The impact of Immersive Virtual Reality on educator's awareness of the cognitive experiences of pupils with dyslexia

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COVER PAGE

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1. Passig, D. Eden, Sigal & Rosembaum, V. (2008) The Impact of Virtual Reality on Parents' Awareness of Cognitive Perceptions of a Dyslectic Child. *Education and Information Technologies*. 13(4), 329-344.
2. Passig, D., Eden, S. and Heled, M. (2007) The impact of Virtual Reality on the awareness of teenagers to social and emotional experiences of immigrant classmates. *Education and Information Technologies*. 12: 267-280.

3. Eden, S. and Passig, D. (2007) Three-Dimensionality as an effective mode of Representation for Expressing Sequential Time Perception. *Journal of Educational Computing Research*. 36 (1), 51-63.

Description

This study used Virtual Reality technology to simulate a variety of reading disorders and examined their impact on the degree of teacher awareness on the cognitive experiences dyslexic pupils encounter while trying to read. It compared the effectiveness of VR to better enhance the awareness of the teachers with the effectiveness of watching a film and found VR to be more effective.

The impact of Immersive Virtual Reality on educator's awareness of the cognitive experiences of pupils with dyslexia

Structured Abstract

Background

In recent years, due to deliberate educational policy in various places around the world, children with dyslexia study in regular classes with non-dyslexic classmates. They do not appear handicapped, because their disabilities do not stem from physical deformities, and therefore, it is not easy to identify them out in a group where the majority of the children are non-dyslexic. As a result, these children continually brave the hardships inherent in a human environment while being largely unaware of their situation.

Purpose

The aim of this study was to test the effectiveness of VR technology in enhancing the teacher's knowledge and awareness of dyslexia—a phenomenon which is very difficult to explain. Not only it is a very difficult phenomenon to communicate, but the research community still needs to suggest and accept a unified typology of the disorder.

Population and setting

Eighty teachers of various subjects participated in this study. They were selected randomly from a variety of schools in the Tel Aviv metropolitan area. Each of the teachers in the experimental group (N=40) experienced a Virtual Reality simulation that simulated ten virtual worlds corresponding to the ten types of dyslexia, we found in existing literature. The experience took 20 minutes to complete and was conducted in a VR laboratory in a type of a clinical setting. The teachers, each separately, in the

control group (N=40) watched a 20-minute film on the subject of dyslexia and reading disorders. All the subjects filled out questionnaires before and after the intervention.

Research Design

The teachers were divided into an experimental and a control groups. In the experimental group, the teachers were exposed to ten 3D virtual worlds which simulated ten cognitive experiences of dyslexic students. The teachers in the control group viewed a film which elaborated on similar experiences. All the subjects filled out questionnaires before and after the intervention. The questionnaires tested the teachers' level of cognitive awareness of the dyslexic student's experience when encountering the written word. In addition, the subjects in the experimental group were interviewed before and after the intervention.

Conclusions

The research results clearly suggested that experiencing a variety of simulated types of dyslexia by Virtual Reality can bring about a greater improvement in teacher awareness of the dyslexic pupil's cognitive experiences than is achieved by viewing a film about dyslexia.

Executive summary

In recent years, due to deliberate educational policy in various places around the world, children with dyslexia study in regular classes with non-dyslexic classmates. They do not appear handicapped, because their disabilities do not stem from physical deformities, and therefore, it is not easy to identify them out in a group where the majority of the children are non-dyslexic. As a result, these children continually brave the hardships inherent in a human environment largely unaware of their situation.

Furthermore, reading is the most basic primary skill learned by a child during his first years at school. There are three main types of learning difficulties which appear in primary school: dyslexia, dysgraphia, and dyscalculia. This study focused on dyslexia. Dyslexia is a catch-all terms which include a variety of reading disorders and disabilities. The professional literature is replete with definitions and descriptions of various types of dyslexia. In order to simplify this research we had to choose one taxonomy according to which we would be able to build virtual worlds and to test their relative merits in increasing the teacher's awareness of dyslexia in general, and of the reading-impaired in particular.

One of the many typologies is that of Friedmann and Gvion. This study aimed at testing the effectiveness of the technology to ameliorate knowledge and awareness of a phenomenon that is very difficult to explain. There was no intention to verify that the 10 distinct patterns of dyslexia exist, and whether they exist independent of particular instructional histories. We chose to base our study on this typology, solely because Friedmann and Gvion were available to assist us validate the virtual worlds we built based on their taxonomy and since their typology was clear enough for reproduction in a simulated world.

The following is the ten major types of dyslexia in Gvion and Friedmann's taxonomy that served as the basis for the Virtual Reality worlds we constructed for the purposes of this study: Visual Letter Agnosia, Neglect Dyslexia, Visual Dyslexia, Letter Position Dyslexia, Attentional Dyslexia, Letter by Letter Dyslexia, Surface Dyslexia, Phonological Dyslexia, Semantic Access Dyslexia, and Deep Dyslexia.

In reviewing the literature we found few studies referring to the question of whether the use of Virtual Reality could assist the teacher in improving his/her awareness to a variety of children's experiences, but we found no studies which addressed the use of Virtual Reality to simulate the cognitive experiences of dyslexic children. Beyond that, we found no studies which addressed the use of Virtual Reality for the instruction of teachers of dyslexic children. To the best of our knowledge, this is the first time Virtual Reality has been used in instructing teachers of dyslexic children and in simulating their cognitive experiences.

Eighty teachers of various subjects participated in this study. They were selected randomly from a variety of schools in the Tel Aviv metropolitan area. Each of the teachers in the experimental group (N=40) underwent through a Virtual Reality experience that simulated ten virtual worlds corresponding to the ten types of dyslexia described above. The experience took 20 minutes to complete and was conducted in a VR laboratory in a type of a clinical setting. The teachers, each separately, in the control group (N=40) watched a 20-minute film on the subject of dyslexia and reading disorders. All the subjects completed questionnaires before and after the intervention.

The research instruments included interviews and observations, as well as three questionnaires: a questionnaire concerning the sense of the teacher's capability regarding the pupil with dyslexia, a questionnaire measuring the teacher's opinion

about pupils with dyslexia, and a cognitive questionnaire composed especially for this study, in order to test the teachers' awareness of the cognitive experience of dyslexia.

For this study, cognitive awareness was divided into two measures: The cognitive measure, which was taken with the help of the Awareness Questionnaire, and the learning measure, which was taken with the help of the Sense of Capability Questionnaire.

Examining the findings of both the measures of cognitive awareness indicate that both the average cognitive measure and the average learning measure rose significantly in the experimental group. In the control group, no significant improvement was found in the cognitive or learning measures.

In our research hypothesis, it was postulated that an experience in virtual worlds which simulates different forms of dyslexia would significantly improve the teacher's awareness of the dyslexic pupil's cognitive experiences, when compared with the control group, which would not show a similar improvement in this measure. This hypothesis was affirmed.

The issue of different media in instruction has been studied and debated for several decades now. For instance, reverting to Marshall McLuhan's position suggesting that “the medium is the message” is an important issue that has been and continues to be debated whether it is applicable to teaching and learning. The landmark studies and meta-analyses conducted by Kulik, Kulik, and Bangert-Downs on instructional modalities are most important in attempting to support McLuhan's premise. However, Richard Clarke refuted this approach and posited that in instruction, the content and a myriad number of other instructional factors were just as influential in learning effectiveness as the delivery mechanisms. In the 1990s, Kosma continued this debate and supported the medium is the message approach espoused by

Kulik et al. This debate continues today. Although we do not want to take sides in this debate, it is possible that newer technologies could shed new light on this old debate. It is possible that the characteristics of newer media are overwhelming, which could suggest that in certain delivery mechanisms such as Virtual Reality the medium is indeed crucial.

The results of this study reflect similar findings regarding the efficacy of Virtual Reality technology in teaching cognitive and emotional concepts to populations of different types. The literature emphasizes the manifest advantages of Virtual Reality in raising the degree of awareness of experiences which are difficult to convey verbally, and which otherwise demand considerable time resources. On this point, the current study serves at least as further validation of Kulik et al studies.

The impact of Immersive Virtual Reality on educator's awareness of the cognitive experiences of pupils with dyslexia

Abstract

This study tested the impact of immersive Virtual Reality on the degree of teacher awareness of the cognitive experiences dyslexic pupils encounter while attempting to read. An experimental group of teachers was exposed to ten 3D immersive virtual worlds that simulated ten cognitive experiences of dyslexic students. A comparable control group of teachers viewed a film that elaborated on similar experiences with audiovisuals. In measures taken before and after the intervention, teachers' were scored on levels of cognitive awareness of the dyslexic student's experience on encountering the written word. In addition, the subjects in the experimental group were interviewed before and after the intervention. Results indicated that experiencing a variety of simulated types of dyslexia with immersive Virtual Reality can bring about improvement in teacher awareness of the dyslexic pupil's cognitive experiences, and that this improvement is significantly greater than that achieved by watching a film about dyslexia.

Keywords: Virtual Reality, dyslexia, cognitive experience, teacher education.

In recent years, due to deliberate educational policy in various places around the world, children with dyslexia study in regular classes with non-dyslexic classmates. Dyslexia is a type of learning disability that manifests primarily as a difficulty with written language, particularly with reading and spelling. It is separate and distinct from reading difficulties resulting from other causes, such as a neurological deficiency with vision or hearing, or from poor or inadequate reading instruction (Murphy, 2004). Dyslexic children do not appear physically challenged as their disabilities do not stem from physical deformities. It is therefore, not easy to identify them in a group where the majority of the children are non-dyslexic. As a result, these children continually brave the hardships inherent in a teaching setting largely unaware of their situation.

The teacher has an important role to play in the social integration of a dyslexic child (Givon, 2000). A positive attitude toward the child on the teacher's part exerts a positive influence, not only on the child's scholastic achievements, but on emotional and social development as well (Carni, 2001). In addition, teachers must be aware of dyslexic children's difficulties if they are to serve them integrate socially and academically (Palti, 2002). This study sought to test whether immersion in a 3D immersive virtual world simulating the dyslexic experiences of reading-impaired pupils would significantly improve teachers' awareness of the dyslexic pupils' cognitive experiences, as compared with teachers who viewed a film about similar experiences.

Reading is the most basic primary skill learnt in the first years of schooling. Three main types of learning disabilities, among others, appear in primary school: dyslexia, dysgraphia, and dyscalculia. This study focused on dyslexia only. As already noted, dyslexia is a disability in which children manifest difficulty primarily

with written language. However, dyslexia can also be a catch-all terms for a number of types of reading disorders and disabilities. The professional literature is replete with definitions and descriptions of various kinds of dyslexia (Murphy, 2004).

Relevant Literature

In this study, we used an available taxonomy of dyslexia, developed by Friedmann and Gvion (2001), to construct virtual worlds and to test their relative merits in increasing the teacher's awareness of dyslexia in general, and of the reading-impaired in particular. The purpose of the study was to test the effectiveness of virtual technology in enhancing teacher knowledge and awareness of this complex phenomenon known as dyslexia. The study did not seek to verify whether the distinct patterns of dyslexia included in the Friedmann-Gvion taxonomy are independent of particular instructional histories. Rather, this taxonomy served us to only validate the virtual worlds we built. The Friedmann-Gvion taxonomy (see Gvion & Friedmann, 2004) consists of 10 distinct categories of dyslexia:

1. Visual Letter Agnosia: A dyslexia that causes difficulties in identifying individual letters, making it impossible for the child to identify letters visually. Children who suffer from Visual Letter Agnosia can identify letters via sensory stimulus. For example, dyslexics can distinguish between letters which have been cut out of woolen cloth. In addition, they can identify letters via kinesthetic stimulus by tracing the letters' shapes with their fingers (Lott & Friedman 1999; Friedmann & Gvion, 2001).
2. Neglect Dyslexia: In this kind of dyslexia, attention is directed to letters located on one side of a word and text (usually the right side). As a result, as the person reads, he or she removes or exchanges letters on the neglected side of the word. For example, 'river' is read as 'liver,' 'cabin' as 'robin,' or 'liquid' as

'squid.' In addition, the person with neglect dyslexia will find it hard to report on the first sound of nonsense words. For example, s/he would have difficulty in identifying the letters ' ti' of the nonsense word ' tiggle.' As reading is influenced by word structure, it seems most likely that this dyslexia cannot be attributed to the result of processing letters or information, but to attention impairment on a higher level of representation (Behrman, Moscovitch, Black, & Mozer 1990; Ladavas, Shallice, & Zanella, 1997; Gvion & Friedmann, 2004).

3. Visual Dyslexia: This is a type of dyslexia where one word is read as another, which is visually similar to it. There is not necessarily visual similarity to the letters that have been exchanged. For example, the word 'pod' could be read as 'pad,' 'colonel' as ' color,' or 'read' as 'road.' (Friedmann & Gvion, 2001; Shallice & Rosazza, 2006).
4. Letter Position Dyslexia: In this form of dyslexia, the letters of the word are identified correctly, but their position within the word is incorrect. As a result, many errors are made by transposing the letters within the word. This dyslexia was first identified in Hebrew. Hebrew is written without vowels, and has a unique morphology, which allows for the existence of many words which share the same letters, but in different order. The native Hebrew speaker would be more liable to be affected by Letter Position Dyslexia than a speaker of a different language (Friedmann & Gvion, 2001; Shallice & Rosazza, 2006).
5. Attentional Dyslexia: In this form of dyslexia, letters are properly identified, as are their position in the word, but letters wander between words, while maintaining their relative position in a word. The identity of the letter is

maintained at the time of reading, but there is a deflection of its position in the word. The difficulty in focusing attention increases with the number of words on a page. Warrington and Shallice (1979) hypothesized that these dyslexics derive meaning while reading since they depend more on the concept than on the semantic process (Warrington & Shallice, 1979; Price & Humphreys, 1993). The movement of the letters may be between adjacent words in a line (horizontal wandering), for example: The pair of words 'win fed' might be read as 'fin fed' (Mayall & Humphreys, 2002).

6. Letter by Letter Dyslexia: This is a form of dyslexia where the most striking characteristic is the reading of words letter after letter, and, only after reaching the end of the word, reading the whole word. The process of reading is very slow, and the pace of reading is dependent on the length of the word being read. The child suffering from Letter by Letter Dyslexia can read all types of words, including abstract words, such as 'destiny,' or concrete words, such as 'table,' or when the word is recorded according to the rules of neat writing, such as 'hand.' The ability to write a word remains intact, but after writing a word, the person with this type of dyslexia has difficulty in reading what has been written, because of his difficulty in identifying letters written down not always in a clear hand (Lott & Friedman, 1999; Montant & Behrman, 2000; Rayner & Johnson, 2005).
7. Surface Dyslexia: A difficulty in reading words written in other than standard ways, or when there is an unusual connection between the written word and its accompanying sound, as in 'yacht,' or 'borough.' People with this type of dyslexia can read words well only if they are written according to the rules.

Examples are words like 'mosquito,' 'hand,' 'state,' and nonsense words, such as ' blape' (Marshall & Newcombe, 1973; Plaut, 1999; Branch-Coslett, 2000).

8. Phonological Dyslexia: A difficulty in reading new words, although the dyslexic person can read words whose writing he has mastered (this dyslexia is a complementary syndrome to Surface Dyslexia). In Phonological Dyslexia, which is acquired after the acquisition of reading, there is a problem only with new words or with nonsense words, as the dyslexic person cannot rely on the connection between letters and sounds. Subjects who were able to read approximately 90% of real words were able to read only 10% of nonsense words (Glosser & Friedman, 1990; Plaut, 1999; Branch-Coslett, 2000). Dyslexic people who possess a mental reserve of written words (an orthographic absorption lexicon) may not have their dyslexia diagnosed, so long as they read words that are familiar to them, but will encounter difficulty in reading new words, the written forms whereof they have yet to see. This is not the case with the developmental phonological dyslexic who has just begun to read. This child will have great difficulty acquiring reading skills. However, gradually, the child will fill his absorption lexicon with words to which he or she has been exposed, and will succeed in reading familiar words in this way. The child will continue to experience difficulty when encountering a new word. In reading nonsense words, the same process takes place as in reading new words of any kind. Nonsense words are not included in the child's orthographic lexicon, and they cannot be read according to the usual rules of attaching sounds to letters, so that the child searches for a familiar word which is similar to the nonsense word presented. The most common error pattern is in exchanging the nonsense word for a familiar one, as when ' phope' is read as

'phone.' The response for nonsense words that are not similar to anything in the orthographic lexicon is "I don't know." (Coltheart, 1980; Temple, 1997; Gvion & Friedmann, 2004).

9. Semantic Access Dyslexia: This form of dyslexia is sometimes called Hyperalexia. People with Semantic Access Dyslexia usually do well in reading familiar and new words, words which are written in a standard and a non-standard way, and also rare words. Despite this, they do not understand the words they read. One must draw a distinction between cases where the problem of understanding stems only from semantic access to the written word, or from a problem in understanding, which becomes apparent in spoken words, as well (Warrington & Shallice, 1979; Gvion & Friedmann, 2004).
10. Deep Dyslexia: A person with this kind of dyslexia can read only via semantics (a storehouse of meanings of words). He or she can grasp the meaning of written words, but will have difficulty in selecting the word from his storehouse, which fits exactly the word seen on the page. For the most part, these children can read words with similar semantics to those placed before them; for example, reading 'knight' instead of 'castle,' and 'canary' instead of 'bird.' Children with this diagnosis may also make visual errors, such as 'scale' instead of 'skate.' A group of words that are difficult are called 'functors.' These include nicknames, prepositions, compound words, and words of reference, or conjunctions such as 'which,' that,' and 'because.' Abstract nouns, such as 'wish,' 'fate,' and 'destiny' are harder to read. It is also difficult for children with this type of dyslexia to read nonsense words, such as ' flig,' which might be read as 'flag' (Marshall & Newcombe, 1973; Plaut, 1999; Branch-Coslett, 2000).

One study from our own lab addressed the question of whether the use of Virtual Reality could serve the teacher to improve his/her awareness of the child's experience. In this study, we developed virtual worlds that simulated a variety of initial cognitive experiences of toddlers on their first day of kindergarten and tested whether VR improved the teachers' awareness of these cognitive experiences (Passig, Klein, & Noyman, 2001). We found that experiencing a virtual world that reflects the real world of children improves the caregiver's awareness to the cognitive experiences that the toddler undergoes in her/his first days in a kindergarten or daycare. No studies that used Virtual Reality to simulate the cognitive experiences of dyslexic children were found. Beyond that, we found no studies that addressed the use of Virtual Reality for the instruction of teachers of dyslexic children. To the best of our knowledge, this is the first time Virtual Reality has been used in instructing teachers of dyslexic children and in simulating the cognitive experiences of dyslexics.

Method

Sample

Eighty teachers participated in this study. The teachers were selected randomly from a variety of public schools located in the Tel Aviv metropolitan area. The larger population included teachers teaching from 1st to 12th grade in a variety of subject areas, including mathematics, English, arts, physics, Bible studies, and elementary-level generalists. Sixty percent of the sample teachers taught in elementary schools and 40% taught in junior and high schools.

The sample was divided at random into an experimental and a control groups. In both research groups, the teachers were professionals with a range of additional academic educations – from a Bachelors' degree in a variety of disciplines to a PhD degree in education. Thirty-nine percent had just a teaching diploma from a teachers'

college; forty one percent also had a Bachelors' degree from a University in a specific discipline (math, physics, etc.); and 20% had also a Master or a PhD degree. The distribution by groups was as follows: In the experimental group: forty two percent held only a teaching diploma, 40% held an additional Bachelors' degree and 18% had an additional Masters or PhD degree. In the control group: thirty five percent held only a teaching diploma, 42% held an additional Bachelor degree, and 23% held an additional Masters or PhD degree.

The two groups were comparable on the following major confounding characteristics: in both groups, the majority of the sample was inexperienced in teaching dyslexic students although their seniority in the profession varied, and there were no minorities in the sample. The results were stratified. However, with possible differences of age, gender and school denomination. Thirty five percent of the teachers taught in public schools, 37.5% in religious schools and 27.5% in orthodox schools. In the experimental group, 30% of the teachers were attached to public schools, 40% to religious schools and 30% to orthodox schools. In the control group, 40% of the teachers were from public schools, 35% from religious schools and 25% from orthodox schools. Chi square tests were calculated to verify no differences across groups on gender, age and teacher's seniority. The tests indicate no significant differences on these variables. Thus, suggesting no confounding variables.

Tables 1-3 show the distribution of the research population according to the subjects' gender, age, and seniority as a teacher.

Insert here table 1

Insert here table 2

Insert here table 3

Procedure

Each of the teachers in the experimental group (N=40) underwent an immersive Virtual Reality experience that simulated ten virtual worlds corresponding to the ten types of dyslexia described above. The experience took 20 minutes to complete and was conducted in a VR laboratory in a kind of a clinical setting. The teachers, in the control group (N=40), each separately, watched a 20-minute film on the subject of dyslexia and reading disorders. All the subjects filled out questionnaires before and after the intervention.

Instrumentation

The research instruments included interviews and observations, as well as three questionnaires, all administered before and after the intervention. The questionnaires were designed to measure the teachers' capabilities in addressing the needs of pupils with dyslexia, teachers' opinions about pupils with dyslexia, and teachers' awareness of the cognitive experience of dyslexia. The last questionnaire, developed specifically for this study, will be described first.

Cognitive questionnaire

This questionnaire tested the responders on the subject of the dyslexic child's way of perceiving words and letters. As we were unable to locate a similar questionnaire in the literature, the items on the questionnaire were composed based on the taxonomy of Gvion and Friedmann (2004). The Cognitive Questionnaire included ten sections (Table 4), each relating to a different type of dyslexia. The ten sections included 25 items, sampling 2-3 questions on each type of dyslexia. The teacher was asked to circle the correct answer for each 25 item, each of which had only one

correct answer. The questionnaire was composed with the help of researchers and teachers specializing in learning disabilities. Its face validity was determined by three educational diagnosticians, two academic advisors, and three special education teachers. The judges were asked to express their opinion regarding the relevance of the items to the subject of our research, and on the clarity of their formulation. The judges found that the questionnaire was appropriate for testing the goals of the study, and it was administered to the research subjects in the form approved by the judges.

Insert here table 4

Capability questionnaire

We used the extant of 23 items for the "Capability" questionnaire adapted from Oren's questionnaire (2001) to examine the teacher's sense of capability for working with dyslexic children. The teacher was asked to what degree he or she felt capable of teaching dyslexic pupils based on a Lickert Scale ranging from 1 "definitely don't agree" to 6 "definitely agree". The response indicated the degree of agreement with each of the items on the questionnaire—the higher the score, the higher the teacher's sense of capability for working with dyslexic children.

This measure was adapted from Oren's (2001) questionnaire testing the variable "cognitive awareness." Oren (2001) devised three sub-scales for her measure—a cognitive scale (8 items), an emotional scale (6 items), and a social scale (9 items). According to Oren's research, the scale measuring cognitive awareness of how to work with dyslexic students has a Cronbach's α value of .78. In our sample we found a Cronbach's α value of .71. For a sample of the items adapted from Oren's cognitive scale for purposes of the present study, see Table 5.

Insert here table 5

Interview

An open-ended interview of 15 questions was administered to the experimental group in order to examine their level of awareness to dyslexia in pupil's behavior. The teachers were asked questions such as: What do you know about dyslexia? What do you know about dyslexic pupils? Interviews were conducted both before and after the Virtual Reality simulation. We conducted a post interview in order to determine whether there had been a change in the teacher's attitude toward the dyslexic pupil due to his Virtual Reality experience. The teachers were asked questions such as: How did you feel being like a dyslexic pupil? How would you change your attitude toward a dyslexic pupil following your VR experience? What would you tell him or her?

Opinion questions

Since the interview was administered after the VR experience to the experiment group only, from its open-ended questions we developed eight short questions (Table 6) to examine both the experimental and the control groups' opinions of difficulties encountered by the dyslexic pupil. We administered the questions before (4 questions) and after (4 other equivalent questions) the experiment to both groups in order to have a wider comparison base of the teachers' opinions. The teachers' responses were sorted and analyzed into three categories reflecting the categories of the Capability Questionnaire: cognition, emotion, and social-mindedness.

Insert here table 6

Control Group: Movie

The control group watched a film titled: "How Difficult Can This Be?" (Lavoie, 1989). We used 20 minutes' of excerpts from the original 70-minute film so as not to tire out the teachers and yet to provide them with an experience lasting the same amount of time as the intervention with the experimental group. The audio-visual clips from the film demonstrated how children with learning disabilities perceive different letters and words. This program allows viewers to learn about the same frustration, anxiety, and tension that children with learning disabilities face in their daily lives. Furthermore, in the film, teachers, social workers, psychologists, parents, and friends who have participated in Richard Lavoie's workshop reflect on their experience and the way it altered their approach to children with dyslexia.

Virtual worlds

The virtual worlds that were the focus of our intervention with teachers were constructed specially for this study. We simulated ten cognitive processes of various types of dyslexia based on the Friedmann-Gvion taxonomy described above. The virtual worlds took place within a building divided into many rooms. In each room, a task was presented based on one of the types of dyslexia. Each room was placed in a floating corridor, so that if a user left the room before finishing the task, he would enter an infinite space. This was designed to simulate for the teacher a feeling of desperation and of "I'm alone in the world...like in the middle of a desert" such as is experienced by a reading-impaired child.

The teachers received instructions on how to use the virtual reality equipment and were given a password which they had to type in as a first assignment. In addition, it was explained to teachers that at the beginning of each experience a sign would appear, and that a click on it would operate the experience's audio instructions.

During the entire experience in the virtual worlds, no additional explanations or instructions were provided as to how to proceed. The participant had to cope on his or her own, or reach the conclusion to ask for help. This feature was intended to bring home the feeling of helplessness experienced by the reading-impaired child, as well as the child's dependence on the teacher.

Each teacher participating in the study began his virtual experience in an experimental world. This world was designed to enable the teacher to gain some practice and experience in working with a 3D immersive virtual world, the Head Mounted Display (HMD) and joystick. In such a world, teachers could move around and act as they wished. When teachers felt comfortable they moved on to World No.1, and the beginning of the intervention. Following are shorts descriptions of two examples of the worlds that teacher participants experienced.

Semantic Access Dyslexia simulation

Before beginning the experiment, a dollar sign ($) appeared on the right side of the virtual space, when the user clicked on it, s/he heard the task one was required to perform. The user entered the corridor and arrived at a corner where he had to choose whether to enter the room on the right or the left, without knowing which choice was the correct one. After a short period of time, a written instruction on where to turn appeared on the wall: "To exit turn aluma." This was impossible to understand. The user tried unsuccessfully to open the door on the right, and then was also unsuccessful in trying to open the door on the left. After a while, a sound was heard. This was a signal that he could receive help if he examined the written instruction again. He found that the word "aluma" had become "left." At this point, the user opened the door on the left side. Children suffering from this type of dyslexia usually read existing words well, but don't understand the words they read.

Insert here illustration 1

Letter-by-Letter Dyslexia simulation

The user entered a library and saw a book lying on a table. On the binding was written "The book's name," and under that a button appeared, on which the word "Press" was written. The user pressed the button. The words "The book's name" disappeared, and in their place the letter C—the first letter in the name of the book appeared. When the user pressed the button a second time, the second letter, the letter I, of the book's name appeared in place of the first letter, and so forth up to the last letter. The user read the letters based on their order of appearance. At the end of the process, a list of words appeared to the left of the book. The user had to select the name Cinderella from the list. When the right choice was selected, the name turned from black and white to full color, the book was closed, and on the cover appeared the name Cinderella and her picture. The disappearance of the letters concretized for the teacher the extent to which reading is a disjointed, non-continuous experience for the dyslexic child. All her resources are invested in decoding the text, leaving little for understanding it.

Insert here illustration 2

Results

This study sought to test whether immersion in a 3D immersive virtual world simulating the dyslexic experiences of reading-impaired pupils would significantly improve teachers' awareness of the dyslexic pupils' cognitive experiences, as compared with teachers who viewed a film describing similar experiences. Reflecting

the literature, our hypothesis was that VR would improve teachers' cognitive awareness in comparison to watching a film describing the phenomena.

For this study, cognitive awareness was divided into two measures: The cognitive measure, which was carried out with the help of the Awareness Questionnaire, and the learning measure, which was taken with the help of the Sense of Capability Questionnaire.

Findings based on the awareness questionnaire

In order to examine the cognitive measure, we first administered the awareness questionnaire and carried out an Analysis of Covariance (ANCOVA) with Repeated Measures in a 2x2 design: group (control group and experimental group) by time (before and after the intervention) with age, previous knowledge and gender as Covariate Variables.

The analysis with repeated measures showed a significant difference between responses pre to post Virtual Reality experience ($F(1,78) = 2467.96$, $p<0.001$, Wilk's Lambda). Similarly, a significant difference was found between the experimental and the control groups ($F(1,78) = 717.64$, $p<0.001$). The average measure obtained in the experimental group after the intervention was significantly higher than that in the control group. The interaction between the research groups (experimental and control) for time (pre and post intervention) was significant ($F(1,78) = 2467.96$, $p<0.001$, Wilk's Lambda), which is to say that there was a significantly different change in time between the experimental group (pre and post intervention) and the control group (pre and post movie). The Covariate Variables were not significant, thus suggesting no important confounding.

In summary, in performing RM (Repeated Measures), it was found that for time, group, and the interaction between them, there was a significant influence for the treatment on the cognitive measure.

Means and standard deviations are presented at Table 7 and Figure1.

Insert here figure 1

Insert here table 7

Table 7 indicates that the average rose from 2.92 (pre-intervention) to 24.73 (post intervention), while the average of the control group remained at 1.6. In order to test the significance of the change separately in each group, a t-test analysis was carried out for the groups, before and after the intervention. With this analysis, we found a significant difference before and after the intervention in the experimental group ($t(40) = 49.6$, $p<0.001$), in contrast to the control group, in which no improvement was found.

Findings based on the capability questionnaire

The learning measure in this study was tested with the Capability Questionnaire. In addition, a variance analysis was performed with repeated measures in a 2x2 formation, according to the type of group (experimental and control groups) and time (pre and post intervention). The findings appear in Table 8.

Insert here table 8

Table 8 indicates that in the experimental group the average rose from 4.51 (pre intervention) to 5.27 (post intervention), while in the control group the average rose

from 4.62 (pre movie) to 4.70 (post movie). In order to test the degree of significance of the difference within each group separately, we carried out a t-test analysis of the groups before and after the intervention. This analysis revealed a significant difference before and after the intervention ($t(40) = 49.6$, $p<0.001$). In the experimental group there was a high degree of significance ($p<0.001$), while in the control group there was a marginal degree of significance ($p=0.47$). It might be possible to conclude that the change in the control group was less significant.

In the variance analysis with repeated measures a statistically significant difference was found between the results of the learning measure before the Virtual Reality experience and after it ($F(1,78) = 120.74$, $p<0.001$, Wilk's Lambda). In other words, there was a significant difference in the learning measure over time in the repeated measure. Similarly, a significant difference was found between the experimental and control groups on the learning measure ($F(1,78) = 12.02$, $p<0.001$).

The average learning measure as tested by the Capability Questionnaire in the experimental group after the experiment was significantly higher than in the control group. The interaction between the research groups (experimental and control) and time (before and after the intervention) was significant ($F(1,78) = 79.01$, $p<0.001$, Wilk's Lambda). In other words, there was significant differential change in teachers' capability over time between the experimental group (before and after the experience) and the control group (before and after the movie).

In sum, in the repeated measures analysis we found that time, group, and the interaction of these two factors all had significant influences on the cognitive measure. The findings appear in Figure 2.

Insert here figure 2

An examination of Figure 2 indicates that the average learning measure rose significantly in the experimental group, in contrast to the control group, where a similar, significant improvement was not found.

Examining the findings of both the measures of cognitive awareness shows that both the average cognitive measure and the average learning measure rose significantly in the experimental group. In the control group no significant improvement was found in the cognitive or learning measures as a result of viewing the film.

Findings based on the opinion questionnaire

In addition, we tested teachers' level of knowledge of the special difficulties encountered by the dyslexic child in a standard classroom. Teachers responded to two similar questions. Before the intervention, they were asked: "Does the dyslexic child in a conventional classroom have difficulties? What is your opinion? Elaborate." After the intervention they were asked: "Does the dyslexic child in a conventional classroom have difficulties? What is your opinion? Elaborate." The similar formulation of the questions was intended to create a basis for comparison. We investigated whether there was a change in the teachers' statements after the experience, in comparison to their statements before the experience.

A qualitative analysis of teachers' statements yielded three categories: cognitive, emotional, and social. Statements were coded accordingly and numbered. Change was measured by percentage increase.

Our findings showed that after the Virtual Reality experience there was a large increase in the number of times that teachers said they related to the pupil's difficulties, in contrast to the responses of the teachers in the control group who viewed a film. There was an improvement of 15% in the teachers' attitudes towards

pupils' cognitive difficulties in the experimental group, compared with 2.5% in the control group. In attitudes toward emotional difficulties, there was an improvement of 17.5% in the experimental group, and 2.5% in the control group. In attitudes toward social difficulties, there was an improvement of 12.5% in the experimental group and 10% in the control group. These findings are presented in Table 9.

Insert here table 9

We conducted interviews with the experimental group too. Through the interviews before the intervention we found that 67% of the teachers had some knowledge of dyslexia, while 32% reported a lack of real knowledge. At the same time, the majority of the teachers had difficulty in completing the Cognitive Questionnaire presumably due to a lack of experience in teaching dyslexic students. Ninety percent stated that they employed logic in filling out the questionnaire, while only 10% said that they were aided by previous knowledge about dyslexia or personal experience with dyslexic children.

In the post intervention interviews, we found that all the teachers reported that they had altered their approach to the dyslexic child ("to criticize them less... to say 'no' less … to stop shouting at them… etc.") persuant to their experience in the course of this research. This could be attributed to their realization of the great importance of the teacher's role in the life of a dyslexic child, which they could grasp as a consequence of their own need for assistance during the Virtual Reality experience. There were those who informed us that without the assistance they received in this intervention, they would not have succeeded in performing their tasks in the Virtual Reality worlds. Some even stressed that without assistance, they would have terminated the experience.

This type of remark suggests that the Virtual Reality experience was much more comprehensive and immersive than the experience of watching a film.

Similarly, all the teachers said that the Virtual Reality experience contributed to their understanding of the cognitive experiences encountered by the dyslexic child ("I didn't know how complex the problem was…It's good that I experienced dyslexia from different angles…I didn't know that there were so many kinds of dyslexia, and some of them surprised me."). Despite the many frustrations which the teachers encountered during the 3D immersive Virtual Reality experience, most of them expressed interest in further experiencing the virtual world of the dyslexic. They were enthusiastic about being introduced to a technology that seems to be able to bring to light unfamiliar cognitive territories. Many of them stressed that "it is so different from any media we have ever used."

It is interesting to note that after the Virtual Reality experience all the teachers reported that they had no difficulty completing the questionnaire, and that their responses following the experience stemmed from real information about the different types of dyslexia.

Discussion

The aim of this study was to test whether immersive Virtual Reality could impact teachers' understanding of the needs of dyslexic students and their cognitive experience. In this study, we did not test whether Virtual Reality could have a similar impact on behavior that might lead to improved reading outcomes for dyslexic students. In order to test whether Virtual Reality has such an impact, teachers who experience the VR simulations would need to be followed up in their classrooms. We, thus, believe that there is a future need for this type of study.

Nonetheless, the present study reflects the promise of efficient technologies in teacher education. Using VR in teacher education should be seriously considered especially since its practicality has been increased in recent years. It is already only a matter of employing an HMD and a laptop in order to introduce VR into any educational setting. Teacher education is constantly being challenged to produce better educated alumni, aware and knowledgeable in many aspects of the teaching profession. This study responds to that challenge in addressing whether the use of Virtual Reality can achieve a higher level of awareness of the phenomena of dyslexia in students, in comparison to watching a film and the descriptions it provides.

The issue of using different media for instruction has been studied and debated for several decades now. Reverting to Marshall McLuhan's position that "the medium is the message," the question of the relative value of different media in instruction remains a matter of debate. The meta-analysis conducted by Kulik, Kulik, and Bangert-Downs (1985) on instructional modalities supports McLuhan's premise. However, Richard Clarke (1994) refuted this approach, positing that in instruction, the content and a myriad number of other factors are just as influential in learning effectiveness as the delivery mechanisms. In the 1990s, Kosma (1991) continued this debate and supported the medium is the message approach espoused by Kulik et al., and the debate continues today. Our research suggests that newer technologies could shed light on this old debate. It is possible that the characteristics of newer media are so powerfully overwhelming that in certain delivery mechanisms, such as immersive Virtual Reality, the medium is indeed crucial.

The results of this study reflect similar findings regarding the efficacy of immersive Virtual Reality technology in teaching cognitive and emotional concepts to populations of different students (Passig, Klein, & Noyman, 2001). The literature

emphasizes the manifest advantages of immersion in Virtual Reality that raises the degree of awareness of experiences that are difficult to explain verbally, and otherwise demand considerable time and resources (Regain & Shebliske, 1992). On this point, the current study serves at least to further support the position of Kulik et al.

Vellutino & Fletcher (2005) summarized the research on dyslexia, debunking visual perceptual theories as well as visual tracking theories as origins of dyslexia. Their review points to phonological coding deficits as the more likely source of the origins of dyslexia. They contended that excessive dyslexia research has mistaken the results of poor/misguided initial teaching for some biological/neurological etiology. It is important to note that our study focused only on improving the knowledge and awareness of the dyslexic experience as suggested by one of the many typologies of the phenomenon in the literature. It was beyond our ability to engage in the debate Vellutino & Fletcher (2005) have stirred to suggest a cohesive typology or even to hint that the typology we used is a candidate to evolve into such a typology.

Implications

Nonetheless, to the best of our knowledge, the current study represents a unique attempt in concretizing for professionals a problem they are too often expected to "solve," and a situation they are expected to improve. The functioning of the child's brain has always been veiled in layers of mystery. Many professional studieshave been devoted to understanding the way children think at different stages of their emotional and cognitive development. Parents as well as teachers have been expected to become familiar with the results of this academic effort. The teachers and, most certainly, the parents of the children subject to the disabilities are in need of emotional resources in order to experience for themselves the difficulties encountered by the

child having the disability, and to familiarize themselves with its behavioral expressions. This has not been easy, as the professional literature dealing with disabilities is multi-faceted, and has yet to be organized into a complete, comprehensive theory. We realized this when designing the different phases of this study. As noted at the outset of this paper, we discovered many definitions of dyslexia, and were not always able to state that all those who researched the field were in agreement on its parameters. Thus we made a deliberate decision to develop our virtual worlds according to a taxonomy which seemed sufficiently simple for translation into a virtual environment.

If we encountered difficulties in arranging the different reading disabilities in one clear, simple list, we assume that the teachers and others who care for children with this disability perform their work from within the context of a haze of conflicting elements of information. As noted above, participants in our research expressed this unreservedly. In the interviews we conducted, teachers unequivocally stated that they simply provided answers to the questions on the Cognitive Questionnaire based on guesswork when it was administered to them before the Virtual Reality experience.

Beyond this, as best we can estimate, the teachers who presently work with dyslexic children together with other children in their classes have difficulty even identifying dyslexics. This is especially so in an age when many parents of children challenged by disabilities request that their children's situation should not be disclosed to the teachers concerned. The results of the present study point in the direction of a solution to this problem, albeit an imperfect one, in that it moves the reading-impaired child's cognitive world closer to that of his teacher.

Even more important, this work offers a tool which makes it possible to test the teacher's level of awareness of the difficulties encountered by a child with reading

disabilities. The research demonstrates that it is more effective to improve the teacher's awareness with the help of experiential simulation in comparison to using the long and wearying method of memorizing the existing theories of dyslexia or even watching a film about it.

We also believe that there are two noteworthy challenges arising from this study that apply to future researchers. Both concern the typology of dyslexia we used in this study. One is that the typology needs validation, since there is no research-based support for the existence of the 10 dyslexic subtypes that we adopted. The typology needs, as one of the referees of this paper suggested, at least one single large-scale study (N= 1000 dyslexic subjects whose instructional histories are well documented) that employs discriminate function analysis, factor analysis or something of similar nature, to verify that 10 distinct patterns of dyslexia exist, and whether they exist independently of particular instructional histories. We are in agreement with this particular referee and are indebted to him for his comment to the effect that without such a study, the 10 subtypes must be considered, at best, hypothetical, and perhaps, simply imaginative.

Nonetheless, this study offers a second challenge for researchers. The field critically lacks a typology that summarizes what is known to date about reading disabilities or/and dyslexia, in order to use leading-edge technologies such as Virtual Reality to develop efficient learning materials that better educate teachers, parents and the general public about the various reading disabilities that exist. This challenge is no less important than studying the reasons for the different types of disabilities. This study demonstrates that relevant technology capable of simulating reading disabilities, has matured for that task. Unfortunately, however, there are no substantiated types

and subtypes of reading disabilities that are sufficiently clear to simulate, and that we can be sure actually exist with some degree of certainty.

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Table 1: Distribution of the research population by gender*

Gender	VR - Experiment	Movie - Control	Total
Teachers (females)	32 80.0%	29 72.5%	61 76.3%
Teachers (males)	8 20.0%	11 27.5%	19 23.8%
Total	40 100%	40 100%	80 100%

χ^2 (1) = 2.34, p>.05

Table 2. Distribution of the research population by age*

Age	VR - Experiment	Movie - Control	Total
20 – 30	17	10	27
	42.5%	25.0%	33.8%
31 – 40	8	18	26
	20.0%	45.0%	32.5%
41 – 50	10	9	19
	25.0%	22.5%	23.8%
51 – 60	5	3	8
	12.5%	7.5%	10.0%
Total	40	40	80
	100%	100%	100%

χ^2 (3) = 4.06, p>.05

Table 3. Distribution of the research population by seniority*

Seniority - Teaching years	VR - Experiment	Movie - Control	Total
1 – 10	19	21	40
	47.5%	52.5%	50.0%
11 – 20	11	13	24
	27.5%	32.5%	30.0%
21 – 30	8	5	13
	20.0%	12.5%	16.3%
31 – 40	2	1	3
	5.0%	2.5%	3.8%
Total	40	40	80
	100%	100%	100%

χ^2 (3) = 1.74, p>.05

Table 4: A sample of items from the Cognitive Questionnaire

	Cognitive Questionnaire		A	b	c	d
1	Visual Letter Agnosia	A dyslexic student, who fails to recognize letters, will read the word 'black' as:	Slack	cab	s/he can not read the word	
2	Neglect Dyslexia	A dyslexic student, who fails to read and report letters on a specific side of the word, will read the word 'play' as:	Lay	pay	pong	page
3	Visual Dyslexia	A dyslexic student, who makes visual paralexias, will read 'bad' as:	Baby	Dab	door	red
4	Letter Position Dyslexia	A dyslexic student, who makes errors of letter migration within a word, will read 'bread' as:	Breakfast	reading	Beard	dare
5	Attentional Dyslexia	A dyslexic student, who `migrates` letters from one word to another word in the same position, will read hut-pot as:	hit-pit	hat-pat	pity-big	hot-put

6	Letter-By-letter	A dyslexic student will read the letters first, and then the complete word	True	false		
7	Surface Dyslexia	A dyslexic student, who translates letters to sound, will read 'come' as:	common	some	rome	cone
8	Phonological Dyslexia	A dyslexic student, who fails to read nonsense words, will read 'klack' as:	black	lacy	lack	cake
9	Semantic Access Dyslexia	A dyslexic student, who fails to understand the word, will not match a picture to the correct sentence	true	false		
10	Deep Dyslexia	A dyslexic student, who substitutes words with the same context, will read little as:	liter	letter	small	bottle

Table 5: A sample of questions from the Capability Questionnaire

	Capability Questionnaire	1 Definitely agree	2 Agree	3 Tend to agree	4 Tend not to agree	5 Don't agree	6 Definitely don't agree
1	There's no reason to invest in a dyslexic child since his/her capabilities to gain some achievements is limited.						
2	A teacher can contribute greatly to the improvement of the emotional state of a dyslexic child.						
3	The teacher's ability to assist a dyslexic child in social matters is limited since one cannot deal with his abnormal behaviour.						

Table 6: Opinion open questions before and after

	Before	After
1	Does a dyslexic child who is taking part in a regular class have special difficulties?	A dyslexic child has joined your class. Do you think he has unique difficulties?
2	How, in your opinion, can you contribute to the calm of a dyslexic child?	A dyslexic child with anxiety and a low self-image has been assigned to your class, what would you do and why?
3	What would you do with a dyslexic child experiencing anxiety and low self-esteem?	A dyslexic child is part of your class. How could you calm his restlessness?
4	What would you do with a dyslexic child who is rejected by his surroundings and feels lonely?	A dyslexic child in your class is not well acquainted with his classmates, hence he feels lonely. What would you do?

Table 7: Means and Standard Deviations of the Awareness Questionnaire for the experimental and control groups, before and after the intervention

		Experiment - VR	**Control - Movie**
Before	Mean	2.92	1.6
	SD	2.97	2.39
	N	40	40
After	Mean	24.73	1.6
	SD	0.45	2.39
	N	40	40
	Significance	P<0.001	

Table 8: Means and Standard Deviations of the Capability Questionnaire in the experimental group

		Experiment - VR	**Control - Movie**
Before	Mean	4.51	4.62
	SD	45.	17.
	N	40	40
After	Mean	5.27	4.70
	SD	44.	21.
	N	40	40
	Significance	P<0.001	

Table 9: Teacher's knowledge of special difficulties on the part of the reading-impaired/dyslexic – findings from the interviews

	Categories	Experiment group N=40		Control group N=40	
		N	%	N	%
Before the experiment	Cognitive difficulties	15	37%	19	47%
	Emotional difficulties	10	25%	9	22%
	Social difficulties	11	27%	8	20%
After the experiment	Cognitive difficulties	21	52%	20	50%
	Emotional difficulties	17	42%	10	25%
	Social difficulties	16	40%	12	30%

Illustration 1: A simulated Semantic Access Dyslexia

Illustration 2: A simulated "Letter-by-Letter Dyslexia"

Figure 1: Means on the cognitive measure for the experimental and control groups, before and after the experience

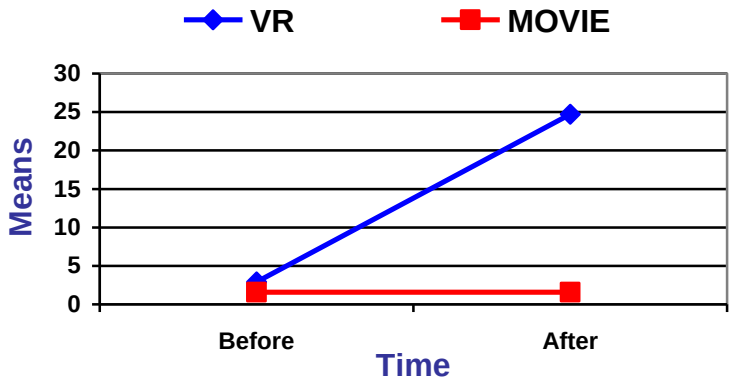

Figure 2: Learning Measure means for the experimental and control groups before and after the intervention