MIRNA: Adaptive 3D Game to Assist Children's Distance Learning Difficulties; Design and Teachers' Intention to Use

Dheya Mustafa
Department of Computer Engineering,
Faculty of Engineering, The Hashemite University,
Zarqa, 13133, Jordan
dheya@hu.edu.jo

Intisar Ghazi Mustafa
Department of Educational Sciences,
Qatar University, Qatar
intisarghazi@qu.edu.qa

Samah Zriqat
Department of Information Technology and Computer Science,
Yarmouk University, Jordan
samah.zrigat@ses.yu.edu.jo

Qutaibah AlThebyan
Department of Cybersecurity, Al Ain University,
Al Ain, UAE
qutaibah.althebyan@aau.ac.ae
Jordan University of Science and Technology, Irbid, Jordan
qaalthebyan@just.edu.jo

Abstract: *The global transition from traditional classroom instruction to online learning has been hastened through COVID-19. Notwithstanding its benefits, students were unable to quickly adjust to the difficulties of change. This research offers MIRNA, an assistive 3D instructional tool for slow learners in primary school, mostly for Arabic, English, and Math topics, to address academic issues that develop with online education. The proposed tool can be fully integrated with remedial programs to assist students who struggled to adjust to distant learning during the pandemic, slow learners, or even those who are unable to attend school. This application categorizes students based on academic performance rather than age and automatically adjusts to their limitations. Additionally, MIRNA offers a simple interface that allows teachers to personalize it with their own content and game scenarios. We carried out an empirical investigation to assess teachers' intentions to use MIRNA as an online learning platform in the learning process. The findings of the study show that teachers' attitude towards the game was positive, and they intended to use the game in the learning process in the future.*

Keywords: *Distance learning, game engine, education, 3D graphics, games for learning.*

Received April 1, 2023; accepted May 10, 2023
https://doi.org/10.34028/iajit/20/3A/10

1. Introduction

These days, after the COVID-19 pandemic, education has become through online educational platforms away from the classroom, which has caused difficulties for students, teachers, and parents to teach children at home [6]. On the other hand, the Internet plays a key role in our children's lives, as they prefer to spend their time on games rather than books, and they even spend a lot of time on digital games to the point of getting addicted [12]. Many applications have appeared that allow children to learn interactively and independently using computers or smartphones [2, 3].

E-Learning is continuously engaging with increased importance along with a traditional classroom. E-learning saves time and allows the student to access it from anywhere, provides interactive, scalable content, and allows learners to choose the appropriate method and path for them. When learners clearly understand the goals and easily use the game controls, they can develop the skills embedded in the actual content [21, 22].

E-Learning can be considered as an electronic educational technique that enables students to learn at anytime and anywhere through the Internet [14], which is an educational platform that contains different types of media such as videos, audio, animations, images, etc. that enables the student to distance learning via the Internet, through which the student can access content with more creative concepts in less time than traditional methods [5].

Many researchers point out that teaching methods affect students' motivation to learn and have a significant impact on student's performance [24]. Studies have shown that the application of games in education is better than traditional learning. Many students do not respond to instructions that lack some attractive features in the classroom, so it is encouraged to use educational games to provide them with an appropriate and stimulating environment [7]. Educational games should cover the characteristics of challenge, fun, and imagination [8].

The use of electronic games in distance education made the learning process more attractive, added fun to the educational process, added a competitive, enjoyable

framework for learning, allowing the freedom to explore and experiment effectively within the electronic educational game to learn concepts and cognitive skills [17], and develop social skills by building team spirit among students [4]. Furthermore, games provide new ways of understanding and solving problems in real life easily through the use of electronic games in teaching languages and mathematics extensively [22].

The purpose of this study is to investigate the teachers' attitudes and intentions to use game-based learning platforms in the learning process. Primary school teachers will be targeted to design educational games in the proposed application. Fifteen high school teachers in Jordan were selected as target groups for this study. The teachers were given training related to the use of the game in the learning process. At the end of the project, they were asked to make their own game using the proposed platform. The data were collected using close-ended questionnaires to determine the teachers' attitudes and intentions to use the proposed game.

The study aims to improve the e-learning process for primary school students through games by training teachers to design educational games. The proposed tool is a game for children in primary grade that gives them attractive and joyful electronic learning.

In previous work, we presented a beta version of the game [16]. This paper presents MIRNA, an enhanced 3D game, and conducts a study to measure teachers' intention to use this game.

MIRNA is designed to suit all levels of students in the first three grades, as it includes different levels and multiple teaching methods. This game aims to teach the child entertainingly using interactive movements of the 3D models in it, supported with visual and auditory hints. This will attract students' attention. While it has an Arabic\English interface, the game concepts can be implemented to support other languages [3]. The game performs a student-level test using binary research to choose the appropriate level to start with.

The main contributions of this study include:

- Improving the educational process by training teachers, who do not have programming skills, to transform the main subjects in the Jordanian curriculum into electronic games that enables students to learn at anytime and anywhere.
- Presenting MIRNA, a Game-based E-learning platform that can enhance students' motivation to learn and increase their educational attainment by making the teacher aware of the characteristics of education game applications. Teachers can design educational games using the proposed application that increases the efficiency of their work.
- Providing insight for schools, decision-makers, and technology developers to improve the educational process by transforming assignments into educational games.

2. Background

2.1. Game-Based E-Learning

Game-based e-Learning is one of the best educational methods that provide students with a better environment. It gives them knowledge and skills in a graphical atmosphere that attracts children to their objects and encourages them to gain more confidence while learning [15]. Game-based e-Learning includes virtual reality games, online and web-based games, and simulation games.

Sung and Hwang [19] found that students who learn through a game-based learning method manifested better learning outcomes. Students are motivated to compare and observe while playing, which enhanced their problem-solving skills, and showed high self-effectiveness. Educational games should cover the characteristics of challenge, fun, and imagination [8].

Games are a useful tool in the teaching process and their benefits allow the learner to participate and compete across demographic boundaries, help children develop their mental skills, and provide personalized learning opportunities. Games are fun and motivating [16].

Sánchez-Mena *et al*. [18] studied teachers' perceived usefulness of educational video games and its impact on their intention to use them during classes to engage students during lessons. Therefore, studies are encouraged to adopt them as an educational approach. The perceived usefulness and perceived ease of use are directly affected by the design features. For example, the perceived usefulness is teachers' perception of the game's fit with the topic they are teaching and their ability to easily design a game that fits the topic. The authors found that the age and gender of the teachers significantly affect their intention to use educational video games [18].

2.2. Game Engines

Game engines are reliable, well-tested middleware designed to shorten the time-to-market, and reduce the cost required in the development of video games.

Game engines provide high-efficiency benefits by reducing the depth of knowledge required to make games. They can be minimal in their highly optimized generic game functionality, allowing game developers to focus entirely on writing gameplay code. When compared to developing games from scratch, game engines give a magnificent advantage for developers, allowing them just to focus on making the best game possible [10].

The rapid development of the games industry has created new requirements for gamers as providing a variety of scenes and changing scenarios has led to the need to integrate AI modules into games. AI is a powerful tool for developing educational games. New

creators without programming skills have open horizons creating new approaches to game-based learning [9].

2.3. 3D APIs

Popular APIs for 3D computer graphics are Microsoft DirectX, OpenGL, Simple Direct Media Layer (SDL), and Panda3D.

Panda3D is a 3D engine that is equipped with a library of subroutines for game development. It includes graphics rendering, audio, I/O, collision detection, and other abilities. Python is the game development language with Panda3D. The library itself is C++ with a set of python bindings to control the complete functionality of the engine in a Python interface. Panda3D was created for commercial game development that emphasizes four areas: power, speed, completeness, and error tolerance. The main advantages of using Python are rapid development and advanced memory management. Some manual pages offer Python and C++ information as they are the most commonly used languages in Panda3D [10].

2.4. Blender

Blender is a free and open-source 3D tool for computer graphics suites. It is used for game creation, visual effects, rendering, animation, art, 3D-printed models, motion graphics, interactive 3D applications, virtual reality, video games modeling, simulation, compositing and motion tracking, and even video editing. It runs on Linux, Windows, and Macintosh computers.

Advanced users employ Blender's API for Python scripting to customize the application and write specialized tools; often these are included in Blender's future releases. Blender is well suited to individuals and small studios, which benefit from its unified pipeline and responsive development process. Blender's interface uses OpenGL to provide a consistent experience.

3. Game Platform design

This paper develops a proof-of-concept platform and uses it to implement a few stories in Arabic, English, and Math for the first three primary grades.

3.1. Game Story

Each game has a certain flow; the game flow diagram defines what the players can do in a certain part of the game. A game-screen flow shows everything the player can do in the game, as shown in Figure 1. The game starts displaying the main menu, where the player can choose one of the games (multiple questions or rearranging letters).

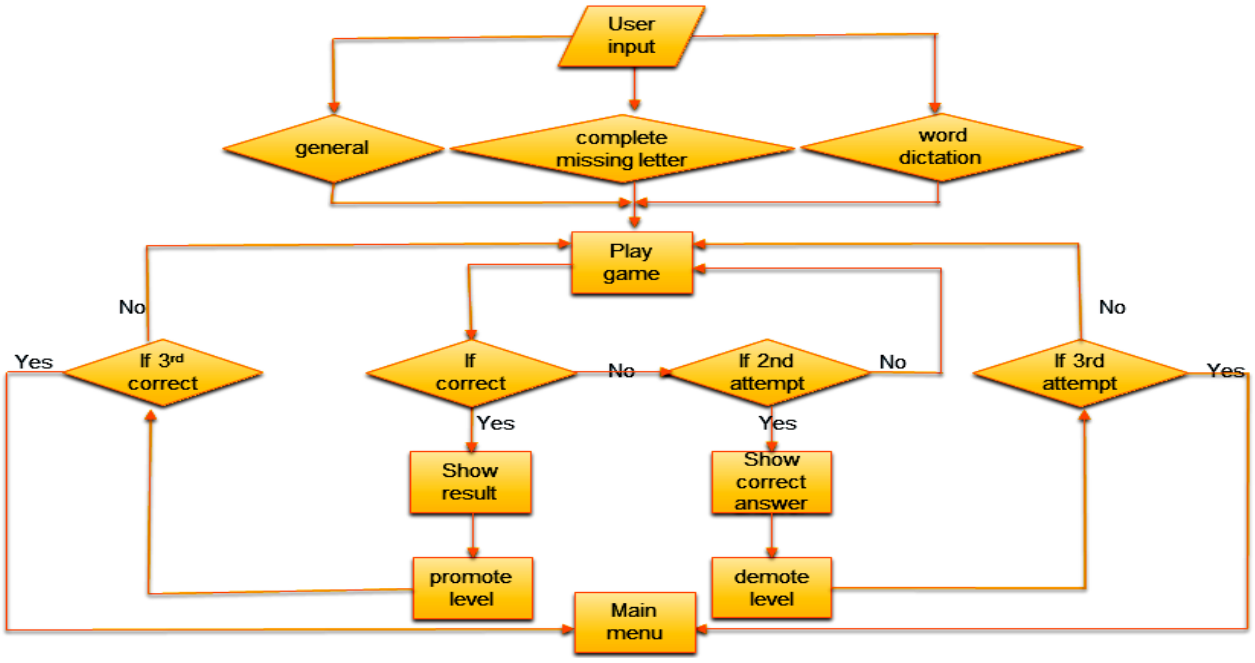

Figure 1. Game Flowchart for one of the stories.

The player chooses one of the game's stories, which could be a general question, complete the missing letter or detection. Each game story has 3 levels; if a student answers the question correctly, then the game level will go up. The student wins the game when he collects three stars, and he will be moved to the main menu to pick another game story. If the answer is wrong, the student will be encouraged to try again through a supportive screen with visual and sound effects. He gets two attempts, after that the game will display the correct answer and decreases the level.

When writing the script of the game, we had to choose appropriate teaching methods for the target age, and that method should be easy to use for the teacher. For example, when adding levels within the arithmetic game option [13],

we used the opinion of psychiatrists for the levels, where the lowest level (Easy level) is the numbers from one to five, the next one (Medium level) is from six to ten, and the (Hard level) that have carried numbers from eleven to fifteen [11]. Furthermore, it was necessary to pay attention to the teacher and provides him with various question formats that can be presented in several diverse ways.

3.2. 3D Animation

Blender is chosen as a 3D modeling program to add and animate some characters known as models. We can edit models and add shapes like cubes to form a different model. Animating a model is done using armature, by which we define the movement around the bones we added to the model. Figure 2 presents a bird 3D model, while Figure 3 shows added bones to implement the bird's wings animation.

Figure 2. Bird 3D model design using Blinder.

Figure 3. Bird wings animation using the Blinder.

Model coloring and background adjustment are done on separate layers. A set of ready-to-use models are prepared for inexperienced teacher with this technology.

3.3. User Interface

This section describes the main interface features of MIRNA platform. It was designed to support all the necessary facets, the quests, the level design, the characters, and the sound effects. Figure 4 depicts the start window for the Arabic spelling game. Falling leaves in the background are animated models. Furthermore, we added background music. The design is meant to be colorful and attractive.

Figure 4. Arabic words spelling game: start window.

Figure 5 shows a main menu with the Arabic interface, while Figure 6 shows another menu with an English interface. The student can select a challenge by clicking the book icon.

Figure 5. Main menu- Arabic Interface.

Figure 6. Main menu- English Interface.

3.4. Sample Questions and User Control

MIRNA platform provides several interesting ways for students to interact with the game. The following subsections describe main user control features.

3.4.1. Mouse Click

Figures 7, 8 shows an example of a Multiple-choice question with visual and sound effects. Students should

click on the appropriate letter that completes the word correctly. Visual and sound hints are provided.

Figure 7. Spelling question with visual and sound effects.

Figure 8. Multiple-choice question with visual and sound effects.

3.4.2. Fill in A Box Using The Keyboard

Students can write the answer in the textbox using the keyboard as illustrated in Figure 9. Hamming bird is a 3D model that continuously flips its wings and slightly moves up and down to imitate flying.

Figure 9. Math question with a textbox made as a 3D box.

3.4.3. Drag and Drop

Figure 10 presents a spelling question using drag and drop. Letters are floating 3d models that can be dragged and dropped to form a word. animated visual and sound effects are added for correct and incorrect answers. Figure 11 illustrates another spelling question using drag and drop control with a different format. Letters are 3D models floating, where students are asked to drag them next together forming the correct word. The dog is a 3D model that jumps and barks occasionally as a visual hint to students, employing point-and-learn techniques.

Figure 10. Another spelling question with different interface. Letters are floating. Clicking a letter will cause it to fly and form a word with the other letters.

Figure 11. Spilling a word, using drag and drop feature.

3.4.5. Handwriting

Targeting tablets and devices that support touchscreen, this interface provides students with an effective way to practice handwriting. Figure 13 presents a question template that supports both handwriting and keyboard input. While grading currently is basic, future work includes machine learning algorithms to recognize Arabic letters and numbers in handwriting [25].

3.5. Teacher Design Interface

We implemented a convenient interface for teachers that simplifies customizing games to meet learning objectives. Figure 12 illustrates MIRNA log-in screen.

Figure 12. Login screen.

The teacher design screen is depicted in Figure 13. This screen was designed to allow the teacher to design a tailored game for his students through many tools, and it is divided into two parts.

The first section shows the tools to add an element such as text, image, icon, box, and media, and the program gives the option to add a pen for handwriting.

As shown in the figure, any image can be added, such as a rabbit, a bear, or a squirrel, through the text. there are many lines that he can choose, and a voice has been added to read the questions.

Figure 13. Teacher screen.

The second section is the display screen in which the design made by the teacher appears, and through the movement section, objects can be moved and shown at a specific time or hidden. There is a menu bar at the beginning of the screen through which you can insert, edit, save, and also help to ask any question. Also, through an option, it is possible to determine which category the game belongs to and create a link to distribute it to students.

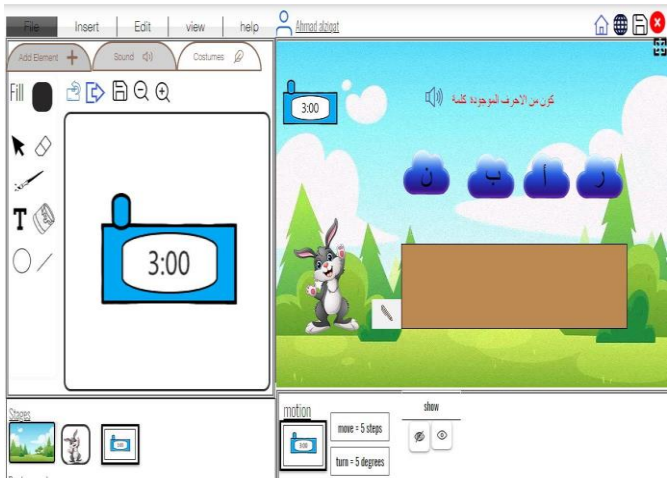

Figure 14. Teacher screen, inserting an object.

This screen was designed to allow the teacher to add any shape or draw it himself as depicted in Figure14. It provides many tools to help teachers customizing their games, such as inserting shapes (circle, square, and rectangle), straight and zigzag lines, and adding text to the drawing.

4. Teacher's Intention to Use

In this study, we selected a group of primary school teachers will be and made them use the proposed application to design educational content through a game based on the Jordanian curriculum, and then they will evaluate the programs through a questionnaire distributed to teachers to measure their satisfaction with the applications.

The participants of the study were 16 elementary school teachers in Jordan as target groups for intervention. There were 8 male teachers and 8 female teachers. 12 teachers are classroom, while 4 teachers are English teachers. The participants' age ranged from 25 to 40 years old with an average of 28.3 years. All participants received training about how to use *MIRNA* platform in their class. The participants also filled out the questionnaire after one month of using the platforms

4.1. Measurement Items

We designed a questionnaire that measures the game perceived usefulness and ease of use, teachers' satisfaction, attitude, and Intention to use. We used the common 5-point scale that is composed of:

1. Strongly disagree.
2. Disagree.
3. Neither agree nor disagree.
4. Agree.
5. Strongly agree. Table 1 summarized measured items and associated questions with each item.

Table 1. Measured items and associated questions.

Variable	Questions
Perceived usefulness (Venkatesh, 2000) [20]	1. Using the application improves my performance in my job. 2. Using the application in my job increases my productivity. 3. Using the application enhances my effectiveness. 4. I find the application to be useful
perceived ease to use (Venkatesh, 2000)[20]	1. My interaction with the application is clear and understandable. 2. Interacting with the application does not require a lot of mental effort. 3. I find the application easy to use. 4. I find it easy to get the application to do what I want it to do.
Satisfaction (Wu, 2018) [23]	1. I enjoyed the educational game design. 2. I enjoyed how the learning materials were expressed. 3. Completing the design of each game gave me a feeling of accomplishment. 4. I learned some things that were surprising from the learning game application
Attitude (Akhtar *et al.* 2019) [1]	1. Is fun. 2. Enhance the learning process. 3. Is easy to use. 4. Provides many benefits.
Intention to use (Akhtar *et al.* 2019) [1]	1. I was able to make a lesson with a learning game application. 2. I will use learning game applications in class sessions and E-learning platforms. 3. I will study learning game applications more deeply. 4. I would recommend learning game applications to a school.

4.2. Results

We used the common 5-point scale that is composed of

1. Strongly disagree
2. Disagree
3. Neither agree nor disagree
4. Agree
5. Strongly agree.

Table 2 shows items measured using the survey for teachers under study. Most of the teachers in the study population had never used a game-based learning platform in their learning process. Teachers were able to use our platform after proper training. English teachers adapted to the system faster than classroom teachers did. Female teachers are more enthusiastic than male teachers. The population age average is under 30, and all participants use handheld devices and computers on a daily basis. Some teachers requested Arabic GUI. One major concern of the teachers is the applicability of game-based learning for those who can't afford a tablet and internet access

Table 2. Items measured for teachers under study.

		Teacher gender		Teacher specialty	
Measure	**Avg score**	**Male**	**Female**	**Classroom**	**English**
usefulness	4.1	4.1	4.1	4.1	4.1
Satisfaction	4.7	4.6	4.8	4.64	4.9
Attitude	4.2	4.0	4.4	4.1	4.5
Intention to use	4.6	4.4	4.8	4.55	4.75

5. Conclusions

In this article, an adaptive teaching tool for students in the first three grades of elementary school was described. The suggested tool is a kid-friendly game that offers them a fun and engaging digital learning experience. Furthermore, we offered teachers a platform to create their educational game and gave students diversity and continuous eLearning renewal by utilizing the game engine concept. With a survey, teachers' intentions to use were assessed, and positive feedback was gathered. Plans are for enhancing question templates to span a range of skills and adding more dynamic visual effects employing GPU capabilities. Further tools will also be added so that teachers may monitor children's development and produce reports for parents. Machine learning techniques can be used to grade handwriting exercises and improve the game.

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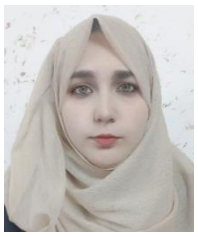
Dheya Mustafa received the bachelor's degree in computer engineering from the Jordan University of Science and Technology, Irbid, Jordan, in 2004, a master's degree in computer engineering from the University of Kentucky, Lexington, KY, USA, in 2009, and the Ph.D. degree in electrical and computer engineering from Purdue University, West Lafayette, IN, USA, in 2013. From 2012 to 2015, he was a Component Design Engineer at Intel, Austin, TX, USA. He is currently an Assistant Professor at the Department of Computer Engineering, The Hashemite University, Jordan. His research interests include parallel computing, performance evaluation, computer architecture, high-performance computing, and artificial intelligence.

Intisar Ghazi Mustafeh received a B.A. Degree first-class honor in Islamic Law (Shari'a) from Yarmouk University, Jordan in 1995. She obtained a Master's degree in Islamic Education from Yarmouk University, Jordan in 1997, and a Ph.D. in Education (pedagogy), From Exeter University, UK 2003. She worked as an assistant professor, then associate professor, and Full Professor at Yarmouk University, Jordan from 2003-2017. She is currently a member of the Department of Science Education at the College of Education-Qatar University since 2017; Intisar has broad academic experience including supervising bachelor, diploma, and Masters Students in practicum. Also, her teaching and research duties have been including, but are not limited to, teaching a wide spectrum of courses in education and curriculum and assessment, classroom management, and research methods, as well as, Integrating Technology in Teaching and Learning, at the College of Education, Qatar University.



Samah Zriqat received a bachelor's degree in Management information systems (MIS) from Yarmouk University, Irbid, Jordan, in 2016, and a master's degree in Management information systems (MIS) from Yarmouk University, Irbid, Jordan, in 2022. From 2017 to 2018 she worked as a promoter of e-government services at the Ministry of Communications and Information Technology, Amman, Jordan. Her research interests include education technology, software engineering, and security management.

Qutaibah Althebyan is an associate professor and Dean of College of Engineering at Al Ain University, UAE. He has been there since January 2018. Prior to joining Al Ain University, he was an associate professor of Software Engineering at Jordan University of Science and Technology (JUST) since August of 2008. Dr. Qutaibah Althebyan finished his Ph.D. degree in Computer Science from the University of Arkansas - Fayetteville and his Master's degree in Computer Information Systems from the University of Michigan-Dearborn. Dr. Althebyan published several papers in high-ranked journals and conferences. He is also a reviewer for many journals and conferences. Dr. Althebyan main research interests are, but not limited to, information security, database security, security in the cloud, big data management, health information systems, information assurance, software metrics and quality of open-source systems. Lately, he has been working in different security, e-health and software engineering projects, namely; Large Scale Insider Threat Assessments and damage assessment in the cloud in the area of cloud security.