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Effects of Using Computer Games as an Instructional Tool on Third Grade Students' Acquisition of Higher Order Thinking Skills

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Abstract: *The purpose of this study is to investigate the effect of computer games as an instructional tool on third grade students' acquisition of higher order thinking skills. Three instructional computer games that cover the content of three lessons in Arabic, Mathematics and Science textbooks were used. Thirty-two students served as the experimental group and were taught via computer games, and 31 students served as the control group and were taught the same content without using computer games. Subjects were all chosen from a public school in Irbid in the northern part of Jordan. The target higher order thinking skills were analysis, synthesis, and evaluation, assessed by an achievement test designed for this purpose. The results of the study revealed significant differences among students in the acquisition of the three levels of higher order thinking skills in favor of the experimental group, indicating a significant effect of computer games on acquiring higher order thinking skills. (**keywords**: Computer assisted instruction, computer games, thinking skills).*

أثر استخدام ألعاب الحاسوب كونها وسيلة تعليمية في اكتساب طلبة الصف الثالث الأساسي لمهارات التفكير العليا

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ملخص: هدفت هذه الدراسة إلى الكشف عن أثر العاب الحاسوب كونها وسيلة تعليمية في اكتساب طلبة الصف الثالث الأساسي لعمليات التفكير العليا، وتم استخدام ثلاث العاب تعليمية تغطي محتوى ثلاثة دروس من كتب اللغة العربية والرياضيات والعلوم للصف الثالث الأساسي. وقد تكونت عينة الدراسة من 32 طالباً مثلوا العينة التجريبية التي درست المحتوى باستخدام العاب الحاسوب كونها وسيلة تعليمية، و31 طالبا درسوا المحتوى نفسه باستخدام الوسائل الاعتيادية، وقد تم اختيار أفراد الدراسة جميعهم من إحدى المدارس الحكومية في مدينة إربد في الأردن. وتحددت مهارات التفكير العليا بمهارات التحليل والتركيب والتقويم، وتم تقييمها باستخدام اختبار تحصيلي صمم لهذا الغرض، وقد أظهرت نتائج الدراسة وجود فروق دالة إحصائياً بين أفراد عينة الدراسة في اكتساب مهارات التفكير العليا وعلى مستويات التفكير الثلاثة ولصالح أفراد المجموعة التجريبية. (**الكلمات المفتاحية**: التعليم بالحاسوب، ألعاب الحاسوب، مهارات التفكير).

Playing games is one of the most common activities used in elementary schools. They play an important role in the psychological, social and intellectual development of children. Playing is a voluntary activity that is intrinsically motivating. Therefore, teachers use it as one technique that increases activity and makes learning a pleasant experience, affording joy, fun and humor (Rieber, 1996). Indubitably, these attributes closely match those of modern educational theories (Behavioral theory and Cognitive theory) where learning should be a self-motivating and rewarding activity.

Because of the development in utilizing computers in all aspects of life, the nature of games children play has changed dramatically. Playing games has switched from traditional instructional practices to a technology-based learning environment. This transition has attracted a great deal of interest especially after the widespread of computers (Bright & Harvey, 1984). Computers have spread through schools, homes and society. They have taken over children's minds and the way they view the world. Studies revealed that the most popular home activity preschool children enjoy is playing computer games (Mumtaz, 2001). It has been argued that the computer age has replaced book-based learning and a recent survey found that 15-year-old boys spent less than two hours a week reading books for pleasure, compared with 11 hours a week watching television and nine hours playing computer games (Kerawalla & Crook, 2002).

Studies all over the world confirm that games are the most common application of computers especially among children. A study in the UK carried out by Livingstone and Bovill (1999) examined computer use both at home and at school for children aged 6-17 years and found out that most home computer activity (77%) centers on games. Worldwide, another piece of research conducted by Setzer & Duckett (1994) revealed that over 10.5 Billion US Dollars were spent worldwide on electronic games for home use in 1993.

Because of the popularity of electronic games, educators began considering their applications to classrooms. Educators discovered that electronic games can fit into the educational environment in a variety of ways,

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ranging from creating total-learning systems to serving as components in more traditional learning environment (Al Mubireek, 2003).

Many people consider games just as a means of entertainment and not as part of the educational software, thus having little connection with the schools' agendas. Some researchers went on to say that the prolonged and excessive use of electronic games contribute to an obsessive, addictive behavior, dehumanization of the player, desensitizing of feelings, health problems and development of anti-social behavior as well as other disorders (Setzer & Duckett, 1994). Most researchers, however, confirm that the advantages of computer games overweight their disadvantages. According to Tzeng (1999), children may obtain many benefits when playing games. Games typically elicit complete mental involvement from participants, have concrete goals and rules that help focus attention and direct action, require a high degree of player interaction, provide immediate feedback, incorporate variable levels of challenge to keep players involved as their skills increase, enhance recall and transfer of knowledge, and evoke mental imagery that facilitates the retention of educational materials embedded in the game (Quinn, 1997). Klein and Frettag (1991) noted that the essential elements of computer games such as 3D sound, graphics, and story telling, provide a powerful sense of interactivity and control, while immersing the user with the information or content of the game.

Researchers in technology-based learning environment have found that playing computer games contributes to the enhancement of thinking skills. Games could significantly facilitate children's cognitive processes such as making inferences and logical thinking skills. The researchers assert that incorporating games into an instructional design improves students` skills in practical reasoning, making inferences and engaging in inductive reasoning (Pillay, Brownlee, and Wills, 1999). Moreover, computer games enhance higher order thinking skills through the combination of visual and interactive learning experience that includes sounds, pleasant signs, applause, and other forms (Pogrow, 1994; Arnas, 2002). They often include problems that develop critical thinking defined as the analysis and evaluation of information in order to determine logical steps that lead to concrete conclusions (Doolittle, 1995). Visualisation, which is an important element of computer games, is a key cognitive strategy that plays an important role in discovery and problem solving (Betz, 1995-1996). In addition, many of the problems presented in games require students to form mental representations and manipulations of objects or elements (Amory, Naicker, Uincent, and Adams, 1999).

Studies of expert and novice computer games players (Pillay et al, 1999) suggest that in moving from a novice to an expert player, cognitive processes may be enhanced. The studies revelead that expert players highly organised knowledge structures. Since the recreational computer games players would need a highly organised knowledge structure in their internal representations, these would help them efficiently deploy knowledge and make meaningful inferences when confronted with situations. These studies suggest that experts have efficient cuing and linking mechanisms in their knowledge stuctures. Playing recreational computer games involves encoding explicit information presented in the game and consructing internal representation. Initially, novice players would be reliant on surface features in their knowledge construction that, over time, would presumably become organized knowledge structures when prompted with certain games situations.

It is undeniable that playing games requires skills children need in order to simultaneously and selectively attend to a number of different pieces of information displayed on the screen (Fromme, 2003). Often this takes place under specific time constrains that restrict the extent of exploration one can afford (Amory, et al, 1999). In addition, when a student plays recreational games, it is necessary for him to use a mixture of his own idea and technical concepts in the simulation which makes him navigate through the given information and make connections between information from different scenes. Such a process requires maintaining temporal information in memory as one moves between screens (Gokhale,2002).

Playing computer games requires many skills such as processing information explicitly in graphics in addition to skills of processing complex mental representations such as those found in most problem-solving tasks. Studies conducted by Pillay, Brownlee, and Wills (1999) indicated that while playing computer games, players practiced complex cognitive processes such as interpreting explicit and implicit information, inductive reasoning, metacognitive analysis, and problem solving. All of these cognitive processes suggest that playing computer games can benefit the development of thinking skills that could not necessarily be encouraged easily through other media. The British Communications and Technology Agency (BECTA,2001) funded a pilot study in computer games in education. One of the conclusions of the study was that students can receive immediate feedback on their actions and decisions as well as invite exploration and experimentation through games.

The need to prepare students for the Information Age is a recurring theme in the Educational Reform Movement. The arrival of the Information Age has made the acquisition of higher-order thinking skills among learners crucial, and developing these skills has become a national goal in many countries. Many researchers (e.g, Pogrow, 1994; Scott, Cole, Engel, 1992) argue that for students to be competitive in years to come, teachers need to be able to provide them with cognitive strategies that will enable them to think critically, make decisions, and solve problems.

Educators believe that knowledge of the basics is no longer sufficient in the ever-changing society; therefore, thinking skills have become at the top of their agendas. Harris (1999) states that generations of the information age must learn not only how to access information, but more importantly how to manage, analyze, critique, cross-reference, and transform it into usable knowledge. These high level skills of thinking are best acquired when learners construct knowledge rather than passively ingest information (Hopson, 1998)

The above review of literature suggests that computer games can play an effective role in enhancing thinking skills if incorporated into the instructional practices. Not only can computer games enhance basic skills of thinking, but also they can enhance higher order levels of thinking, which this study examines.

Through reviewing the literature, the researcher has not encountered any empirical study addressing this issue in the Jordanian setup in spite of the ongoing efforts that the Jordanian government has put to utilize computer in education and, in spite of the educational policies in Jordan that tend to make the development of higher order thinking skills among its main priorities.

Higher-order thinking essentially means thinking that takes place in the higher-levels of the hierarchy of cognitive processing. Bloom's Taxonomy is the most widely accepted hierarchical arrangement of this sort in education and it can be viewed as a continuum of thinking skills starting with knowledge-level thinking and moving eventually to an evaluation-level of thinking.

Research Question: This study addressed the following research question:

Does using computer games as an instuctional tool contribute to the development of higher order thinking skills among third grade students in Jordan?

Significance of the study: This study will enrich the limited research on the use of computer in the elementary stage in general and the use of computer games in particular to enhance the development of the students' higher order thinking skills. What makes this study more important is the popularity of computer games among children and the high probability of utilizing them for the benefit of school-age children. It will ultimately provide data that may be used to make the use of computers in the elementary school more effective. The results of the study will also be useful for educators who are formulating technology plans in Jordan and in other Arab countries as well.

Operational Definitions of Terms: In this study, key terms are defined as follows:

Higher order thinking skills: They are the cognitive skills that allow student to answer questions that require him/her to function at the levels of Analysis, Synthesis, and Evaluation according to Bloom's Taxonomy of the cognitive domain. The questions were derived from the content of three lessons in the third grade' textbooks of math, science, and Arabic language in Jordan.

Analysis: It is the ability of the third grade student to answer questions in math, science, and Arabic, and to break down a whole object or idea into its component parts.

Synthesis: It is the third grade students' ability to answer questions in math, science, and Arabic language that require him/ her to combine component parts or ideas to create a whole or a solution.

Evaluation: A third grade student's ability to answer questions that require him/her to make quantitative and qualitative judgments in math, science, and Arabic.

Instructional Computer Games: Three instructional computer games were used in this study chosen from a group called "School of Digital Heroes". The games were presented to students in Arabic and covered a content of three lessons in the Arabic Language, Mathematics, and science textbooks of the third grade in Jordan.

Methods

Subjects: A school was randomly chosen out of four schools in Irbid in north Jordan that have computer labs and more than one section of the third grade. Two sections consisting of 63 students were randomly chosen from that school; one of the selected sections which consisted of 32 students was assigned to the experimental group, and the other section that consisted of 31 students was assigned to the control group.

Materials: The following materials were used in the study:

Instructional computer games: Twelve instructional games representing the Arabic language, mathematics, and science were selected. All the games were given to a jury of six experts in the field of Elementary Education and Educational Psychology at the college of Education at Yarmouk University. The experts were asked to choose three games, one in each subject, they thought they were the most appropriate for the sample of the study. Most experts (80%) chose three instructional games from a group Called "School of Digital Heroes"; these games were part of an electronic textbook designed by an educational technology company in Jordan.

The three games were designed in the Arabic language and were part of electronic textbooks of three subjects; namely the Arabic Language, Science, and Mathematics. The textbooks were designed in a way so that most of their activities can be used as Instructional games. Games in these textbooks were used as a tool to facilitate learning and make it more enjoyable. This may enable students to play and learn simultaneously, as instructional games may help them learn through creating situations in which learning is associated with fun, excitement and suspense. The games used are the following:

A. Digital gate: This game represents the content of the math lesson (The multiplication). The games used to encourage mathematical and strategic thinking. At the beginning the student has to select a number from one to ten. After selecting the

number, the student is given a math problem. Each problem has three answers; only one of them is correct. Every time the student chooses the correct answer, it will help the children in the game move a step toward the digital gate and players will get reinforcement in the form of music, cheering sounds, and clapping. If a wrong answer is given, the digital gate shut down; going through the gate is forbidden, and the student has to start the game again.

B. Digital monsters: this game covers the content of the science lesson (Space Invasion). In this game the student is asked to help digital kids in their fight with monsters. The student has to think of different ways to provide help. Answering questions given to him about the content of the lesson is the most effective way to kill the monster. Each time a student gives a correct answer, one of the monsters is killed. The student is allowed to give the wrong answer three times, after that he starts the game from the lowest level. After finishing the game the student gets reinforcement and saves the world from the monsters.

C. Hunting Pokemons: This game covers an Arabic lesson (Cooperation) from the Arabic Language textbook. In this game, a player walks through a maze to reach and hunt a Pokemon at the end of the maze. Player students have to think of ways to hunt Pokemons and all the ways require an understanding of the content of the lessons. A student moves one step forward if he gives a correct answer. If he gives a wrong answer, he has to start over the games and meets new questions. When he answers all the questions, the student reaches the end of the maze and catches the Pokemon.

Higher Order Thinking Skills Test: An achievement test was constructed to measure higher order thinking skills. The test that covered the content in the instuctional games was derived from science, Math, and Arabic textbooks. From each subject a lesson was coverd. The lessons were "cooperation" from the Arabic Language textbook, "multiplication" from the Math textbook, and "Space Invasion" from the science textbook The achievement test consisted of thirty-multiple choice items, each item has three alternatives. Each correct answer was given one point, while the incorrect answer was given zero. The thirty items were distributed equally on the three levels of higher order thinking (analysis, senthysis, and evaluation).

In the first draft, the achievement test contained 45 items; it was given to a jury of 12 experts in the field of Elementary Education and Educational Psychology. The experts were asked to determine to which level of thinking each item belongs and the appropriateness of each item to the cognitive level of the students. After making the modifications and changes they requested, the researcher kept 30 items that constitute the final version of the test. The items that were kept are the items that 80% of the experts agreed on. Here is an example on each level of thinking from the three lessons which were translated from Arabic to English:

Analysis level:

- The similarity between the actual moon and the artificial moon is:

A. Both of them are lighting.
D. Both them rotate around the earth.
E. No human beings live in both.

Synthesis level:

A family has four children all of them are in schools; each child needs 12 JDs each year to buy textbooks; how many JDs do children need to buy in three years?

A. 84
B. 96
C. 144

Evaluation Level: What would happen to the Arab countries if they united and became one state?

A. Their problems would increase.
B. They would become more powerful.
C. They would become weak.

To determine the test reliability, the researcher used Kudar Richardson 20 formula, which revealed a reliability coefficient of 0.72.

Procedures: Two graduate students from the college of education at Yarmouk University helped the researcher in training the experimental group to gain the basic skills in using the computer, in particular the skills of using the mouse, which is the main skill students need to play computer games. The subjects were trained for a week (an hour a day) working with Microsoft Paint and playing Solitaire. The students in the experimental group were taught the three lessons by their teacher using instructional computer games in the computer lab, simultaneously with their peers in the control group, who studied the same content in their classroom using the traditional method of teaching which is the method of teaching that students used to. Each lesson was taught in one day. After studying the content, both groups took the post-test.

Results and Discussion: To answer the research question, the researcher calculated the means and standard deviations of students' performance on the higher order thinking skills test and presented them in Table (1)

Table (1): Means and standard deviations of the subjects' performance on the post test

Level of thinking	Groups					
	Experimental			Control		
	Mean	SD	N	Mean	SD	N
Analysis	8.8125	.8206	32	7.9032	.7463	31
Synthesis	8.6563	.7453	32	7.2903	.9379	31
Evaluation	7.5000	.7184	32	6.8065	.7033	31

Table (1) shows differences in the achievement between the control and the experimental groups. To determine the significance of these differences and since the study is qusi-experimental, multivariate analysis of co-variance (Mancova) was conducted and the results are represented in Table (2)

Table (2): Multivariate analysis of covariance (Mancova) of students' performance on the posttest

Effect	Multi variate Test	Value	F	Hypothe-sis df	Error df	Sig.	Eta Squared
PANALYSI	Wilks' Lambda	0.55	14.97	3	56	0.00	44.5%
PSYNTHES	Wilks' Lambda	0.74	6.67	3	56	0.00	26.3%
PEVALUAT	Wilks' Lambda	0.76	5.93	3	56	0.00	24.1%
GROUP	Hotelling's Trace	1.78	33.26	3	56	0.00	64.0%

Table (2) shows that there is a significant difference between the two groups in their performance at different levels of higher order thinking skills. To determine which levels of thinking, the difference Analysis of covariance was conducted. The results are presented in Table (3).

Table (3): Analysis of covariance (Ancova) for students' performance on the three levels of thinking skills

Effect	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared
Pre-ANALYSI	ANALYSIS	14.566	1	14.566	45.385	0.000	43.9%
Pre-SYNTHES	SYNTHESIS	7.081	1	7.081	16.884	0.000	22.5%
Pre-EVALUAT	EVALUATION	6.322	1	6.322	17.905	0.000	23.6%
GROUPS	ANALYSIS	12.081	1	12.081	37.642	0.000	39.4%
	SYNTHESIS	30.333	1	30.333	72.325	0.000	55.5%
	EVALUATION	7.457	1	7.457	21.119	0.000	26.7%
Error	ANALYSIS	18.614	58	0.321			
	SYNTHESIS	24.325	58	0.419			
	EVALUATION	20.478	58	0.353			
Total	ANALYSIS	50.603	62				
	SYNTHESIS	72.984	62				
	EVALUATION	38.413	62				

Table (3) shows significant differences between the experimental group and the control group on all three levels of thinking skills, in favor of the experimental group (see Table 1).

This result suggests that using computer games in the classroom can enhance the levels of thinking skills. The result can be attributed to many factors. One of the main factors is the fact that playing games requires students to involve mentally in the game. This involvement happened through manipulating objects and making inferences and decisions. More than that, the game itself represents an interactive learning experience, and incorporating computer games in teaching practices can make learning more entertaining and more fun. These results, also, support the ideas of Klein and Frettag (1991) who argued that the fantasy fulfillment elements of computer games allow players to become more excited and more adventurous and controlling their experience. This kind of experience allows students make extra effort more than the effort they make in the traditional learning situation. Computer games can also provide students with more challenges that entertain and engage the mind differently than the ones provided in books and other traditional media. The challenge may be how to solve puzzles or how to get the next level of a game. These activities required students to make an analysis and evaluation in order to determine logical steps. Incorporating computer games in the classroom instruction represents a new strategy of teaching, a strategy that is close to real and favorable life experience.

In early grades of elementary schools most teachers tend to use the traditional methods of teaching. This environment, where teachers dispense information, has greatly inhibited students` opportunities to think. In addition, most curriculum in early grades focuses on memorizing information rather than analyzing, synthesizing, and evaluating information. This environment caused difficulty in solving problems that require higher order thinking skills among students. All the activities that students get involved in will make students active learners and give them a chance to make decisions and take the responsibilities for these decisions.

The rationale for using games is that they help create a classroom atmosphere in which students at various levels of ability can collaborate in order to promote interest, motivation, enhancement of critical thinking and decision-making skills, and retention of information (BECTA, 2001). Computer games give enough freedom to students to search, discover, and learn to use self-activity (Alfaqih, 1995)

There are many elements in computer games that can make games an effective teaching strategy and enhance thinking skills. One of the main elements that helped the experimental group to perform higher than the control group is the adequate pay off they received when they accomplished a difficult task successfully. The rewards that students got came in different forms like sounds, pleasant signs, applause, and other forms. This element, as mentioned by Aranas (2002), can make learning experience have a tremendous effect on students` performance and improve their higher order thinking skills. Besides, incorporating computer games into teaching practices can make learning experience more interactive, provide higher levels of activity, and provide visual and audio themes and effects. Amory, Naicker, Vincent, and Adams (1999) suggested that a combination of these elements could make classroom learning exciting and fun.

Conclusion and recommendations: The results of the study revealed that using computer games as an instructional tool can contribute significantly to the enhancement of all levels of higher order thinking skills: analysis, synthesis, and evaluation. The results indicated that when students enjoy and love what they are doing, both their focus and attention to their tasks will increases, which eventually affects their thinking skills positively.

Since elementary schools in Jordan are highly equipped with computers, teachers are recommended to take advantage of this instructional tool to make their methods of teaching more effective. The focus of utilizing computers in Jordan is still limited to help students in acquiring basic computer skills. The need for teachers to be well-trained in incorporating computer games in their instructional practices seems to

be important in order to have them contribute to achieving the national goal in Jordan, namely preparing a new generation with high levels of thinking skills. The results of the study should encourage education decision makers in Jordan to put forward national plans to train teachers to be highly qualified in utilizing computers in all aspects of students' learning and integrate computer games into all subjects.

Since the relevant research indicated that using instructional games is the most effective strategy in elementary schools and the results of the present study support this idea, teachers in elementary classrooms are advised to activate this strategy and use computers effectively in designing and representing these games.

Finally, since the Arabic literature lacks the research in computer games and its utilization in all aspects of the children's development, the researcher recommends conducting other studies examining using computer games in developing other skills among learners and in teaching different subjects in different levels.

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