Teaching intervention through a hypermedia application for children with learning and communication difficulties

Eleni Morfidia*, Tasos A. Mikropoulosa, Ioanna Belloua

aDepartment of Primary Education, School of Education, The University of Ioannina, Ioannina, 45110, Greece

Abstract

Two separate studies have been undertaken in order to evaluate a hypermedia application designed to help children with learning and communication difficulties acquire pre-mathematical concepts. First, an intervention study with six cases of children who had learning and communication difficulties is described. Second, a separate study examined twenty five educators’ perspectives after having used the application. Overall, it was evident that the application has the potential to serve as an assistive teaching tool, but there are concerns emerging from the empirical evaluation regarding its usability and utility.

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1. Introduction

The increasing demand for computer-based teaching interventions has led researchers, developers and professional educators to exploit opportunities presented by Information and Communication Technologies (ICT). The diversity of characteristics encountered by children with learning and communication difficulties may present an extra challenge for potential hypermedia application developers. Evaluation of available material may help to inform on their design and delivery and improve future efforts. The ultimate goal of such exercise is to facilitate the learning environments of the target population, assuming that the problem lies with the environment not the disability and therefore needs adapting [1, 2, 3].

LT125ThinkingMind (available at http://earthlab.uoi.gr/hyperdomi) is a software application designed and developed for the purpose of assisting the educator towards an individualized approach to teaching pre-
mathematical concepts like directionality, order, position and classification. It was designed to serve children with learning and communication difficulties [4].

The application provides alternative user interfaces: the teacher interface where the educator designs the learning activity, and the student interface, where the activity is executed. In the teacher interface (Fig. 1), the user can choose among four different subjects (chameleon, monkey, toucan, and seal) and four different objects (train, car, house, and helicopter) available in four different colors and sizes. The teacher can choose one of the four subjects and one or two of the four objects in various colors, sizes and positions (i.e. above, below, in front, behind, inside, outside) according to the purpose and level of difficulty of the activity. In the student interface (Fig. 2), the child is asked to use the different subjects and/or objects exploiting the differences in size, color and position. The exploitation of the numerous combinations is tapping on cognitive processes such as recognition (e.g., object, size, color, etc.), discrimination (e.g., objects, sizes, colors, etc.), sorting and classification (e.g., classify same objects by color, size, etc.). The designed activity can be symbolically represented using icons, thus minimizing verbal communication.

The activity is executed in two steps: First the teacher designs the activity in the teacher’s interface before he/she moves to the student’s interface where the child is asked to act in order to solve the problem as requested. In case the problem is solved correctly, there is immediate positive feedback. If the child fails, the
application resets the icons in their initial position in order to allow for another attempt. The application is accompanied by a teacher’s manual which provides pre-structured learning activities of increasing difficulty.

The implementation of LT125ThinkingMind was shown to present difficulties to users and its advantages and disadvantages should more clearly be articulated so that potential users can be aware of them, and developers may seek improvisations leading to better outcomes [4].

The purpose of the current work is to further explore the advantages and limitations of the application through the investigation of (a) the effectiveness of a teaching intervention using LT125ThinkingMind with children who have special needs and weaknesses related to its scope, (b) teacher views on the application after use, following usability and utility criteria for the evaluation of educational hypermedia applications [5]. Therefore, two separate studies have been designed. The first study aimed to provide six different examples which describe how the application can be utilized to address the educational needs of children with related weaknesses. The second followed a user-centered approach to examine the usability of the application.

2. Study 1

The aim of the first study has been to examine the efficiency of the application in assisting children with mental retardation and autism to learn the specific concepts. First we report on the three case studies with mental retardation, followed by cases with autism. Five of them were located in Ioannina, and one in Thessaloniki, Greece. Teaching intervention studies often involve case study designs because it is notoriously difficult to identify and intervene to large numbers of special populations that satisfy certain research criteria. Similarly, a small sample of seven cases has been used for the examination of computer use by individuals with disabilities [6].

2.1. Principles of assessment and intervention

The baseline assessment was carried out using two mediums, that of the software application and the simple pictorial using icons. The teacher was introducing the process using both formats in order to identify areas of real weakness. Alternative terms e.g. ‘bird’ instead of ‘toucan’ were acceptable. A decision was made to prioritize on those components that the children had weaknesses using both mediums. In the beginning of each session revision of the components took place. The teaching goal was achieved step by step. It was defined that mastery of the targeted component was evident only when the child had achieved it with accuracy on three successive trials. A step by step, repetitive approach to teaching was followed. Sessions occurred every two or three days and lasted from 20 to 45 minutes.

2.2. Mental Retardation: case 1. KP

2.2.1. Birth and development

The chronological age of KP was seven years six months, and he was attending first grade in a mainstream school for a second time. According to the school report his overall performance level was two years below his chronological age. He had delayed receptive and expressive language, memory, motor skills, emotional and behavioural difficulties.

2.2.2. Baseline assessment

The initial assessment for KP showed that he cannot discriminate between blue and green colours and the directions ‘in front’ and ‘behind’.
2.2.3. Teaching

First session: the aim has been to recognize all subjects and objects with blue and green, and use the known directions (e.g., put the (blue) monkey in the blue car). After all combinations of subjects and objects using the same colour had been achieved, at a second step, subject and object of different colours had been trialled (e.g., put the blue monkey in the green car).

Second session: the aim had been to maintain the two newly established colours, and practice the direction ‘behind’ with all subjects and objects alternating the green and blue colours.

Third session: The two target colours with all subjects and objects had been used to practice the direction ‘in front’.

Fourth session: Subjects and objects of green and blue colours had been used to practice the directions ‘in front’ and ‘behind’ simultaneously in one session.

Fifth session: Use of the two colours with all subjects and objects to practice all directions.

2.2.4. Outcomes

During the sessions KP achieved at high levels. He achieved at 85% (first session) and 75% (second and third sessions). In the fourth and fifth sessions he performed the highest 90% indicating a satisfactory level of mastery.

2.3. Mental Retardation: case 2. GB

2.3.1. Birth and development

GB is a seven year old boy attending the first grade of a mainstream school. According to the school report, he had the level of ability of a five year old. He had speech perception and production (intelligibility) problems and attention deficit.

2.3.2. Baseline assessment

During initial assessment GB did not recognize the blue colour and he failed to show proper use of ‘above’ and ‘below’. In addition, he had unstable command of ‘in front’ and middle size.

2.3.3. Teaching

First session: Recognition of all subjects and objects in blue; execution of simple activities with known directions.

Second session: Recognition of all subjects and objects in blue; activities with one subject and one object including ‘above’.

Third session: Recognition of all subjects and objects in blue; activities with one subject and one object including ‘above’ and ‘below’.

Fourth session: Discrimination between blue and other colours (with two conditions, 1: one blue subject, one blue object, one different colour object-distractor; 2: subject in multiple colours, one object in multiple colours, second object in blue); practice all directions.

Fifth session: Recognition of middle size. All subjects in blue in different sizes are offered for recognition multiple times. Practice of middle size subjects with different directions.

Sixth session: Middle size subjects in different colours are used to practice all directions.

Seventh session: Full manipulation of colour and size to practice directions with all subjects and objects.

2.3.4. Outcomes

Performance reached 100% (first session), 87% (second session), 100% (third session), 90% (fourth and
fifth sessions), 100% (sixth and seventh sessions).

2.4. Mental Retardation: case 3. DM

2.4.1. Birth and development
The chronological age of DM was seven and her ability level was approaching that of three years and six months. She has been attending a rehabilitation centre for four years. She had been following a special preschool education programme supporting children with physical and developmental disabilities from infancy to school age on motor, sensory, verbal, cognitive, social, emotional and intellectual development.

2.4.2. Baseline assessment
During initial assessment she showed excellent use of the computer, and knowledge of all subjects, objects, colours, two sizes (small, big) but only one direction (inside). Therefore, the priorities for her teaching programme had been a) instruction on the five directions and b) middle size.

2.4.3. Teaching
First session: The aim of the first session was the acquisition of the direction ‘outside’. After a short revision of objects, subjects, etc., the new direction was introduced and trialed several times. In order to generate several occasions for practice, three different conditions were applied: one when subject and object shared the same colour, a second when the subject varied in colour and a third when the object varied in colour.

Second session: The aim of the second session was the acquisition of the direction ‘above’ in the same fashion.

Third session: Similarly, the aim of the third session was the acquisition of the direction ‘below’ in the same fashion.

Fourth session: Repetition of the three last directions (‘outside’, ‘above’ and ‘below’) in order to achieve mastery.

Fifth session: The aim of the fifth session was the acquisition of the direction ‘in front’ in the same fashion described above.

Sixth session: The aim of the sixth session was the acquisition of the direction ‘behind’.

Seventh session: Repetition of the two last directions (‘in front’, ‘behind’) in order to achieve mastery.

Eighth session: One session revising the five directions all together to maintain mastery.

Ninth session: The aim of the ninth session was acquisition of middle size. Therefore, recognition of middle size was the first step. Practice using the above directions was the second.

2.4.4. Outcomes
Performance on the above sessions varied from 81% (first session), 75% (second session), 93% (third session), 81% (fourth session), 75% (fifth session), 69% (sixth session), 96% (seventh session), 100% (eighth session). Explicit teaching of middle size (ninth session) soon reached 100% as well as the repetitive practice on the taught directions.

2.5. Autism: case 1. DD

2.5.1. Birth and development
DD was a five years and six months old girl who had been attending the special class of a preschool for a second time in Thessaloniki, Greece. She had relatively good reading and writing skills, language delay and
2.5.2. Baseline assessment

Initial assessment showed that two of the subjects and objects were not familiar to her (subjects: chameleon, seal, objects: helicopter, train) as well as two of the directions (‘in front’ and ‘behind’). She knew all the colours but none of the sizes.

2.5.3. Teaching

First session: The aim of the first session was mastery of the subjects. After several repetitions through recognition and discrimination, all the subjects and the two familiar objects were used for practicing the directions she was familiar with.

Second session: The aim of the second session was mastery of the objects. After several repetitions through recognition and discrimination, all subjects and objects were used for practicing the directions she was familiar with.

Third session: The next step was to practice all the subjects and objects and one of the directions she had difficulty with (‘in front’).

Fourth session: The aim of the fourth session was mastery of the direction ‘in front’ and introduction of the direction ‘behind’.

Fifth session: The aim was mastery of newly acquired direction ‘behind’ and contrast with all other directions.

Sixth session: In this session the aim had been acquisition of two sizes ‘big’ and ‘small’ through recognition and discrimination.

Seventh session: The two sizes, all subjects and objects were used to practice all directions.

Eighth session: This session was considered necessary because the activities of the previous session did not reach 100% mastery. In the last session performance was both accurate and speeded.

2.5.4. Outcomes

Overall, DD had good response ranging at high levels: 100% (first and second sessions), 75% (third and fourth sessions), 85% (fifth session), 70% (sixth session), 85% (seventh session), 100% (eighth session).

2.6. Autism: case 2. BK

2.6.1. Birth and development

BK was eight years old and entered school for first time. Placement in the first grade (regular class) did not work due to behavioural problems. Therefore, he was moved to the special class of the local mainstream school. BK had spent significant time hospitalized due to his poor health condition (kidney failure and gastro esophageal reflux). He is experiencing emotional and behavioural difficulties and family problems.

2.6.2. Baseline assessment

The initial assessment showed that BK encountered difficulty with three directions (‘in front’, ‘behind’ and ‘inside’).

2.6.3. Teaching

First session: The aim of the first session was to successfully direct all subjects ‘inside’ the objects. The poor response on the first session due to lack of teacher-student collaboration, kept the first introductory session short.
Second session: Despite the limited success of the first session, the aim of the next session was to accomplish the direction ‘in front’. The situation did not change significantly; neither did the level of achievement.

Third session: Similarly, the aim of this session was the achievement of direction ‘behind’.

Fourth session: Repetition of the first session aiming to improve original results.

Fifth session: Repetition of the second session aiming to improve original results.

Sixth session: Repetition of third session aiming to improve original results.

Seventh session: Repetition of the first and fourth session aiming to achieve greater success.

Eighth session: Repetition of the second and fifth session aiming to achieve greater success.

Ninth session: Repetition of the third and sixth session aiming to achieve greater success.

2.6.4. Outcomes

During the three first sessions achievement was 50%, 50%, and 60% respectively. In the fourth, fifth and sixth sessions it was 70%, 70%, 75% respectively, while in the last three 85%, 80%, and 80% respectively.

2.7. Autism: case 3. BI

2.7.1. Birth and development

BI had the chronological age of seven years and five months. He had been attending first grade (regular class with support teacher) and spent one extra year in preschool. His parents were highly educated and contributed a lot to his education. His literacy and numeracy skills were good, as well as his skills in computer use. He is a well-behaving child.

2.7.2. Baseline assessment

BI performed really well in all of the components. He had little difficulty with directionality and the two unstable ones had been ‘in front’ and ‘behind’.

2.7.3. Teaching

First session: The aim of the first session was to achieve good use of ‘in front’ practicing with all subjects and objects (one per time).

Second session: Maintenance of newly established skill using (a) two subjects and objects of the same colour, (b) two subjects of different sizes and two objects, (c) two subjects of different colours and two objects.

Third session: The aim has been to be able to use ‘behind’ with 100% accuracy.

Fourth session: Further establish what he achieved using (a) two subjects and objects of the same colour, (b) two subjects of different sizes and two objects, (c) two subjects of different colours and two objects.

Fifth session: Review of the six directions using two subjects and two objects.

2.7.4. Outcomes

His achievement reached very high levels in all sessions ranging from 90% (second and fourth sessions) to 100% (first, third and fifth session).

3. Study 2

A separate study was designed in order to investigate teachers’ views on the application after having experience using it. Twenty five teachers, who had been trained during a university in-service course on special education, were asked to use the software at least three times with individual cases of special needs children as
part of their training course. They had eight to twenty four years of teaching experience and moderate experience with educational software.

After completing their assignment, they filled in a short questionnaire addressing aspects of content efficacy, teaching innovation and facilitation. The questions addressed the following: a. appropriateness of content, b. content suitable for the level of the children, c. innovation for teaching, d. clarity of teaching aims, e. flexible material, f. guidelines for planning an intervention, g. differences from traditional teaching methods, h. advantages and disadvantages. Questions a to g were scored on a four point scale. Table 1 presents the results.

Table 1. Means and Standard deviations of teachers’ responses

<table>
<thead>
<tr>
<th>Questions (max. score 4)</th>
<th>Mean</th>
<th>Std</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appropriateness of content</td>
<td>2.72</td>
<td>0.63</td>
</tr>
<tr>
<td>Content suitable for children’s level</td>
<td>2.56</td>
<td>0.76</td>
</tr>
<tr>
<td>Innovation for teaching</td>
<td>2.60</td>
<td>0.64</td>
</tr>
<tr>
<td>Clarity of teaching aims</td>
<td>3.00</td>
<td>0.82</td>
</tr>
<tr>
<td>Flexible material</td>
<td>2.24</td>
<td>0.92</td>
</tr>
<tr>
<td>Guidelines for planning an intervention</td>
<td>2.32</td>
<td>0.98</td>
</tr>
<tr>
<td>Differences from traditional teaching methods</td>
<td>2.60</td>
<td>0.70</td>
</tr>
<tr>
<td>Advantages and disadvantages</td>
<td>See below</td>
<td></td>
</tr>
</tbody>
</table>

The advantages can be summarized as follows. The software is complying with repetitive and structured rules (4/25). It provides feedback (4/25), promotes computer use (9/25), and has interesting representation of colours and objects (8/25). It is pleasant (3/25), easy to use (1/25), and engages in active participation/enhances motivation (2/25). Three of the 25 participants did not find any advantages to report.

The disadvantages included technical issues such as difficulty to execute ‘behind’ and ‘in front’ (confused with ‘left’ ‘right’) (8/25), unusual subjects and/or objects (e.g., toucan) (7/25), requires familiarity with the computer (4/25), difficulty in achieving graded difficulty (3/25), technical problems – demands high level of accuracy in execution (3/25), problems with mouse use (2/25), lack of 3D environment (2/25), and feelings of boredom or frustration (2/25). Three of the 25 participants did not find any disadvantages to report.

4. Discussion

Two separate studies using teaching intervention and educators’ perspectives have been undertaken in order to evaluate the usability and utility of a hypermedia application for children with learning and communication difficulties. Six cases with mental retardation and autism have been taught using the application. The baseline assessment indicated which components should be targeted. All of the children showed significant progress after instruction on the specific components. BK did not reach a satisfactory performance, perhaps due to the emotional and behavioural difficulties which prevented school adjustability and benefits from instruction. If extra sessions had been offered he may have reached the expected level.

The required number of sessions for all children varied according to their ability level and severity of their needs.

Overall, it seems that the application has the potential to help children learn the concepts it addresses. However, any systematic, repetitive, step by step, individualized teaching approach may lead to positive learning outcomes. Besides, it is not clear whether the professional teachers’ experience had made a difference
in delivering the activities. In order to better evaluate the educational implications of the application, a control group with matched subjects should be used. The experimental and control groups should be matched and taught on the same concepts with (experimental) and without (control) the application. Only after having compared the performance of both groups one could identify its strengths. Furthermore, a follow up of both groups is necessary to test the longevity of acquired skills.

The second study showed moderate to high users’ satisfaction. More enlightening has been the report on the advantages and disadvantages revealing usability problems of the user interface, issues of flexibility and adaptability, as well as the educational usefulness of its components such as the feedback provided, its repetitive and structured approach. Future developments of the application should reconsider aspects of the pedagogical content, the instructional presentation and technical adequacy. A full evaluation of the application should employ triangulation from experts’, teachers’ and children’s perspectives.

References