The Effectiveness of Using Interactive Simulation in Kindergarten Children's Acquisition of Physics Concepts

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Reham Al-Mohtadi[1], Mustafa Jwaifell[1], Yahya Al-Dhaimat[1], Laiali Almazaydeh[2](✉)
[1]Faculty of Education, Al-Hussein Bin Talal University, Ma'an, Jordan
[2]Faculty of Information Technology, Al-Hussein Bin Talal University, Ma'an, Jordan
laiali.almazaydeh@ahu.edu.jo

Abstract—The study aimed to investigate the effectiveness of using interactive simulation in developing some physics concepts in a sample of kindergarten children. To achieve the study objective, a semi-experimental method was used. The study sample consisted of the (45) kindergarten children of 'The Pink Bird' Kindergarten in Petra. They were randomly divided into two groups: an experimental group of (22) children who were taught using interactive simulation, and a control group of (23) children who were taught by the traditional way. Contrary to the traditional method of education. An achievement test was used to measure the Kindergarten Children acquisition of physics, where its validity and reliability were confirmed. The study results proved the effectiveness of interactive simulation in the acquisition of physics concepts among kindergarten children. It was also found that around 61% of the change in the dependent variable (physical concepts) is due to the use of interactive simulation in teaching. Eventually, the study included a set of recommendations in the light of its results.

Keywords—interactive simulation, physics concepts, kindergarten children

1 Introduction

Physics is considered as one of the essential sciences that include many abstract concepts that are quite difficult for students to fully understand what they mean. It is also concerned with the study of behavior and relationships among a wide range of concepts and physics phenomena. Thus, through learning physics, students acquire conceptual knowledge [1].

Forming and developing scientific concepts is one of the main objectives of teaching science for kindergarten children. It is also considered crucial to construct the scientific knowledge, where types of concepts differ according to their nature, levels, sources, and the way they are formed.

Computer simulation technology is one of the technological innovations that have influenced education. In fact, it has proved its effectiveness in students' understanding of abstract concepts and facilitating their teaching [2]. Therefore, computerized

education is an important advanced teaching method that increases the effectiveness of learning and provides the learner with activities and skills that are appropriate to their abilities considering the individual differences between students. This type of education promotes the student's self-reliance, awareness-building, autonomy, and the development of induction, deduction and inference strategies as he interacts with educational activities especially those programs are not the same parents' native language, which is very short in some of countries as Arabic for instance [3].

Since physics particularly, contains abstract concepts, using computers in teaching scientific subjects contributes to illustrate concepts tangibly. It has been proven that simulation is one of the most important computer programs used in active and effective education, because it transmits reality to the learner virtually, and allows him to experiment and interact safely which increases his motivation to achieve results. Interactive simulation allows the designer to intervene and add new variables or change the values of existing variables [4]. Also, interactive video can present information in different formats. It provides information using video footage, still frames, text, graphics, and sounds. The educational theory says that the greatest value of learning is achieved when information is presented in different formats [5].

The simulation software on the PhET website was designed by science specialists and was tested with students before using it. It was also developed by a team at the University of Colorado in the United States, so that users can download it from any device without having to connect to the Internet. Each simulation is designed to represent an independent learning tool that can be used in a variety of educational contexts to give the teacher the opportunity to choose what is appropriate to his lesson [6]. Moreover, the website provides these experiences in many languages, including Arabic, which saves the Arab teacher's effort to find a teaching tool that is effective for scientific topics in one site.

2 Problem statement

Upon investigating the interactive national curriculum of kindergartens in Jordan, one cannot find any focus on the different scientific concepts (physics, chemistry, biology) and that there are deficiencies in science programs particularly as there isn't a science book dedicated to this specific stage. Moreover, the modern educational programs applied in kindergartens in Jordan focus on stuffing children's minds with facts and knowledge, without providing the child with scientific skills and the different skills of research and thinking through various educational activities and games in a way that provokes their thinking.

Also, some kindergarten teachers are not convinced with the significance of using the appropriate means in the appropriate educational situation because of their ignorance about the psychological dimensions of the child's capabilities growth. This fact contributed to the process of introducing many concepts in a traditional way focusing only on stuffing the learner's mind with information and this is contrary to what has been proven by experiments and studies that children can deal with the computer as an educational tool and system in a creative and exciting way. However, what is seen

so far is that the computer is limited to being a curriculum taught and not used as an educational tool or means, especially in kindergarten stage.

Al-Debsi in [7] pointed out that the reasons for pupils' low ability to absorb scientific concepts are attributed to several factors; some are related to teachers and how they are not trained or qualified enough to use effective teaching methods or are unwilling to develop themselves. Other factors are related to pupils who lack proper thinking methods to deal with the scientific material and curriculum.

In order to correct learners' misconceptions about many scientific concepts and help them acquire these concepts in a functional way, science education at the elementary stage must be done using enquiring-based learning methods that adopt a sensible approach as the basis for teaching learning activities [8].

2.1 The study questions

1. What is the effectiveness of using interactive simulation in kindergarten children's acquisition of physics concepts?
2. What is the effect size of using interactive simulation on kindergarten children's acquisition of physics concepts?

2.2 The study purposes

1. Preparing a list of physics concepts that should be included in the interactive national curriculum for kindergartens.
2. Using computerized software based on interactive simulation that helps in kindergarten child's acquisition of physics concepts.
3. Identifying the effectiveness of using interactive simulation software in kindergarten children's acquisition of physics concepts.

2.3 The study significance

With its theoretical framework, this study draws the attention of those in charge of the educational process to the child's comprehension of physics concepts that help him to understand and interpret many of the things that are related to the environment, respond to them, and increase his ability to use scientific information in problem-solving situations. The child's comprehension of these concepts and relationships is associated with the formation of facts and practices carried out by the child, and then little by little he corrects them to acquire generalizations and rules associated with the concept absorbed by the child at a later stage.

It also serves to draw the attention of those who design the interactive national curriculum for kindergartens in Jordan to develop it by adding a variety of scientific concepts (physics, chemistry, biology, geology). Thus, providing kindergarten teachers with strategies and computerized program based on interactive simulation, which hopefully intends to make a qualitative change in teaching concepts for children.

On the practical level, the study is helpful to educational supervisors when holding educational meetings and training courses to train teachers on educational programs that support technology and methods appropriate to teach kindergarten children scientific concepts. The study results may also pave the way for graduate students and researchers of kindergartens teaching methods to conduct similar research and studies.

3 Literature review

3.1 Interactive simulation

Computer simulation programs are among the most used modes of learning. Students find it difficult to deal with some subjects that require a great deal of imagination, or facts that are difficult for the student to be in their real environment such as nuclear interactions, celestial bodies, deep seas, or others [9]. It is an integrated system that offers a variety of interactive teaching materials, media and learning styles that help in implementing education and modifying it through different methods to fulfill the needs of every learner and thus achieve the principle of individual differences [10].

Bellinger in [11] explained that it is processing a model or taking it in a way that makes it work overtime and place so that the learner can recognize interactions that might seem ambiguous.

AlGareeb in [12] defined it as dynamic and interactive computer software, designed as a model for information and educational experiments, which students can study through sharing and discovery.

Thus, it is a method in which events are presented artificially, taking into account the simplification and ease, and gives the learner the opportunity to control these events in terms of the possibility of recurrence or time of occurrence. Hence, the learner can indulge in the educational situation through the multiplicity and diversity of computer means, in addition to the multiplicity of the learner's interaction interfaces with the program. In so doing, simulation programs can be defined as a virtual system of reality.

The importance of interactive computer simulation in education can be illustrated by considering the studies that have tackled this issue such as Holzinger et al. [13] and Wieman et al. [14] which confirmed that computer simulation makes it easier for the student to easily save and retrieve information. It also encourages thinking and application processes, since thinking or meditating without practice leads to misguidance, as well as practicing without meditating is unlikely to succeed in the application. It also helps to learn new concepts through accurate reformulation of misconceptions and allows learners to control and process system variables and get immediate feedback on these changes, which further improves their conceptual comprehension and thus develops their attitudes towards learning. Furthermore, it provides the teacher and the learner with the opportunity to save time especially that there may be experiences that take the teacher only one minute to conduct and allows the learner to learn how events occur by placing them under observation and study.

Interactive simulation has many advantages among of which are control and interactive behavior. Control is defined as the students' ability to determine the speed of shots succession, while interactive behavior involves educational activities where content

is determined in successive shots through students' procedures [15]. It also allows the learner to make mistakes that do not cause negative consequences and exercise some freedom in the learning process. Through interactive simulation, processes and procedures can be explored and studies easily if the traditional method is helpless in this case. Moreover, it reduces the learning time, simulates interactive learning, increases motivation towards the learning process, and helps to achieve discovery learning in a way that leads to developing learners' concepts, mastering skills, and saving large expenses spent for training through actual reality [16], [4]. Alfar in [17] listed four types of simulation: physical, procedural, situational, and process. The following is a brief explanation of these types:

Physical simulation. Typically, a group of objects appear to the learner reflecting a virtual context and represent the elements of a realistic system that the learner can interact with to achieve the system output. For example, the learner learns to operate a machine, where the machine parts appear to be active. Thus, if the learner presses the power switch, the simulation software shows that the machine is in a working state. It also includes learning to operate and use laboratory equipment so that the learner can practice using the device and understand its mechanism in a virtual environment [18] before he starts using the actual device.

Procedural simulation. Procedural simulation relates to the content of the simulated in terms of action steps or following a correct sequence of steps that constitute a procedure or the best procedure that can be followed to achieve a specific goal, which helps to uncover the students' talents and abilities in creating easy and fast methods of diagnosis and treatment.

Situational simulation. It is also called simulation of situations in which the individuals' behavior in certain situations is revealed and their attitudes towards different situations are identified. It is different from procedural simulation in that it focuses on the learner's discovery of the impact of a method or strategy followed or present in the simulated and not following specific procedures to reach the results of the simulated system. What distinguishes it from other types of simulation programs is that it makes the learner one of the elements of the simulated to play an active role that might be in the form of a function or one of the system organisms, such as an animal and ways followed by this organism in trying to survive.

Process simulation. In the three simulation programs, the learner has an active and interactive role. For instance, in physical simulation, he acts as a learner and discoverer of the elements' roles of the simulated. In the procedural simulation, he plays the role of following a series of procedures, whereas in the situational simulation, he acts as one of the simulated program elements. However, Process simulation programs makes the learner an experimenter scientist who changes and modifies the elements and functions of the simulated system to discover laws and rules by linking the components relationships of the simulated elements.

3.2 Physics concepts

Among the objectives of teaching science for children is forming and developing scientific concepts. This goal requires a teaching method that includes the integrity

of scientific concepts, as well as forming and acquiring them. Therefore, developing scientific concepts for kindergarten children according to a studied scientific program that is consistent with the child's nature and the requirements of this age has become a significant and crucial issue that is worthy of attention [19].

Piaget in [20] believes that the concepts of children at this stage are distinctly different from the concepts of adults not only in terms of size, but in terms of composition, quality, and characteristics. In other words, the child cannot reach the levels of knowledge appropriate to his age and level of maturity only by himself. Thus, he believes that appropriate education can accelerate the child's mental development within his or her potential by organizing the environment and experiences in a way that helps to develop his concepts of knowledge, classification, sequencing, time, space, and other concepts related to the child [21].

Contemporary trends of pre-school children education have emphasized the importance of exposing the child to various stimuli and endowing him with the appropriate concepts that pave the way for the child to catch up with this huge technological development of science so that time is not wasted nor his energies and mental abilities, and not to deprive him of many experiences before school age [22].

Science education experts argue that the acquisition of scientific concepts enhances children's interest in the vocabulary of science, and increases their motivation to learn them, because it boosts their abilities to interpret, control and predict which form the main functions of science. Science curriculum documents of all school levels focus on common objectives, like the need to teach scientific concepts functionally [23].

Allam in [24] emphasized the need for teaching kindergarten children the physics concepts which help them understand and interpret many of the things that might interest them in their environment, things that children can learn and respond to through playing. Such a method is perceived as an active behavior through which children discover their surroundings.

The recommendations of some previous studies, such as Moore in [25] and Harrington in [26], stressed the significance of developing scientific concepts for kindergarten children since they allow them to understand the properties of things which strengthens the bond between the child and his environment, and helps him cope with and adapt to it and thus avoid risks.

The issue of the three states of matter (solid, liquid, and gas) is among the topics addressed by the child in science subjects at various stages, from kindergarten to university. So, if a student has misconceptions about certain concepts regarding the three states of matter, this will affect his university study. Therefore, it must be said that it is important for the student to learn correct scientific concepts accepted in the elementary education stage.

4 Related studies

The results of several studies conducted in the educational field showed the importance of interactive simulation in developing different scientific and mathematical concepts among children of elementary and advanced school stages. The study findings of

Eiydat and Aldwairi in [27] stressed the impact of using interactive simulation on tenth grade students' achievement physics and their attitudes towards them. The study in [6] by Almasoudi and Almazroui concluded that computer simulation is effective in developing conceptual assimilation in physics among third secondary science grade students. Whereas Gonen study in [28] showed that there are statistically significant differences regarding the levels of knowledge and understanding in favor of computer simulation teaching and structural learning on the achievement of secondary school students and their attitudes towards physics. Also, the study in [29] by Sheehy and Wylie proved the effectiveness of using computer simulation in developing children's abilities to solve environmental problems in science course.

The study of Alebadi in [30] showed the importance of developing physics concepts among kindergarten children through the using of different strategies such as an educational program based on scientific inventions. Usgs study in [31] showed the difference among children at the age of 4 and 5 years with regard to the level of their understanding of physics concepts according to the level of scientific thinking, the educational attainment of parents, IQ, and observation and questioning skills.

In China, Ding and Fang in [32] conducted a study aimed at using simulation to improve physics learning. To achieve the study objectives, a C++ physics laboratory was designed for students to identify the experiment quantities and discover the Diffraction of Law Grating. The study was conducted on 64 university students. The results showed that students accomplished high scores in research assignments, which encourages the use of simulation in physics.

Aldahmash et al. study in [8] showed that primary level students have alternative misconceptions about concepts related to the three states of matter and its features. The results also showed that interactive simulation experiments have a direct and positive impact on students' understanding of scientific concepts and on modifying their alternative misconceptions about scientific concepts.

5 Methodology

The study population consisted of all the (45) kindergarten students at Pink Bird Kindergarten in Petra city. They were distributed into two groups: an experimental group consisting of (22) children who were taught using the interactive simulation software and a control group consisting of (23) children who were taught the traditional way, according to the following statistical methodology design:

G1: O1 X O1
G2: O1 - O1

Where: G1: the experimental group of (22) kindergarten students
O1: Achievement test in physics concepts.
X: Experimental group members are taught using interactive simulation software.
G2: The control group of (23) male and female kindergarten students.
- The control group members are taught the traditional way.

Measurement Tools:

1. The study used interactive simulation software from Colorado website [33]. Figure 1 shows a screenshot of the simulation software. The validity of the educational software has been extracted through content analysis and then presented to six arbitrators of university professors to determine its suitability to achieve the objectives that include the physics concepts of kindergartens. Around 85% of the test items have been modified in the light of the arbitrators' notes.
2. The achievement test of physics concepts: The study used the illustrated achievement test of physics concepts constructed by the researchers. It consisted of (15) items to measure the physics concepts. The reliability of the achievement test was calculated using Pearson's correlation (test/retest) which reached (0.75); the suitable value for the study purposes.

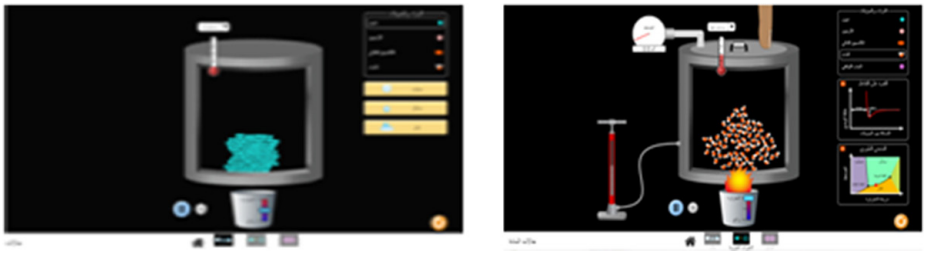

Fig. 1. Screenshot of the simulations [33]

6 Findings and discussion

6.1 Results related to the first question: what is the effectiveness of using interactive simulation in kindergarten children's acquisition of physics concepts?

To answer the first study question, mean and standard deviation of the study of two groups' responses to the test of physics concepts were extracted. And ANCOVA analysis test was conducted to examine the significance of the apparent differences between the pretest and posttest means of the two-study group, Table 1 show mean and standard deviation of the study.

Table 1. Means and standard deviations on the test of physics concepts

Group	N	Pretest		Posttest	
		Mean	S.D	Mean	S.D
Experimental	22	4.32	1.32	10.41	0.91
Control	23	1.78	0.74	6.13	1.10

Based on the Table 1, there are apparent differences between the means of the experimental and control groups in the pre/posttests of physics concepts. To examine the

significance of these differences, ANCOVA analysis was used. Table 2 shows the covariance analysis results.

Table 2. ANCOVA results

V.S	SS	df	M.S	F	P
Pre-test	1.246	1	1.246	1	0.274
Teaching Method	67.879	1	67.879	66.796	0.000
Error	42.681	42	1.016		
Total	131.806	44			

The results of the ANCOVA analysis show that F = 66.796 is a statistically significant at the level ($\alpha \leq 0.05$) and thus the null hypothesis is rejected, and the alternative hypothesis is accepted. As a result of using interactive simulation, it appears that there is a statistically significant difference at the level ($\alpha \leq 0.05$) between the means of the children's degrees in the pre/post- applications of testing physics concepts. In other words, it is quite effective to use interactive simulation to enhance kindergarten children's acquisition of physics concepts. This result can be explained by the fact that interactive simulation is characterized by its ability to stimulate learners' motivation towards learning through providing audio-visual media, which helps the child to involve more than one sense to perceive physics concepts. This serves different categories of learners, including people with special needs [34]. The human brain processes, stores, and manipulates the picture in a more effective way than dealing with oral linguistic description. The result can also be attributed to what Eiyadat and Aldwairi emphasized in [27]; that the interactive video provides learners with the opportunity to interact with and control the content presented to them and learn according to their own pace and method that suits them, which helped them to correctly acquire scientific concepts in terms of exchanging and discussing information with the teacher. Also, the video playback feature provided by the interactive video is helpful in retaining information in long-term memory, which has helped children maintain scientific concepts for a long time.

Moreover, the educational material was presented in an interesting and engaging way where images, sound effects and movement overlap, making the child active and interactive. The supremacy of interactive simulation is also attributed to the immediate feedback provided by the interactive video at every response the child generates, which creates a sense of challenge with himself, encouraging him to continue to achieve the desired goal. This finding was consistent with the findings in the studies of Eiydat and Aldwairi in [27]; Almasoudi and Almazroui in [6]; Sheehy et al. in [29]; and Aldahmash et al. in [8].

6.2 Results related to the second question: what is the effect size of using interactive simulation on kindergarten children's acquisition of physics concepts?

To determine the effect size of the interactive simulation software, Eta squared ($\eta 2$) was calculated to determine the effect size of using interactive simulation on the acquisition of physics concepts. It reached (61.4%), or approximately (61%) of the

dependent variable (physics concepts) as a result of using interactive simulation in teaching. The reason for this is that the use of interactive simulation allows children to convert microscopic images into macroscopic images and thus see phenomena that cannot be seen with the naked eye, which leads to introducing information into the child's mind correctly. This in turn leads to forming correct mental models, as well as correct physics concepts. The repetition of training by reusing an e-learning environment based on computer simulation has helped learners find meaning, connect ideas, use evidence that demonstrates the depth of what they have learned, and indulge in ideas related to physics concepts and how to use them.

7 Recommendations

In light of the study findings, the researchers recommend: activate using of interactive simulation as a teaching method in kindergarten stage, conduct studies on the impact of interactive simulation in developing other concepts among children at different school stages, train teachers in general and kindergarten teachers in particular to design and produce interactive video through different training workshops due to its effectiveness in the educational process, and conduct research studies on physics and chemical misconceptions among kindergarten primary stage children.

8 Conclusion

The study revealed the importance of using interactive simulations, even for kindergarten children in such a field of Physics. It is very essential for country like Jordan to establish a repository for data mining by schoolteachers and children alike, contains the necessary software and programs in Arabic language.

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10 Authors

Reham Al-Mohtadi is currently an associate professor in Faculty of Education, Al-Hussein Bin Talal University, Jordan. E-mail: dr.almohtadi@ahu.edu.jo

Mustafa Jwaifell is currently a full professor in Faculty of Education, Al-Hussein Bin Talal University, Jordan. E-mail: jwaifell@ahu.edu.jo

Yahya Al-Dhaimat is currently an associate professor in Faculty of Education, Al-Hussein Bin Talal University, Jordan. E-mail: yahya.a.aldhimat@ahu.edu.jo

Laiali Hussein Almazaydeh is currently an associate professor and the dean of Faculty of Information Technology, Al-Hussein Bin Talal University, Jordan. E-mail: laiali.almazaydeh@ahu.edu.jo

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