

# The Inter-Disciplinary Impact of Computerized Application of Spatial Visualization on Motor and Concentration Skills\*

Esther Zaretsky

Giv'at Washington Academic College of Education

D.N. Evtah, 79239, Israel

## ABSTRACT

The present inter-disciplinary research is aimed at investigating the impact of computerized application of spatial visualization on motor and concentration skills. An experiment composed of experimental and control groups for checking the central hypothesis among subjects of the same age group was carried out by physical education MA students. Virtual simulations offer MA students and teachers the unique opportunity to observe and manipulate normally inaccessible objects, variables and processes in real time. The research design focused on a qualitative research comparing the pupils' percents of success in spatial visualization and motor skills between pre- and post-training. The findings showed that just as the students realized the experimental group pupils' achievements, the computer's inter-disciplinary impact on motor performance and concentration skills became clear to the MA students. The virtual computerized training based on spatial visualization mostly contributed to the inter-disciplinary research, physical education and communication. All the findings lead to the conclusion that computerized application of spatial visualization seem to mediate between virtual reality and developing motor skills in real time involving penalty kick, basketball, jumping, etc.

Keywords: Computerized Application, Communication, Concentration, Education, Inter-disciplinary, Motor Skills, Research, Spatial Visualization.

## 1. INTRODUCTION

Customarily, research science has been limited in its approach to investigate one specialized discipline at any one time. This approach is particularly evident in medical science where, for example, there is specialization in dental medicine, the hand or foot, knees and hips, and so on. Inter-disciplinary research, too, which has been gaining ground lately, is based on cooperation among researchers that specialize in sub-divisions of a particular specialization. (1) (2). The present inter-disciplinary research focuses on an integration of computers, spatial visualization, motor and concentration skills while examining the inter connections between them.

## 2. THEORETICAL REVIEW

Seemingly, the disciplines of computers and physical education are contradictory since most physical educators do not use computers in their lessons. There is existing research that shows the connection between virtual simulations and science (3), and also between virtual simulations and medical imaging (4). Before their practical teaching experience with their pupils, the MA physical education students are skeptical regarding the inter-disciplinary impact of the computerized

application of spatial visualization on ADHD pupils' motor performance. The computerized application focuses on visualizing figures that appear over computer screens randomly, and rapidly change their position in space while learners or just players are manipulating them as required.

In order to understand the interconnections between the concepts: inter-disciplinary research, computerized application, spatial visualization and the achievements gained in motor and concentration skills, it is required to explain each of them separately, and then to interpret the connection between them in theoretical studies.

### Inter-Disciplinary Research

Callaos and Horne (5) studied deeply the issue of inter-disciplinary research focusing on thinking and reflecting and even doing some research on the concept of notion that inter-disciplinary study is "the most under-thought critical, pedagogical and institutional concept in modern academy" (6). This concept is generating countless specialties, sub-specialties and sub-sub-specialties, with their respective special languages; which were "created for discrete local areas of research based upon the disconnected branches of science." (7) "On the other hand, scientific, technical and societal problems are requiring multi- or inter-disciplinary consideration." The pedagogical concept includes also the education that is in our case, physical education.

**Communication** exists between pupils and computers for knowledge creation (5). The pupils manipulate the objects over the computer screen according to the situation.

### Spatial Visualization

According to McGee's review (8), 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: 9, 10, 11). 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 (9). Virtual reality technology allows the participant to feel multisensory experiences coming from perceptual information: visual, auditory, and tactile stimuli. According to Pizer (12, as cited in Rheingold), 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. Simulations allow visualizing complex dynamic processes. Visualization enables us to show information that would otherwise be hard to come by.

### Motor skill

The domains of development (social, emotional, motor, cognitive and language) are tightly interrelated. The development and transformation of a single domain influences

\* Successful Attempt at Teaching Novice Computer Users

the formation and development of others. Movement is very important during a child's development. It shapes the body scheme, the sense of time and space, and the ability to plan and adapt. It promotes self-esteem, self-confidence and an individual's motor skills. Movement also advances motor learning, sense of cooperation, respect and diversity (13). Motor function relies upon gesture skills. Skillful movement should be precise, planned, and executed in the shortest possible time with the least possible expenditure of energy (14).

#### **Deficit and Hyperactivity Disorder Attention (ADHD) Skill**

Attention-deficit hyperactivity disorder (ADHD) is one of the most prevalent disorders in children (15). It is characterized by inattention, hyperactivity, and/or impulsivity and has a negative impact in many areas of children's life. In a classical theoretical model of ADHD, inhibition has been proposed as the principal deficit of this disorder (16). This inhibition deficit is thought to alter the efficiency of four executive neuropsychological functions: working memory, self-regulation of affect, internalization of speech, and reconstitution. This model predicts that such inhibition and executive functions difficulties have a negative impact on motor control. (17). Children with ADHD who exhibit high rates of delinquency are at risk for later substance use and may require targeted prevention, intervention, and follow-up services. (18).

#### **The Interconnections between the Concepts**

##### **Spatial Visualization and Motor Skills**

Computer simulations, based on spatial visualization, for example, have helped conduct research on tennis and table tennis and have recently led to proposed changes in ball, racket and surface regulations. Also of interest to player and scientist alike are the interactions between racket and ball, ball and surface, and player and surface (19). The simulations are based on virtual reality (VR) which was defined by Pantelidis (20) 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 reality by giving perspectives on processes that are impossible to be performed in the real world (21) (22).

In particular, science has been helpful in defining training computerized programs to improve players' fitness; guiding players nutritionally and psychologically in their preparation for competition; informing players of the strategy and tactics used by themselves and their opponents; providing insight into the technical performance of skills; understanding the effects of equipment on playing; and accelerating the recovery of players from injury (19).

##### **Motor and Concentration skills**

Taking necessary time to reflect on the purpose and outcomes of movement skills, which may be difficult for some children with ADHD and children with movement difficulties (8), is related to an awareness of the important meta-cognitive skills of error deduction, planning, and monitoring of actions (9).

Thematic analysis of physical activity experiences of 12 age-matched boys with and without the attention deficit hyperactivity disorder (ADHD) (23) revealed the differences that were found between these two groups.

Examples of differences between boys with and without the attention deficit hyperactivity disorder (ADHD) are such as: the boys with ADHD reported that while playing with friends they paid little attention to detail as compared to the boys without ADHD who reported while playing with friends

they paid a lot of attention to detail. Furthermore, the boys with ADHD experienced limited motor activity experiences and had limited acquired knowledge (24) while the boys without ADHD experienced non-limited physical activity experiences and had non-limited acquired knowledge. The research that deals with the connection between ADHD and computers mostly refers to the physiological-medical aspect.

#### **Motor and Concentration Skills through Spatial Visualization**

Wii Sports that are based on spatial visualization provided disabled children with chances to play sports just like children without disabilities (25). The Virtual Golf game involves hitting computer-generated golf balls by swinging a real club. Watching to see where the ball goes on the simulated golf course that is displayed on the screen, players can monitor the distance and accuracy of each shot and work on making their swing better (26). The present research focuses on the connection between spatial visualization, learning and coordination.

Since the impact of computerized training based on spatial visualization on motor skills might seem a bit unlikely (although video replay technology is already being used in many sports), we selected the computerized application "Bobblehead Basketball" to show this impact by using it to improve ADD/ADHD pupils' various motor skills. Doctors, pilots, and astronauts routinely use computers to learn new skills, and to perfect those they already have (27). We have not found yet other researchers dealing with the impact of practicing this computerized application on improving ADD/ADHD pupils' real-motor skills in physical education lessons. Steinberg et al. (28) found that "obese children with associated disorders such as perceived clumsiness or Attention Deficit Hyperactivity Disorder (ADHD) will have reduced balance ability and are more likely to exhibit motor abnormalities compared to obese children with no associated disorders."

#### **The Computerized Application as a Mediator between Spatial Visualization and Motor Skills**

Nowadays, new computerized applications do not include learning levels, instructional remediation and algorithms of learning and assimilation. There are a variety of applications but only some of them can apply specific inter-disciplinary training. In the present research, the computer application serves as a means for measuring the pupils' achievements in motor and concentration skills.

The computer application "Bobblehead Basketball" requires manipulating virtually while the users race to shoot the ball into the basket on the screen. In the game, the pupils simulate the position and the proper direction on the game board. They adjust the players in the suitable direction, 'navigate' the hands of the game player up or down, to the right or left side in order to shoot the ball into the basket. The pupils need eye-hand coordination for controlling the ball over the game board. The pupils successfully manage to control the ball over the game board. It links the concrete and the symbolic by means of feedback. The manipulations of the figures' hands and the ball over the computer screen (rotating them up or down, to the right or to the left side) link the symbolic commands to a sensory-concrete turning action (22).

The technology enables presentation of information in three-dimensional formats in real time (29) (30) Situations which are too complicated to perceive in a real time learning environment can be presented and viewed in many different perspectives in a computerized application environment (31). Such an environment can provide the opportunity to repeatedly practice a skill without the fear of injury or embarrassment. The reported effects on children include: gaining a new perspective (30),

increasing participation and access (29) (30), and instilling a sense of confidence, competence, self-control and mastery (30).

### 3. RESEARCH PRESENTATION

#### Procedure

The research group included 45 MA physical education college students – tutors of ADD/ADHD elementary and high school pupils in the training program. The course lasted three months and included five stages: learning the rationale of the course, explaining the rationale of the method and its application among their ADHD pupils, randomly assigned to experimental and control groups. Each participant in the course worked with a group or groups of pupils.

#### The Research Method

The students planned their research and reported on each stage they completed.

#### The Main Stages of the Inter-Disciplinary Research

We took longitudinal research as our model (32). The course lasted one semester (actually only three months) and included five stages:

Stage 1: Learning the rationale of improving real-time motor skills in physical education lessons by computerized application training.

Stage 2: Planning research:

- Choosing pupils diagnosed with ADD/ADHD.
- Testing the achievements in the examined skills.
- Building and performing virtual activities.
- Explaining the rationale of the computerized application and training with it.

Stage 3: Retesting the achievements in the examined skills.

Stage 4: Data processing and analysis.

Stage 5: Writing the research report.

The students wrote their analysis using a professional PowerPoint presentation, and related practice to theory.

This article presents a representative student research (33), conducted within the course framework.

#### Objectives and Media

The overall objective was to improve the pupils' physical performance, focusing on dribbling and shooting the ball into the basket, and also the behavior in their physical education lessons. The secondary objective was to raise the pupils' motivation, self-perception, self-confidence and diligence in carrying out their tasks.

Media: The computerized application "Bobblehead Basketball" based on spatial visualization was used especially to improve motor skills. In order to shoot the ball into the basket, the player has to press on the left button of the computer mouse and navigate it to the figure 'hands' in the appropriate position for shooting the ball. The player then releases the ball by releasing the mouse button.

The pupils learn how to deal with losing control of the ball over the game board. They manage to shoot the ball into the basket with different degrees of difficulty.

The subjects of this research were ten ADHD 4<sup>th</sup> grade pupils (girls) randomly assigned to experimental and control groups with optimal control of intervening variables, namely classroom, age, sex, socio-economic background and concentration skills.

#### Research Tools

Figures Test (34) aimed at discrimination between right and left on another person.

Motor test composed of dribbling a ball along the course of slalom, reversing the direction and repeating the same dribbling activity, then shooting the ball into the basket.

#### A Description of the Training Program

- Choosing pupils diagnosed as having ADD/ADHD.
- Constructing dribbling and shooting tests:
  - Dribbling on a marked course: The pupils were asked to dribble while looking at the area around them in order to be able to make detours around the cones.
  - Checking the pupils' shooting performance.
- Checking the discrimination between the figures.
- Training spatial visualization using computerized application.
- Rechecking the pupils' dribbling, shooting and discrimination between the figures.

#### Hypothesis

The achievements (percents of success between pre- and post-training) of the experimental group's pupils who train with the computerized application are expected to be higher than those of the control group's pupils who do not get any computerized training in the course of this program.

#### The Research Process

The research lasted a month. Every pupil in the experimental group made 10 trials with the computerized application, two meetings with each pupil. During the research process, the application was not accessible to the pupils. Its use was limited to the training with the MA college student.

The tests were administered before and after the training.

The computerized training took place in the school library and the motor tests took place in the school yard with cones and a basketball. The student met the pupils individually.

#### Evaluation

Evaluations were made on comparing:

- The students' level of writing the research and planning the training program.
- The pupils' percents of success in spatial visualization and physical skills between pre- and post-training.

### 4. FINDINGS

The findings show an improvement in the pupils' achievements in all the capabilities we checked: dribbling ability along the cone course and shooting the ball into the basket, including 2D and 3D space-related skills. In addition, the MA students that participated in the research became more aware of the inter connection between the contrasting disciplines and also between the theoretical-scientific approach they used in their research and its application.

The research showed that the students' reports became then clearer and more detailed as well (See table 1). Furthermore, the motivation and self-confidence of the MA students and pupils were enhanced.

Table 1: An Example of Differences between the Level of Research Performance of the Students at the Beginning and the End of the Course

Start of Course	End of Course
Focusing exclusively on theory.	Applying the theory to teaching

Start of Course	End of Course
Editing the research, in general, without using authentic examples	Editing the research according to the standards.  Using examples taken from the computerized application of spatial and motor skills.
Writing long, complex sentences related to one motor skill only.	Writing brief, structured sentences, focusing on real world motor skills and computerized application training.
Copying the articles' text.	Writing the text in their own words.
Focusing on some objectives.  Having difficulty differentiating between primary and secondary objectives.  Having difficulty formulating the assumptions.	Focusing on the main objectives and assumptions.
Having difficulty planning a research project including more than one pupil based on qualitative research, assigning the pupils (up to 20) to experimental and control groups.	Planning and performing a research project including experimental and control groups.  Performing qualitative research.  Checking the pupils' achievements before and after training.
Mixing results and discussion.  Misunderstanding the impact of training with computerized application on motor and concentration skills.  Misunderstanding the issue of inter-disciplinary research especially in the context of the former contrast ones.	Differentiating between results and discussion,  Summarizing briefly each table showing the results.  Concentrating on the discussion and analyzing the results according to theory.  Emphasizing the inter-disciplinary impact of the computerized application training based on spatial visualization on motor and concentration skills.

All the MA students succeeded in their studies, while their experimental group's pupils achieved high percents of success between pre- and post-training in the examined skills. The students' academic reports relating their pupils' improvement strengthen the research described in this article as well as the rest of the MA group's research projects. We might highlight the progress noted among the pupils guided by the student's representative research demonstrating the project that was performed.

### The Experimental and Control Groups Pupils' Percents of Success in the Examined Skills

The data displayed in tables no. 2, 4 and 6 show an improvement of the experimental group pupils' performance in all examined skills\*.

The data displayed in tables no. 3, 5 and 7 show mostly a non-improvement or decrease of the control group pupils' performance in all examined skills.

**Table 2: Experimental Group Subjects' Shooting Percents of Success between Pre- and Post-Training**

Subject**	Experimental Group (%)
1	18.75
2	5.55
3	58.33
4	13.33
5	20.0

The findings in table 2 show an improvement in the experimental group subjects' shooting percents of success. All the values are positive.

**Table 3: Control Group Subjects' Shooting Percents of Success between Pre- and Post-Training**

Subject	Control Group (%)
1	-23.08
2	-42.86
3	0
4	-30
5	-28.57

The findings in table 3 show a decrease of the control group subject' shooting percents of success. Most of the values are negative.

**Table 4: Experimental Group Subjects' Dribbling Percents of Success between Pre- and Post-Training**

Subject	Experimental Group (%) .
1	14.82
2	11.11
3	12.5
4	3.71
5	6.07

The findings in table 4 show an improvement in the experimental group subjects' dribbling percents of success. All the values are positive.

\*In view of the participants amazing success in the present research, I hope to increase the number of participants in the next study in order to provide additional proof of the findings.

\*\*There is not a parallelism between the sequence of the subjects' appearance in the tables of the experimental and control groups.

**Table 5: Control Group Subjects' Dribbling Percents of Success between Pre- and Post-Training**

Subject	Control Group (%)
1	8.37
2	-17.64
3	-39.29
4	-7.7
5	-23.53

The findings in table 5 show a decrease of the control group subjects' dribbling percents of success. Most of the values are negative

**Table 6: Experimental Group Students' Figures Discrimination Percents of Success between Pre- and Post-Training**

Subject	Experimental Group (%)
1	100
2	45.45
3	186
4	53.33
5	100

The findings in table 6 show an improvement in the experimental group subjects' Figures Discrimination percents of success between pre- and post-training. All the values are positive.

**Table 7: Control Group Subjects' Figures Discrimination Percents of Success between Pre- and Post-Training**

Subject	Control Group (%)
1	0
2	0
3	0
4	9.09
5	0

The findings in table 7 show that the values of the control group subjects' Figures Discrimination percents of success are mostly zero. Only one value is positive over zero but is low related to those found in the experimental group's data.

### Main Changes in the MA Students

- Understanding the inter-disciplinary impact of computerized application training based on spatial visualization on the pupils' motor and concentration skills.
- Understanding the transfer in learning process which leads the pupils to perform the required motor activities without additional computerized training.
- Improving their academic writing.

### The Students' Feedback:

"This is the first time I am doing such research. It was a privilege to experience such a type of research. From my perspective, it was fascinating to deeply investigate this domain in research and examine the findings. Thanks to Dr. Esther Zaretsky for her supervision along the amazing process I went through with her".

### The Pupils' Feedback

"The pupils were enthusiastic about all stages in the research and their level of collaboration was very impressive. They wanted to take part in the research process. They enjoyed themselves and became more analytical and also did the physical and cognitive efforts during the stages of the research. They would like to participate in more such studies."

## 5. DISCUSSION

The question raised in this research is, "What is the inter-disciplinary contribution of training with computerized applications of spatial visualization to motor and concentration skills?" In spite of the short time of training and the absence of experience in using technological tools such as computers before training, a significant improvement was recorded, as a result of this original and innovative mode of learning. In this research study we focused on the inter-disciplinary integration of spatial imagery and learning through the use of a computer program involving physical movement as the dominant mode of learning. The application requires the student to perform manipulations on virtual images to activate the simulations.

The findings strengthen the hypothesis. As was stated above, in view of the participants amazing success in the present research, I hope to increase the number of participants in the next study in order to provide additional proof of the findings.

All the experimental group pupils' findings show positive values of achievements in contrast to controls. The experimental group demonstrated an extremely high percentage differential in their ability of figure discrimination between pre- and post-training and also significant improvement in basketball shooting skills that demonstrates the inter-disciplinary impact of the spatial visualization application on motor skills. The spatial visualization skill examined by the Figures Discrimination test develops the pupils' ability of rapid critical thinking and solving real life problems by imagining the solutions.

This spatial visualization training gives the students the capability of looking at objects from different perspectives, as Callaos (35) indicated that "Inter-disciplinary communication extends and possibly changes a participant's point of view. Debate affirms a participant's own point of view" (35).

The unexpected finding in this study was the percentage of decrease in the scores of the control group. There is no current hypothesis formulated to explain this finding. The findings from the control group show that if the pupils do not experience the integration of computerized application and spatial visualization they do not show any improvement or even reduce their percents of success. The data show that the decrease of success in the spatial visualization among the control group's pupils is not a statistical aberration indicated by their actual performance. The negative values found in this group indirectly strengthen the positive contribution of the computerized application training based on spatial visualization to motor skills whereas its absence may cause a negative impact on the same skills.

Generally, students in teacher-training and even MA college students do not learn how to teach through researching the impact of computerized applications on pupils' achievements and through pre- and post-training testing. In this course, they learned how to conduct research in the framework of a regular college course and MA teaching, and learned how to conduct pre- and post-training tests to measure pupils' achievements, to compare findings, and to draw conclusions concerning future work with their pupils.

A relationship between improving computerized application performance and improving motor performances exists.

The training with computerized application enables the students and pupils to perform activities that are not available in real life (12). Real life motor skills refer to immediately and actually performed activities rather than computerized ones.

The training with computerized application included experiencing the application "Bobblehead Basketball". The results showed an improvement after working with the application. It would be interesting to investigate a group that uses this application versus groups that use other applications.

### Inter-Disciplinary Impact of Computerized Application and Spatial Visualization on Motor Skills

The third dimension helps give game players a sense of "presence" in the game. (36). "As digital worlds become more immersive, there is greater potential for the gamer to live in the virtual world, that is the most important reality" according to Cohen & Taylor (37). These researchers suggest that sport media studies need to expand its theoretical and empirical practice away from the focus on texts to a focus on the phenomenology of gaming and sport (38).

The findings emphasize the available transfer from the computerized application training to better functioning in motor activities in the gym or field without computers, while manipulating the fast-changing environment over the computer screen. The same skill is needed for performing motor skills, especially dribbling along the course without fumbling the ball. The student (33) suggests encouraging physical education teachers to do such research for improving pupils' motor performances, physical fitness and concentration skills.

Such research enables the MA students to:

- Translate theoretical concepts into practical language
- Apply them during their teaching practice in physical education classes
- Interpret the results of the experiences by looking at them through the perspective of the theoretical approaches he/she has applied. Such courses usually focus on the basics of the use of computers only.

## 6. SUMMARY AND CONCLUSIONS

This study, first and foremost, examined the motor skills improvement in physical education lessons as a function of computerized application training. According to the MA college students, before the training in their practical work, they had great doubts that any impact of computerized application exists on physical performance in a gym or a sports field. However, especially after looking at the findings, they were convinced of the existence of such a contribution. Consequently, the participants in the course asked the lecturer to extend their course research to the final project for getting their MA degree. As everyone knows, it is highly unusual to use computers in a gym or on a sports field. The contribution of the research in this context becomes clearer as the spatial visualization and motor skills become better even in non-computerized environment.

In this framework of research, computerized applications were used in order to get better control of the environment and of precision of the data. The applications were selected with the overriding consideration that they would best display spatial visualization and response speed, which aid improvement of motor activity and attentiveness. Students like learning through discovery and investigation, and to observe the impact of training with computerized applications on pupils motor skills' percents of success between pre-and post-training.

The research and findings reflect an important and potentially very useful research, in which several disciplines are related in order to integrate academic activities to real life problem

solving. The way in which several disciplines are related might potentially generate more inter-disciplinary research, education, and communication. This is especially affirmed by the findings that "Using computerized application in their practical work, the students reported improvement in pupils' motor and concentration skills. Moreover, the students and pupils' motivation was enhanced. Their self-confidence was also enhanced." (39).

Additional studies are being carried out with various applications of this kind on various population groups. It would be worthwhile including the positive results of this short study. It is also very important to note the fact that the integration of theory and practice is clearly reflected in the students' research, as well (40).

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