The Impact of Virtual Simulations, Communication and Peer Reviewing on Spatial Intelligence and Mathematical Achievements

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ABSTRACT

The research is aimed at enabling special education pupils to use computers in everyday life, and improving spatial intelligence and mathematical achievements through computers. The method of training focuses on enabling pupils to create computer simulations, communicate by electronic mail while evaluating each other's products and navigate Internet sites. The creation of such simulations is based on manipulations of the virtual environment similar to the real world as much as possible in order to utilize the unique characteristics of the computer such as spatial visualization.

The researcher taught the teachers the basics of the use of computer and trained them how to use the method in their classroom. Then the teachers used the method with their special education pupils in accordance with their cognitive and motor abilities. The objects were taken from the pupils' everyday environment. The teachers trained the pupils in pairs. Such procedures were held among different populations.

The teachers improved their mastery of computers. In spite of their lack of experience before the experiment, they built high-level PowerPoint presentations and used them with their pupils in the classroom including even virtual simulations. They sent their products by Electronic mail (E-Mail) for the peer reviewing process and navigated relevant Internet sites.

The teachers reported pupils' high motivation and their success in the various virtual activities. As a result, the spatial intelligence and mathematical achievements of the pupils were improved. The teacher-pupil interaction and the social relationships between the pupils were also improved.

Keywords: Computer, Innovative Technologies, Manipulations, Mathematics, Simulations, Spatial Intelligence, Virtual Reality and Visualization.

1. INTRODUCTION

Many special education pupils, especially those with complex handicaps are known to be trained through software by following one specific stimulus by eyes only. Sometimes the pupils get software where they are asked to choose one out of a few answers. Some of the pupils tend to guess the correct answer and become bored very quickly. Some teachers give the pupils single words for typing on the computer. The words or texts might be meaningless for some of the pupils. In all such cases the pupils cannot create and build computer presentations and simulations on their own. Teachers are not aware enough of the pupils' ability of mastering computers, According to the theory of Piaget & Inhelder (1), the creativity leads to a significant construction of knowledge. Generating a center of self-control, developing control over the reality and compatibility with the environment occurred while creating virtual simulations and reviewing the peers' work.

2. THEORETICAL REVIEW

Definitions

According to McGee's review (2), there are two different sets of spatial skills: Orientation in space and Spatial Visualization. Mastery of these skills enables the pupils to locate the position of objects in space and perceive the relations between them from a changing viewpoint (see also: (3) (4) (5)). The application of spatial visualization enables him/her to predict and imagine potential spatial changes in the observer's position, or those of any other object in his/her vicinity for a long term (3). The spatial concepts have metaphoric implications. Thus we must distinguish between the meaning of the concrete spatial concepts, such as above-under, in front of-behind etc. and **metaphorical expressions** based on such concepts (verbal translations of spatial concepts, which do not always make sense when transferred from one language to another). For example: "fields" of interest, "levels" of thought (6). These metaphoric meanings extend the benefit of improving spatial skills to language comprehension and application. Greenfield & Schneider (7) and Greenfield & Westerman (8) found parallelism between the three-year-old children's ability to organize the syntactic structures in sentences and the manipulation of objects in space.

Lohman (9) stated that the visualization is the main factor to spatial ability (See also: (6) (10) (11) (12). Lohman (13) argued that the ability to think and orient in new situations is amenable to learning. Spatial orientation can be carried out by Artificial Intelligence. "Put the red ball under the brown chair" (14). The same procedure is used in the exercises to manipulate space in "referential communication" with human subjects (15) (8).

The Relationships between Spatial Intelligence and Mathematics

Many studies showed the relationships that exist between the level of spatial skills and mathematical achievements in all ages. Battista (16) researched the relations between spatial visualization and success in mathematics at the university. He further showed that the ability to imagine changes in 3-D structures affected significantly the scores of students in Algebra and Geometry courses in the middle classes of Junior Schools.

Training Spatial Intelligence by Computers

The newest and up-to-date method of developing academic skills is based on creating virtual simulations and sharing them by sending the products through e-mails (Zaretsky, 2003). The uniqueness of this method lies in manipulating objects over the screen by the child himself, as in many computer games (17). These exercises should be complemented by verbal interaction aimed at teaching spatial concepts and training their application. Computers were used by pairs of pupils (18).
The simulations are based on virtual reality (VR) which was defined by Pantelidis (19) as a multimedia interactive environment which is computer based and enables the user to become an active partner in the virtual world. This technology allows to present information in three dimensional formats in real time. It enables the user to become an active part of the environment and benefit from interactive communication. Thus virtual reality allows to convert the abstract into concrete by giving perspectives on processes that are impossible to be performed in the real world (20) (21).

3. RESEARCH PRESENTATION

The research included 8 teachers in 4 classes, two first-year student teachers who majored in special education (at the first year of their learning in a college of education) and 20 mentally retarded pupils at ages ranging from 8 to 20. The pupils were assigned randomly to experimental and control groups, with optimal control of intervening variables.

Procedure

Teachers' training lasted for three weeks at the beginning of the year, and consisted of three meetings, one 3-hour meeting each week. Afterwards the teachers gave model lessons to pupils under the researcher's guidance. The whole experiment lasted 14 meetings. The tests were conducted for 4 meetings per a pupil, a total of 50 minutes per a pupil before and after the intervention program which lasted for 12 weeks, two hours per a week This is a pilot research of using computer focusing on PowerPoint Software and Internet. Hence it is based on a qualitative analysis (22).

The Training Method and its Uniqueness

The method focuses on manipulating objects over the computer screen according to the context of the background presented on the screen, and reviewing the products by the peers. The teachers instruct the special education pupils how to activate the objects using their cognitive and motor abilities. The objects are taken from the pupils' everyday environment which enables them to manipulate everyday situations. Trials were held among mentally-retarded pupils. The teachers trained the pupils in pairs.

Stages of teachers' training

- Clarifying the importance and contribution of using computers for teaching, in general, and for teaching mentally retarded pupils, in particular.
- Teaching the basics of the use of the computer.
- Teaching how to create PowerPoint presentations while using up-to-date multimedia and their accessories.
- Teaching additional computer programs and integrating them with Office environment.
- Using E-Mail for communication between the teachers and student teachers, and peer reviewing.
- Exemplifying the intervention program through the computer while working with the pupils.
- Discussing and analyzing the results, then planning the next stages.

Research Tools

The research tools included:

Non-verbal tests which measure spatial abilities, along with the tests showing their achievements in mathematics and spatial intelligence.

<u>Raven matrices test</u> (23)
The participants' analytic skills are tested on the basis of their ability to complete a matrix according to logical rules.

<u>Dots test (24)</u>

<u>Ordinal Numbers (25)</u>

<u>Mathematical achievements</u> (26)
This test checks basic skills in mathematics such as ordering, sequencing, basic exercises in addition, subtraction, multiplication and division, based on the "reversal law".

Media

The Software and media used were PowerPoint and the Internet.

Evaluation

1. Comparing the level of computer products created by both teachers and pupils at the beginning, in the middle and the end of the intervention period.
2. Comparing the pupils' achievements before and after the training.

4. FINDINGS

The teachers reported pupils' high motivation and their success. The manipulations of objects over the computer screen created opportunities for experience in a variety of learning domains. Consequently, the academic achievements of the pupils increased and teacher-pupil interaction was improved.

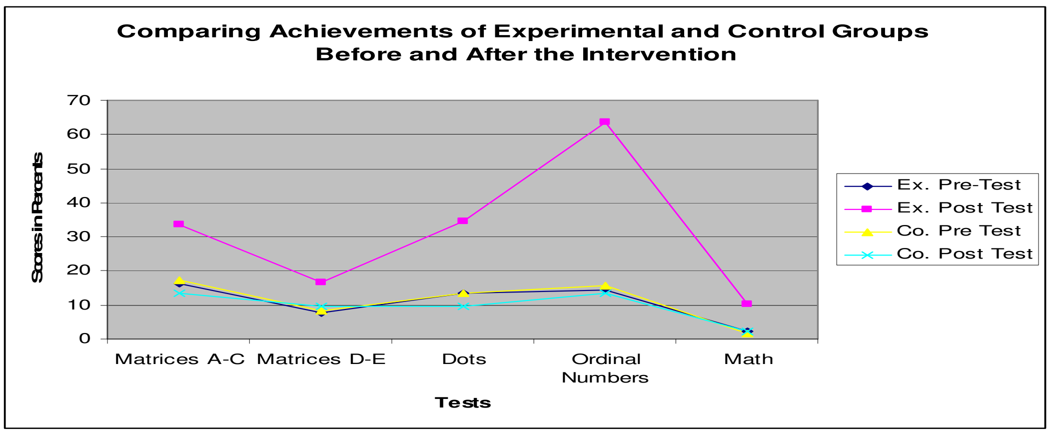
The communication between the pupils through e-mail also increased and became much better. They added words or short sentences related to their intellectual level.

They got used to finding Internet sites which fit their unique needs.

Both teachers' and pupils' computer skills and mastery were enhanced.

The mathematical achievements and spatial intelligence level of the pupils in the experimental group increased (See graph no. 1).

Graph No. 1: A Comparison between the Pre and Post Tests of the Experimental and Control Groups in the spatial Intelligence and Mathematics (The scores are in %)



The dark blue and yellow curves show a close similarity between the scores of the Experimental and Control groups before the intervention period.

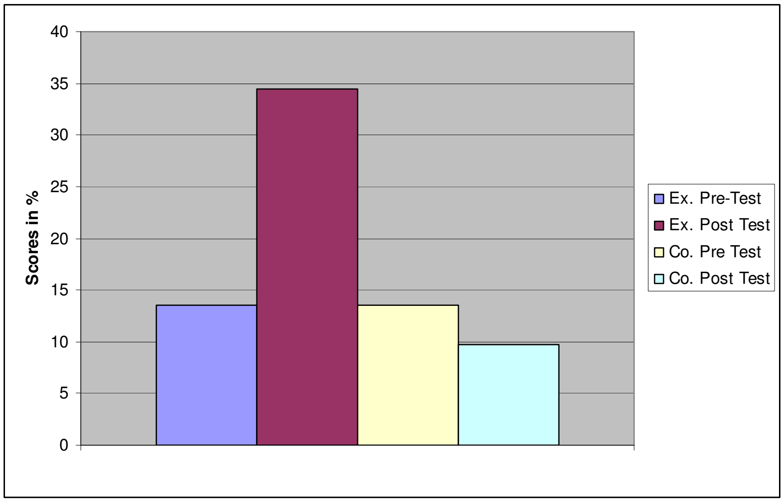
The purple curve depicts the achievements of the experimental group after the intervention period. The graph shows high improvements of the pupils in the experimental group after the intervention period in most of the skills which were examined, especially, the dots test, ordinal numbers test and Matrices of Raven (a-c)

On the other hand, the results in the control group after the intervention period, which are represented by the blue curve, show a regression in some of the tests, for example, in the dots test, where the pupils are required to copy precisely complex forms over nets of dots (See table no. 1 and diagram no. 1).

Table No. 1: A Comparison between the Pre and Post Scores of the Experimental and Control Groups in the Dots Test

Test	Ex. Pre-Test	Ex. Post-Test	Con. Pre-Test	Con.Post-Test
Dots Test	13.52%	34.52%	13.53%	9.72%

Diagram No. 1: A Comparison between the Pre and Post Scores of the Experimental and Control Groups in the Dots Test



Experimental Group Control Group

The diagram shows the improvement of the experimental group versus the regression of the control group.

It might be noticed that in spite of some improvement of the control group in the mathematical test, this improvement is still lower than the improvement found in the experimental group (final score of each group: Experimental 10%, Control 2.38%).

Changes in the Teaching Staff

- The research program developed the teachers' and student teachers' awareness of the pupils' ability to perform tests and computer tasks.
- The teachers and student teachers learned to diagnose the pupils objectively.
- Teachers' and student teachers' self-confidence in using the computer was enhanced.

The Progress of the Pupils in their Learning Process

- The pupils understood the instructions given during the computer activity, while using the concepts of the specific software (like "Insert", "Activate") and of the computer in general (like "Enter", "Esc"), according to their cognitive level.
- The pupils succeeded gradually in performing a successive set of computer acts.
- The pupils learned to create simulations on their own, while controlling the space over the computer screen.
- The use of computers changed the learning gradually from mechanical to meaningful and relevant to the pupils' everyday environments. Working with the software, the pupils used the concepts that were learned in the classroom at the same period of time. The program provides the connection between the learning via the software and the community. The spatial intelligence and mathematical achievements were improved.

5. DISCUSSION

The question raised in this research is whether developing virtual simulations, communicating through E-Mail while reviewing peers' work, and using the Internet by special education pupils could enhance their mastery of computers in everyday life, improve the academic achievements and raise the level of spatial intelligence. In spite of the heterogeneous population, a significant improvement of the spatial skills and academic achievements was recorded, as a result of different modes of training.

The teachers improved their mastery in their classroom, apparently, due to the use of computers. In addition, the teachers' self-image in using computers was enhanced. In spite of their lack of experience before the experiment, they became able to build high- level PowerPoint presentations and use them with their pupils in the classroom.

The pupils who participated in the experimental group improved their skills in the examined domains and their self-image was enhanced. Zaretsky (12) found that it is possible to advance the mathematical skills of pupils from a variety of populations (such as mentally retarded, with learning disabilities, deaf) through developing their spatial orientation by the use of the computer method which enhanced the mathematical skills (See also: 27).

Different manipulations can also be used to assess whether students understand the studied idea or just have learned to use material in a rote manner. The computer manipulations help to form connections between mathematical ideas (28). Certain computer manipulations encourage easy alterations of scale and arrangement. Such manipulations are encouraging way beyond what can be done with physical manipulations in situations that demand increasingly complex and precise specifications. Learners learn to use such manipulations as tools for thinking about mathematics. Manipulating objects over the computer screen develops the skills of improvising the organization of the space, guide learners how to alter and reflect upon their actions, predict and explain what they are doing.

6. SUMMARY AND CONCLUSIONS

Through the development of virtual simulations, communication and peer reviewing, the motivation and self-image of the teachers, student teachers and the pupils was enhanced. This situation resulted in a feedback cycle of increasing academic achievements of the pupils and enhancing all the participants' self-image and motivation for teaching/learning according to the method suggested here, which in turn positively affected the achievements.
The study presented was based on the pupils' everyday experience. The relevant spatial concepts related to dimensions and directions, should be stressed during the lessons through the computer. The teacher should verbalize the relevant concepts such as: "Go ahead and turn to the left" etc. Generally a mediated instruction, which emphasizes the language, is needed (29). The use of computers in learning and instruction is very abundant. In this research, computers were utilized in a unique dynamic and interactive mode of learning.

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