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Student attitude and learning outcomes of multimedia computer-assisted versus traditional instruction in basketball

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Abstract The purpose of this study was to examine the effect of multimedia computer-assisted instruction (MCAI), traditional instruction (TI), and combined instruction (CI) methods on learning the skill of shooting in basketball. Additionally, a comparison of the students' attitudes towards the MCAI and TI methods was made. Seventy-five middle school students of seventh and eighth grade were randomly assigned into three teaching method groups: TI, MCAI and CI. Each group received ten 45-min periods of instruction divided into three sections: (a) 5-min introduction, (b) 30-min instructional time and (c) 10-min questions and review. Students took pre-, post-, and retention written test covering techniques and rules of the games. Participants in the CI group also completed a post-test attitude survey towards the MCAI and TI methods. Two-way analysis of variances (ANOVA), with repeated measures on the last factor, were conducted to determine effect of method groups (MCAI, TI, CI) and measures (pre-test, post-test, re-test) on knowledge test. Paired samples t-test analyses were conducted to measure students' attitude towards the MCAI and TI methods. Post-test results indicated no significant differences between the groups concerning the written test. Nevertheless, the attitude test scores of the CI group were more favourable to MCAI method than the TI method. Retention test results showed that groups retained the knowledge acquisition. However, the combine method of instruction tended to be the most effective on cognitive learning.

Keywords Instructional technology · Multimedia software · Traditional instruction · Cognitive learning · Attitude · Basketball · Physical education

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1 Introduction

The use and integration of information technology in the classroom remains an important factor at many secondary education schools. Today, more traditional types of classrooms utilize some form of technology as part of instruction. Computer-assisted instruction (CAI) and especially interactive multimedia is one of those forms that technology presents for use in various ways to promote learning. Fincher and Wright (1996) defined computer-assisted instruction (CAI) as "any form of instruction that uses the computer to present instructional information." Multimedia simply refers to the use of a variety of mediums to convey information. For the sake of discussion in this manuscript, the terms multimedia instruction and computer-assisted instruction will be used interchangeably.

The use of multimedia software is becoming more popular with the improvement in computer technology. But should it be used because it is popular or because it meets the instructional objectives? There is debate going on about the effectiveness of multimedia computer-assisted instruction (MCAI) versus the traditional instruction (TI) approach or teacher-led approach. In general, the literature reveals that the use of MCAI as a supplement to traditional teacher-led approach produces achievement effects superior to those obtained with traditional instruction alone (Christmann and Badgett 2000; Dalton and Hannafin 1988; Lowe 2001; Schacter and Fagnano 1999). These findings are relevant to students of different ages and abilities and learning in different curricular areas. The above studies, while not representing an exhaustive listing of research, are offered in support of this assertion. The following meta-analyses also indicate that CAI is generally effective in education environments for a broad range of student ages.

Blok et al. (2002) examined the effectiveness of computer-assisted instruction (CAI) programs in supporting beginning readers. Their review included 42 studies from 1990 onward, and they found the corrected overall effect size estimate was 0.19. Their findings were similar to earlier meta-analyses by Kulik and Kulik (1991) and Bangert-Drowns (1993), which also examined the effects of CAI and found it to have positive but small effects. Lowe (2001) reviewed several other meta-analyses from the 1980s and 1990s and concluded each of the reviewed meta-analyses showed a small positive effect size for computer-based education over traditional instruction. However, Lowe (2001) states that research indicates that, where CAI and traditional instruction is delivered by the same instructor, the CAI advantage is reduced to insignificant levels; further, simulation and tutorials as supplements to traditional instruction appear to be the most effective. Wiemeyer (2003) reviewed nine meta-analyses of earlier and different multimedia issues and suggested that multimedia learning can be more effective and efficient than traditional learning. But this effect depends on many factors like the features of the learners, the teachers, the learning stuff, the type of learning, the features of the study, etc. Further, a meta-analysis of 167 studies (Bernard et al. 2004) concluded that a very weak learning advantage for multimedia in empirical studies is based on uncontrolled instructional methods.

One area in which there have not been many meta-analyses and systematic reviews of the research is how teaching and learning with multimedia technology impacts student outcomes in physical education. This area is important because some

studies have found that multimedia technology can change teachers' pedagogic practices from a teacher-centered or teacher-directed model to a more student-centered classroom where students work cooperatively, have opportunities to make choices, and play an active role in their learning. Antoniou et al. (2003), for example, examined the effect of multimedia computer assisted instruction (MCAI), traditional instruction (TI), and combined instruction (CI) on learning rule violations in basketball by university physical education students. Written test results indicated that students in all groups improved their knowledge of rule violations but only those in the TI and CI groups retained this knowledge. Also, the researchers found that TI group showed significantly greater retention than the MCAI group both in the written test and in total performance.

Wiksten et al. (2002) investigated the effectiveness of MCAI in an introductory athletic training laboratory class as a supplement to TI approach. The results showed no significant differences between groups on either the written or practical examination. Student attitudes toward the CD-ROM software were favorable, and the qualitative data suggest that students would use this type of educational resource. In another study that examined the effectiveness of MCAI in teaching subjects of health-related fitness to primary students as compared with traditional approach, Siskos et al. (2005) found that MCAI was superior to traditional classroom teaching in the transmission of health-related fitness and nutrition knowledge.

Vernadakis et al. (2004) reported that MCAI is a functional method in teaching the skill of basketball shooting to middle school students, aged 12–14 year old and is as effective as traditional teaching method. The results of this study showed that there were no significant differences between the MCAI, TI and CI groups with regards to the knowledge and skill test. In another study Wilkinson et al. (1999) found that junior high school girls in both classes (TI and MCAI) significantly improved in their knowledge of volleyball rules and in performance of most skills (pass, set, and underhand serve) during the 16-day unit. The MCAI class had significantly better scores on the forearm pass, more successful passes/serve, set/serve, total contacts/serve and more sets than the TI class. However, no significant differences were found between the two classes in knowledge of rules. Survey results revealed that the majority of the treatment class felt that using the multimedia software helped improve their motor and cognitive skills.

Taking these factors into consideration, it would be interesting to see the effectiveness of MCAI in a learning environment, more specifically in a physical education learning environment and then to point out the lacuna that needs to be filled. But first, it is important to find out how students feel about it as it is they who will be instructed through the whole gamut of the learning process.

Therefore, the purpose of this study was to compare three different instructional methods (MCAI, TI and CI) by means of the knowledge test scores, obtained from three groups of middle school students. Additionally, a comparison of the students' attitudes towards the MCAI and TI methods was made. The tests assessed the learning of the shooting skill in basketball. More specifically, the study was conducted to explore the following five research questions:

1. Should one or more items on knowledge test be deleted or revised to obtain a better measure of shooting skill in basketball?

2. Do students, on average, report differently on knowledge test using the TI, the MCAI and the CI teaching approaches?
3. Do students, on average, report differently on knowledge test for the pre-test, post-test and re-test measurements?
4. Do the differences in means for knowledge test between the TI, MCAI and CI teaching method groups vary between the pre-test, post-test and re-test measurements?
5. Are students more favourable on the average about TI or MCAI teaching approaches?

2 Method

2.1 Participants

To obtain permission for conducting the field experiment, the researchers contacted local middle schools in a northern city of Greece. All school principals expressed their willingness to participate. The private school Dellasal of Thessaloniki, having an indoor gymnasium and essential network equipment, was chosen for the experiment. Seventy-five (n=75) middle school students (40 girls and 35 boys) of seventh and eighth grade, 12–14 years of age (M=13, SD=1.12), selected for this study by random sampling method, enrolled in the basketball course. Participants were randomly assigned to one of the three different teaching methods: TI, CI and MCAI creating three independent groups of 25 students. All participants had no formal training on learning the skills of shooting in basketball. Prior to group assignments, participants were orientated to the purpose of the study and participant requirements. Following the orientation, informed consent was obtained from each participant. The students should have returned the informed consent form signed by his/her parent or guardian in order to participate in the research.

2.2 Apparatus

2.2.1 Hardware

Ten 3.06 MHz Pentium IV class computers equipped with a 17-in. color monitor, CD-ROM, hard disk drive, soundcard and small headset, running Windows XP Professional SP2 were used.

2.2.2 Software

A multimedia program was created and programmed in Asymetrix ToolBook to administer experimental events including 159 screens; six screens were introductory, one was main menu, 51 were information, 32 were practice, 60 were feedback, and nine were help. Material for the multimedia application was taken from a basketball shooting textbook (Burrall and Patrick 2001) and modified for this study. Systematic Instructional Design (SID) concept was used to design the multimedia learning material. The application consisted of five sections: (a) court and player's position,

(b) history, (c) rules, (d) skill fundamentals and (e) skill exercises. Two choices menus, one for the termination of the program and one for help, were also included at the bottom of the screen and were always available. The help menu contained a description of the active picture-buttons and suggestions for the program use. The program started with an introductive video of international basketball federation (FIBA). The main menu with four active picture-buttons which serve as links to the other sections of the program followed.

The first three major sections addressed basic knowledge of the basketball game pertaining to vocabulary used, history of the game, rules, court dimensions, and names of positions. The skill fundamental and skill exercise sections introduced basic shooting skills and exercises for practical work in terms and levels that were appropriated for beginning basketball players. A step by step instructional format that was accompanied by an exceptional graphic simulation depicting proper form of shooting skill at different stage was included in these sections. A discussion of possible errors, what causes these errors, and what may be done to correct these errors was provided in the description of shooting skill. This was followed by "animated graphics" that showed the skill in a continuous movement pattern. When the user had seen enough of the shooting skill, he could supplement a short quiz (multiple choices, true/false) regarding the technique and concepts that were presented.

Each section included different relevant material like text, sound, pictures, animated vector images, graphics and video. The video presented professional basketball players performing the shooting skills. Each skill was demonstrated several times and was shown from different angles. Close-up shots revealed the details of important points such as hand or foot position. Audio was used to explain each action and give execution cues to help focus the attention of the user. The user navigated through the sections from the menu that appeared on each screen. At the end of the program, a screen with the title of the program, the names of the author and the institution were presented.

2.2.3 Knowledge test

A knowledge test was developed to determine students' achievement on cognitive learning from the skill of shooting in basketball. A table of specifications was developed to reflect the interrelationship between the identified course content and the levels of learning. Initial drafting of questions for the instrument relied upon survey research handbook by McGee and Farrow (1987). Based on these specifications a 20-item, multiple-choice test was constructed. Each test item had four options in order to reduce the probability of guessing. The test construction was based on the linear model which required that the test scores were obtained by summing the number of correct answers with equal weighting over the items. The questions were written on the basis of the learning objectives outlined in the Ministry of Education's Basketball Curriculum Guideline.

After the questions were constructed as explained above, a panel of experts in basketball teaching and coaching was used to evaluate and judge the content validity of the test instrument. This group reviewed the test items and established whether each item measured the target skill. Every time a set of changes was made, the

questionnaire was reviewed again by the consultants, until the instrument was deemed adequate.

The revised version of the knowledge test consisted of a 17-item multiple-choice test. Questions included in the knowledge test fell into one of the following categories: (a) 12 skill concepts and (b) five general rules associated with the skill. A pilot study was performed to access item difficulty and clarity of questions. Questions were scored one point for a right answer and no point for a wrong answer.

2.2.4 Attitude questionnaire

To assess students' attitude, a questionnaire was used consisting of 12 bi-polar items, divided in two sections from the Teaching Method Attitude Questionnaire (TMAQ, Antoniou et al. 1999). Each section contained six-point Likert scale numeric indicators ranging from "5" (powerful) down to "0" (weak). The first section was referred in TI method and the second in MCAI method with a common point (0). This format allowed participants to select a response from "0" to "5" representing their disagreement or agreement on each section of the particular item respectively (Appendix B). The questionnaire addressed two aspects of attitude: (1) positive (alpha=0.74) and (2) negative (alpha=0.76). The sum scores of positive surnames, minus the sum scores of negative surnames indicated the students' attitude scores in each teaching method (MCAI, TI). The difference of these scores between the two teaching methods (MCAI, TI) represented the students' overall attitude scores. The TMAQ instrument was designed for understanding students' attitude toward MCAI and TI teaching method in a specific situation such as a classroom setting (Antoniou et al. 1999). This attitude questionnaire was given to CI group as post-test.

2.3 Procedure

When the MCAI program was developed, the researchers gave it to an instructional technology specialist, a subject-area expert, and three subject-area teachers for evaluation. Researchers revised and improved the multimedia application according to the feedback received from those experts.

A pilot study was followed to determine the reliability and validity of the knowledge test. Participants consisted of 36 seventh and eighth grade middle school students. This population was chosen to keep the pilot study similar to the main study regarding participant's age. The method of instruction used for the pilot study was TI, which incorporated a direct style of teaching such as lectures, demonstrations, teacher questions and student questions. Participants were given two 45-min class periods of instruction and review concerning the skill of shooting in basketball. This was done to take into account the fact that participants had not received formal instruction pertaining to this particular skill for almost 1 year. The knowledge test was administered on the third day on a paper and pencil test consisting of 17 multiple-choice questions. The instruction took place in an indoor gymnasium in order to avoid complications associated with weather conditions.

After the pilot study, a main study was conducted to compare the scores obtained by 75 seventh and eighth grade middle school students for a knowledge test. The experimental design consisted of a pre-test, a post-test and a re-test for the three of

the independent groups. The knowledge test was administered on the first day to measure participant's baseline performance on the selected shooting skill. Procedures for the knowledge test were the same as the pilot test. There were five fewer questions, reducing the number of questions to twelve (Appendix A).

On the third day, 12 computers were set up in a blocked-off hallway adjacent to the gymnasium. Each computer had a basketball skill CD-ROM created by the researchers. Computers were separated as much as possible to create individual workstations. Before the experiment started, the MCAI and CI groups were given a 45-min introductory session on how to use the multimedia application program prepared for this study. Then the physical education instructor gave a 45-min lecture to all participants introducing the unit of basketball. Instruction, practice, and testing for this study were held on six separate and successive weeks. The groups met for 45-min, two times each week in an indoor gymnasium.

The TI method incorporated a direct style of teaching including lectures, demonstrations, teacher questions and student questions. Students were given verbal instruction for 15-min as well as 15-min of practice time following the formal instruction time and they were able to ask questions. The instructor responded to questions that required clarification, repetition of a verbal description, or a repetition of a demonstration. Also, the instructor gave verbal instructions before every drill and feedback about their performance every five trials during the 15-min of practice time. Students were allowed to work alone or with a partner. There were 5-min of introduction at the beginning of the period and the remaining time of approximately 10-min was for questions and review.

Participants in the MCAI group were allowed to work independently or with a partner. The students were given 15-min of computer time on a Pentium IV computer. A multimedia program was developed for the purpose of this study, which was based on hypertext, graphics, animation, media and video. The MCAI program consisted of five topics, which corresponded precisely to theoretical and practical work. Students received 15-min of physical practice time following the time spent on the computer. There were 5-min of introduction at the beginning of the period and the remaining time of approximately 10-min was for questions and review. The instructor was present for organization and management supervision only. No verbal or visual reinforcement of any kind was offered by the instructor.

The CI group followed the same procedure, while implementing both the multimedia program and the traditional instruction. In the first 3 weeks the students participated with the traditional method group, and the remaining weeks with the MCAI method group. The theoretical session consisted of the same instruction and text information, which took place in the TI and the MCAI methods. Material for the three method groups was taken from a basketball coaching textbook (Burrall and Patrick, 2001) consisting of five topics: (a) court and player's position, (b) history, (c) rules, (d) skill fundamentals and (e) skill exercises.

At the end of the treatment, the knowledge test that previously served as a pre-test was given to students and the following day the attitude test was given to CI group as a post-test. One week later, the knowledge test procedure was repeated on the re-test to measure the level of retention in the selected shooting skill. During the experiment, the participants in the three groups had no access to multimedia or to traditional learning environments beyond what was utilized as part of the

experiment. All groups had the same learning conditions, such as topics and principles introduced in the treatments, and equal opportunities to achieve their learning outcomes.

2.4 Design

Due to practical limitation, a field experiment instead of a laboratory experiment was conducted to test the research questions. The experiment on knowledge test was a factorial design with teaching method groups (MCAI, TI and CI) and repeated measurements (pre-test, post-test and 1-week retention test) as independent variables, and knowledge learning as dependent variables. The experiment on attitude determination was a factorial design with CI teaching method group and post-test measurement as independent variables, and student's attitude as dependent variable.

3 Results

Homogeneity of variance and Sphericity was verified by the Box's *M* test, the Levene's test and the Mauchly's test (Green and Salkind 2003). Initial differences between the three groups for the mean knowledge scores were tested using one-way analysis of variance. An item analysis using the responses of the pilot study was conducted to determine the difficulty rating and index of discrimination. In determining the internal consistency of the knowledge test, the alpha reliability method was used. Two-way analysis of variance (ANOVA), with repeated measures on the last factor, were conducted to determine effect of method groups (MCAI, TI, CI) and measures (pre-test, post-test, re-test) on knowledge test. Paired-samples *t*-tests were conducted to compare students' attitudes (CI group) towards the MCAI and TI teaching methods. Each variable was tested using an alpha level of significance 0.05. A listing of the results from the item analysis of the knowledge test in the pilot study can be found in Table 2. Means and standard deviation for the MCAI, TI and the CI group in pre-test, post-test and re-test are presented on Table 1, while results of each analysis are presented separately below.

Table 1 Means and standard deviations for pre-test, post-test and re-test scores of the three groups on knowledge test

	Group	*N*	Mean	Standard deviation
Knowledge Test 1st measure	TI	25	6.00	1.98
	MCAI	25	6.12	2.40
	CI	25	6.36	1.52
Knowledge Test 2nd measure	TI	25	8.24	2.67
	MCAI	25	8.28	1.14
	CI	25	8.80	1.16
Knowledge Test 3rd measure	TI	25	8.08	2.68
	MCAI	25	8.20	1.12
	CI	25	8.76	1.17

3.1 Item analysis

The pilot study knowledge test had a mean difficulty rating of 51%. When all items were analyzed, two questions, or 11.8% of the items, had unacceptable difficulty rating values. The utilization of a difficulty rating criterion of between 10% and 90% resulted in 88.2% of the items yielding an acceptable level of difficulty. The pilot study knowledge test had a mean index of discrimination of 0.38. When all items were analyzed, two questions, or 11.8% of the items yielded an unacceptable index of discrimination values. The acceptable value for index of discrimination was 0.20 or higher. Acceptable index of discrimination values were observed for 88.2% of the items. Finally one more question, or 5.9% of the items, had unacceptable index discrimination and difficulty rating values. As indicated by the information in Table 2, five of the items (5, 8, 13, 14 and 17) were therefore deleted from the test for the main study.

3.2 Reliability analysis

Reliability measures for knowledge test and attitude questionnaire were assessed. An alpha reliability coefficient.75 was computed based on the inter-item correlation coefficients of the pilot study knowledge test. While the Cronbach a coefficients of the attitude questionnaire was 0.84 and 0.91 for the two aspects of attitude: (1) positive and (2) negative, respectively, with all >0.70. According to Green, and Salkind (2003), the reliability coefficient should be at least.70 for the test to be considered reliable. Thus, the determination was made that the pilot knowledge test and the attitude questionnaire were reliable measurement instruments.

3.3 Two-way repeated-measures analysis of variance (ANOVA)

There were no significant initial differences between the three teaching method groups for the mean knowledge test scores, $F(2,72)=0.210$, $p>0.05$. Mauchly's test

Table 2 Summary of item analysis for pilot study knowledge test

Questions	Index of discrimination	Difficulty rating (%)	Results
1	0.34	48	Retained
2	0.40	53	Retained
3	0.26	61	Retained
4	0.42	51	Retained
5	0.12	76	Eliminated
6	0.69	35	Retained
7	0.28	57	Retained
8	0.07	78	Eliminated
9	0.49	67	Retained
10	0.39	62	Retained
11	0.45	54	Retained
12	0.62	32	Retained
13	0.02	97	Eliminated
14	0.44	08	Eliminated
15	0.49	45	Retained
16	0.57	33	Retained
17	0.45	09	Eliminated

of sphericity was significant so a lower-bound (=0.500) transformation for the degrees of freedom was applied. A significant main effect was noted for the measurements, $F(1,72)=82.485$, $p<0.05$ but not for the group, $F(2,72)=0.814$, $p>0.05$, while the interaction measure X group was also not significant, $F(2,72)=0.161$, $p>0.05$.

Difference and repeated contrasts were conducted to follow up the significant measurements main effect. Differences in mean rating of knowledge test in TI group were significantly different between pre-test and post-test, $F(1,24)=51.410$, $p<0.05$ and between pre-test and re-test, $F(1,24)=26.382$, $p<0.05$. Differences in mean rating of knowledge test in MCAI group were significantly different between pre-test and post-test, $F(1,24)=13.500$, $p<0.05$ and between pre-test and re-test, $F(1,24)=17.647$, $p<0.05$. Finally differences in mean rating of knowledge test in CI group were significantly different between pre-test and post-test, $F(1,24)=46.903$, $p<0.05$ and between pre-test and re-test, $F(1,24)=54.109$, $p<0.05$. As shown in Fig. 1, the post-test and re-test knowledge scores were remarkably greater than pre-test knowledge scores for the three groups, while the difference between the post-test and re-test was not significant.

3.4 Paired-samples *t* test analysis

Paired-samples *t* test were conducted to evaluate whether CI group students were more favourable with TI or MCAI teaching approaches. The results indicated that the mean positive attitude ($M=15.63$, SD=5.99) was significantly greater than the mean negative attitude ($M=7.81$, SD=3.29) for the MCAI teaching approach $t(24)=5.264$, $p<0.01$. No significant difference was found between the mean positive attitude ($M=9.56$, SD=4.65) and the mean negative attitude ($M=8.31$, SD=7.88) for TI teaching approach $t(24)=0.741$, $p>0.05$. Also, significant difference was found between the mean scores of the MCAI teaching approach ($M=15.63$, SD=5.99) and the mean scores of the TI teaching approach ($M=9.56$, SD=4.65) for the positive aspect of the questionnaire $t(24)=3.112$, $p<0.01$. On the contrary, no significant difference was found between the mean scores of the MCAI teaching approach ($M=7.81$, SD=3.29) and the mean scores of the TI teaching approach ($M=8.31$, SD=7.88) for the negative aspect of the questionnaire $t(24)=0.383$, $p>0.05$. As shown in

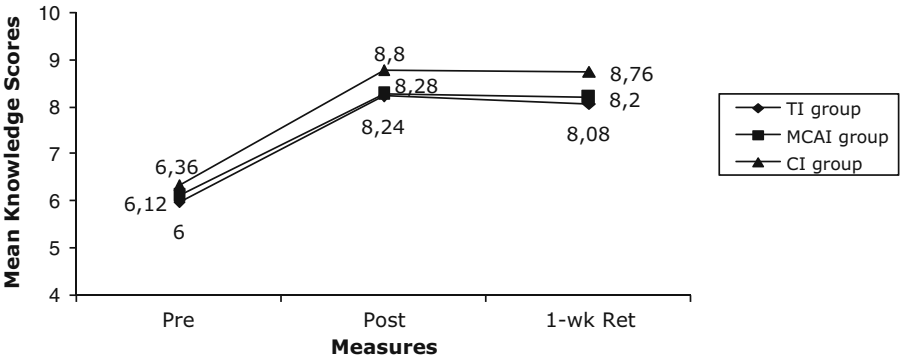

Fig. 1 Performance of the three groups on all measures of the Knowledge Test

Fig. 2, the CI group students were more favourable with MCAI teaching approach than TI teaching approach.

4 Discussion

Despite nearly two decades of research on multimedia learning tools, we are still a long way from knowing how best to exploit the power of this technology to support learning. It is clear that large individual differences exist among learners and that the freedom to jump and move at one's own pace through material is not equally beneficial to all. Despite these and other limitations, the present study was designed to examine differences that may occur when individuals learn a motor skill under different instructional teaching methods and replicated previous findings by showing differential attitude and cognitive performance dependent on teaching methods. With regard to the knowledge test, all groups improved their cognitive learning in basketball shooting skill, after instruction. Post-test results indicated no significant differences between the groups concerning the written test. Nevertheless, the attitude test scores of the CI group were more favourable to MCAI method than TI method. Retention test results showed that groups retained the knowledge acquisition. However, the combine method of instruction tended to be the most effective on cognitive learning.

The significant improvements in knowledge test scores from the pre-test to the post-test for the TI group, the MCAI group and the CI group while not having significant differences between the groups on the learning variable are consistent with the results reported in the literature. Wiksten et al. (2002) did not find a significant learning difference between computer-assisted instruction and the traditional method of instruction in an introductory athletic training laboratory class on either the written or practical examination. Vernadakis et al. (2002) developed a multimedia application for the instruction of the setting skill in volleyball and reported that the study provided no evidence to indicate that the multimedia computer-assisted instruction application contributed significantly more to student learning when compared to the control group which had been instructed by traditional means. In earlier studies comparing the impact of MCAI and TI method, Adams et al. (1991) and Kerns (1989) found no significant differences in scores of tests in golf and tennis rules.

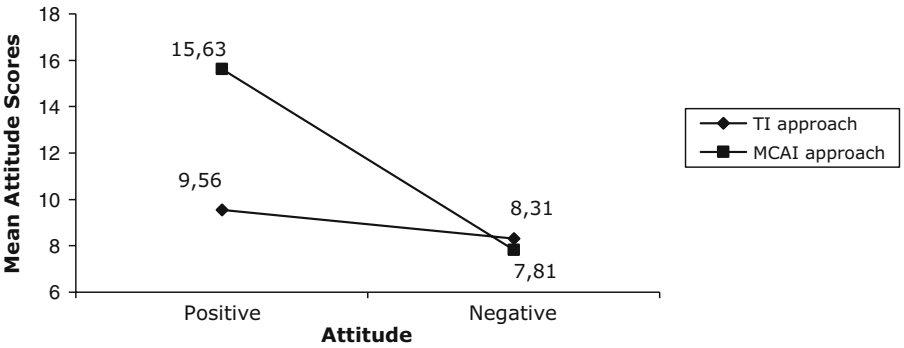

Fig. 2 Profile plot of the positive and negative scores for each teaching approach

On the other hand, there are previous studies in physical education supporting the view that computer assisted instruction is consistently superior to the traditional forms of instruction while other evidence is contradictory. From a recent multimedia study on learning rule violations in basketball, Antoniou et al. (2003) found that university physical education students receiving lecture instructions performed significantly better than the MCAI group. In other study, Siskos et al. (2005) found that MCAI was superior to traditional classroom teaching in passing knowledge in health-related fitness and nutrition subjects.

One can hypothesize that the features of the training likely to have been responsible for the observed improvement in TI, MCAI and CI method groups' performance were the structure and discipline provided by classroom meetings and instructors that distinguish the CI method from MCAI method but not from TI teaching method, and the opportunities for practice, assessment, and feedback provided by computer-mediated performance activities that distinguish the CI method from TI method but not from MCAI teaching method. The structure of the learning environment was likely to help students manage their time and remain on task. The frequent performance activities served as a way of causing students to be actively involved in the learning process throughout the entire training period, to facilitate transfer, and to stimulate the development of new, functional behaviours.

The lack of significant differences from the post-test to the re-test for the three instructional method groups is inconsistent with the meta-analytic study (Cotton 1991) which integrated the findings of 59 independent evaluations of computer-assisted instruction during the 1980s and reported that CAI as a supplement to traditional teacher-directed instruction produces maintenance scores superior to those obtained with traditional instruction alone. Research is inconclusive regarding the comparative effectiveness of conventional instruction alone and CAI alone. Antoniou et al. (2003), for example, found that traditional lecture instruction was superior to MCAI in the retention of basketball rule violations knowledge. On the contrary, Yildirim et al. (2001) reported that multimedia applications increase the ability of information maintenance. Also, Vernadakis et al. (2006) found no significant differences between post-test and re-test for the three instructional methods (TI, MCAI and CI) in the long jump event knowledge test.

However, Mayer (2001) reported that well-designed multimedia applications increase the ability of information maintenance. In the current study the evaluation of the learning maintenance, showed that the three instructional method groups mean scores did decrease slightly from the post-test to the re-test, however the difference was not significant. The time period between the administration of the post-test and the re-test was short, 7 days. While the re-test mean scores indicated that learning may have been affected differently during this period for the tree instructional groups, long term retention differences would be purely speculative.

The attitude survey showed that the MCAI teaching method had a stronger positive effect on students' attitude, than the TI teaching method. Students did state that learning about basketball shooting skill on the multimedia application made the subject matter more interesting, which could imply that this method of teaching can be used effectively. Students rated the activities as intelligent, meaningful, and pleasant for learning and remembering, and they particularly valued the interactive nature of the learning experience and the visual nature of the presentation. They

seemed to understand and comprehend the material better. In light of this, these findings reaffirm previous studies that concluded that the use of multimedia computer-based instructional programs improve students' attitude scores as compared to the use of traditional or regular methods of instruction (Astleitner and Wiesner 2004; Kiboss and Ogunniyi 2003; Liao 1999).

However, Bernard et al. (2004) in a comprehensive meta-analysis of 232 empirical studies conducted between 1985 and 2002 concluded that courses reporting high levels of student interest also tended to report lower levels of achievement. They also concluded that end of course measures of interest tended to be negatively correlated with end of course achievement. Thus, as achievement increased in multimedia studies, student interest and satisfaction decreased. They conclude that interest satisfaction may not indicate success but the opposite, since students may spend less effort learning, especially when they choose between multimedia education and regular courses for convenience purposes.

Although the research flowed smoothly, there were a few items that needed to be addressed. First, students were from one middle school of Thessaloniki. A larger and more diverse sample would provide a more stringent test for cognitive learning on a MCAI program. Additionally, the results reported in this study are based on a single MCAI program. This is a case-specificity problem. It is possible that a different type of MCAI package covering different content would yield different results.

Secondly, the age of students might be critical when it comes to learning independently. Since the participating students were all around 13 years of age when this study was conducted, they might not possess the learning skills that are needed in order to work independently using individual computers. Besides, research has also found that first-time users of computers are often overwhelmed by the vast amount of materials and information that can be presented by multimedia courseware (Renshaw and Taylor 2000). These types of differences between the three groups, therefore, might be reflected in the students' post-test and 1-week retention knowledge test scores.

Thirdly, no attempt was made to control possible differences in computer skills and multimedia experiences of the students or the effective learning time of the students' real engagement in multimedia learning. If these limitations had been controlled and the effective learning time had lasted longer, the researchers might have reported more precise results for the effectiveness of MCAI, TI, and CI methods on cognitive learning of the basketball shooting skill.

Fourthly, the pupils' beginner status in basketball shooting skills was not examined as a factor of potential impact, and the same applies for their expectations and potential motivational responses to different teaching methods. Perhaps, the beginner students have a high degree of motivation, they are more focused and filled with enthusiasm at the prospect of living the experience of a new teaching method. On the contrary, advanced students might have more realistic expectations about the MCAI experience and a more relaxed attitude about multimedia applications. Therefore, researchers might had considered these limitations when investigating differences that may occur on learning a motor skill under different instructional teaching methods.

Finally, students did not receive the intervention on consecutive school days due to school holidays. That may have caused problems regarding retention of information for some students. For those reasons, further research may be needed to replicate this study.

Those limitations of the research learning environment may have significantly affected the experimental groups' ability to learn and to retain the knowledge acquisition of the basketball shooting skill. However, it would be difficult to be certain, that the MCAI group would have been more successful than TI and CI groups on cognitive learning if the above limitations could have been eliminated. In that sense, these results indicate that students can be taught through the use of multiple effective teaching techniques. Multimedia programs have been generally successful especially when it has been used in connection with regular classroom instruction (Vernadakis et al. 2004).

5 Conclusion

From an instructional point of view, multimedia applications in the lecture setting were found to be quite helpful and more pleasant in describing basketball events (e.g., the shooting skill). The fact that examination scores from CI lectures were slightly higher compared to those from TI and MCAI lectures (Fig. 1) suggested that the three methods were at the least equally effective in helping students learn the material. These results lend support to the supplemental role of MCAI to more traditional instructional methods in the context presented in this investigation. Any generalizations from this research should be avoided for many reasons. The multimedia development may be deficient, thereby affecting the outcome of the research. Extraneous factors, including dynamics and issues of the participants, could affect the outcome. Technical issues, varying skill levels, such as reading and learning styles, and other inevitable differences present significant variables in the research. Teacher–student relationships affect engagement in lessons, which in turn affect educational outcomes (VanDeWeghe 2006). Therefore, these conclusions are limited to students aged 12–14 years old using this particular multimedia application. However, multimedia software and computer technology is now an accepted instructional tool in physical education. In that respect, we might conclude that MCAI can be useful as one of a number of instructional approaches in one's teaching repertoire. The combination of the two instructional teaching methods (TI and MCAI), designed to help students contextualize what they were learning by applying it to other athletic courses and other situations, may have contributed to the transfer required to increase knowledge in other courses. Further research will be required to determine the specific contribution of these and other features of the CI approach to its overall effectiveness.

Appendix

Appendix A: Knowledge test

Circle or underline the correct answer

1. Which shot provides one of the easiest scoring opportunities in the game?
   a. Lay-up
   b. Set shot

c. Free throw*
d. Jump shot

2. What type of spin is on a well-executed foul shot?
   a. Backspin*
   b. Forward spin
   c. Side spin
   d. No spin
3. What should a player do before shooting a free throw?
   a. Check the score clock to see what the score is
   b. See that teammates are properly placed on the lane
   c. Check to see where the player is who is assigned to guard him or her
   d. Relax and concentrate on the shot *
4. When should a player shoot when performing a jump shot?
   a. Jump and shoot at the same time
   b. Jump and shoot on the way down
   c. Jump, then shoot at the top of the jump*
   d. Jump and shoot as soon as the feet leave the floor
5. Which shot is the most difficult to guard?
   a. Lay-up
   b. One-hand set shot
   c. Jump shot*
   d. Set shot
6. When shooting a free throw, a player should:
   a. Bend his knees*
   b. Close his knees
   c. Not bend or close his knees
   d. Bending or closing knee doesn't matter
7. What is the key to accuracy in making a basketball free throw?
   a. Extending the shooting arm quickly
   b. Keeping the elbow straight*
   c. Directing the ball with the fingers and with the wrist
   d. Supporting the ball with the non-shooting hand
8. When shooting free throws and three-point baskets, the players should grip the basketball by applying pressure to the ball with:
   a. The shooting thumb
   b. All fingers on the shooting hand*
   c. The finger pads and thumbs on the shooting hand
   d. Gripping the ball with the shooting hand does not help
9. Which body part is essential to keep in line with the basket when shooting a basketball jump shot?
   a. Legs
   b. Hips
   c. Arms
   d. Shoulders*
10. What call is made by the official after a player dunks the ball?
    a. Violation
    b. Technical foul

c. Basket is good*
d. Goaltending

11. What is goaltending?
    a. Touching the net when the ball is the air
    b. Giving up the ball without getting a shot
    c. Touching the backboard while the ball is flight
    d. Affecting the downward flight of the ball*
12. A basket is shot and made at the end of the game. When does it count?
    a. When the ball has left the shooter's hand before the buzzer*
    b. When the shooter has already started motion to shoot
    c. When the ball is being tapped after the buzzer
    d. When a personal foul is committed after the buzzer and a basket scores

Appendix B: Post-test attitude scale

Table 3 Express your feeling with the following statements on a 0–5 scale where 0=weak and 5= powerful by comparing TI and MCAI teaching methods

TI	Scale											MCAI
Good	5	4	3	2	1	0	1	2	3	4	5	Good
Bad	5	4	3	2	1	0	1	2	3	4	5	Bad
Foolish	5	4	3	2	1	0	1	2	3	4	5	Foolish
Intelligent	5	4	3	2	1	0	1	2	3	4	5	Intelligent
Meaningful	5	4	3	2	1	0	1	2	3	4	5	Meaningful
Meaningless	5	4	3	2	1	0	1	2	3	4	5	Meaningless
Unattractive	5	4	3	2	1	0	1	2	3	4	5	Unattractive
Attractive	5	4	3	2	1	0	1	2	3	4	5	Attractive
ugly	5	4	3	2	1	0	1	2	3	4	5	Ugly
Beautiful	5	4	3	2	1	0	1	2	3	4	5	Beautiful
Unpleasant	5	4	3	2	1	0	1	2	3	4	5	Unpleasant
Pleasant	5	4	3	2	1	0	1	2	3	4	5	Pleasant

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