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Effects of multimedia computer-assisted instruction (MCAI) on academic achievement in physical education of Greek primary students

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Abstract

Computer technology has become an integral part of physical education, yet there have been few studies exploring the use of multimedia technology in the instruction of Physical Education. The purpose of this study was to investigate if **C**omputer **A**ssisted **I**nstruction (CAI) in Physical Education is functional in the school environment. An interactive multimedia CD-ROM program was developed, especially for the needs of the study, titled «The tree of Health». This intervention trial involved 12 fifth- and sixth-grade classes (N = 248 students), randomized into 3 groups: Multimedia Computer Assisted Instruction, Traditional Approach to teaching (TA), and Control. Students were tested using pre and post-tests that measured knowledge of «Health related fitness» subjects. The experiment lasted 12 class hours, two classes per week over six weeks. The results of an analysis of covariance indicated that there was a significant increase in achievement post-test for the (MCAI) group when compared to either the (TA) or control groups, $F(1, 238) = 13.486$, $p < .0167$; $F(1, 238) = 53.872$, $p < .0167$. These results indicate that this new educational tool is an effective way to introduce health-related physical education programs for young students in typical classroom settings.

Keywords

Multimedia, computer, MCAI, physical education, health, learning.

Introduction

The promise of educational benefits, anticipated since the early days of computer use, has accelerated with the increased availability of computers and the Internet in schools. The widespread proliferation of computers in schools is based on the assumption that computers have a significant role to play in education and that their use can and will result in the advancement of education (Drenoyianni, 1998). Students are expected to learn more through computer use: test scores can rise, and students would learn at a faster rate (Hokanson, & Hooper, 2000). Moreover, computer-assisted education could assist students in their preparation to enter and compete in a modern, global workforce (Oppenheimer, 1997).

Interactive Multimedia (IMM) is a relatively new educational innovation in primary, secondary and tertiary level classrooms (Herrington & Oliver, 1997). Viewed by Halal and Liebowitz (1994, p.21) as the technological key to future education, multimedia is defined as "a powerful combination of earlier technologies that constitutes an extraordinary advance in the capability of machines to assist the educational process. Interactive multimedia combines computer hardware, software, and peripheral equipment to provide a rich mixture of text, graphics, sound, animation, full-motion video, data, and other information".

The assumption that multimedia information facilitates the learning process has led to an increasing use of IMM in computer- assisted instruction (Najjar, 1996). The interactive nature of multimedia makes it especially attractive in youth education because interactivity encourages children to take an active role in the learning process (Hughes, Noppe, and Noppe, 1996). Likewise, as Brooks (1997, p.14) notes, "the interaction implies that energetic learning will be encouraged". Furthermore, research has shown that children are much more attentive to programs when animation and narration are used (Najjar, 1996). This study demonstrated that sound, video, and animated images convey information to children better than flat text, thereby enhancing comprehension and retention.

An examination of research studies that have investigated the impact of multimedia computer assisted instruction (MCAI) systems on student achievement shows mixed results (e.g., Wilson, 1993;Butzin, 2000). While some studies suggest that MCAI can improve students' understanding of academic material (e.g., Kim, and Lee, 2000; Chu, & Chen, 2000; Hornung, Lennon, Garrett, DeVellis, Weinberg, and Strecher, 2000), others report that, in some instances, the use of computers to teach basic skills had no effect on academic achievement (Chou, 1996; Matthew, 1996). Moreover, other studies report that MCAI is most effective when learners work with IMM individually or, better in pairs or small groups (Park and Hannafin, 1993; Simpson, 1994).

Mohnsen (1998) identified a number of reasons for using Computer-Assisted Instruction

(CAI) in health-related physical education. Among them there are suggestions that CAI provides students with the "why" behind health-related fitness, since it provides unlimited practice, review, and remediation and so students stay actively involved. So far there has been little investigation into the effectiveness of IMM in physical education instruction in schools (Alvarez-Pons, 1992). Previous studies in physical education have shown that Computer Assisted Instruction is not consistently superior to the traditional forms of instruction, (Skinsley & Brodie, 1990; Adams, Kandt, Thogmartin and Waldrop, 1991; Ross, 1994; Alvarez – Pons, 1992; Antoniou, 1998; Vernadakis, 1999) but most of these studies focused on secondary, high school and college students.

Chu and Chen (2000) developed a multimedia prototype on serve of badminton and conducted an experimental research in elementary school classes (sixth grade) to explore whether the multimedia material is a helpful tool to motor skills learning. The multimedia computer-assisted instruction group had better results on the cognitive test but not on the motor skill test than the traditional instruction group. Similar findings emerged in the Ross (1994) study involving primary school children aged 9 to 11. Alvarez-Pons (1992) assessed the efficiency of computer-assisted instruction of tennis regulations in comparison with the traditional instruction method. The duration of the experiment was five weeks and involved 10 to 12 years old students. This study also revealed no between-group differences in learning.

This study looks at the effectiveness of MCAI in teaching subjects of «Health related fitness» to primary students, as compared with the Traditional Approach to teaching. The main reason to use «Health related fitness» as syllabus of our intervention was its cognitive focus. Knowledge and concepts about bones, muscles, health, and nutrition can be taught in a variety of ways but we assume that like in other cognitive subjects the most effective way is through multimedia computer assisted instruction.

Method

Sample

The sample consisted of 248 students in the 5^{th} and 6^{th} grades from Primary schools in the prefecture of Serres, Greece. The students were aged between ten and twelve years old. After a short explanation of what health-related fitness is about, students were asked if they want to learn more about this topic. All students expressed their willingness to learn more about it and eventually to take part in the experimental.

Ten schools were selected for the study. These schools were randomly selected from all schools in the prefecture of Serres. Schools were matched according to their demographic characteristics (urban and rural, economics status) and then were randomly assigned to three different experimental groups: (1) the Multimedia Computer Assisted Instruction (MCAI) group (two schools, one from a rural and one from an urban area, n = 64) , (2) the Traditional Approach to teaching (TA) group (four schools, two from a rural and two from an urban area, n = 88) , and (3) the Control group (four schools, two from a rural and two from an urban area, n = 96). Table 1 shows the number of subjects examined according to gender, grade and treatment condition.

GROUP			***GENDER***		Total
			Male	*Female*	
MCAI	*GRADE*	5th	15	13	28
		6th	18	18	36
	Total		33	31	64
TA	*GRADE*	5th	23	20	43
		6th	23	22	45
	Total		46	42	88
CONTROL	*GRADE*	5th	15	15	30
		6th	37	29	66
	Total		52	44	96

Note. MCAI = Multimedia Computer Assisted Instruction group ; TA = Traditional Approach to teaching group

Table 1: Distribution of subjects examined as a function of gender, grade and treatment condition

The (TA) group received instruction on «Health related fitness» by traditional instruction in a classroom setting, whereas the (MCAI) group interacted only with the multimedia computer instructional program. The Control group didn't receive any instruction on «Health related fitness» but they attended the typical sport skill-related curriculum for Physical Education of the Ministry of Education. Four Physical Education teachers (two men – two women) with more than a ten year experience in primary school physical education teaching taught the TA group while the four teachers who taught the Control group were men with more than a ten year experience in primary school physical education teaching too. All of them were the formal teachers who taught Physical Education in those schools. The (MCAI) program was made available in two primary schools (one urban and one rural). Each school had a computer laboratory, which was equipped with 10 personal computers and essential peripherals. An orientation to the program was given to students prior to the beginning of the intervention.

All teachers participated voluntarily in the study. The TA group teachers reported that they liked teaching health-related concepts and they were did it quite often in their classes. However, they admitted that they were not supported in the teaching of health-related concepts and were not properly equipped with relevant teaching material and resources. Hence, they found the teaching material described below very valuable for their work.

Instrumentation

Achievement Test (AT)

A 16-item multiple choice achievement test (AT) was used to measure the students' achievement outcomes of the subjects. Each test item had four options in order to reduce the probability of guessing. The items 1-10 appearing in the Appendix were selected from the test of Hopper, Fisher & Munoz (1997). Six additional items were developed (11-16) to assess taught topics that are not captured by Hopper's et al., (1997) test.

To ensure that the syntax and vocabulary of the instrument were age – appropriate and appealing to the target audience, two teachers with more than a twenty year experience in primary school language teaching education were consulted. After examining the instrument, they found that the vocabulary and the syntax were appropriate for the 5th and 6th grade level.

Measures

Two equivalent achievement tests, the pre and post-test were used to measure the achievement scores of the subjects. The data of this study were the numbers of the correct answers that students gave during the completion of the AT. The aim of the pre-test was to measure student knowledge regarding the «Health related fitness» prior to the beginning of the study and was given to students one week before the experiment. The post – test was used to measure mastery of the instructional materials and was administered at the end of the study.

Both the pre and post achievement tests were written and administered as a classroom event. Prior to their completion the Physical Education teachers explained that for each item there was only one correct answer and they asked their students to select it. No further comments were offered. The student completed silently the AT in approximately 10 to 15 minutes.

Procedure

Software development

Computer CD-ROM technology was used as the medium for the multimedia intervention. The CD-ROM was entitled, "The Tree of Health" and was developed by the investigator using Macromedia Director (Macromedia, Inc., San Francisco, CA). "The Tree of Health" was specifically designed and developed by the researcher according to the guidelines for designing multimedia-learning environments for children (Druin, & Solomon, 1996; Lopuck, 1996; Heinich, Molenda, Russell, & Smaldino, 1999). The investigator developed the storyboard, including text, instructional design, and possible graphics. The program contained colourful cartoons as well as digital narrations and texts, graphics (moving and static), digital audio and video. The next step of the development was the actual creation of the module. The narrations were recorded and entered first. In order to attract the attention of the children and give an alternative presentation of information, children were used as narrators. We have tried to avoid the use of long texts in each screen in order to minimize the overload by children, but we placed concise information, considered important by the experts, in an effort to enhance student's understanding of the material. Appropriate graphics to accompany the text, colours, and fonts were selected in an attempt to make the (MCAI) module more effective and more attractive. Graphics were obtained from the Internet, and from various computer software programs. Multimedia (video, animation, and sound) was the last components added to the module. Video, animation and sounds were obtained by downloading files from the Internet. After these components were added, tested, and evaluated, the module was packaged.

The central screen of application gives the possibility to the user to navigate in the three basic thematic units: «Health», «Fitness», «Nutrition», each of which can be negotiated separately, according to proportion with its content, that is the basic idea of "Health related fitness", and contributes to the achievement of pedagogic goals. Each thematic unit has its own central screen, with the help of which the user can surf through hot spots in the chapters of the unit, adjust the volume, receive help or abandon the application.

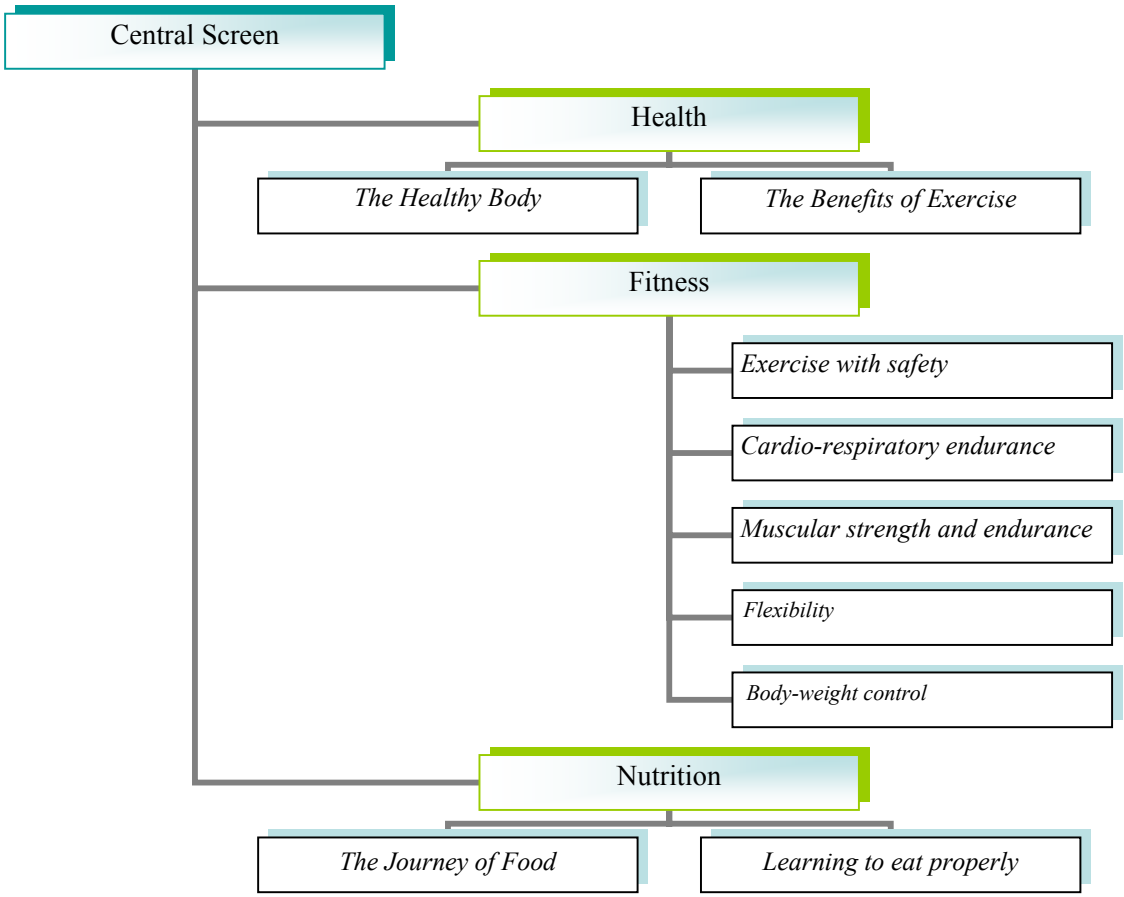

Figure 1:. Diagram of structure and content from application "The Tree of Health"

Each chapter has its own central screen, with the help of which the user can surf in its surface, either serially or through links. Every such screen includes linkages to the following parts: "Presentation", "Something more" and "Knowledge game". There are also shortcuts-linkages at the bottom of the screen for volume control, for transit to the

thematic unit or to the central screen of the application, for help and for exit from the application.
In the "Presentation" there is a brief introduction to the topic the chapter deals with which through timing turns to another screen where the user can choose the sequence in which the units of the chapter will be presented. These units are short and concise, and constitute the "knowledge" unit that can stand on its own as far as the meaning is concerned, making the material presented clearly understood.

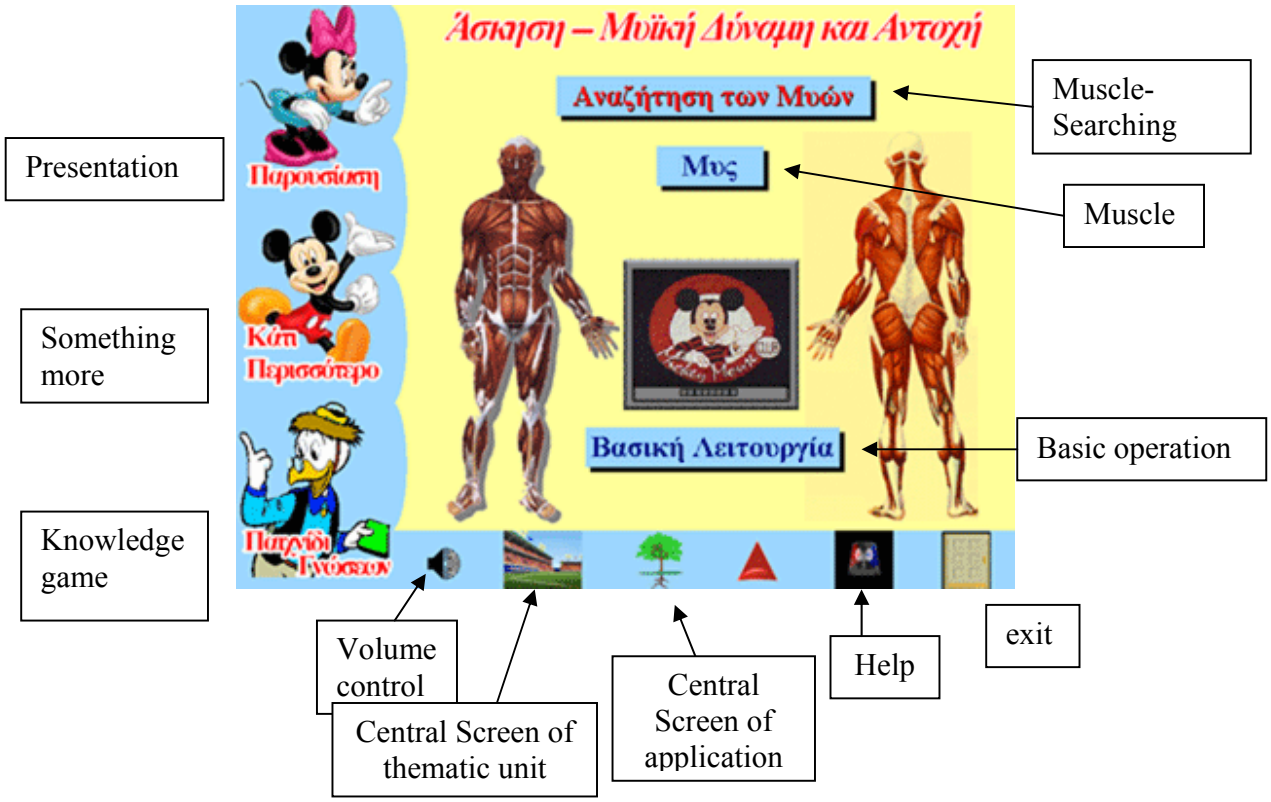

Figure 2. Example screen from Muscular strength and endurance chapter

The parts of the application "Something more" and "Knowledge game" have been designed in such a way so as to contribute efficiently both to the depiction of knowledge and to the amusement of the user in an educational way. In "Something more" additional information is given about the topic of the chapter along with activities helping the user to better understand the topic. In the "Knowledge game" children are given the chance to be tested through games on the comprehension of the chapter because the application gives direct feedback.

Health-Related Content

In the beginning, the topics that would constitute the syllabus of the experimental intervention were chosen. It was decided that the syllabus contain topics about exercise aiming at health, taking into account how important it is, along with the learning of kinetic skills and sports taught to children in the Physical Education lesson to inform them about and teach them the general principles of exercise, nutrition, keep-fit habits etc. (Anspaugh, Hamrick & Rosato, 1997). The selection of the topics was based on the researcher's ideas as well as on the instructions about the compilation of such programs in primary education applied in other countries (Pate & Hohn 1994, Kirchner & Fishburne, 2001).

The sources used to design and develop the content of the lessons were: (a) detailed lesson plans (after relevant license) taken from the doctoral thesis "Development of Positive Attitudes towards Health Issues in a Physical Education Curriculum in Secondary School" (Digelidis, 2000; Digelidis, Papaioannou, Christodoulidis & Laparidis, 2003) , (b) lesson plans with topics on exercise aiming at health, found and assessed after relevant thematic search in the Web, and (c) the book "Health-related Fitness for grades 5 and 6" written by Hopper, Fisher & Munoz (1997). Moreover, information and instructions provided by Anspaugh, Hamrick and Rosato (1997), Pate and Hohn (1994) and Kirchner and Fishburne (2001) were taken into account.

These lesson plans, which formed the chapters of the syllabus, were: the Healthy Body, the Benefits of Exercise, Exercise with Safety, Cardio-respiratory endurance, Muscular strength and endurance, Flexibility, Body-Weight Control, The Journey of Food and Learning to eat properly. These lesson plans constituted the educational material used in both traditional teaching and MCAI. In both methods the content was the same. The overall educational material was finally composed of: a) the printed material and overheads for the lectures in the traditional teaching approach, and b) the educational software "The Tree of Health" used in the MCAI group.

Intervention

The experiment intervention took place during Physical Education classes and was repeated for 12 class hours, two times per week over six weeks. Each class hour lasted 45 minutes. In the traditional and MCAI groups nine instructive 20-minute sessions were used.

Before the intervention was implemented, all the teachers in the study received both written and verbal instructions about how to conduct the study protocol. The teachers in the (TA) groups received the printed materials and overheads of the «Health related fitness» curriculum as well as printed cognitive quizzes for all students, written by one of the authors. The teachers in the TA groups had these materials for each daily lesson and were asked to instruct their students using a combination of lecture and discussion methods. The instructive lesson of the intervention took place in the first 20 minutes, of a 45 minute lesson, and then the students continued the typical physical education curriculum suggested by the Ministry of Education.

Students in the (MCAI) group did not receive any direct teacher instruction on «Health related fitness» subjects, but interacted independently with the Multimedia Computer Assisted Instruction program "The Tree of Health" in a computer laboratory. Due to the fact that there was not a sufficient number of computers for each student to work independently, the students were divided in two groups. While the first group of students interacted with the program in the laboratory, with the presence of a researcher who did not give any guidance, the other group was taught the typical physical education content suggested by the Ministry of Education by their teacher in the school yard. The students in the first group interacted with the program for 20 minutes and then went out to the school yard to continue with the physical education lesson and were replaced at the laboratory by the students of the other group who interacted with the program for the next 20 minutes.

Students in the Control group received no formal instruction on «Health related fitness» subjects before the post test. They received instruction on elementary physical education content, unrelated to «Health related fitness» subjects, during the class time between the pre-test and the post-test. In the Control group, the teachers were asked to teach physical education according to their normal protocol.

Results

The purpose of this study was to detect if there were any significant differences among the three group means in the students' achievement post-test. A one-way analysis of covariance (ANCOVA) was conducted to evaluate the effectiveness of the three methods of teaching. The independent variable was the type of intervention (method of teaching) and included three levels. The dependent variable was the measure of student's achievement obtained after the experiment was completed. The covariate was the measure of student's achievement obtained before the experiment began. ANCOVA adjusts for initial differences between groups and for correlation between means; it also allows for comparison of groups on one variable when information is available on another variable correlated with it (Isaac & Michael, 1972). If a student was absent during one of the pre or post achievement tests, he or she was excluded from all the analyses. The students' pre-and post-test means, standard deviations and mean gains are shown in Table 2.

		Pre-test		**Post-test**		*Mean*
Treatment groups	*n*	*mean*	*SD*	*mean*	*SD*	*gain*
MCAI	64	8.03	3.53	11.64	3.51	3.61
TA	88	8.61	3.45	10.44	3.15	1.83
CONTROL	96	7.32	2.74	8.14	3.41	0.82

Note. MCAI = Multimedia Computer Assisted Instruction group; TA = Traditional Approach to teaching group; *SD* = Standard Deviation*;* Maximum score = 16.

Table 2:Means, standard deviations and mean gains of students on Achievement Test

The results indicated that there was no significant interaction between the covariate (achievement pre-test scores) and the teaching methods $F(2, 236) = 2.092$, $p = .126 > .05$, partial eta square = .017). Also, the covariate achievement pre-test scores were linearly related to the dependent variable (achievement post-test scores) within all levels of the teaching methods. The assumption of equal slopes was met and we could proceed to conduct a one-way ANCOVA.

The results of the ANCOVA indicated that there were significant differences among the three adjusted means, $F(2, 238) = 27.150$, $p < .001$). Pair wise comparisons using the Bonferroni procedure to control for type I error across three comparisons at 95% level of confidence, that is, at $p = .05 / 3 = .0167$, suggested that all comparisons were significant. Table 3 shows that there were significant differences in the adjusted means between Multimedia Computer Assisted Instruction and Traditional Approach to teaching, $F(1, 238) = 13.486$, $p < .0167$. The adjusted means indicated that the (MCAI) group scored significantly higher than the (AT) group in the Achievement post-test.

TREATMENT GROUPS	***ACHIEVEMENT TEST***			
		Post Hoc Pairwise Comparisons		
	M		*F*	*p*
MCAI	11.62**	*MCAI* **VS** *TA*	13.486	.000
TA	10.04**	*MCAI* **VS** CONTROL	53.872	.000
CONTROL	8.52**	*TA* **VS** CONTROL	15.123	.000

Note. MCAI = Multimedia Computer Assisted Instruction group; TA = Traditional Approach to teaching group

Table 3:Adjusted Means of students on achievement post-test after analysis of covariance

There were significant differences in the adjusted means between Multimedia Computer Assisted Instruction and Typical Instruction, $F(1, 238) = 53.872$, $p < .0167$. The adjusted means indicated that the (MCAI) group scored significantly higher than the Control group on the Achievement post-test.

There were significant differences in the adjusted means between Traditional Approach to teaching and Typical Instruction, $F(1, 238) = 15.123$, $p < .0167$. The adjusted means indicated that the (TA) group scored significantly higher than the Control group on the Achievement post-test (Table 3).

Discussion

This study showed that MCAI was superior to traditional classroom teaching in the transmission of health-related fitness and nutrition knowledge. Kolb (1984) suggested

that the use of (MCAI) might enhance students' performance through facilitation of active and experiential learning. The present model of (MCAI) may have promoted active learning because it encouraged students to take an active role in the learning process and have better control over their education. It can also be suggested that the individualized nature of MCAI maybe challenged more students than the whole-class or small-group instruction in TA groups. Indeed, Filipczak (1995) suggested that MCAI increases students' motivation to learn. The present research methodology did not allow to clarify what caused the better student performance in the MCAI groups in comparison to the TA groups. Further research employing different methodology is needed in order to replicate these findings and clarify what causes these outcomes.

This study's finding is supported by the findings of previous studies in which students who learned academic material (subjects) using (MCAI) performed significantly better than those taught using the traditional method. Specifically, Kim and Lee (2000) found that an experimental (CAI) system was effective in improving students' understanding of academic material. Also, Chu, & Chen (2000), claimed that Multimedia Computer Assisted Instruction (MCAI) had a significantly better effect than Traditional Instruction on cognitive learning of motor skill. In addition, these findings are consistent with Hornung et all (2000), who found that the interactive CD-ROM multimedia intervention for learning about skin cancer was the most effective method for increasing skin cancer knowledge and awareness in schoolchildren when compared to a teacher-led, didactic intervention and a control group receiving no intervention. The important point about these four studies, which had similar findings, is that they focused on Primary school students of the same age as the ones in this study.

On the other hand, there are previous studies in physical education supporting the view that Computer Assisted Instruction is not consistently superior to the traditional forms of instruction (e.g., Adams et al., 1991; Skinsley & Brodie, 1990). It should be emphasized here that these studies focused on secondary, high school and college students while our study focused on students in primary schools. In addition, previous studies investigated the effects of MCAI on motor skill learning (e.g., Vernadakis, 1999), but as the Chu and Chen (2000) study showed, the positive effects of MCAI are more evident in learning academic-related content.

Conclusions

The results of this study suggest that the use of Multimedia Computer-Assisted Instruction can be beneficial in the implementation of health-related physical education curricula, particularly in teaching concepts and principles of academic nature. There were some limitations in this study that should be mentioned. First of all, the effectiveness of computer-assisted instruction depended on the quality of the multimedia program while the effectiveness of traditional teaching was depended on the effectiveness of the Physical Education teacher. The small number of teachers participating in this study is not a proper representation of physical education teachers in Greece. Although the present teachers participated voluntarily and showed enthusiasm in teaching the

proposed health-related physical education curriculum, it could be argued that other teachers could be more effective than these ones. A relevant limitation is concerned with the relatively little focus on health-related issues in the present Greek physical education curriculum. Teachers in TA groups could have been more effective if they had devoted greater proportion of their teaching in health-related concepts in the past.
Further studies, targeting at different populations with different ages and/or cultures would aid in determining the possibility to generalize the present results. Additionally, based on this study, the following are some of the ideas proposed for future research:
First, of all replicate the study with more variables, including attitudes towards using computers, attitudes towards Physical Education, teacher and students' motivation.
On the other hand look into physical education curriculum and evaluate what information can be best applied to a computer environment in order to develop new software programs and evaluate them in the school environment.

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Appendix: **Achievement Test**

Directions: Circle or underline the correct answer.

1. The pulse indicates:
   a) how many blood cells are in the body
   b) how fast a person is breathing
   c) how fast a person's heart is beating
   d) all the above

2. The recommended way to lose fat or to keep from becoming fat is to:
   a) exercise frequently and eat a balanced diet
   b) eat only once a day
   c) stop eating foods that have added sugar in them
   d) go on diet

3. Flexibility is the ability to:
   a) run fast
   b) run for long distances
   c) lift heavy weights
   d) bend and stretch easily

4. To become physically fit, a person needs to:
   a) eat nutritionally sound meals
   b) exercise frequently
   c) get sufficient sleep
   d) all the above

5. Which of the following should you avoid to lower the total intake of fat in the diet?
   a) roasting
   b) broiling
   c) frying
   d) barbequing

6. Which of the following protein sources does not contain cholesterol?

a) roast beef
b) tuna fish
c) rice
d) cheese

7. Weak abdominal muscles could result in:
   a) lower back pain
   b) protruding abdomen
   c) poor posture
   d) all the above

8. What would be the safest way to lose weight:
   a) drink eight glasses of water each day and eat only fruits and vegetables
   b) reduce caloric intake by skipping lunch
   c) "fast" for three days and then begin exercising
   d) reduce caloric intake and increase physical activity

9. Which of the following commonly eaten foods are high in salt (sodium)?
   a) cheerios
   b) cottage cheese
   c) meat
   d) apple

10. It is generally accepted that to be fit and healthy, a person needs to do aerobic exercise for 20 minutes a minimum of:
    a) one day per week
    b) two days per week
    c) three days per week
    d) seven days per week.

11. Which of the following risk factors for heart disease can't be checked?
    a) heredity
    b) decreased physical activity
    c) obesity
    d) cholesterol

12. What is the aim of warm-up before vigorous exercise?
    a) it prevents from injuries
    b) it prevents the pain from muscles
    c) it increases the flexibility of muscles
    d) all the above

13. To maintain a healthy heart, a person needs to:
    a) eat a healthy diet
    b) avoid tobacco; alcohol and drugs
    c) lead a physically active lifestyle
    d) all the above

14. We can improve our flexibility by:

a) eating a healthy diet
b) playing team sports
c) running long distances
d) stretching

15. What is the aim of cool down after vigorous exercise?
    a) it helps in progressive transition from vigorous exercise to low activity
    b) it strengthens the heart
    c) it increases the strength
    d) it helps to lose weight

16. What happens in our body when we exercise:
    a) the heart becomes stronger
    b) the fat of body is decreased
    c) the bones and the muscles become stronger
    d) all the above