. 2009). Despite the fact that other age groups profited from the use of VEs, when challenge and familiarity with the medium were incorporated (see Experiments seven and eight), children aged eleven to thirteen years old were found consistently not to benefit. In the second study the participants were allowed to explore the environment longer by being trained and tested twice after a short interval. The same strategy has been employed in classroom for children using 2-D timelines (Dawson, 2004). Still, the result showed that even extra exposure did not provoke the participants to perform better in the VE. An additional variable was tested, exploring the lasting effect of the use of VEs. The result also showed that further studies are needed to understand the reasons as to why children remembered equally well across three conditions—thus failing to show any lasting effect that the VE exposure might offer. Although most of the results were non-significant, the present study demonstrated that children in the second part of the experiment showed a better understanding of materials learnt in a PowerPoint format. The present findings are therefore in disagreement with previous results consistently demonstrating the ineffectiveness of PowerPoint learning (Experiments six, seven and eight). Finally, the gender variable also showed to be non-significant, showing that materials learnt in a 3-D environment were equally well remembered by males and females. This is in agreement with previous findings (Sandamas et al. 2008).

There are several possible explanations for the fact that middle school children consistently failed to benefit from VE use. First, as suggested above, they may suffer an overload of information, which could be related to rapid biological/hormonal changes that may indirectly affect their ability to concentrate on a task or remember any new materials. The changes that children experience in their lives at this age should not be underestimated; they experience novel activities that require independent thinking and are encouraged to take full responsibility for their actions (such as travelling to school independently, and learning new routes and strategies). This may reflect changes taking place in their cognitive styles and skills. Studies (see Flickinger and Rehage, 1949; Jahoda, 1963 and Friedman, 1982) have previously argued that this is a stage at which children's spatial memory is undergoing important changes. However, in the context of the present studies, this is important since it means that children approach the test situation with immature structures and strategies that might be expected to make high demands on working memory. In other words, they have greater difficulty than other age groups, in employing the necessary strategies to encode materials in chronological time-space. Representational issues are further discussed below (Chapter 10). Examination and identification of strategies and procedures to use virtual displays to assist children of this age to overcome any barriers or difficulties are clearly needed, given the clear results of the studies reported above, but this issue is beyond the scope of the present studies.

The relatively small sample sizes used in the present study were not responsible for the absence of significant group differences. In previous studies, significant effects, where they occurred between VE, PowerPoint and Paper groups were evident with comparable sample sizes**.** Besides, other studies that used the same protocol (using VEs) also employed relatively small groups (e.g., Ruddle et al. 1997, Foreman et al. 2004; Cockburn, 2004). Moreover, where significances were obtained in the present study, these favoured the Paper condition and were therefore in a direction that invalidated the experimental hypotheses (Prangsma et al. 2009). There were no marginal significances in the direction predicted by the experimental hypotheses. Indeed, in practical terms, for the VE procedure to be useful, a VE would need to be demonstrably effective with class-sized groups of typically 10-15 pupils. Future research should concentrate more on how improve the lasting effect of using VEs. Also, future research should try to understand factors that prevent middle school children from benefiting from the potential that VEs might offer.

7.6 Conclusion: Single timelines

From the previous studies, it is evident that the use of a VE format to present sequential historical material for retention might not be beneficial for all ages, especially for middle school children. Undergraduate participants did retain more historical information from VE exposure compared to the other conditions. This can be explained in terms of their familiarity with computers and computer games, though it could also reflect better developed spatial capacities. When challenge and pre-training experience were introduced, undergraduates showed virtually error-free learning, but children at primary level also substantially improved their performance in retaining historical chronological materials. It seems that a computer "game" format might be effective in the teaching of historical chronology when using a VE as it allowed active participation and engagement, and introduced challenge that encouraged participants to be more motivated and try harder. In addition, most of the studies showed that a PowerPoint presentation might not be effective; participants tended to retain less historical information after PowerPoimt experience when compared to other two conditions. Haydn's (2002) scepticism regarding the use of PowerPoint presentations in teaching history thus proved to be valid. The gender variable did not seem to be an issue when performance was tested across three conditions. Male and female participants performed equally well on most of the variables.

Chapter Eight: Can VEs depicting multiple parallel timelines be effective in teaching chronology?

"Not to know what happened before one was born is always to remain a child"

(Cicero)

8.1 Experiment eleven: Use of VEs in conveying parallel timelines: art and music

8.1.1 Introduction

Following from the success of studies carried out with undergraduate students working with a VE format (see above), the present study was designed in a similar fashion, using the same paradigm as previously with the same age group, but including an additional domain of information. The number of items presented in each timeline above was nine (the upper limit of the conventional 7+/- 2 short term memory capacity, first proposed by Miller (1956). Competent participants could acquire the ability to remember nine items in correct chronological order after passing through the VE, with challenge i.e., with the need to anticipate each up-coming stimulus, after typically three to five passes. However, since the ultimate goal of the present series of studies is to create a situation where a comprehensive understanding of many related or unrelated historical events can be acquired and remembered within a more global historical space, it is important to go beyond situations where the maximum number of items that could be recalled was 9, ie. to know whether this number can be exceeded, using a more complex VE timeline. In practical terms, to give the situation validity, it is as though an individual has recently moved into a small town with two parallel roads, each containing rows of shops. At first, travelling along each road separately, that individual will develop a cognitive ‘map’ of the space within which each successive shop will be remembered. Further passes through the environment will increase the amount of information remembered so that in reality (as, hopefully, in a VE) a limit such as 7+/-2 appears entirely inappropriate since spatial memory, used to remember long sequences of places, will clearly contain many times the amount of information that is contained in a single learning experience. However, with time, that same person will, by travelling many times along parallel roads, acquire some understanding of the relationship between shop locations along each of the two roads and they will be able to cross-reference from one to the other. Applying this analogy to the learning of historical events, with two lines of materials each depicting successive historical events may, after several passes along each street (exploratory trips around the virtual ‘town’) a participants may be able to cross-reference between the domains of data depicted in the two parallel historical timelines.

An alternative proposition – unlikely, given our experience of learning places and committing many places within a locality to a spatial memory store -- is that if the short term memory buffer is the limiting factor, and if it becomes overloaded as successive items are remembered, art information will be dislodged by musical information, so that the total items remembered from the display may total nine but will not exceed it.

In an initial study designed to investigate the storage capacity for materials learned from a VE, the present study used a single timeline but with both art and musical materials presented simultaneously. In this case, a single timeline was used but which incorporated two domains of information – music was played as a line of successive pictures were viewed. The situation replicated what is sometimes reported anecdotally: that a particular piece of music can help spatial recall of a place, or that returning to a place (in this case, viewing a picture) might evoke a memory of music previously heard there. Examples of evocative paintings would seem particularly appropriate to this purpose. The use of spatial memory would be indicated were the amount of information recalled from this timeline greatly exceed nine. For both art and music events, the name of the picture and the tune, the name of the artist and the composer, and the year/period in which they were both created were presented in combination, so that a total of 45 items of information were presented in the course of a participant's passing from the start to the end of the VE. It was hypothesized that (1) after several successive exploratory trips through the VE, the total information remembered would exceed nine, and (2) a greater proportion of these 45 items of information would be recalled after exploring the time line in a VE format than by either hearing the extracts of music while viewing the linked pictures as PowerPoint screens or while viewing them conventionally printed on sheets of paper.

8. 1.2 Method

8.1.3 Participants

Twenty-five undergraduates (9M, 16F) took part voluntarily in the current experiment. They were randomly allocated to three conditions VE (N=7), Power Point (N=11) and Paper (N=7). The average age was 25 years old. All participants were asked about their vision but none reported problems.

8.1.4 Materials

The VE images were displayed on a 30 x 25cm monitor (see details in Chapter four). The nine images were placed in correct chronological order with the title of the paintings, the name of the artist and the year in which the painting was produced, superimposed on a featureless region of the picture. A text adjacent to the picture gave details of the music (name of composer, title of the extract, and year in which it was composed). The extract was programmed to begin playing as the corresponding picture was approached.

Challenge was introduced into the three environments. In the VE condition, there was a grey line (depicted directly ahead of the viewpoint) that was activated as the participant approached it and which helped participants to know at which point they could successfully click on the mouse in order to view the paintings' and music details. A pair of head phones (RP-F295) was used to allow participants to listen to the music excerpts in the VE condition. In a second condition PowerPoint was used, the same protocol being used as in the VE condition, such that participants viewed the same paintings along with the music excerpts. Similarly, the music details as well as the paintings' details were also shown on the screen. In the third, Paper condition, the painting was provided on a plain piece of paper with the name of the artist and the title of the painting. In contrast, to the other two conditions, the music was not played at the same time as the pictures were shown, but the details of the music were displayed.

The music and paintings were selected and paired in such a way that they were chronologically matched. The painting (artist)-music (composer) pairs were, in chronological order, as follows (see Appendix 10).

8.1.5 Procedure

Individual training was provided for each participant in the VE condition. Participants were seated in front of the computer screen in a comfortable position and at a comfortable viewing distance of approximately 40 cm. They were asked whether they could see the paintings. The participants were told that they would see a succession of nine paintings in front of them and their task was to remember the order and details of each painting as it appeared on the screen. The forward key on the number pad was used to progress through the environment. Other keys were deactivated so that the participants could only move forward but not in any other direction. The paintings appeared only when the participant had progressed to a set point, close enough to view another painting and the left hand mouse button was clicked. The painting was displayed for ten seconds. At the same time as the painting was displayed the music was played, matching the duration of time with the painting displayed. After this, participants were told to move forward to reach another painting; the same protocol was used throughout the environment. The participants were instructed to look at each painting along with the details of the music. Also they were told that they would be later asked to anticipate which painting was going to appear next. To meet a criterion, the participants had to guess nine paintings correctly twice in a succession. After completing the first fly through, they were asked whether they felt confident enough to complete a task i.e. to recall the images in correct order. If they did not feel confident enough, the experimenter would reset the environment from start point until the participant completed the task successfully. The participant had to recall each painting by saying the name of the artists, the title of the painting or by describing the themes of the images.

For the first test, all nine paintings including the artists' name and the title were presented randomly on a desk. The participants were asked to place them in historical chronological order, the order in which they were displayed during training. The experimenter had marked the order of the images. For the second part of the experimental procedure, the participant was asked to place the name and the title of the corresponding music in chronological order on a desk. For the final part of the experiment, the experimenter instructed the participants to match the music details along with the name and the title of the images. The experimenter marked the order of the music as well as the paintings. There was no time limit to perform this task. The whole procedure would typically take about four to five minutes to complete. After completion, the experimenter questioned the participants regarding the methods that had been used to retain information. After having completed all tasks, participants were debriefed.

The dependent measures of the present study were:

The number of correct images placed in chronological order

The total number of error made in sessions (rounds)

The number of fly through trials (VE condition) or presentations for both text condition and Power Point until the learning criterion was met

The amount of information remembered in three testing conditions (correct chronological order in music, placing paintings and matching music and paintings together). Ability to place items in an orderly chronological sequence was assessed using a REM score (Foreman et al. 2007).

8.1.6 Results

Table 2. Mean and SD for REM and Round variables for undergraduate students in Experiment eleven.

Conditions	Mean/SD	REMpic	REMmusic	REMpicmusic	Rounds
VE	Mean	.00	14.3	10.8	5.6
	SD	.00	10.9	9.9	1.9
Text	Mean	.6	12.8	10.2	6.1
	SD	.9	8.3	7.4	2.7
PP	Mean	2.1	8.8	10.7	3.2
	SD	2.3	7.4	9.8	.07

A one-way independent ANOVA was used to analyze dependent variables (REM pictures, REM music, REM music/pictures, Rounds and Correlation between REM and Age scores. The analysis of the variables showed that the REM picture measurement was significant, $F(2,22)=3.98$, $p<.05$. The REM music variable showed no significant difference between conditions, $p>.05$. REM music and pictures also showed that there was no significant difference between control and experimental groups. However, the Rounds variable revealed that condition differed significantly, $F(2,22)=7.087$, $p<.05$. The REM picture variable showed that there was a significant difference obtained between VE and PowerPoint groups suggesting that VE trained participants made fewer errors when they were tested on placing pictures in order, $p<.05$. Paper and VE conditions yielded no significant difference, suggesting that participants did equally well across two conditions, $p>.05$. Paper and PowerPoint groups did not differ significantly either ($p>.05$). A Post-Hoc comparison test (Tukey) was further conducted to investigate differences on the Round variable. It showed that there was a difference between VE and PowerPoint groups, in such that VE trained participants required more attempts to pass through the environment to meet researcher's criterion, $p<.05$. Further analysis using a Post-Hoc test showed that the Paper group performed no better than PowerPoint, $p>.05$. Other variables showed no significant differences. Further analysis of the Gender variable, using an independent t-test showed that the groups differed nearly significant when tested on the REM music variable, since males made more errors than females, $t(23)=1.73$, $p=.09$. However, when the same participants were tested on the REM picture variable using an independent t-test, the result showed that males made fewer errors compared to female counterparts, $t(23)=-2.439$, $p<.05$. An additional variable was investigated to explore any possible correlation between age groups and the three conditions. When Age and REM music variables were correlated, the result showed that age did not have any effect on how well participants performed on placing music in order (r=-.031, p<.05). In addition, no correlation was detected between Age and REMpicture, r =.-255, p>.05 and REM music/picture, r=-.297, p>.05. However, there was strong positive correlation between REM music and REM music/picture r =.745, p<.05, suggesting that if participants did well on one variable, they tended to do well on the other variable, showing consistency throughout.

Table 3. Mean and SD for the Gender variable amongst undergraduate students in Experiment eleven.

Gender	Mean/SD	REMpic	REMmusic	REMmuspic	Rounds
Male	Mean SD	.00 .00	15.3 10.2	10.4 8.4	5.5 2.2
Female	Mean SD	1.6 2.1	9.3 7.1	10.7 9.3	4.9 2.1

8.1.7 Discussion

The result of the present study showed that the use of VEs in educational settings can be seen as interesting, but controversial. The previous findings with undergraduates showed that the VE format can be an effective tool to be used in learning new materials (Foreman et al. 2005, Jansen–Osman and Wiedenbauer, 2004). The present experiment was based on the success of the previous findings, but included an additional variable – music, with successive items of music played while the participant observed a picture related to the music in time. Besides, challenge and a scoring system were also integrated into the environment, designed to increase the amount of information retained. Contrary to the researcher's hypothesis, when the additional variable was added – music-- participants' performances varied but was not universally enhanced. Not all information was equally well remembered. Clearly, the addition of music might have distracted and detracted from the learning of the art materials. On the other hand, participants recalled more information, judging from the REMpics variable (placing pictures in order). However, other variables failed to yield any significant differences. A very surprising aspect of the study was that participants who were exposed to the VE condition required more time (compared to PowerPoint) to go through the environment until they made sufficiently few errors to qualify for the next stage of the experiment. On the Round variable, participants in the PowerPoint condition needed less time to memorize the content of the environment in order to proceed to the next stage. This is not in line with the previous findings in which the PowerPoint condition proved to be less beneficial for retaining information (see also Haydn, 2000, Experiment eleven, Chapter seven). Further investigation is needed to see whether PowerPoint is indeed a reliably effective medium in this context. As for the Gender variable, the findings were not straightforward insofar as males performed better than women when required to place music items in order. Female participants, however, performed significantly better when asked to place the pictures in order. The present findings should be explored further to find out what factors determined such discrepancies in gender-related performance.

Chapter Nine: Using multiple timelines in learning different domain of information

"History: gossip well told"

Elbert Hubbard (1856-1915).

9.1 Experiment twelve: Can undergraduate students acquire knowledge effectively in art, general history and the history of psychology simultaneously by using a VE with three parallel timelines?

9.2 Introduction

A previous study using a nine item fly through showed that undergraduate participants benefited significantly from learning about the history of an imaginary planet by using VEs, when exposed (without challenge) to just one time line (Experiment two, Chapter five). A further series of studies working with primary school children also showed the benefit of using VEs, especially when children had adequate time to explore the environment and when challenged by using a game format (Korallo, Foreman, Boyd-Davis, Moar, Coulson and Newson, submitted).

In the present study a different form of environment was used, incorporating twelve items in three different timelines, history of psychology, general history, and art. Participants were given more time to explore the VE (over a two week period) after which they were asked to return and participate in a series of tests. From previous research, and experiments above, it was evident that longer exposure to the environment improves participants' performance in the short term; despite some authors having exposed participants to virtual environments for only a few minutes (Waller, 2000) the acquisition of spatial information from very large scale virtual environments has been said by others to require a considerable period of time (Darken and Silbert, 1999).

9.2.1 Method

9.2.2 Participants

Twenty-seven participants (21F, 6M) took part, fourteen in the VE group (4M, 10F) and thirteen in the Booklet group (2M, 11F). They were randomly selected from the Year 1 Middlesex University student population. They were not selected on any academic criterion, but it was ascertained that they did not have specialist knowledge in advance, of any area covered by the timelines beyond a Year 1 knowledge of Psychology. Their average age was twenty four years. None had any visual problem. An informed consent form was signed by each participant prior to participation.

9.2.3 Materials

The same computer and software were used as in previous experiments. Three VE timelines were produced using Virtools software, running in parallel. The same materials (images and information) were used to produce three booklets (in A4 format with coloured images) were produced. All information was obtained through the internet and history books. Events were selected randomly and matched according to the year in which they occurred, so at equivalent distances along the three timelines (see Appendix 11 and Figure 35). Note that it was not possible to incorporate 3 parallel timelines into a PowerPoint presentation and therefore this condition could not be incorporated into the present experiment.

9.2.4 Procedure

When recruited, participants were asked to read a brief introduction to the study which specified what they needed to do. Participants were randomly divided into two groups, one (experimental group) that was exposed to the VE and another (control group) who worked with a paper version of the environment designed in a booklet format. The VE group received training that consisted of passing through the environment together with a researcher, who ensured that the participant knew how to operate (load, run and fly through) the environment. After the training procedure was complete, the participant was asked to take the environment home [or they were sent it as an e-mail attachment] where he/she could explore it in greater detail at their leisure, i.e., to learn the content of the fly through and especially the order of all historical events depicted. The latter was strongly emphasized by the researcher. Also, the researcher pointed out that all information presented in the environment should be considered, as if the participant was being asked to revise for an examination. The control (booklet) group was effectively given the same task, but asked to learn the materials in the three timelines by using three separate booklets depicting the same historical events as presented in the VE. A similar amount of time was spent with controls, explaining the booklets and required procedure, as was spent with the VE group explaining the fly-through. All participants were provided with a chart, on which they had to indicate the amount of time (i.e., log the number of hours) they had spent on working with the materials (VE or booklet). The participants were asked to return after two weeks for a testing stage, although the objectives of the test were not disclosed in advance. The testing stage, for both groups, consisted of four parts. In Test 1, the participants had to recall the items learnt in their condition, but not in any particular order. In Test 2, they had to place events presented in a selected timeline in the correct chronological order. The same procedure was repeated for each time line. In Test 3, participants had to place together the events that took place in the three domains, i.e., History of Art, History of Psychology and General History, simultaneously. Finally, a questionnaire was designed to investigate whether participants could relate one timeline to another, and whether simultaneity could be identified between the events in the timelines. For instance, one of the questions asked: "What happened in the History of Psychology when an event X occurred in the History of Art?" All answers were recorded by the researcher. The testing took one hour to complete. After this the participants were debriefed about the nature of the research and the experiment specifically.

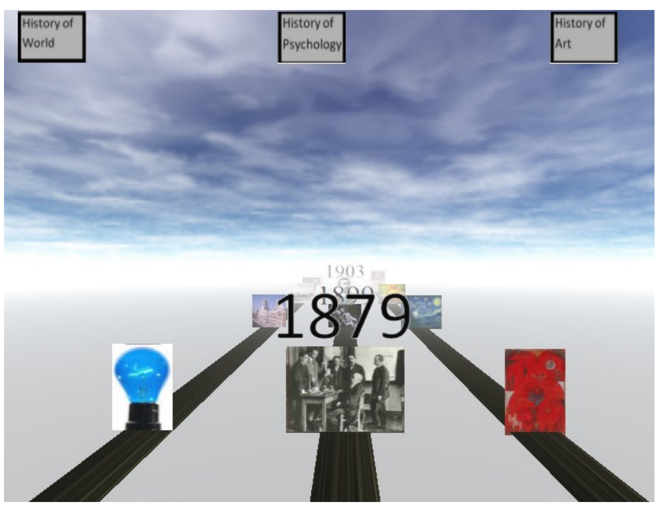

Figure 35a. An image of the three timeline environment used: History of Psychology, History of Art and General History.

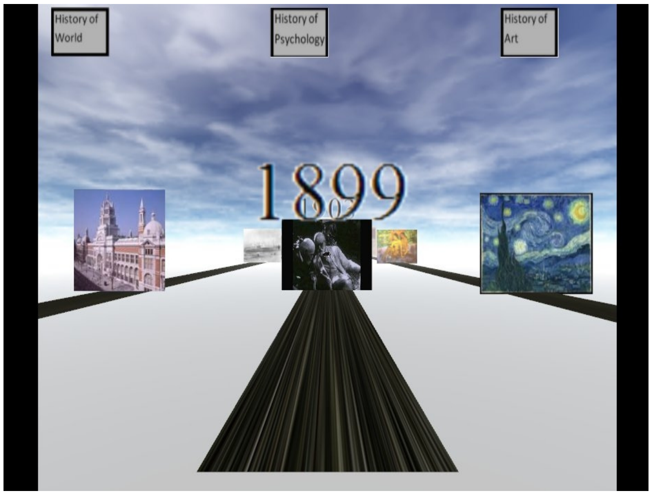

Figure 35b. **An image of the three timeline environment used: History of Psychology, History of Art and General History.**

Figure 35c. An image of the three timeline environment used: History of Psychology, History of Art and General History.

9.2.5 Results

The independent variables in the present study were the domain (art, psychology, general history), condition (Virtual Environment versus Booklets), and the gender of participants.

Fourteen dependent variables were measured, as follows:

(a) REM scores when each timeline was tested individually:

REM indA- REM score for the History of Art time line when tested alone

REMindP- REM score for the History of Psychology timeline when tested alone

REMindG- REM scores for the General History timeline when tested alone

(b) REM scores when all three timelines were laid out alongside one another:

REMcomA- total REM score for the History of Art timeline when placed along with the other two timelines

REMcomP - REM scores for the History of Psychology timeline when placed along with the other two timelines

REMcomG – REM scores for the General History timeline when placed along with the other two timelines

(c) Number of items placed in their correct chronological positions in each time line when timelines were tested individually:

CorindA- Items placed correctly for the History of Art

CorindP- Items placed correctly for the History of Psychology

CorindG- Items placed correctly for General History

(d) Number of items placed in their correct chronological positions when the three timelines were laid out alongside one another:

CorcomA- History of Art

CorcomP- History of Psychology

CocomG- General History

Totaltest1—the total number of historical items recalled across the three timelines (Test 1)

Totaltest4-How many questions were answered correctly when participants were quizzed about the simultaneity of events (Test 4).

An independent t-test was used to analyze the data. The results showed that six out of fourteen variables that were under investigation in the course of the present study revealed a significant statistical difference between the two groups. REMcom data are shown in Figure 36. The REMcomP variable [REM scores for Psychology; see above] was significant, $t(25)=-2.7$, $p<.05$ (two-tailed), indicating that participants who were trained in the VE performed significantly better than controls. The REM comG variable [REM scores for general history; see above] was also significant, $t(25)=-2.4$, $p<.05$ (two-tailed), showing that the VE group performed better in terms of correct recall of list positions for this time line. Corcom data are shown in Figure 37. The variable CorcomP [correctly ordered materials in psychology when tested together with other timelines; see above] was significant, $t(25)=2.2$, $p<.05$ (Equal variances assumed), indicating that participants from the Virtual group could answer more questions correctly than controls. The significant difference for the CorcomG variable [correctly ordered items in general history], $t(25)=2.4$, $p<.05$ (Equal variances assumed), indicated that the VE group performed significantly better than the booklet group. The TotalTest1 variable [total items correctly remembered, across all 3 timelines] was on the verge of statistical significance, $t(25)=2.02$, $p\leq.05$, showing that participants in the VE group could write down more items from memory than controls (Figure 40). Lastly, and perhaps most importantly, the TotalTest4 variable was highly significantly different between groups, $t(25)=3.15$, $p<.05$, revealing that the VE group performed much better overall than controls in terms of their ability to relate together the events occurring simultaneously in the three timelines (Figure 38).

There was no difference yielded between the groups in terms of the amount of time they spent in studying the materials, either reading the booklets or learning the materials from the VE. On average the two groups spent three hours on the activities prescribed by the researcher.

When the Gender variable was examined, there was no overall statistical difference between males and females on any of the above measures.

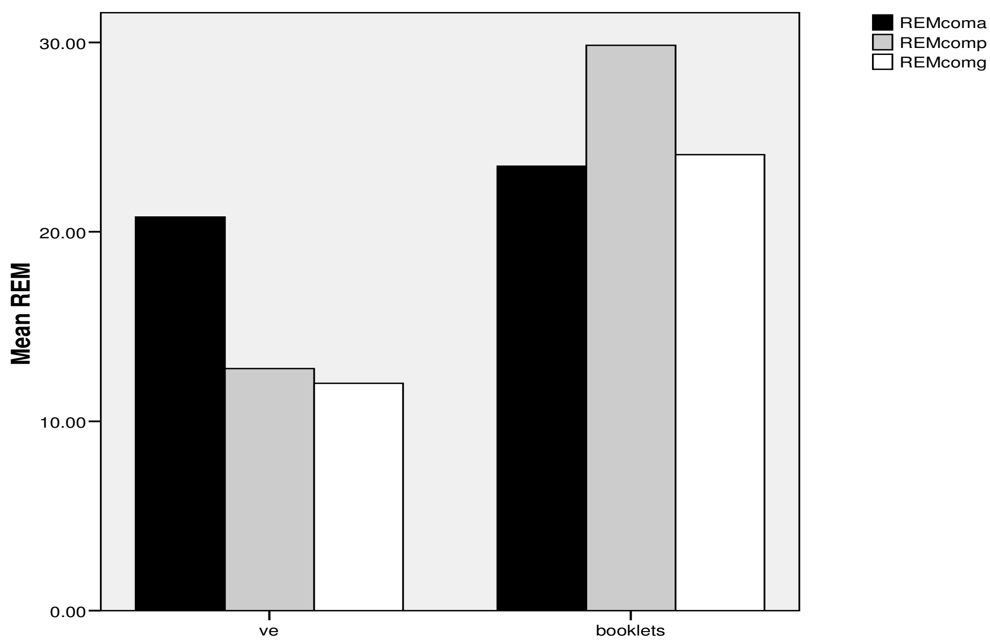

Figure 36. REMcom: Mean REM scores for each domain/time line when the three were tested together (a=art, p=psychology, g=general history). (Experiment twelve).

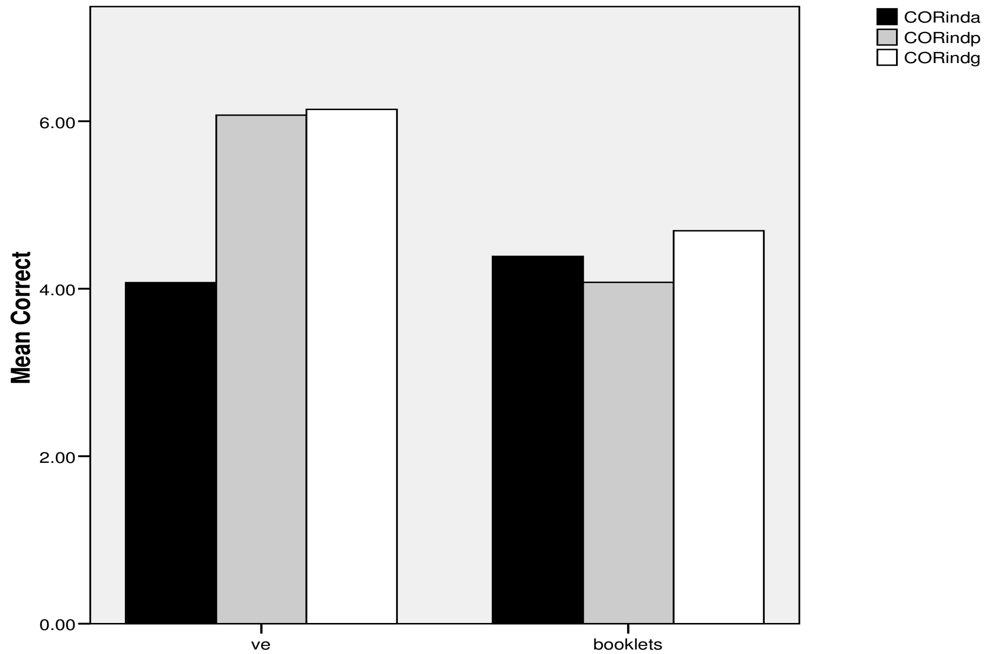

Figure 37. Mean number of correctly placed items for each domain/time line when tested independently (a=art, p=psychology, g=general history). (Experiment twelve)

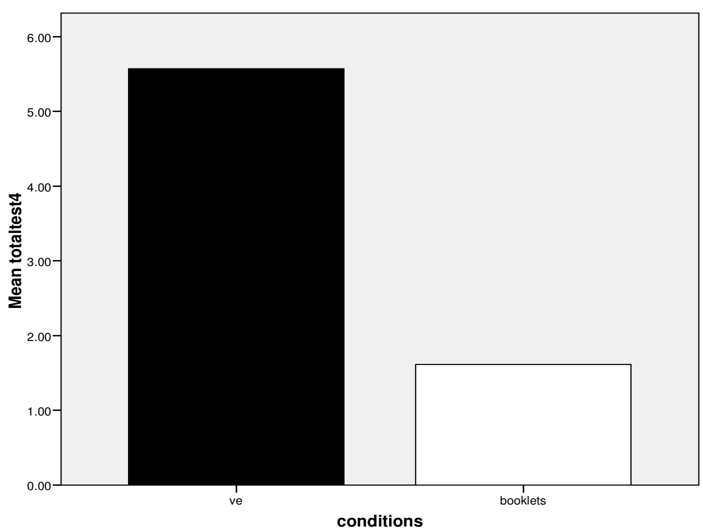

Figure 38. The total number of items recalled across all three timelines in Test 4 by two groups (Experiment twelve)

9.2.6 Discussion.

The present study differed from those above in that a VE group was compared only with a group learning from a booklet, though using a booklet to learn historical materials is a suitable control since students would usually learn history from text books (including opportunities for cross-referencing); it is unlikely that PowerPoint would be used for this purpose, and, in any case, as pointed out above, it would be difficult to construct a PowerPoint presentation that allows 3 parallel time lines to be sampled simultaneously on a single screen. More information was incorporated in this study than in previous studies within each chronological sequence (twelve items in each of three timelines). Also, participants were given much longer familiarization periods, to encourage the use of spatial encoding and the memorizing of materials rather like learning the layout of a small town when making daily trips through its streets.

The results suggest that this protocol was highly successful. They consistently showed that using a VE gave significantly better performance than learning from a booklet. Six variables, REMcomP, REMcomG, CORcomP, CORcomG, TotalTest1 and TotalTest4, showed a statistically significant difference between the two groups, demonstrating the effectiveness of a VE, at least for this undergraduate age group. The amount of information to be remembered was substantial, in total 36 items to remember, with dates and textual information, yet still VE participants remembered more than their counterparts using booklets. According to the verbal reports of VE participants, the most important factor that helped them achieve on the TotalTest4 variable was their ability to connect events with each other -- to see a structure and a point of reference, being able to look across the three timelines, suggesting in turn that they were genuinely using a "survey" form of cognitive representation (c.f., O'Keefe and Nadel, 1978; Jansen-Osmann and Wiedenbauer, 2004).

This can be explained in terms of the fact that initially VE participants, unlike booklet participants, were exposed to the three timelines simultaneously, movement in virtual space giving them a better experience of time-space, allowing them to change their position fluently in relation to landmarks, historical images, and facts, i.e., an ability to switch from one time to another without any difficulty (c.f., Moffat et al. 2001). As for the control group, they were limited in performing these activities in the sense that they could not easily visualise which historical facts happened simultaneously. For them the information that they were asked to memorize was presented with items isolated from each other, so lacking a sense of historical coherence, structure and organization. The result of the present study strongly suggests that VEs have enormous potential for further investigation, because although only three timelines were used in the present study, there is no reason why a more elaborate spatial environment could not encompass many timelines and a quantity of information similar to that remembered (as buildings, streets, squares) in a familiar town. In the present study, timelines covering the history of religion, art, clothing, architecture or medicine could have been introduced, helping participants to have a much broader sense of historical coherence and unity. Then they could potentially understand more about what happens in different disciplines at the same time, and in turn build up relationships between events and help them to understand more about cause and effect phenomena. Of course, the use of such a protocol does require a time commitment, and would need the enthusiastic participation of staff to encourage classes of students to persevere, not only with repeatedly visiting their timelines, but also perhaps adding their own materials to extend and elaborate a time line beyond the information given.

Based on the findings obtained from the present study, one may hope to save future students from being disorientated in the midst of various events, facts, and dates. They might hopefully be more confident to claim that they know and understand history and what happened beyond historical names and dates. This in turn might allow them to better understand relationships among chronological events, and make it easier for them to achieve the broader objective of “seeing the bigger picture” where history is concerned.

Chapter 10: General Discussion and Conclusions

"If you did not know history, you did not know anything.

You were a leaf that did not know it was a part of a tree"

(Michael Chircuton)

10.1 General Discussion

The present research has generated interesting but challenging results. It started from a very naïve hypothesis, arguing that just flying past events presented in a virtual environment as pictures would instil these as places in people's spatial-temporal memory and make them very memorable in correct order. The starting hypothesis, although naïve, still proved to be a good starting point, being entirely plausible from previous work in which VEs have successfully conveyed spatial information (Foreman et al, 2005; Ruddle et al., 1997). The results overall have suggested that the technology could be developed in such a way as to be valuable in classrooms for specific purposes and if used in the correct ways. There have been a number of examples showing how useful VEs can be in medicine, archaeology, and museums. Archaeological studies have used VEs to create representations of long-demolished buildings, as a way of illustrating history passing and historical change. However, there has been no previous attempt made to show experimentally that there is a measurable benefit of using VEs in educational settings, where they are only useful if learners learn more or achieve deeper learning as a result (National Centre on Assessing the General Curriculum report, 1998; Munzer et al. 2006; Passig and Eden, 2001, 2003; Cooke et al. 2002; Cockburn, 2000, 2004; Brown et al. 1999; Tavanti and Lind, 2001; Pedley, Camfield and Foreman, 2003; Kullberg, 1995; Eggarxou and Psycharis, 2007; Johnson, et al. 1998; Whitelock, Brna and Holland, 1996; Winn, 1993;

Grove, 1996; Furness et al. 1997). Teachers and educationalists have claimed that they often use timelines in classrooms to encourage pupils, and to make chronology and history more exciting and understandable (Hodkinson, 1995; West, 1978; Hoodless, 1996; Wood, 1995; Dawson, 2004), though benefits tend to be assumed rather than tested. Mostly the timelines used in classrooms were designed using a two-dimensional format such as a washing line, personalized time chart, or a linear timeline, variously represented as circles, cycles or zigzags (Collicot, 1990; Diem, 1982). However, the present research employed the advances recently made in computer technology and implemented a three-dimensional format that allowed users to have autonomous control over the environment – a factor that, alone, might be expected to improve retention of the materials encountered (Sandamas et al, 2009). The use of a VE relies on spatial memory, which is thought to be of unlimited capacity (Foreman et al. 2006; Moffat et al. 2001). When the very first studies were conducted, with primary school children, the findings were disappointing, revealing that those children who were trained to learn chronological consequences of historical events depicted in VEs suffered rather than benefited—they could remember very little from the VE (Experiment four).

One of the reasons for the failure to acquire new information from the environment could be that children in the VE were distracted by the incorporation of animations, additional sounds and other technological features used in the environment, incorporated in an attempt to make it exciting and engaging. These findings prompted further study to investigate what kind of environment was more appropriate for teaching chronology effectively. After having compared three environments that differed in their complexity, and demands made on participants, the conclusion was drawn that the latter variables did not significantly affect participants' ability to retain the information. So long as participants had spent an adequate amount of time exploring the VEs before undertaking training, their performance did not differ significantly across the three environments that varied in detail, demands and complexity (Experiment one). This inspired confidence that in later studies, where it was necessary to adopt different protocols, such modifications were unlikely to have influenced the results.

At this point, the next logical step was to identify what other factors could promote better performance at test. After discussion and consultation with teachers and colleagues, a further series of experiments was conducted, which revealed factors that were also important in determining the effectiveness of VEs. One of the main factors found to promote retention was challenge, such as having to anticipate which image would be encountered next in the virtual chronological sequence, as participants passed through the VE. This form of challenge undoubtedly encouraged engagement (being similar to the challenges posed by popular computer games), and the provision of an accumulating score increased the incentive to remember. High scores were obtained in such conditions (Experiments, five, seven and eight). For instance, in Experiment five, participants could remember much more information acquired from a VE than their counterparts trained with other media, and those trained in a VE took fewer trials to reach criterion during training than the control groups.

It is important to emphasize the fact that the present research was limited in terms of its relation to the learning of broader aspects of history. It investigated how well participants could remember a selection of chronologically sequenced items presented to them, but this is only a first stage, a prelude to teaching them to relate historical events together in the wider sense, to recognise how sequences of items and events are related to one another (in the causal sense), and ultimately to relate general history to their present lives; ideally, they might be able to say, at the end of such a process, what lessons they had learned from learning about history -- a criterion recommended by Haydn (2000). Finally, it was discovered that having prior experience of the VE medium was a significant factor. Participants needed to be given adequate familiarisation with the VE (at least, when applied to the learning of historical materials), especially when younger groups were tested (i.e., primary school children in Experiments four, six, seven and eight). They may have been familiar with 3-D computer games, but they appeared to need to be given time to familiarize themselves with this novel way of learning historical materials. Certainly this was evident in primary age pupils to a greater degree than undergraduate students, who always showed a VE advantage, whatever the condition in which they were trained. (Note, however, that even undergraduate students performed exceptionally well, almost all with zero error scores, when tested with challenge). Based on these observations, it was decided that extra training with the VE should be introduced routinely, as participants should be allowed to have more time to learn about the structure and layout of the environment, and to gain practice in manipulative aspects of operating the input device. The inclusion of a pre-training stage improved primary school participants' performances significantly. In Experiment seven, primary school participants trained with a VE performed significantly better than those trained in a Paper condition. In fact, the VE training produced error free learning in this primary school group.

Taking all the data together, a combination of challenge in the form of anticipation, using a game type of format, the introduction of the scoring system and a pre-training familiarisation stage all made a big impact on the recall of both undergraduate and primary school participants. However, the data from Experiments three, nine and ten illustrated that not all groups benefited from these improvements. Middle school pupils consistently failed to benefit from VE use, whether tested with Ukrainian or English historical materials, with or without pre-training and with or without challenge. Previous research has pointed to the cognitive transitions that occur at this age (Flickinger and Rehage, 1949; Jahoda, 1963; Friedman, 1982). Some authors have claimed that understanding and perception of time undergoes a radical change between 11-14 years old. For instance, Jahoda (1963) believed that it was not until the age of 11 that children understand the implication of historical dates, so that the age of 11 years is arguably a turning point in this conceptual development. Friedman (1982), in his classroom studies, claimed that a total and global understanding of time occurs after the age of 11 years. It is perhaps not surprising that when children reach an age at which they are able to use new forms of cognitive representation, they may at first show a plateau (in indeed a temporary decline) in performance before improving, as the new forms of representation become embedded. Interesting in this regard is the work of Karmiloff-Smith (1992) whose "representational redescription" model makes just such a prediction. Uttal and Perlmutter (1989) regard cognitive development as a balance between gains and losses. Weir (1964) found that on a button-pressing task with probabilistic reward densities, the performance of participants aged 7-15 was worse than that of either older or younger ones, because of strategy usage: a simple solution yielded rewards for younger participants and older ones deduced the nature of the task, but school-age children doggedly persisted with optimisation strategies that were ineffective (see Uttal and Perlmutter, 1989). Skeen and Rogiff (1987), although also concerned with transitions occurring at school joining age, noted that different types of instruction could affect children's spatial learning. Five, seven and ten year-olds explored a large playhouse, but only some were asked specifically to remember the rooms. Five year-olds were unaffected by the instructions, but Skeen and Rogoff suggested that 7 year-olds remembered less when asked to remember because this caused them to try and impose a list strategy, that was less efficient than a spatial strategy. These and the present findings indicate a need for further research, to explore other media that might be more suitable for the particular needs of children – in this case, in the 11-13 year age group –and to shed light on ways of improving the effectiveness of VEs when used with this age group.

Data in Experiment ten demonstrated that participants trained in a PowerPoint condition could place more items correctly after being tested after a two week interval compared to a VE condition, which contrasts sharply with the earlier experiments above that showed PowerPoint to be the least effective medium for all age groups tested (Experiments six, seven, eight and nine). In other words, while PowerPoint is generally ineffective in conveying historical chronological information (cf. Haydn, 2000), this may only apply to immediate recall. Indeed, it may have a positive benefit in terms of longer-term recall.

It is important to emphasize the heuristic nature of the present research; it began with a pioneering idea that had never been tested or empirically assessed and in that sense was aimed at testing the potential for applications of VEs in the context of teaching historical chronology. The choice of VEs in the forms used in these studies was also arbitrary. As a result, many new features were introduced during the course of the progress of the research, some of those introduced being effective (challenge), while others (introduction of relevant-redundant 3-D props and cues) were not successful.

It was not possible, in the present studies, to compare age groups using the same paradigm and materials. It would be a trivial finding to show that primary school children remember fewer items than undergraduate students, and the type of material used in each experiment was suitable for that age group, corresponding to what is usually taught to that age group at their national curriculum stage. The question posed for each age group was the same: would they remember more from a VE than from other media? Undergraduate students were tested in Experiment two using imaginary historical materials, which has he benefits that all participants can be assumed to have no advance knowledge (making general knowledge of history and educational achievement less significant), also that materials could be neatly divided in terms of time intervals between events. Classroom studies could in future use such materials, although in the present experiments it was important to conform to the requests made by teachers, that the materials used should be relevant to what children were learning (or would learn) in school. Similarly, when testing Ukrainian samples it was necessary to use historical materials from Ukrainian history. Although this might be a factor that limits the comparability of results, it is noteworthy that UK and Ukrainian samples at primary and middle school levels gave entirely consistent results. It is unlikely, from the present results, that cross-cultural factors or frequency of computer use influence the usefulness of the virtual medium.

Another issue is the use of booklets or textual media as controls. Booklets or sheets of information were used because these are commonly used in schools, they therefore represent a benchmark on which VEs (or PowerPoint) media must improve, to have demonstrable classroom application. Clearly, the use of computers involves a greater level of motivation than reading from texts, which was the rationale for including a PowerPoint control. If the use of a computer per se is what makes the VE medium effective, this should equally apply to PowerPoint, although the results of the above studies clearly showed that, in terms of immediate recall, PowerPoint was the least effective of the media employed. It is fair to conclude that VEs, where they are effective, benefit from the availability of technological features – free movement through the environment, incorporation of challenge, a spatial layout of information – that are not features of any other medium.

The absence of double-blind procedures weakens the results reported here since there may have been evident experimenter enthusiasm for the use of VEs. On the other hand, this factor would apply equally to all of the three age groups tested, yet middle school children consistently failed to benefit from VE use.

Overall, the present research has shown that there is indeed a substantial potential for VE applications, in line with previous research that has demonstrated benefits of technology use in classrooms (Cockburn, 2000, 2004). However, the benefit of using 3-D environment may depend on many other factors such as the nature of task, and the structure of the information (Wickens et al. 1997). It is not impossible to imagine that with better representations of historical events such as animations and virtual agents, situated within a virtual fly-through that allows the user to "stop off" and experience in a very personal way an actual historical event, that the use of VEs might indeed be used to allow children to experience history evolving. This does, however, raise other issues. Of course, the results of the final experiment reported here, with 3 parallel time lines, suggest that a time commitment would need to be made; participants may need to return to the information "village" many times to become familiar with it. In that case, a class of pupils might adopt an environment in which to paste information from different periods or domains of history, as they encounter them. Moreover, simply flying through many events, or spending time in a VE of any particular historical event in a sequence, would make additional demands on spatial (or temporal-spatial) working memory and could detract from the acquisition of sequential chronological aspects of the display. This requires investigation. Moreover, it is important that longevity of memory is further explored, since there was no evidence in the present studies that materials that were effectively learned from a VE in the short term (for example, with challenge incorporated into the environment) were learned in a more permanent way than materials learned from 2-D media.

As far as the present studies are concerned, the participants claimed to enjoy the process of learning historical chronology using a VE; there was never any difficulty in obtaining volunteers to participate, and both teachers and pupils were enthusiastic. Previous studies, for instance Masterman and Rogers (2002), also innovative in terms of the introduction of new technologies in the classroom, also reported great enthusiasm for using a multimedia display, but they did not investigate the success of the material or protocol, beyond recording the popularity with teachers and pupils. The present research has assessed the effectiveness of the VE paradigm, and demonstrated empirically the effectiveness of a VE, at least in some contexts. Perhaps, when software is introduced to schools, incorporating all findings obtained from the present research, children will cease to complain about history being boring and irrelevant to their lives (cf., Questionnaire study two, Section 1.4). Perhaps, with a more extensive environment, with clearer linkages among items, use of such a VE would not only impart substantial information about both parallel and sequential developments but might be a good medium in which to convey more complex topics such as cause and effect phenomena, not only in history, but also in relation to other events taking place simultaneously with well-known events in world history. This would give children more understanding of history in general and would help to establish relationships between all disciplines involved, bringing a sense of coherence and a "bigger picture".

Another novel aspect of the present research was its cross-cultural nature. From the studies with primary and middle school children in Ukraine (Experiment eight), it was shown that regardless of educational background, cultural differences, and limited exposure to computers, younger children, when well-trained in using VEs, gave the same results in both countries. For instance, primary children in the Ukraine could answer more questions correctly after being trained with the VE than with PowerPoint. When the serial order effect was analyzed, VE groups were found to place more items correctly in middle list positions than PowerPoint group. This rather subtle effect emphasises the consistency of data across the two cultures. Furthermore, when teachers' responses to an informal questionnaire were analyzed, the same comments were made by teachers in both countries, experiencing the same problems with teaching history, in particular their perceived inability and need to represent historical chronology in a more exciting way. This reinforces the need to develop effective teaching techniques for use in the UK and elsewhere, including multimedia techniques.

Some aspects of the findings of the present research were rather disappointing insofar as materials learned in VEs were not fixed in memory for longer than in other conditions. When VE participants were asked to return and repeat the same test after 2-6 weeks, their results did not differ significantly from those of control groups. For instance, in Experiment eight, children trained in a VE gave fewer correct answers on the Correct 1 variable than those in the Paper/Text group. This suggests that alternative protocols should be considered when attempting to fix materials more permanently in long term memory. One of the possibilities to be considered in future studies is to ask participants to create their own virtual historical environments, thus increasing their involvement and bringing a more active approach to the study (Haydn, 2000; Dawson, 2004, referring to 2-D timelines) and to return to revisit VEs on a regular basis. Cross-over designs could be used in future, using different eras of history but with each group of pupils learning different eras with different media (VE, PowerPoint and Text). This would allow the use of a within-subject comparison, avoiding some effects due to individual variation in learning skills.

Teachers might be encouraged to use VEs, when they have a particular sequence of events that they want a class to remember, but which children frequently remember in the wrong order. For instance, from the single linear time line studies, if a teacher wants children to remember the order of the wives of Henry VIII, a VE could help, especially if they are encouraged to fly through the environment several times. Due to the limited time scale for the present project it was impossible to investigate how many times children might need to revisit VEs, or whether, with extended exposure, more than nine items could be reliably remembered from a single sequential time line. These are yet further questions that need to be answered in future studies.

Perhaps, by taking the environment home with them, this would allow users, particularly children, to spend more time with it, adding new images and reading more information about events. This could be done as an on-going process throughout the school years, and the information learned might be retained more effectively, since it would become a part of participants' or classes' lives (cf. West, 1978, 1981; Wood, 1995)

In Experiment twelve a first step was made to demonstrate the enormous potential that VEs may offer for education, using a wider and more spatially complex virtual terrain. Based on the success of the present study, in which it was shown empirically that participants remembered more items correctly when learned in a three dimensional format as opposed to reading about the same materials in a booklet form, a new software can be developed that would allow users to add their own timelines or other timelines that might not be used effectively in alternative formats. By introducing a number of timelines simultaneously covering e.g., the history of medicine, the history of religion, the history of architecture, the history of transport, and the history of ancient discoveries etc., users could become generally more knowledgeable about historical facts, in particular being able to relate information across and between domains, thus understanding the relationships between developments in those separate areas. The findings from Experiment twelve revealed that participants found the present environment to be very useful and user friendly despite their having to make efforts to use it regularly. They claimed that they had more freedom to work with the environment, being able to "view across" domains, and learn a lot more from different domains simultaneously. More importantly, the feedback obtained from the participants showed that such an exercise made them consider history in a more thoughtful way, making them question some aspects of it in ways that they would otherwise not have done. Also, they all agreed that this activity was more interesting and engaging than reading dry facts presented to them in the form of the booklets. Overall, more items were remembered when using the three timeline protocols. The three timeline environment was like learning the layout of a village—twelve items per line, so there was a total of thirty six to remember. It is rather a lot of information to absorb, but the participants trained in the VE remembered significantly more compared to their counterparts in the booklet condition. This might suggest that there was a greater chance of engaging spatial memory, which seems to be unlimited in capacity (Foreman et al. 2007). So in other words, with using a VE format, children and adults are more likely to learn more information than if they were limited to reading text books. Knowing this, teachers could use a VE with pupils regularly and expect that they there would be benefits if children were given time to get to know it well. The purpose of using VEs is to ultimately provide a source of a large amount of chronological material. In the studies with single time lines, the maximum that could be learned was nine items, but this was an arbitrary limit. Where two and three time lines were used, participants were able to remember more than 14 items—so with a very large VEs of the type used by Kullberg (1995), there is the potential to remember a large amount of historically related material, especially if participants spend a lot of time with the environment and really get to know it well. In other words, VEs could really represent a wide range of historical material.

The Gender variable was routinely included in the studies above as an independent variable. For instance, in Experiment four, the serial position analysis showed that boys recalled materials better than girls in early list positions. Experiment six showed that there was a significant gender difference in performance following VE exploration. Other experiments, however, showed no gender difference. In most cases there were not enough male participants for statistical differences to appear reliably. Overall, the gender differences findings may be interpreted as suggesting that, at least in the context of the small group sizes in class rooms, once girls are trained to use new technologies, they tend to perform as well as boys for all practical purposes (Thomas et al. 1999; Chan, 2007; Sandamas et al. 2009).

In conclusion, it has been an interesting journey full of disappointments and challenges. However, the more the study progressed, the more new discoveries were unveiled. Sometimes, it was difficult to gather data; sometimes participants were not very much interested and excited about the project. However, strong determination and strong belief in the idea helped to overcome all practical difficulties. This is just a foundation that opened up lots of opportunities and potentials for future research. There are still a number of questions to be answered as to the effectiveness and optimal use of VEs. At the beginning the research was driven by intuition that the VE medium seemed to be especially memorable, although this was found to be difficult to prove empirically. After going through a long journey, not necessarily an easy one, a clear picture begins to emerge that draws together a jigsaw of evidence that reveals a coherent story. However, studies should further develop the multiple timeline paradigm. Moving images should be integrated to allow participants to become engaged with the environment. A further collaboration with the Russian partners who specialized in 3-D presentation of history (see Chapter three) could be developed, in which an active participation should be encouraged by introducing a layout for the participants so that they can construct their own timelines, using their own images and information that they should find themselves through various resources.

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Appendices

Appendix 1: Questionnaire distributed to 100 participants in Questionnaire Study two

You are invited to participate in a study of history learning and teaching. I would be grateful if you would complete the following questionnaire:

Age: Sex:

School: Country in which you grew up: Age at leaving school:

Experience of history teaching:

How much did you enjoy learning history at school?

What could have improved your experience of learning history?

Please place the following items in the correct chronological order (the order in which they occurred), starting with the earliest (number 1) and finishing with the most recent (number 12).

The fall of the Berlin Wall	
The Battle of Hastings	1066
The French Revolution	
The Russian Revolution	1918
The Roman invasion of Britain	
The death of Socrates	
The Great Fire of London	1666
The plague in London	1665
The Opium wars with China	
Introduction of votes for women in the UK	
The ending of the Vietnam war	
The Invention of the telephone	

Appendices for items in single time line studies

Appendix 1: General history

The fall of the Berlin Wall (1989)

The Battle of Hastings (1066)

The French Revolution (1789)

The Russian Revolution (1917)

The Roman invasion of Britain (55-54BC)

The death of Socrates (399BC)

The Great Fire of London (1666)

The plague in London (1665)

The Opium wars with China (1840)

Introduction of votes for women in the UK (1918)

The ending of the Vietnam war (1918)

The Invention of the telephone (1876)

Appendix 2: Art

Mona Lisa (Leonardo da Vinci), 1503

A young girl reading (Jean-Honore Fragonard), 1776

Sunflowers (Vincent van Gogh),1888

The old guitarist (Pablo Picasso), 1903

Abstract painting (Elizabeth Bell), 1914

Disintegration of Persistence (Salvador Dali), 1931

Twilight (Vasiliy Kandinsky), 1943

Movements in Squares (Bridget Riley), 1961

A bigger Grand Canyon (David Hockney), 1998

Appendix 3: Imaginary planet

Aliens land on Planet Gozon 2080

Massive monuments erected to honour moon god 2100

The crowing of the Great King 2120

Devastating eruption of Fire Mountain 2140

The building of the Grand Palace 2160

The Great Battle 2180

The crowing of Queen Vanessa 2200

The Great Flood of 2220

The Fire of 2240

Appendix 4. Feudal England.

Edward the confessor is king

Edward sends Harold on a mission

Death of Edward the confessor

Harold the King is crowned

King Harold is killed

William the Conqueror crowned

Wooden castle building begins

Stone castle building begins

Appendix 5. General history

[*effect*] = additional effects added in the second part of the study

Ancient Egypt—Egyptian Pyramids, 3000 BC [*3-D pyramids added*]

Ancient Greek Mythology--- Theseus and the Minotaur, 1500 BC

Celts' round houses in small village, 600BC [*houses modelled*]

Roman Centurion, 200BC

Helmets worn by Anglo Saxons, 449 AD

Viking ship, 787 AD [*boats modelled with moving oars*]

Normans--- Battle of Hastings, 1066AD [*battle sounds added*]

The Great Fire of London, 1666 AD [*sounds of burning*]

Evacuees leave London in World War2, 1939 AD [*hurricane aircraft flies overhead*]

Appendix 6. Art

Mona Lisa (Leonardo da Vinci), 1503

Market woman with vegetable stall (Pieter Aertsen) 1567

Venus playing the harp(Giovanni Lanfranco) 1630

A young girl reading (Jean-Honore Fragonard) 1776

Sunflowers (Vincet van Gogh) 1888

The old guitarist (Pablo Picasso) 1903

Twilight (Vasily Kandinsky) 1943

Movements in squares (Bridget Riley) 1961

A bigger Grand Canyon (David Hockney) 1998

Appendix 7. History of Ukraine

Chersones Tavrijski (5 BC)

Spaso-Preobrojenski Cathedral built in Chernigiv, in 1033-1041 [labeled 1033].

Sofievski Cathedral built in Kiev, 1037.

Kievo-Pecherska Lavra, built in Kiev, 1057

Kamyanesc-Podilsk fortress, built in 1062

Xotunska Fortress built in 1325

National Park, Xortuscy, built in 1436

Grigorij Savuch Skovoroda, Ukrainian philosopher, poet, writer, traveller, 1722-1794 [labeled 1722]

National Theatre, located in Lviv, built in 1900.

Appendix 8. History of Ukraine

Chersones Tavrijski (5 century BC)

Spaso-Preobrojenski Cathedral built in Chernigiv, in 1033-1041.

Sofievski Cathedral built in Kiev, 1037.

Kievo-Pecherska Lavra, built in Kiev, 1057

Kamyanesc-Podilsk fortress, built in 1062

Grigorij Savuch Skovoroda, Ukrainian philosopher, poet, writer, traveller, 1722-1794

Taras Grigorivich Shevchenko, a Ukrainian poet (1814-1861)

Lesya Ukrainka, a Ukrainian poetess, 1871-1913

Andrey Shevchenko, a Ukrainian footballer, 1976-present.

Appendix 9. General History

Battle of Hastings – 1066

Horse and Cart – 1800

The Abolition of Slavery – 1833

The flyer – 1903

World War 1 – 1914 to 1918

Hitler's Genocide – 1939 to 1945

The Speech by Martin Luther King – 1960

War in Iraq – 2003

Obama's Supporters – 2008

Appendix 10. Art and Music

A young girl reading (Jean-Honore Fragonard) -- Violin Concerto No5 (Mozart), 1776

Sunflowers (Vincent van Gogh) -- Violin Sonata No 3 (Brahms),1888

The old guitarist (Pablo Picasso) -- Estampes (Debussy), 1903

Abstract painting (Elizabeth Bell) -- 7 Canciones popular espanolas (Falla), 1914

Disintegration of Persistence (Salvador Dali)—Piano Concerto in g (Ravel), 1931

Twilight (Vasiliy Kandinsky) -- Concerto for Orchestra No. 4 (Bartok), 1943

Movements in Squares (Bridget Riley) -- Cello Concerto No3 (Britten), 1961

A bigger Grand Canyon (David Hockney) -- Victor's Lament (Glass), 1998

Appendices for the three time line study:

Appendix 11: History of psychology

Wundt's Psychophysics Lab was founded in Leipzig (1879)

The first edition of S. Freud's *Interpretation of Dreams* (1899)

IQ was developed by Alfred Binet (1903)

Behaviourism. John B. Watson outlines the tenets of behaviourism (1913)

The development of child's concept of the world by Jean Piaget (1920)

Pavlov's death (1936)

The discovery of first drug to treat depression (1951)

Cognitive Psychology. George Miller wrote his most famous paper "The Magical Number Seven, Plus or Minus two: Some limits on our capacity for Processing Information" (1956).

"Perception and Communication" book published by Broadbent (1958)

Milgram's study of obedience to authority (1961)

The Cyril Burt Scandal (1976)

The Foundation of Positive Psychology (1998)

General history

The invention of Thomas Edison's lightbulb (1879)

The establishment of Victoria and Albert Museum (1899)

Wilbur and Orville Wright Brothers the first powered aircraft (1903)

Marcel Proust publishes the first volume of "*La Recherche de Temps Perdus"*, *"In Search of Lost Time"* (1913)

The invention of the first hair dryer (the vacuum cleaner) (1920)

Summer Olympics open in Berlin (1936)

British conservatives win the election (1951)

Soviet launched an attack on Hungary (1956)

Nikita Kruschev becomes Soviet Premier and 1st Secretary of Communist Party(1958)

Yuri Gagarin becomes 1st person to orbit Earth in Vostok (1961)

Apple Computer Company is formed (1976)

Bill Clinton's testimony (1998)

History of art

Klee Paul was born, a Swiss painter (1879)

"The Starry Night" was painted by Van Gogh (1899)

Paul Gauguin died in 1903

The Armory Show was the first exhibition mounted by the Association of American Artists (1913)

Florence Cane developed what is known as the scribble technique (1920)

Summer Olympics in Berlin, art competition (1936)

Henry Moore turned down his knighthood (1951)

"This is Tomorrow"—British Pop art (1956)

Paul Cadmus painted his "Night in Bologna" (1958)

Picasso marries his model, Jacqueline (1961)

Henry Moore—Three pieces reclining Figure Draped (1976)

Jackson Pollock retrospective opens at MoMA (1998).

Oral presentation at Cognitive Psychology Section 26th Annual Conference, BPS, 1-3 September, Hertfordshire University

Title: Using VEs to enhance chronological understanding of history in middle school children.

Principle author: Liliya Korallo.

Co-authors: Professor Nigel Foreman1, Dr. Stephen Boyd-Davis2, Dr. Magnus Moar2, Peter Molife3.

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2. Lansdown Centre, School of Arts, Middlesex University, Cat Hill.
3. Northumberland park Community School, Trulock Road, Tottenham, London N17 0PG.

Theme: Cognition and learning.

Studies with computer-experienced children in the UK and less experienced in Ukraine explored the potential for VEs in teaching historical chronology to middle-school children aged 10-12 years old. Active fly-through VEs had been previously used successfully with primary school children aged 8-9 years old (given specific training with the environment) when they were subsequently tested for their ability to order events chronologically. All VEs in the present studies included a training element and active challenge, both found previously to enhance learning in other age groups. Ukraine children were trained and tested. UK children here were trained and tested, then retrained and retested to examine savings. Unlike other age groups, no significant benefit was seen for VE training compared with PowerPoint and Text conditions in either study. Possible explanations for the ineffectiveness of VE training for children of middle school age will be discussed.

Oral presentation at Middlesex University summer conference, 25 July 2009

Title: Using VEs in learning history

Studies with computer-experienced children in the UK and less experienced in Ukraine explored the potential for VEs in teaching historical chronology to children of primary and middle schools age (8-13 years). Using passive fly-through VEs had been previously found to be disadvantageous with both age groups when subsequently tested for their ability to order events chronologically. All VEs in the present studies included active challenge, previously shown to enhance learning in older participants (undergraduate students). With primary school children in the UK, no significant effect was found between VE, PowerPoint and Text conditions with minimal pre-training, but excellent (error free) learning occurred when VE children were allowed pre-training exploration. In Ukraine, training in a VE produced better learning in the VE group compared to PowerPoint, but no better than in a Text condition. As for the middle school children, two studies were conducted to determine whether this applies equally to the following age group (11-13 year-olds) and whether general computer familiarity is important. Pre-training keyboard familiarization was always provided and challenge (in a form of game format) always incorporated in the VE. In the Ukraine, children relatively unfamiliar with computers explored nine images depicting the history and historical places in the Ukraine and following training to criterion were tested for their ability to place events in order. No significant benefit was found for VE training over PowerPoint or Paper/text. In the UK, an equivalent age group who used computers frequently studied nine major universal historical events presented chronologically in the same three conditions. All materials used in this study were selected with the teachers' assistance, following National Curriculum requirements. Training to criterion was followed by testing, and the whole procedure was repeated 3 weeks later to assess retention of learning and savings. No significant VE benefit was obtained at any point in the procedure, and PowerPoint was found to be significantly better than VE or Paper/text conditions in terms of retention following the repeated procedure. Possible reasons for the absence of superiority of VEs in conveying historical chronology to this age group were discussed.

Poster presented at 11th European Congress of Psychology, Oslo, Norway 7-10 July, 2009

Title: Using VEs to enhance chronological understanding of history in primary school children

Author

Korallo, Liliya

Middlesex university

United Kingdom

Topic: 12 Cognitive psychology and neuroscience

Prefered form of presentasion:

Abstract text: Studies with computer-experienced children in the UK and less experienced in Ukraine explored the potential for VEs in teaching historical chronology to children of primary school age (8-9 years). Using passive fly-through VEs had been previously found to be disadvantageous with this age group when subsequently tested for their ability to order events chronologically. All VEs in the present studies included active challenge, previously shown to enhance learning in older participants. With primary school children in the UK, no significant effect was found between VE, PowerPoint and Text conditions with minimal pre-training, but excellent learning occurred when VE children were allowed pre-training exploration. In Ukraine, training in a VE produced better learning in the VE group compared to PowerPoint, but no better than in a Text condition. The results confirmed the benefit of using challenge with primary age children, but only with adequate prior familiarisation with the medium.

Paper and Chapter submitted to 3rd Annual International Conference on Psychology

8-11 June 2009, Athens, Greece

Title: Using VEs to enhance chronological understanding of history.

Principal author: Liliya Korallo.

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Theme: Cognition and learning.

Abstract

People have difficulty remembering historical events in chronological order. For example, English people often confuse 1066 (Battle of Hastings) with 1666 (Fire of London), because the dates are (semantically) similar. Children in particular may have difficulties with the concepts of time and chronology because of their abstract nature. In the present studies, an attempt was made to exploit a new paradigm (virtual environment technology, VET) that ought to engage spatial memory, to teach historical chronology. Spatial memory appears to have an unlimited capacity, and therefore using VE historical fly-throughs that engage spatial memory might improve

participants’ memory for chronological ordering of many sequential events. Three age groups (undergraduates, middle and primary school children) were trained, using a VE format, to learn events from history, depicted sequentially in time-space (like encountering successive events in a time machine). Controls saw the same events but as images on paper or as successive PowerPoint screens. Undergraduates were found to remember most after using a VE, irrespective of the format in which materials were presented. Participants of all ages performed best (often achieving error-free performance) when tested with challenge – when they had to actively anticipate up-coming events (as though in a competitive computer game). It was concluded that VEs have potential as a means of imparting chronological knowledge, so long as they are sufficiently challenging. Only middle school children did not show substantial VE benefits, either at initial learning or when “savings” were assessed using a repeat testing “revision” paradigm.

Paper submitted to Instructional Science

Title: Do challenge, task experience and computer familiarity influence the learning of historical chronology from virtual environments in 8-9 year old children.

Editorial Manager(tm) for Instructional Science
Manuscript Draft
Manuscript Number: TRUC335

Article Type: Original Research
Keywords: children (8-9 years), virtual environments, historical chronology, computer experience, computer familiarity
Corresponding Author: miss liliya korallo, BSc, Master, completing PhD
Corresponding Author's Institution: Middlesex University
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Order of Authors: liliya KORALLO, BSc, Master, completing PhD; Nigel Foreman, Professor; Stephen Boyd-Davis, Doctor; Magnus Moar, Doctor; Mark Coulson, Doctor

Abstract: Studies examined the potential use of VEs in teaching historical chronology to children of primary school age (8-9 years). The use of passive fly-through VEs had been found, in an earlier study, to be disadvantageous with this age group when tested for their subsequent ability to place displayed sequential events in correct chronological order. All VEs in the present studies included active challenge, previously shown to enhance learning in older participants. With primary school children in the UK who were regular computer users, no significant effect was found between three conditions (Paper, PowerPoint and VE) with minimal pre-training, but excellent (error free) learning occurred when children were allowed greater exploration prior to training in the VE. In Ukraine, for children with much less computer familiarity, training in a VE (depicting Ukrainian history) produced better learning compared to PowerPoint, but no better than in a Paper condition. The results confirmed the benefit of using challenge in a VE with primary age children, but only with adequate prior familiarisation with the medium. Familiarity may reduce working memory load and increase children's spatial memory capacity for acquiring sequential temporal-spatial information from virtual displays.

Paper published in Instructional Science

Title: Can virtual environments enhance the learning of historical chronology?

Journal	Instructional Science
Publisher	Springer Netherlands
ISSN	0020-4277 (Print) 1573-1952 (Online)
Issue	Volume 36, Number 2 / March, 2008
DOI	10.1007/s11251-007-9024-7
Pages	155-173
Subject Collection	Humanities, Social Sciences and Law
SpringerLink Date	Thursday, April 05, 2007

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Abstract Historical time and chronological sequence are usually conveyed to pupils via the presentation of semantic information on printed worksheets, events being rote-memorised according to date. We explored the use of virtual environments in which successive historical events were depicted as "places" in time–space, encountered sequentially in a fly-through. Testing was via "Which came first, X or Y?" questions and picture-ordering. University undergraduates experiencing the history of an imaginary planet performed better after a VE than after viewing a "washing line" of sequential images, or captions alone, especially for items in intermediate list positions. However, secondary children 11–14 years remembered no more about successive events in feudal England when they were presented virtually compared with either paper picture or 2-D computer graphic conditions. Primary children 7–9 years learned more about historical sequence after studying a series of paper images, compared with either VE or computer graphic conditions, remembering more in early/intermediate list positions. Reasons for the discrepant results are discussed and future possible uses of VEs in the teaching of chronology assessed.

Keywords Chronology teaching - Virtual environments - Primacy and recency effects

Paper published in The Journal of Virtual Reality

Title: The incorporation of challenge enhances the learning of chronology from a virtual display

Journal	Virtual Reality
Publisher	Springer London
ISSN	1359-4338 (Print) 1434-9957 (Online)
Issue	Volume 12, Number 2 / June, 2008
Category	Original Article
DOI	10.1007/s10055-007-0078-2
Pages	107-113
Subject Collection	Computer Science
SpringerLink Date	Wednesday, May 23, 2007

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Abstract In earlier studies investigating the learning of historical chronology, virtual fly-throughs were used in which successive historical events were represented by images on virtual screens, placed in temporal-spatial sequence. Undergraduate students benefited more than school-age children from virtual 3D (compared to 2D) training, perhaps because they took on the task as a challenge. In this study a modification of the earlier paradigm was used, in a game-like format, in which successive screens (paintings, representing epochs of art history) had to be memorised and anticipated during training, the participant's score accumulating on the screen. Compared with PowerPoint and verbal-semantic training conditions, VE training resulted in more rapid learning, better recall of associated semantic information and error-free recall of the picture sequence. Possible applications of this paradigm for teaching were discussed.

Keywords Chronology - Art history - Virtual environment - Game

Examples of posters presented at conferences

Poster presented at XXIX International Congress of Psychology Berlin, Germany 25 July, 2008.

Poster presented at 11th European Congress of Psychology Oslo,

Norway 7-10 July, 2009