Developing Digital Simulations and its Impact on Physical Education of Pre-Service Teachers

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ABSTRACT

The creation of digital simulations through the use of computers improved physical education of pre-service teachers. The method which was based on up-to-date studies focuses on the visualization of the body's movements in space. The main program of the research concentrated on building curriculum for teaching physical education through computerized presentations. The pre-service teachers reported about their progress in a variety of physical skills and their motivation in both kinds of learning was enhanced.

Keywords: Computer Simulations, Digital Simulations, Multi-sensory, Physical Education, Technology, Computer, Virtual Reality, Visualization.

1. INTRODUCTION

Many people associate virtual reality and computer simulations with science fiction, high-tech industries, and computer games; few associate these technologies with education, mainly. They are used in applied fields such as aviation and medical imaging. These technologies have begun to edge their way into the primary classroom (1). However, only few studies concern the efficiency of virtual reality to physical education were made (see: (2) (3) (4)). The concretizing of objects makes learning more straightforward and intuitive for many students and supports a constructivist approach to learning. Students can learn by doing rather than, for example, reading about them. They can also test theories by developing alternative realities. This greatly facilitates the mastery of difficult concepts, for example, the relation between distance, motion and time (5). The virtual manipulations of the body or the objects help the students to understand the process of performing physical acts consecutively (6). Physical phenomena that are complicate to perceive or to measure in usual experiments can be presented in a virtual world and viewed in many different perspectives in a virtual reality laboratory.

Virtual reality technology allows the participant multisensory experiences coming from perceptual information visual, auditory, and tactile stimuli. According to Pizer (as cited in Reingold, (7)) the main advantage of Virtual Reality regarding perception is the ability to move and change our view of things as we would do in the real world in order to give us an adequate perception. Virtual Reality technology is developing interfaces that mirror more natural human behaviors and the given physical laws governing the objects they interact within the environment. Dynamic Simulations allow visualizing complex dynamic processes (8). Visualization enables us to show information that would not normally be available (9). Andrew and Ellis (10) remark that "Visualizations of real-world events can be accomplished, and actions might be taken depending on their nature". According to Horwitz (9) visualizations are what we choose to show users, simulations are what we let them do and models are what link the two.

The similarities between digital simulations and physical education are as following::

- Both experiences include motor activity and require inter-sensory coordination
- Both experiences refer to the basics of the motion: body, space, time, power and flow.

The use of computer also differs from physical activities in some aspects (See Table 1).

Table 1: The Differences between the Use of Computer and Physical Activity

Computer Simulations	Physical Motion
The computerized activity is performed by hands only.	The body movement includes vigorous activity of the whole body.
The computerized activity is based on visual perception.	The physical activity is based on kinesthetic perception.
The experience can be done individually or communicatively.	The movement in the learning situation serves always also as a social event.
The software focuses the relevant information on the computer screen.	The motion is related to the environment and includes many stimulations that disturb the focus of learning.

2. THEORETICAL REVIEW

Definitions

Digital-Computer Simulations are computer-generated versions of real world objects. They may be presented in two dimensional, text-driven formats, or increasingly, three dimensional multimedia formats. Computer simulations can take many different forms ranging from computer renderings of 2-D geometric shapes to highly interactive computerized laboratory experiments (11).

Virtual reality is a technology that allows students to explore and manipulate computer-generated, three dimensional multimedia environments in real time. The immersion virtual reality environments enable users to fly through space and observe objects from any angle (11). Pantelidis (12) defines virtual reality (VR) as a multimedia interactive environment that is computer based and enables the user to assimilate and to become an active partner in the virtual world. This technology enables presenting information in three dimensional formats in real time. It allows the user to become an active part of the environment and to benefit from interactive communication without using words. Thus virtual reality enables converting the abstract into concrete by giving perspectives on processes that are impossible to perform in the real world (13) (14).

Learning by Computers

Computers serve as symbol-system manipulation tools (15) (16) (17). Advances in computer technology has allowed for the development of real-time three dimensional graphics, auditory and kinesthetic environments in which the learner can be perceptually immersed. (18).

Thus, the characteristics of 3-D interactive environments, namely virtual reality are closely aligned with those of an optimal learning environment. The 3-D interactive environments that are referred to as virtual reality regarding physical activities are described as a computer created, three dimensional environment in which the student is an active participant (19) (20). The perceived advantages of the virtual environment as an instructional tool include the whole body experimental learning (21), presence (22) (23) (24), multi-perceptual engagement (25), the opportunity to change perspectives at will (26) and abstract concept representation (27) (28) (29) (30).

Virtual versus Physical Environments

The virtual reality and multimedia are similar since both of them are multi-perceptual. Visual, auditory and haptic senses are engaged to navigate and interact within the environment. It differs from multimedia in three different ways as following:

1. The whole body can be used to navigate and interact within the virtual space.
2. The technology can engender a sense of presence, the perceptual quality of being in the virtual environment, rather than in the physical space.
3. The participant has substantial control over movements and interactions within the environment, rather than navigation by pre-programmed controls.

Virtual reality is as Beardon (31) describes it "a simulation in which we are invited or perhaps persuaded to amend our belief in what is real". It is a tool for experiencing alternate views of both physically real and imagined environments.

The Uniqueness of the Virtual World and Digital Simulations to Physical Education

Ainge (32) provides evidence that virtual reality experiences can offer an advantage over more traditional instructional experiences at least within certain contexts. Ainge showed that students who created and investigated 3D solids with a desktop virtual reality programs developed the ability to recognize 3D shapes in everyday contexts, whereas peers who constructed 3D solids out of paper did not. The students who participated in the virtual reality program were more enthusiastic during the course of the study. Barnea & Dori (33) reported that the use of computer simulations improved 3D visualization. Inman & Loge (34) have created virtual reality programs that help physically disabled children to operate motorized wheelchairs successfully. Virtual Reality researchers have pioneered the use of VR (Virtual Reality) technology to help training orthopedically impaired and sight-impaired children.

The computer-generated environment simulates a busy street much as in a computer game and, through virtual reality technology, the child has the experience of driving the wheelchair. Zaretsky & Bar's research (35) proved that acting by the computer in virtual reality effected significantly the academic achievements of special education pupils regarding their spatial perception, measured by their ability to solve the Standard Progressive Matrices of Raven. The ability of these pupils to read, write and compute was also improved. Zaretsky (36) showed that many participants including students in colleges and pupils in schools, are more active and dynamic during the computerized activity, especially if the activity concerns simulations or movies that they filmed by the Eye Internet camera or by the digital camera and transferred them to the computer, while their action enhances when they create the simulations by themselves. The duration of concentration also increases.

Research founds that holding a better body image effects directly or indirectly the academic skills and especially those of reading and mathematics. When body image with **spatial intelligence** are enacted together by the use of virtual and physical motions, this spatial intelligence expresses itself through the ability to solve problems regarding spatial acts (37). The general ability of solving problems includes also the ability to decode the problem and make the correct decisions apt for such act. The spatial intelligence is consisted of two central skills which differ from one another: spatial orientation (location of objects and the relations between them) and the visualization of space (38) (39) (40), both are developed through virtual reality manipulations (35) (36).

Computer simulations and virtual reality offer students the unique opportunity of experiencing and exploring a broad range of environments, objects and phenomena within the walls of the classroom. Students can observe and manipulate normally inaccessible objects, variables and processes in real-time. The ability of these technologies to make what is abstract and

intangible concrete and manipulate suits them to the study of natural phenomena and abstract concepts, "Virtual reality bridges the gap between the concrete world of nature and the abstract world of concepts and models" (5, p. 294)

Virtual worlds can be linked to the physical world through telepresence, where distant learning systems could be expanded to allow students and teachers to share worldwide learning environments. Real-time access to a multitude of people and information sources opens the virtual world – and the classroom – to the world. Virtual reality learning environments allow entirely new capabilities and experiences. The users have unique capabilities, such as the ability to fly through the virtual world, to occupy any object as a virtual body. Observing the environment from many perspectives is both a conceptual and a social skill: enabling pupils to practice this skill in ways we cannot achieve in the physical world may be an especially valuable attribute of virtual reality. Dynamic programming software enables to add viewpoint control, command structures, manipulations of objects, movement constrains, animations and object behaviors. One instance of the virtual reality is the "Tetris game" that was investigated also in our country (35).

Summing up, Computer-simulated environments are becoming more and more realistic, offering a real-world experience.
The research was aimed at exploring the effect of computer manipulations on the physical performance and the ability to train physical education by college students.

3. METHOD

Research Group

The research group consisted of 22 students who major in physical education. The investigation was carried out in the mode of a longitudinal qualitative research (41) during one semester (4 months).

Research tools

The students filmed themselves by digital video cameras and incorporated these movies with the virtual simulations they created through PowerPoint Presentations, in order to build units of instruction for training and teaching physical education.

The method of training focused on enacting the objects relating to the physical environment. The objects are taken from the everyday environment of the pupils, which enable them to manipulate everyday situations.

Evaluation

Evaluating the improvement of the performance of physical movements that were inspired by computer-based learning was made.

4. FINDINGS

It was found that the intervention program computer-based effects the following:
Improving the student teachers' planning of their movements, improving the student teachers' physical skills and performance in the physical education lessons, increasing their motivation for learning.
This was apparent, for example, in swimming, ground gymnastic, running etc.

The students' ability to use the computer improved.
Table 2: A Comparison between the Numerical Values given by the Students at the Starting and Ending of the Semester
Data is based on questionnaire filled by the students (likert scale 1-5)

	Starting Semester		**Ending Semester**	
	SD	M	SD	M
Level of using computer	0	5	0.84	1.45
Building PowerPoint presentation	0.38	4.82	0.65	0.41
Awareness to the relationship between computer and physical education	0.57	4.64	0	0
Awareness to the impact of building presentations on physical education	0.66	4.5	0	0

Before the course the students did not realized the impact of the Computer on Physical Education. But after it:

Table 3: Samples of Reactions of Students Regarding the Impact of their Use of Computers on their Physical Performance and Ability as Physical Educators

	Reaction
Awareness to the relationship between computer and physical education	The method enables: • Dynamic use of the computer • Transferring knowledge about various domains of sport • Increasing motivation, • Introducing the directions visually, • Saving the products for other lessons and even next years.

These reports showed that the students realized the impact of the enacting of virtual motion demonstrated over the computer screen on improving their physical performance of movements in the lessons. Simultaneously, the students improved their level of using computers by training them to create digital simulations of motion in space, gradually, when their self image as computer users was improved. Consequently, the students' ability to build virtual reality, by using the computers, improved their training of planning both their computer products and body movements, and the exercises they made for physical education in their own practical classes.

Table 4: Example of the Connection between the Acts Performed during Training by Computers and the Ability to Analyze A Motor Skill:

Training by Computers	**Analyzing Jumping into the Swimming Pool**
The shape/ object appears on the computer screen.	Standing on the spring board
Planning the required direction of the shape/ object (planning the next step of the activity)	Choosing the appropriate position and distance from the swimming pool
Adjusting he shape/ object to the appropriate direction	Adjusting the position of the hands and legs in order to jump correctly.
Navigating the shape/object down and to the right or to the left side	Navigating to the sides, and jumping into the swimming pool, then swimming in the pool. .

A comparison of the student teachers' level of using the computer with their answers to the questionnaire indicated that as the use of the computer as well as their level increased, the student teachers realized the connection between manipulating virtual reality and physical activities. Consequently, the student teachers improved their PowerPoint presentations, gradually. They planned the virtual movements over the computer screen, for example: running, swimming,, jumping etc.

The Contribution of the Computer Activity to Physical Skills According to the Answers Given through the Open Questionnaire

The student teachers filled the open questionnaire before and after practicing the building of computerized presentations.
Before training the computer, the student teachers did not realize the connection between the PowePoint software and physical skills.
But after the training:

Table 5: Samples of Answers Regarding the Impact of Using the Computer on Physical Skills

The Skill	**The Answers**
Planning	Predicting and planning the next movement/position in space that applies the given situation.
Thinking	Thinking precisely, Developing spatial and motion thinking, Improvising movements in changing environments.
Orientation in Space	Orienting in narrow spaces, Controlling the directions in space in various environments.
Motor	Developing fine motor
Body Image	Increasing body balance
Concentration and Persistence	Improving concentration and persisting on the task until succeeding it.

Simultaneously, the student teachers improved their level of using computers by training them to use and create digital simulations of motion in space, gradually, when their self-image as computer users was improved. Consequently, the student teachers' ability to build virtual reality, by using the computers, improved their training planning and the exercises they made for their practical work in physical education.
Afterwards the student teachers used their presentations with pupils and reported about progress in performing physical activities relating especially jumping, swimming, ground gymnastic, shooting and motion games.

5. DISCUSSION

The question raised in this article is weather the creation of digital simulations will effect physical education. In spite of the short time of training and the absence of experience in using computers before the training, a significant improvement of the participants' physical skills was recorded, as a result of the different mode of training.

Virtual Reality and Constructivism

According to the constructivist theory, the Immersive Virtual Reality enables first-person experiences by removing the interface that acts as a boundary between the participant and the computer. This is the only way, in which each person constructs his/her knowledge of the world visually, from direct experience in the real world, as portrayed by the Computer, without the need for symbolic descriptions of the experience (28).
Constructivism focuses on tools and environments that help learners to interpret the multiple perspectives of the world by creating their own version of it (42). Through making virtual reality tools and environments available to educators, we may discover more regarding the process of learning. By participating in the development of virtual reality, educators can follow the growing of the use of the technology, and perhaps influence the framework of educational change. Immersive Virtual Reality allows physical and perceptual interactions to occur.

Constructivism and Learning in Technological Environments

An important component of constructivist theory is to focus a child's education on authentic tasks. These are tasks which have "real-world relevance and utility, that integrate those tasks across the curriculum, that provide appropriate levels of difficulty or involvement" (43, p. 29).
According to constructivist theory, children learn whole to part, not incrementally. The ideas and interests of children lead the learning process. Teachers are flexible; sometimes they are the giver of knowledge, but often are the facilitator (44). Bagley and Hunter (45) say that active learning leads to greater retention and higher level of thinking. And as knowledge continues to double every two years, and since it also has a shelf life, students must learn to access information; there is now far too much information to memorize.

In a technology-rich environment we have to remember that the educational focus is on learning and instructional goals instead of the technology itself, because technology is merely tools or vehicles for delivering instruction (46). We have to

focus on the way of using the equipment which makes it relevant to a constructivist classroom (44).
Studies show that in technology-rich classrooms there are many observable changes such as: Students are more actively engaged; students become more cooperative and less competitive; Students learn different things instead of all students learning the same thing; there is an integration of both visual and verbal thinking instead of the primacy of verbal thinking (47).
In one study, student self-esteem and motivation in a technology-rich environment was measured and found to be strong. In addition, student attendance was up and discipline problems were reduced. Students were also coming in on their own time--lunch, recess, after school--to work on their projects. Students shifted from being competitive to collaborating on projects (48).

Learning by Technological Manipulations of the Real-World

Manipulations must be used in the context of educational tasks to actively engage children's thinking with teacher guidance (49). Different manipulations' methods allow, and even encourage, students to choose their own representations material, can also be used to assess whether students understand the idea or just have learned to use material in a rote manner. Certain computer manipulations encourage easy alterations of scale and arrangement, thus they go beyond what can be done with physical manipulations and demand increasingly complex and precise specifications. The Computer Manipulating guides students to reflect on their actions and alter them by predicting and explaining (50). We can add here the improvement of the physical skills, initiating from the student's need to understand the meaning of the movements, the relationships between them and how to perform them successfully.
Gorsky & Finegold (51) reported on the development and application of a series of computer programs which simulate the outcomes of students' perceptions regarding forces acting on objects at rest or in motion. The dissonance-based strategy for achieving conceptual change uses an arrow-based vector language to enable students expressing their conceptual understanding.
According to Mann (52), Students in educational settings utilizing new technologies become empowered by gaining access to real data and work on authentic problems. Often, roles are reversed as teacher and student learn from one another.
Strommen & Lincoln (44) stress the importance of the way of using the technology. "The key to success lies in finding the appropriate points for integrating technology into a new pedagogical practice, so that it supports the deeper, more reflective self-directed activity children must use if they are to be competent adults in the future" (44, p. 473), e.g. computers and other technology should be viewed as tools which are an integral part of a child's learning experience.
It has been suggested by LeBaron & Bragg (53) that the role of technology in education is so important, that it will force the issue of didactic versus constructivist teaching. Teachers will no longer have a choice but will be compelled to use a constructivist approach in a technology-rich environment.

The Significance of Virtual Reality to Learning and Thinking According to the Constructivism

The significance of virtual reality to education is expressed by comparing the implications of Objectivism to those of Constructivism: Objectivism and Constructivism represent alternative conceptions of learning and thinking (54). Objectivism assumes that the role of mental activities is to represent the real world and that the role of education should focus on helping students to learn about the world and replicate its content and structure in their thinking. Whereas Constructivism claims that to a certain extent we construct our own reality through interpreting perceptual experiences, that reality is both in the mind of the knower and in the object of their knowing. Constructivists, rather than prescribing learning outcomes, focus on tools and environments to help learners to interpret the multiple perspectives of the world in creating their own view of it (55). Through making and using virtual reality tools and environments, which are now available to educators, we may discover more about the process of learning. By participating in the development of virtual reality, educators can guide the growth of using this technology, and perhaps influencing the course of educational change.
Computer assisted manipulations guide students to alter and reflect upon their actions, always predicting and explaining. Virtual reality environment is unique in its dynamic representation. Success in building simulations of the real world has its motivating effect on the participants and thus enhances the effect of the training. In this research the effect of the computer simulations on the improvement of physical skills was found.

6. SUMMARY AND CONCLUSIONS

The present study showed that the use of the computer enhanced the physical performance of 22 pre-service teachers, especially while performing in complex movements. The building of digital simulations showed the students that it serves as a mediator for developing physical skills, such as running, swimming, using instruments of gymnastic, ground gymnastic etc. During the computerized creation process, which facilitated the virtual mode, the pre-service teachers realized how the correct mode of their movements should be executed, and which methods to use for improving the plans of physical movements in order to perform them consecutively successfully and fluently. These improvements were also used to design their teaching programs for their future pupils.
To summaries:

- The computer enables the translation of the virtual movement to the real world. When experiencing, the software utilizes dynamic simulations of the learners' environment.
- This method results in improvement of performing physical activities of both, the students in the college and their pupils at school.

The contribution of digital simulations to physical activities is thus focusing on the important findings as following::

- Dynamic simulations allow to visualize complex dynamic processes (8)
- The use of the computer improves 3D visualization and spatial intelligence.
- Virtual reality develops the ability to recognize 3D shapes (33)
- Digital simulations assist to decode the problems and improve the performance.

7. REFERENCES

[1] N. Strangman, T. Hall, and A. Meyer, "Text Transformations". **A Research Paper of the National Center on Accessing the General Curriculum (NCAC).** 2003.

[2] D. Passig, "Sport, Athletics and Virtual Reality". ***Passig E-zine # 27*** **Unsubscribe, Future Law Enforcement Technologies,** 2004**.** http://www.passig.com.

[3] D. Passig, & S. Eden, "Enhancing the Induction Skill of Deaf and Hard-of-Hearing Children with Virtual Reality Technology". **Journal of Deaf Studies and Deaf Education**, Vol. 5, No. 3, 2000, pp. 277-285. Oxford University Press.

[4] W. D. Winn, "Learning in Virtual Environments: A Theoretical Framework and Considerations for Design". **Educational Media International**. Vol. 36, No. 4, 2000, pp. 271-279.

[5] Y. Yair, R. Mintz, S. Litvak, 3D Virtual Reality in Science Education: An Implication for Astronomy Teaching. **Journal of Computers in Mathematics and Science Education,** Vol. 20, No. 3, 2001 pp. 293-301.

[6] T.B. Sheridan, **Telerobotics, Automation, and Human Supervisory Control.** MIT Press, Cambridge, Mass, 1992.

[7] H. Rheingold, **Virtual Reality.** New York: Touchstone, 1991.

[8] H. S. Muscott, T. Gifford, "Virtual Reality Applications for Teaching Social Skills to Students with Emotional and Behavioral Disorders"**. VR Conference Proceedings,** 1994.

[9] P. Horwitz, "Designing Computer Models that Teach", in **Computer Modeling and Simulation in Pre-College Science Education**, 1999, pp. 179 - 196, Nancy Roberts and Wallace Feurzeig, eds., Springer Verlag.

[10] I. Andrew, S. Ellis, Behavioral Modeling in VR. **Virtual Reality Systems**, Vol. 1, No. 2, 1993, pp. 84-87.

[11] N. Strangman, & T. Hall, **Virtual Reality/Simulations**. Wakefield, MA.: National Center on Accessing the General Curriculum, 2003.

[12] V. Pantelidis, "Reasons to Use VR in Education". **VR in the Schools,** Vol. 1, 1995, p. 9.

[13] M.S. Darrow, "Increasing Research and Development of VR in Education and Special Education", **VR in the School**, Vol. 1, No. 3, 1995, pp. 5-8.

[14] K.M. Osberg, "Virtual Reality and Education: Where Imagination and Experience Meet", **VR in the Schools, Vol.** 1, No. 2, 1995, 1-3.

[15] A. Kay, "User Interface: A Personal View". In L. Brenda (Ed.), ***The*** **Art of Human-Computer Interface Design. Reading,** MS: Addison-Wesley Publishing Company, Inc., 1990.

[16] T. Duffy, & R. Jonassen, (Eds.) **Constructivism and the Technology of Instruction: A Conversation.** Hillsdale, NJ: Lawrence Erlbaum, 1992.

[17] W. Winn, "Virtual Reality Roving Van Project". **T.H.E. Journal,** Vol. 5, No. 12, 1995.

[18] M. Scardamalia, C., Bereiter, R.S., McLean, J Swallow,. & E. Woodruff, "Computer-Supported Intentional Learning Environments".. **Journal of Educational Computing Research,** Vol. 5, No. 1, 1989. pp. 51-68.

[19] M. Bricken, 1991 "Virtual Reality Learning Environments: Potential and Challenges". **Computer Graphics**, ,Vol. 25, No. 3, pp. 178-84.

[20] M. Bricken, & C. Byrne,. **Summer Students in Virtual Reality: A Pilot Study on Educational Applications of Virtual Reality Technology.** Seattle, WA: Human Interface Technology Laboratory at the University of Washington, Technical Publications , 1992, R-92-1.

[21] K.M. Osberg,. **Virtual Reality and Education: A Look at Both Sides of the Sword.** HIT Lab Technical Report R-93-7. Seattle: Human Interface Technologies Laboratory, 1993a.

[22] H.G., Hoffman, K. Hullfish, & S.J. Houston,. **Virtual Reality Monitoring.** VRAIS '95 March 11-14, 1995. Chapel Hill, NC. Los Alamitos, CA: IEEE Computer Society Press, 1995.

[23] H. Hoffman, J. Prothero, M. Wells, & J. Groen, **Virtual Chess: Meaning Enhances the Sense of Presence in Virtual Environments**. HIT Lab Technical Report, 1996, P-96-3.

[24] W., Barfield, & S. Weghorst, "The sense of Presence within Virtual Environments: A Conceptual Framework". In G., Salvendy, & M.J. Smith, (Eds.) **Human-computer interaction: Software & Hardware Interfaces,** 1993, pp.699-704,. Amsterdam: Elsevier**..**

[25] L, Brill, "Metaphors for the Traveling Cybernaut Virtual Reality**)". Virtual Reality World**, Vol. 1, No. 1, 1993 Q-S.

[26] C., Dede, M., Salzman, & R. B. Loftin,. **The Development of a Virtual World for Learning Newtonian Mechanics.**. Originally published in the Proceedings of the Multimedia, Hypermedia, and Virtual Reality conference, MHVR ?94. Berlin: Springer-Verlag, . 1996.

[27] C. M. Byrne, **Water on Tap: The Use of Virtual Reality as an Educational Tool.** Unpublished Ph.D. Dissertation, University of Washington, College of Engineering, 1996.

[28] W. Winn, **A Conceptual Basis for Educational Applications of Virtual Reality.** HIT Lab Technical Report R-93-9. Seattle: Human Interface Technologies Laboratory, 1993.

[29] W. Winn, . "It?s Virtually Educational," **Information Week,** March Vol. 28, 1994, p36.

[30] W., Winn & W. Bricken, "Designing Virtual Worlds for Use in Mathematics Education: the Example of Experiential Algebra", **Educational Technology**, Vol. 32, No. 12, 1992., pp. 12-19.

[31] C. Beardon, "The Ethics of Virtual Reality", **Intelligent Tutoring Media**, Vol. 3, No. 1, 1992, pp.23-28.

[32] D.J. Ainge, "Upper Primary Students Constructing and Exploring Three Dimensional Shapes: A Comparison of Virtual Reality with Card Nets". **Journal of Educational Computing Research,** Vol. 14 No. 4, 1996, pp. 345-369.

[33] N. Barnea, Y. J. Dori, "High-School Chemistry Students' Performance and Gender Differences in a Computerized Molecular Modeling Learning Environment". **Journal of Science Education and Technology,** Vol. 8 No. 4, 1999, pp. 257-271.

[34] D.P. Inman, K. Loge, "Teaching Motorized Wheelchair Operation in Virtual Reality. Oregon Research Institute Virtual Reality Labs". ***VR Conference*, Virtual Reality and Persons with Disabilities,** Center on Disabilities. California State University: Northridge, 1995.

[35] E. Zaretsky, V. Bar, "Intelligent Virtual Reality and its Impact on Spatial Skills and Academic Achievements". **The 10th International Conference on Information Systems Analysis and Synthesis: ISAS 2004 and International Conference on Cybernetics and Information Technologies, Systems and Applications: CITSA,** Vol. 1, 2004, pp. 107-113.

[36] E. Zaretsky, "Telecommunication in Special Education Pupils for Lraining their Basic Skills". **The 9th International Conference on Computer, Communication and Control Technologies (CCCT '03),** Orlando, U.S.A., Vol. IV, 2003, pp.237-241.

[37] H. Gardner, **Extraordinary Minds: Portraits of Exceptional Individuals and an Examination of our Extraordinariness.** New York: Basic Books, 1997.

[38] M. G. McGee, "Human Spatial Abilities: Psychometric Studies and Environmental, Genetic, Hormonal, and Neurological Influences". **Psychological Bulletin,** Vol. 86, 1979, pp. 889-918.

[39] K.M. Osberg, **Virtual Reality in Education: A Look at Both Sides of the Sword.** Seattle, WA: Human Interface Technology Laboratory at the University of Washington, Technical Publications , 1992, R-93-7.

[40] K.M. Osberg, "Spatial Cognition in the Virtual Environment". **Human Interface Technology Laboratory, University of Washington, Washington** [Online]. http://www.hitl.washington.edu/publications/r-97-18 , October Vol. 3, 1997a).

[41] O. Hetsrony, U. Shalem, "Alternative Facilitative Communication – Using Cards of Symbols for Autistic Children". **Topics in Special Education and Rehabilitation,** Vol. 13, No. 1, 1998, pp. 33-43 (In Hebrew).

[42] D.H. Jonassen, **Objectivism vs. Constructivism: Do We Need a New Philosophical Paradigm?** University of Colorado in Boulder (unpublished), 1990.

[43] D. H. Jonassen, "Evaluating Constructivistic Learning". **Educational Technology**, Vol. 31, 1991, pp. 28-33.

[44] E. F. Strommen, & B.. Lincoln, "Constructivism, Ttechnology and the Future of Classroom Learning". **Education and Urban Society**, Vol. 24, 1992, August, pp. 466-476.

[45] C. Bagley, & B. Hunter, "Restructuring, Constructivism, and Technology: forging a New Relationship". **Educational Technology,** Vol. 32, 1992, July, pp. 22-27.

[46] R.. Campoy, "The Role of Technology in the School Reform Movement". **Educational Technology**, Vol. 32, 1992, August,. pp..17-22.

[47] A. Collins, "The Role of Computer Technology in Restructuring Schools". **Phi Delta Kappan**, Vol. 73, 1991, September, pp. 28-36.

[48] D. C., Dwyer, C.. Ringstaff, & J. H Sandholtz, "Changes in Teachers' Beliefs and Practices in Technology-Rich Classrooms". **Educational Leadership**, Vol. 48, 1991, May, pp. 45-52.

[49] D.H. Clements, "'Concrete' Manipulatives, Concrete Ideas". **Contemporary Issues in Early Childhood,** Vol. 1, No. 1, 1999, pp. 45-60.

[50] D. H. Clements, S. McMillen, "Rethinking "Concrete" Manipulatives". In D. L. Chambers (Ed.), **Putting Research into Practice in the Elementary Grades** (pp. 252-263). Reston, VA: National Council of Teachers of Mathematics, 2002.

[51] P., Gorsky, & M. Finegold, "Using Computer Simulations to Restructure Students' Conceptions of force". **Journal of Computers in Mathematics and Science Teaching,** Vol. 11, 1992, pp. 163-178.

[52] C. Mann,." New Technologies and Gifted Education". **Roeper Review**, Vol. 16, pp. 1994, February, pp. 172-176.

[53] , J. F. LeBaron & C. A. Bragg, "Practicing What We Preach: Creating Distance Education Models to Prepare Teachers for the Twenty-First Century". **American Journal of Distance Education,** Vol. 8, 1994, pp. 5-19.

[54] N. Goodman, **Of mind and other Matters,** Cambridge, MA: Harvard University Press, 1984.

[55] D. H. Jonassen, **Objectivism vs. Constructivism: Do We Need a New Philosophical Paradigm?** University of Colorado in Boulder (unpublished), 1990.