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Effectiveness of instructional digital platforms in the light of employing simulation models to develop learners' cognitive achievement

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ABSTRACT

The instructional digital platforms are one of the most successful ways used in introducing the instructional content at many universities around the world at the recent time. Some specialists began to think about the possibility of improving the quality of the instructional content and the interaction capabilities in these digital environments. Attention is drawn to the importance of integrating simulation models in these environments, as they are not designed for this purpose. The possibility of creating simulation models leads to effective learning and training in a safe environment. The purpose of this research is to define the effectiveness of instructional digital platforms in the light of employing simulation models to develop learners' cognitive achievement at Umm Al-Qura University. The study adopted a quasi-experimental design "one group pretest posttest." The participants of the study consisted of (25) students from common first-year students at Umm Al-Qura University in the academic year 2021/2022. The results of the statistical analysis of the data from the pre and post-application of the research tool (achievement test) revealed that there is a statistically significant difference at the level (0.01) between the mean scores of the students in the two applications in favor of the post-application, and the value of η^2 is 0.83. This means a high effect size of the independent variable (i.e., instructional digital platforms in the light of employing simulation models) on the dependent variable (i.e., cognitive achievement). The study findings contribute to enhancing the instructional digital platforms design. It is considered an initial step for more scientific research in this field, which could contribute to developing students' satisfaction with eLearning Systems. Moreover, the study helps decision-makers and stakeholders at higher education institutions to plan and reinforce students' achievements in e-learning environments effectively.

1. Introduction

The scientific and technological revolution is one of the major changes that characterize our world, and we are witnessing its effects on various fields; therefore, many institutions especially educational institutions trended to employ technology in activating operations and achieving goals. Recently, a group of applications or software has appeared, known as Learning Management Systems that manage distance teaching and learning activities. They are called Learning Management Systems (LMS), Virtual Learning Environment (VLE), or learning platforms (Ardan, 2020).

The Kingdom of Saudi Arabia has been a pioneer in adopting the latest technological innovations and employing them in all areas of life, especially the use of digital platforms in the educational process. It is mentioned that there is a necessity of using digital platforms to overcome several obstacles to instructional systems, including the increase in the number of learners and the expansion of educational institutions, the distraction of students due to many available sources.

Shen (2018) mentioned that digital platforms are one of the most successful ways used in education at the present time. Because they help to free learning community from the constraints of time and space;

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contribute to low education costs; provide attractive digital content stored and accessible to all students, and create a space for storing and managing documents remotely.

Many studies confirmed the effectiveness of using educational platforms in many fields such as Stergioulas et al. (2014) which confirmed the positive impact of using the digital platform on raising the level of students' performance in various educational activities and tasks. It was revealed the effect of using educational platforms in modifying the concepts of biology among ninth-grade students. Al-Ghamdi (2019) used educational platforms to develop digital learning elements for learning resource specialists. Ardan (2020) showed the effectiveness of employing the electronic platform based on the use of the "Easy Class" platform to develop reflective thinking and engage in learning among students at Hail University.

On the other hand, to improve the quality of the educational content of learning management systems and the interaction capabilities in these digital environments, it is pointed out the importance of integrating simulation programs in these environments, as they are not designed for this purpose. Because of many changes that occurred in e-learning methods and tools, some specialists began to think about the possibility of employing and integrating simulation models and virtual reality in learning management systems. The possibility of building models and embodying characters leads to effective learning and training in a safe environment (Abd Aljawad et al., 2018; Reeves et al., 2021).

Many studies mentioned the effectiveness of using simulation in several instructional situations such as Zacharia and Anderson (2003) which showed the effectiveness of Computer-Based Simulation on High School Students' Conception and Understanding of Mechanics, Waves, Light, and Heat. Cowley et al. (2005) revealed the effectiveness of simulation in developing students' acquisition of the concepts of photophysics. Widiyatmoko (2018) indicated the effectiveness of simulation in science learning on conceptual understanding. Rehman et al. (2021) concluded the effectiveness of the interactive computer simulation to teach weight and mass concepts to high school students.

Consequently, the main objective of this research is to employ simulation models in digital educational platforms and identify their effectiveness in developing cognitive achievement for the common first-year students in physics at Umm Al-Qura University. Bogusevschi et al. (2020) mentioned that a common problem in many educational institutions is a lack of equipment and materials in their labs due to the limited budget and the high maintenance cost of the laboratory. Digital learning environments that support simulations and observations for different experiments provide great opportunities for these institutions to bypass budget and cost issues, and it is vital to improving students' motivation and engagement in the learning process.

The study attempts to answer the following questions:

1. What is the proposed design for a digital instructional platform in the light of employing simulation models to develop the cognitive achievement of common first-year students in physics at Umm Al-Qura University?
2. What is the effectiveness of a digital instructional platform in the light of employing simulation models in developing the cognitive achievement of common first-year students in physics at Umm Al-Qura University?

2. Research hypotheses

The current research attempt to test the following hypothesis.

"There is a statistically significant difference at the level ($P \leq 0.05$) between the mean scores of the students' group in the two applications, the pre and post applications of the cognitive achievement test in favor of the post application."

3. Theoretical framework

In light of the information and communication technology revolution that we are witnessing its effects in various fields, educational institutions seek to benefit from the products of this revolution in activating their operations and achieving their goals. Many educational institutions have used educational digital platforms to provide a virtual learning environment through which various learning activities are managed. Moreover, based on the advantages of simulation programs and what they do to encourage students to integrate into the learning environment. The theoretical framework of this research deals with the following items.

3.1. Instructional digital platforms

A digital instructional platform is defined as an interactive learning environment with electronic content, and it enables teachers to publish lessons, set assignments, assign roles, and divide students into interactive groups (Al-Anezi, 2017). It is an integrated set of information services via the Internet, which provides teachers, learners, and others with information, communication tools, and resources to support the learning process and its management (Homanova and Prextova, 2017). Therefore, a digital instructional platform can be defined as an "interactive learning environment that enables students to complete their learning remotely, allow teachers to manage learning activities, and facilitate communication process among learning community synchronously and asynchronously."

The advantages of using digital instructional platforms are offering modern and effective digital content, providing learning process from any time

and anywhere, reducing the high costs for students, giving enough space to store digital content and its management electronically through the Internet, facilitating the interaction between students and teachers, and providing them with the opportunity to employ many digital resources in teaching, and learning activities (Moreno et al., 2017; Rueda et al., 2018; Weston et al., 2018; Al-Ghamdi, 2019).

It is mentioned that it is possible to divide educational platforms into two types:

1. Commercial platforms, owned or closed source (i.e., they can only be obtained for a fee) such as eCollege, Blackboard, or WebCT
2. Free (open source) platforms, usually free, such as Class Easy, Line Claro, or Moodle.

The researchers used the Blackboard platform, which is the approved platform at Umm Al-Qura University which is defined as an electronic learning management system designed to assist faculty members and learners, as it provides faculty members with tools to author courses, follow up and evaluate students, and allows students to continue in the learning process from anywhere and at any time. While providing space for communication and interaction among students with each other and with their teachers, such as conversations and forums in order to do joint work in new and interesting ways, it helps Education in transforming the Internet to become an effective medium to achieve educational goals.

The Blackboard system is characterized by many advantages. It breaks all the barriers and obstacles facing learners as it provides a lot of options and tools for the learner to choose what suits his needs. It allows learners to interact with their teacher and colleagues by practicing various educational activities and giving the teacher the opportunity to design different types of teaching strategies taking into account the principles of effective learning. In addition, it provides educational media and materials to the student at any time and place and the necessary links for building the course, homework, activities, and tasks without the need to know the programming languages used in creating web pages. Moreover, teachers can add videos, PowerPoint and Word files, and other sources of educational materials easily. Furthermore, It provides communication tools that support communication, dialogue, discussion, and conversation between students and teachers; it manages conversations for the teacher, with the ability to build statistical reports on student answers providing them with immediate feedback (Tekinarslan, 2009; Alsalloum and Radwan, 2013; Abu Alola, 2017).

3.2. Simulation models

Computer simulation is an interactive learning environment based on the modeling of a part of reality and based on a mathematical model that determines how to interact with the user (Min et al., 2000). Simulation is defined as dynamic and interactive computer programs designed and presented for students as models for the origin of information and educational experiences. A computer simulation is a computer program that simulates a system or part of it (Horton, 2011).

Therefore, simulation can be defined as a computer program that is designed as a model of the origin of information and educational experiences that the student studies. It gives the student the opportunity to control the variables of the model, discover its characteristics and the conditions under which it works in a safe environment aiming to increase the student's motivation and encourages him to stay in the educational task.

Due to the new possibilities simulation models can open, they have received much attention and research has discussed their advantages. They help students to acquire information that is dangerous for them while studying it realistically. Moreover, they facilitate understanding abstract information by representing it via computer programs helping students to learn by discovery. In addition, they help students to participate actively in the learning process by encouraging intuition, imaginative thinking, and flexible problem-solving. Furthermore, they provide suspense and excitement in the educational situation helping students to predict the results of the implementation of educational experiments and projects. Additionally, they stimulate students' creative thinking by presenting new educational ideas and they save the expenses of doing repeated educational experiments (Kim et al., 2016; Widiyatmoko, 2018; Rehman et al., 2021).

The simulation models are classified into three categories:

1. Procedural Simulations: Designed to display the procedures of performing work, such as simulating a flight plan, and the installation or operation of a device.
2. Situational Simulations: Concerned with the emotional domain, such as attitudes and behaviors, they aim to test the learner's social behaviors and reveal his trends.
3. Physical Simulations: They allow the learner to watch and conduct experiments, enter numerical values for some variables, and judge the results of experiments; therefore, they are related to practical experiments. And this is the category that will be chosen for the current research.

4. Methodology

4.1. Research design

This research is based on each of the following two methodologies:

1. The descriptive and analytical approach in describing and analyzing the literature related to the research problem, describing and building

research tools, and manipulating and analyzing data statistically.
2. Quasi-Experimental approach to apply and measure the effectiveness of digital educational platforms in the light of employing simulation models to develop the cognitive achievement of students in the common first year at Umm Al-Qura University.

4.2. Research sample

The research sample consists of 25 students from the common first-year Deanship at Umm Al-Qura University in the academic year (2021/2022).

4.3. Research instruments

The research instrument is an achievement test to identify the cognitive achievement level of students in the common first year at Umm Al-Qura University. The test consists of 60 multi-choices questions. The students answer each question by selecting one of four alternatives.

4.4. Experimental design of the research

The researchers followed the quasi-experimental design of "one group pretest posttest." The research included the following variables:

1. The independent variable is Simulation models.
2. The dependent variable is Cognitive achievement.

Fig. 1 shows the quasi-experimental design of the research.

4.5. Research procedures

The research procedures included the following:

1. Reviewing studies and literature related to the research topic.
2. Preparing the electronic course that aims to develop the cognitive achievement of the research sample through following the stages of the instructional designing model (ADDIE).
3. Preparing the research tool (i.e., the cognitive achievement test for the general Physics course (1)) and calculating its validity and reliability.
4. Selecting the research sample from the students in the common first-year Deanship at Umm Al-Qura University.
5. Pre-application of the achievement test on the research sample.
6. The Research sample studies the electronic course in the light of the employment of simulation models.
7. Post-application of the achievement test on the research sample.
8. Statistical treatment for the data obtained from the pre and post-applications of the achievement test.
9. Discuss the research findings.
10. Presenting recommendations and suggestions.

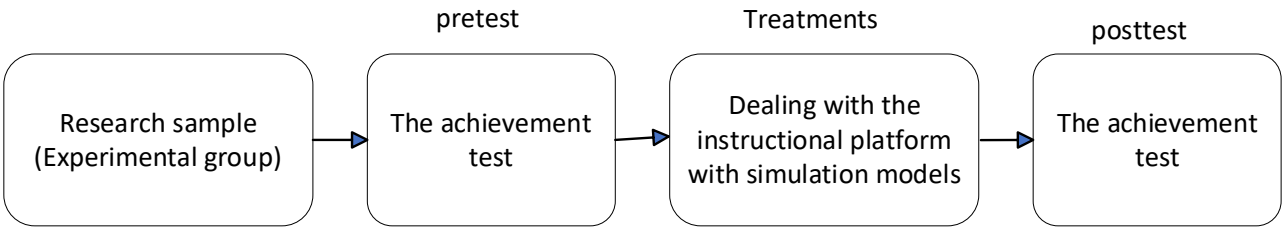

Fig. 1: Experimental design of the research

5. Results and discussion

To answer the first question, what is the proposed design for a digital instructional platform in the light of employing simulation models to develop the cognitive achievement of common first-year students in physics at Umm Al-Qura University?

The researchers followed up on the stages of the ADDIE model as mentioned by Liu (2008) as follows.

5.1. Analysis

This stage starts by defining the objectives of the course (Physics 1) for the common first-year students at Umm Al-Qura University in the academic year 2021/2022 such as:

- Distinguish between fundamental and derived physical quantities,
- Know how to deduce the unit of any physical quantity from the basic units,
- Convert any unit from one system of units to another,
- Describe the motion in one dimension,
- Calculate the instantaneous and average velocities and accelerations,
- Apply Newton's laws to analyze the motion of an object, and
- Estimate the work done by constant and non-constant forces.

Then, the researchers selected the Blackboard Platform as a tool to present the course defining the administrative requirements to get a license for using an account and getting administrative approvals for the application. After that, they analyzed Blackboard components and its tools: communication tools (synchronous and Asynchronous), virtual classroom (Blackboard

collaborate), evaluation tools (e-tests, assignments), content creation tools, etc. N, they defined a timeframe for developing, starting, and presenting the course and its evaluation taking into consideration the start interaction between students and the system that was on September 5, 2021. Finally, they construct teamwork that consists of instructional designers, a media developer, Physics instructors, and specialists in the Blackboard platform.

5.2. Design

This stage includes content identification and its analysis, assessment tools, lesson planning, content-supportive media, and identification of educational strategies (lectures, discussion, collaboration, etc.). Moreover, simulation models are defined, by their roles, contributions to achieving instructional goals, and suitable places all over the course. This stage ends with preparing a visualization for the educational Digital platform that will contribute to achieving the educational goals. Table 1 shows a part of the course description. Fig. 2 shows the content organization according to the course description.

As shown in Fig. 2, the content was arranged chronologically. Each week contains three sessions, the first and the second focus on instructional content, while the third focuses on the summery and problem-solving.

Table 1: Course description

Topics to be covered			
Week #	Sec #	Activities	Topics
1	1	Class	What is physics, Measuring Things, the International Systems of units?
	2	Class	Changing Units, Length, Time and Mass
	3	Problem Solving	Review, Summary, and Problems (calculus biased)
2	4	Class	Motion, Position and Displacement, Average Velocity and Average Speed, Instantaneous Velocity and Speed
	5	Class	Acceleration, Constant Acceleration: A Special Case, Another Look at Constant Acceleration, Free-Fall acceleration, Graphical Integration in Motion Analysis
	6	Problem Solving	Review, Summary, and Problems (calculus biased)
3	7	Class	Vectors and Scalars, adding Vectors Geometrically, Components of Vectors
	8	Class	Unit Vectors, Adding Vectors by Components, Vectors and Laws of Physics, Multiplying Vectors
	9	Problem Solving	Review, Summary, and Problems (calculus biased)
4	10	Class	Newtonians Mechanics, Newton's First Law
	11	Class	Force, Mass
	12	Problem Solving	Review, Summary, and Problems (calculus biased)

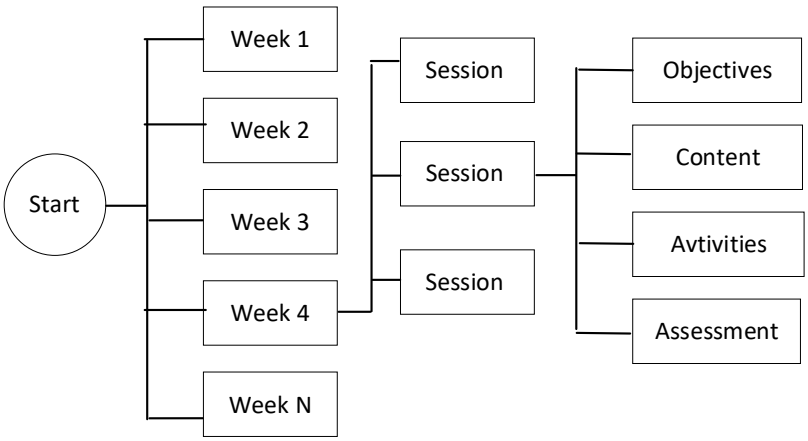

Fig. 2: The content structure of the course

As for the research tool (i.e., the achievement test), the researchers cooperated with the course instructor in designing the test according to the following steps:

1. Determining the objective of the test is to measure cognitive achievement for a sample of common first-year students in the general Physics course (1) according to Bloom's levels: remembering, understanding, application, analysis, evaluation, and creation.
2. Defining a list of objectives to be measured based on the course specification list (65 objectives).
3. Determining the number of questions that can measure the course objectives by defining a question for each objective.
4. Determining the type of test questions (i.e., multiple-choice questions). It is chosen because it is one of the best question types. The correct answers are to be selected from four available alternatives.
5. To ensure the validity of the test, the researcher submitted it, in its initial form, to a number of specialized jury members. The test was modified according to the jury members' comments and suggestions. Thus, five questions were deleted

because of redundancy, and the final form for the achievement test contained 60 questions.

6. To establish the reliability of the test, it was administered to a pilot sample of students other than the basic research sample (n=20) on August 30, 2021. The stability of the test was calculated through the Cronbach's Alpha Formula. The reliability coefficient value α=0.82 indicates a good reliability coefficient and meaning that it gives the same results if it is reapplied to the same individuals under the same conditions.

After step six, the achievement test was completed and become suitable for application to the research sample.

5.3. Development

Some of the Media and simulation models were collectedfrom the Internet, taking into account intellectual property rights, and others were produced and then submitted on the Blackboard platform. Figs. 3, 4, 5, 6, and 7 show screenshots of the structure as appears to the students and in line with the visualization in the previous stage.

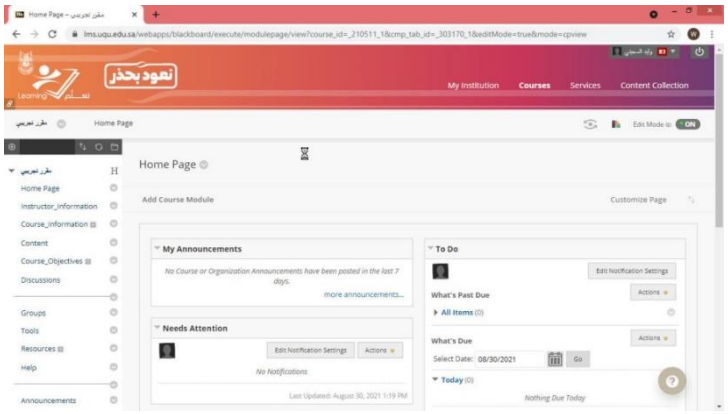

Fig. 3: The home page of the course

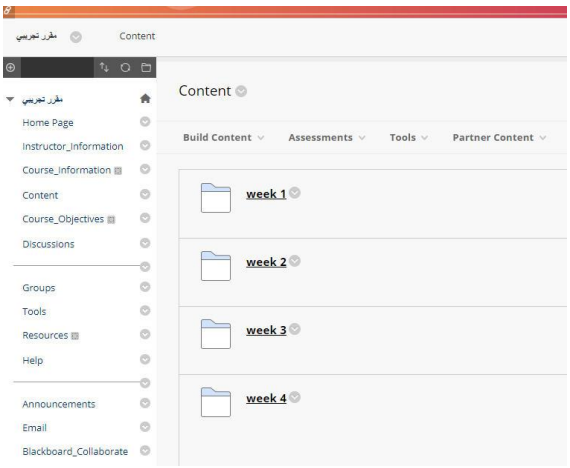

Fig. 4: The content arrangement of the course

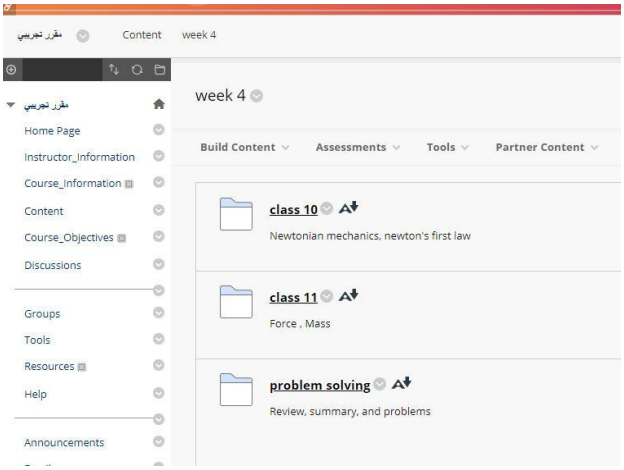

Fig. 5: The content arrangement per week

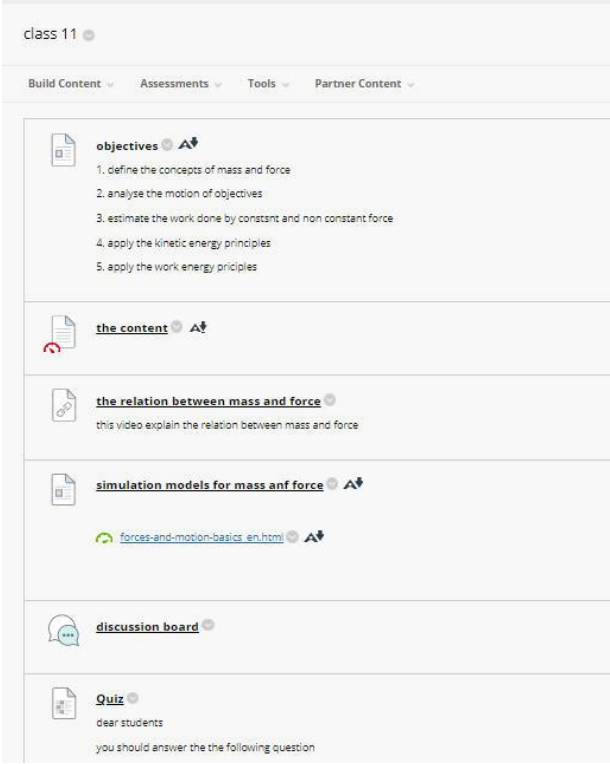

Fig. 6: The content arrangement for each class

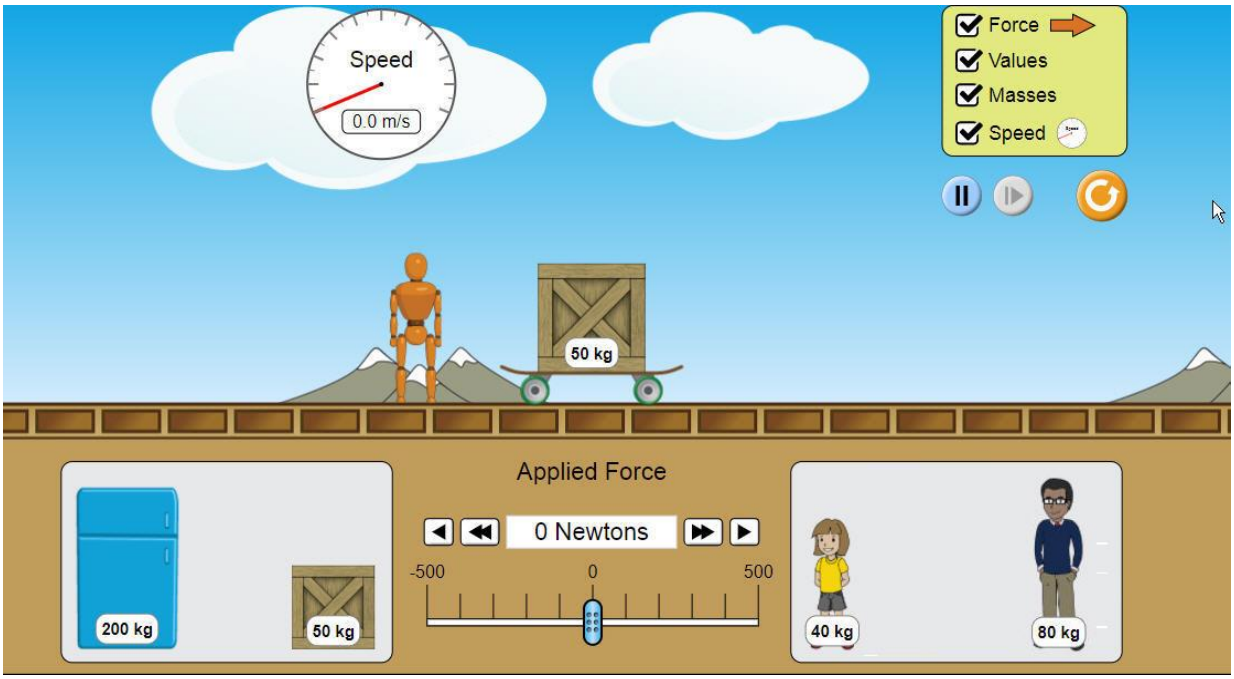

Fig. 7: The simulation model in class 11

As shown in Figs. 3, 4, 5, 6, and 7 the content was distributed weekly in accordance with the description of the course and as it was envisioned in the design stage. Each week contains a number of topics, and the learner begins each topic by identifying the objectives and then viewing the content in the form of a PDF file or a slide show. There are some supported media for content in the form of images or video files. There are also simulation models that the learner interacts with, controls, and changes the model variables several times in a safe environment without fear of failure so that he can comprehend the required concepts and laws. There are also activities and discussions where the learner integrates with his peers and teacher to reach a complete scientific understanding. Finally, there is the interim evaluation to identify the extent to which the learner has achieved the required goals. At the end of this stage, the final shape of the platform is completed and ready to be published.

5.4. Implementation

An introductory meeting was held with students (i.e., the research sample) at the beginning of the first semester with the course instructor on August

29, 2021, to explain the nature of the course, its objectives, the plan of proceeding through it, its prerequisites, how to access it, navigate its pages, and deal with its contents. The research sample started studying and interacting with the content from September 5, 2021, to November 25, 2021.

5.5. Evaluation

The test was opened on Blackboard for the research sample on September 2, 2021. Then, the test was opened again after studying the content on November 30, 2021. Statistical processing of the data of the pre and post-application was carried out to ensure the effectiveness of the platform and the achievement of educational goals.

To answer the second question, what is the effectiveness of a digital instructional platform in the light of employing simulation models in developing the cognitive achievement for common first-year students in physics at Umm Al-Qura University? The researchers tried to verify the following hypothesis.

"There is a statistically significant difference at the level (P≤0.05) between the mean scores of the students' group in the two applications, the pre and post applications of the cognitive achievement test in favor of the post application."

The researchers used the (t) test to verify the validity of this hypothesis. Table 2 shows the results of this test.

Table 2: The value of (t) and its statistical significance for the differences between mean scores and standard deviations in the pre and post measurements of the research group in the achievement test

Research Group	Variable	The measurement	N	Mean	Standard deviation	t value	Significant level
	Cognitive achievement	Pre	25	26.5	4.7	11.4	0.01
		Post	25	43.2	4.9		

It is clear from Table 2 that there is a statistically significant difference at the level (0.01) between the mean scores of the students' group in the two applications, the pre and post applications of the cognitive achievement test in favor of the post application, and this result indicates the acceptance of the validity of the hypothesis of the research.

In order to find out the size of the effect of the independent variable (platform employing simulation models) on the dependent variable (cognitive achievement) the value of η^2 was calculated as Table 3 presents according to the following equation:

$$\eta^2 = t^2/(t^2 + df)$$

where t=t value of the differences between the means, *df*=degrees of freedom.

Table 3: Calculating the effect size of the system on achievement

t value	*Df*	η2 value
10.12	24	0.83

It is clear from Table 3 that the value of η^2 is 0.81 which is ≥0.14. Therefore, the influence of the independent variable is large on the dependent variable. Thus, the results of the research show the effectiveness of digital educational platforms in the light of employing simulation models in developing the cognitive achievement of common first-year students in general Physics courses at Umm Al-Qura University.

This is consistent with many studies that emphasized the effectiveness of using educational platforms in providing various educational courses (Al-Ghamdi, 2019; Ardan, 2020). As well as with many studies that confirmed the effectiveness of employing simulation in developing the cognitive domain, skills, and attitudes of different students (Zacharia and Anderson, 2003; Cowley et al., 2005; Widiyatmoko, 2018; Rehman et al., 2021).

The results can be interpreted depending on a number of factors that return to the advantages and the tools that Blackboard offered. The logical organization of the content according to a specific time frame helped to reduce the distraction factor during the learner's review of the content. In addition, employing multimedia elements such as images, graphics, and texts in the presentation of the educational content in an integrated and interactive manner enabled different students to interact with these media and choose what suits them according to their preferred learning style(s). Moreover, the simplicity of the Blackboard user interface helped the learner to navigate between the course pages and view its various contents easily. To add, Synchronous and asynchronous communication tools contributed to creating an atmosphere of effective participation among students and between students and the teacher encouraging them to progress in an atmosphere of exchanging ideas and opinions among members of a learning community. Furthermore, the diversity of educational activities, their connection to educational goals, and the appointment of dates for their receipt by the teacher contributed to the students' integration into studying the content of the course. The feedback contributed to guiding students during the course and bringing them to the level of mastery in gathering the content of the course. After completing the study of each topic, each student answered a set of questions. Based on the assessment result, the student determines whether to move to the next topic or return to study the same topic again. The possibility of studying the course from anywhere and at any time allowed all students to attend the course according to their time and place of residence.

In addition, other factors return to the advantage usage of simulation models. The presented simulation models allow the student to work independently without fear of making mistakes. The students' control over the presented simulation models in terms of displaying, stopping, and replaying them as needed leads to a full understanding of the presented topics. Furthermore, the simulation models help the student to see the variables and the relationships between them, and the possibility of controlling them. To add, the repetition and watching the results are suitable for the type of student who has difficulty solving problems involving more than one variable at the same time. As the simulated system acts as an external memory that reduces the load on the work of working memory. Finally, providing immediate feedback on the students' performance while dealing with simulation models contributed to giving them the motivation to stay on the task and attracting attention for a long period.

6. Conclusions and recommendations

There is a constant attempt to develop instructional digital platforms. It is one of the most common ways used in instructional institutes to present their courses in order to be able to free the learning community from time and space constraints. Thus, they can provide attractive digital content that is stored and accessible to all students. In addition, they can create a space for storing and managing documents remotely.

Therefore, based on the results reached that confirmed the effectiveness of instructional digital platforms in the light of employing simulation models to develop learners' cognitive achievement to common first-year students in physics at Umm Al-Qura University, a set of recommendations seem pertinent to be proposed:

Traditional courses at Umm Al-Qura University should be converted into electronic ones to be accessed by students from anywhere and at any time. Moreover, decision-makers should be aware of the importance of employing educational platforms in developing courses and providing all needed resources. In addition, faculty members should have training courses on the use of learning management systems and designing educational simulation models in order to use them within digital educational platforms. Furthermore, specialized scientific conferences in the field of developing digital educational platforms should be held to learn new ideas and trends in the field.

This research is a starting point for further research and studies in the e-learning field, e.g. the use of simulation models within educational platforms to develop variables other than achievements such as attitude, practical skills, innovation, and science fiction. There is a real need to compare the different types of simulation within the educational platforms on the development of the various aspects of learning. Further research might wish to investigate the efficiency of educational platforms by using 3D simulation models and virtual reality.

Compliance with ethical standards

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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