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PAPER

Enhancing High School Students' Future Thinking Skills through Interactive Digital Platforms for Teaching Energy Issues

Asem Mohamed Ibrahim[1](✉), Ibrahim Ahmed Al-Farhan[1], Eman Wefky Ahmed[2], Ahmed Sadek Abdelmagid[3], Majed A. Al-Zahrani[4], Nusaibah J. Dakamsih[5]

[1]Faculty of Education, Department of Curriculum & Instruction, King Khalid University, Abha, Saudi Arabia

[2]Faculty of Education, Department of Curricula and Teaching Methods, Sohag University, Sohag, Egypt

[3]Faculty of Education, Educational Technology, King Khalid University, Abha, Saudi Arabia

[4]Riyadh Education Administration, Riyadh, Saudi Arabia

[5]Faculty of Arts and Languages, Department of English Language and Literature, Jadara University, Irbid, Jordan

amibrahim@kku.edu.sa

ABSTRACT

In this paper, we investigate the potential of teaching energy-related topics to enhance secondary school students' future thinking skills, including problem-solving, predicting, and envisioning. A physics enrichment program was conducted using the "Madrasati" digital platform in a semi-experimental design involving two groups of students (experimental and control). Utilizing a pre-post measurement approach, the study employed a novel instrument to assess future thinking across three distinct levels. The analysis, involving ETA squared, Cohen's effect size, and independent sample t-tests, revealed a significant improvement in future thinking skills for the program group. These findings suggest the potential of incorporating energy-related topics and digital platforms into secondary science curricula to enhance critical thinking skills necessary for addressing future challenges. The study further underscores the potential of digital tools and innovative teaching approaches in optimizing students' development of future thinking competencies.

KEYWORDS

future-thinking abilities, energy challenges, interactive digital platforms

1 INTRODUCTION

The advancements in science and technology observed during this period have materialized. Therefore, individuals must make an effort to keep pace with the rapid advancements in various sectors, rather than merely being aware of this progress. To achieve this, efforts must be made to ensure that future generations will advance in step with it. According to [1], the advancement of science and technology has led to a wide range of software and apps that cater to societal needs. These days, internet users actively participate in and collaborate with the educational process. Traditional learning theories, such as behavioral and cognitive theories, have

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struggled to explain how learning takes place in the face of this change. A theory that explains this type of learning, along with its guiding principles and technical implementations, has been necessary. Siemens's communication theory has addressed this requirement. This theory is based on the idea that learning involves recognizing and establishing connections between different sets of data and information. It also recognizes that the learning environment in schools functions as both a real-world and virtual network, enabling students to engage in cooperative and self-directed learning. Through these exercises, students can identify their strengths, areas needing improvement, and opportunities for skill development [2].

The communicative hypothesis states that learning requires exposing children to a significant amount of information. As a result, in order for individuals to learn, they must be taught how to process, validate, evaluate, and understand data. Acquiring knowledge takes place in foreign environments with dynamic core components. It is marked by confusion, chaos, resistance, unsociability, and social affiliation with students' interests and activities, although it is not solely determined by students. Social network analysis is a potent tool for assessing the impacts of education. Building and maintaining networks of relationships is the foundation of learning. It is an ongoing endeavor that lasts a lifetime. It is a networked foundation that encompasses mental and extramental activities for students [3], [4], [5], [6], [7], [8].

According to communication theory, e-learning settings, especially digital platforms, offer the ideal environment for learning. Active learning, a focus on cooperative learning, and the development of learning communities are some of the important features of these environments [9], [10], [11], [12], [13], [14]. According to [1], e-learning is essential for enhancing the quality and effectiveness of education. It places the student at the center of the educational process, positively impacting various learning environments and providing clear opportunities for learning through engagement.

Digital platforms are essential for providing high-quality online courses because they offer superior forms of education that ignite curiosity, making learning more enjoyable and engaging. The idea that everyone should be able to utilize educational platforms freely and without hindrance is the foundation of the concept that educational platforms embrace. Publication and open sharing with society are the cornerstones of this ideology [15], [16]. A competent educator uses digital channels for communication, teamwork, and teaching. These platforms provide a framework for learning that emphasizes the instructor's role in the classroom and in organizing and conducting instructional activities [17].

The findings of the study conducted by [18] demonstrate that utilizing an online learning platform grounded in communication theory can enhance the physics achievement of fourth-grade students. According to a study by [19], teaching physics on YouTube has a positive impact on students' physics achievement and increases their enthusiasm for learning. [20] This study demonstrates the effectiveness of an electronic program that utilizes Microsoft Teams, a digital platform, to raise awareness of health issues related to first aid, personal hygiene, preventive education, and healthy eating. According to [21], digital platforms are important for learning new information and linguistic skills.

[22] provides evidence of the effectiveness of digital platforms in enhancing sixth-grade pupils' knowledge of health issues and influencing their attitudes toward them [23]. The findings of [24] demonstrate how e-learning can enhance physics performance and foster scientific research ethics among secondary school students. The efficacy of the flipped classroom approach using the digital platform "Edmodo" in fostering self-learning abilities and enhancing academic success in the biology course is demonstrated.

[25] propose an idea for utilizing digital platforms in higher education for academic purposes. The findings of the study by [26] demonstrate the effectiveness of the "Edmodo" platform in improving the academic performance of middle-school students. The [27] findings demonstrate the effectiveness of web-based digital platforms for teaching the Network Interconnection Course.

[28] highlighting the importance of meeting the requirements for utilizing digital learning platforms in education is crucial, especially considering the intelligent transformation occurring across different educational levels. [29] Underscoring the importance of implementing digital platforms in accordance with structured guidelines and legally mandated protocols. This involves developing a strategic plan to efficiently implement digital transformation, establishing dedicated departments within educational institutions to manage the platforms, eliminating the reliance on external service providers, and requiring school administrators to submit progress reports on behalf of their students. There should also be an accountability framework in place. Enhancing transparency in evaluating achievement levels, increasing the network's server count, strengthening servers, linking student accomplishments to assessments, and evaluating the work performance of supervisors and teachers.

Various digital platforms are used in education. The Madrasati educational platform is a crucial resource for public education due to its ability to provide access to technology education. It seeks to enhance students' academic performance, improve the learning environment they are in, and strengthen the intellectual and instructional capacities of instructors. The foundation of educational activities on this platform is teachers and students. The platform's strategy is to create a virtual classroom that provides instructors and students with access to the enrichment materials necessary to achieve academic objectives. The platform's goal is to increase accessibility to educational activities by giving teachers and students equal importance.

One of the main objectives of teaching science in secondary education is the development of thinking abilities, particularly future-oriented thinking skills [30]. For global systems and modern communities, developing future thinking and its multifaceted abilities are equally crucial. This approach helps students anticipate, prepare for, and even discover viable solutions for future environmental issues and calamities. They will then be able to make well-informed judgments that successfully address environmental challenges. Accordingly, [31] clarifies that the ability to think ahead includes predicting, foresight, and planning. Students can develop and enhance these skills, which will assist them in understanding future-related information, anticipating potential issues, and predicting future events. By doing so, they can achieve the goal of understanding, predicting, and controlling the future.

According to [32], contemplating the future is a creative intellectual pursuit with numerous perspectives and dimensions, rather than an intellectual indulgence. It is based on the analysis of reality in all its forms and dimensions to formulate goals, future visions, and workable plans and programs that facilitate the advancement of the intended future. Several essential traits characterize future thinking, with the most crucial ones being a comprehensive vision, analysis, and anticipation for the future.

According to [33], the capacity to anticipate is crucial for decision-making, particularly when addressing potential future challenges. These abilities also aid in the development of lifelong learning, the promotion of current scientific knowledge, the growth of research and critical thinking, the facilitation of adaptation to a rapidly changing world, and the fostering of creativity through future-focused introspection. It also provides a comprehensive perspective on one's attitude and life by systematically evaluating the advantages and disadvantages of various scenarios and making deliberate, well-founded decisions about future outcomes. According to [34],

developing future thinking abilities is advantageous for foreseeing risks and issues, preparing for potential crises, creating thorough plans via study and introspection, and enhancing cognitive abilities to address potential future issues, irrespective of their likelihood of occurrence.

Given the speed at which the modern world is changing, it is imperative that students enhance their future thinking abilities, as they are crucial to their success in life. A comprehensive understanding of future milestones and competencies is essential for learners to maintain their success in life. One of the primary and crucial foundations of everlasting success is future thinking, which is the subject of this concept [35].

Thus, the goal of the current project is to develop an enrichment program in physics that will utilize digital platforms to educate students about energy concerns and assess how this will impact the future critical thinking abilities of secondary school students.

2 RESEARCH PROBLEM

Energy concerns, due to their direct impact on human life, are significant topics addressed in physics curricula and are essential for both individuals and society. One of the main goals of secondary physics education is to increase awareness of energy-related issues. It is critical for individuals, society, and the environment to be aware of energy-related challenges. Improving one's relationship with the environment and society, as well as addressing energy-related issues, is also crucial. In light of this, [36] highlights the importance of drawing attention to energy-related issues to influence people's attitudes towards changing their behavior. In addition to developing community skills, it is critical to involve people and communities in the process of addressing energy and environmental issues. Participants are involved in problem identification and prevention for the future.

According to reference [37], educating individuals about energy-related issues is crucial to ensuring that students have the knowledge, attitudes, and behaviors necessary to effectively manage energy resources. This awareness aids in the search for answers to the issues and difficulties that people encounter in their surroundings. It also provides industries and society with guidance on how to understand the environment, reduce wasteful energy use, manage and enhance it, and lessen the adverse impacts of an over-reliance on conventional energy sources.

According to [38], understanding energy-related issues is essential for contributing to environmental preservation and the development of natural energy resources. This involves considering the behavioral, social, and cognitive aspects of energy awareness, changing people's views on energy-related issues and conservation, promoting attitudes and values that endorse environmental preservation, and fostering positive behaviors concerning energy-related matters. Previous research has focused on increasing learners' knowledge of energy concerns due to the necessity of doing so, the environmental impact of these issues, and the requirement for physics curriculum to address them [39], [40], [41].

Effective enrichment, according to [42], is the process of filling gaps, fixing flaws, or addressing curricular deficiencies. The objectives, content, activities, and evaluation—the four components of the curriculum—must all be adequate, cohesive, and interconnected. The enrichment program should align with the topic and its subjects, as stated by [43]. It should also be suitable for students at their respective levels, considering their individual differences. It should also take into account human talents, time, resources, educational objectives, and scientific advancements. It should also align with the teacher's background and credentials.

A test was developed to assess the future thinking abilities of secondary school students regarding energy concerns. The test was administered to a sample of thirty-five students. The average test score for high school students was 6.13, reflecting a decrease of 25.54%. The findings showed that these skills were inadequate. Given the foregoing, the research challenge was determined to be the necessity of enhancing the secondary school physics curriculum by incorporating energy-related topics, utilizing digital platforms to teach these subjects, and addressing the deficiencies in students' future thinking abilities. Thus, the goal of this research was to create a physics enrichment program that utilizes digital platforms to educate secondary school students on energy-related topics and enhance their critical thinking abilities for the future.

2.1 Research questions

The following were the research questions:

1. Which physics enrichment course is the most suitable for educating high school students about energy challenges through interactive digital platforms?
2. How can future thinking abilities be developed in secondary school students through the teaching of energy challenges using interactive digital platforms?

2.2 Research hypothesis

The study attempted to confirm the following hypothesis: in the dimensional application of the future thinking skills test, there were no statistically significant differences between the average scores of the students in the experimental and control research groups at the significance level of 0.05.

2.3 Research objectives

The goal of the present study is to:

1. Create a physics enrichment program that uses digital platforms to educate secondary school students on energy-related subjects.
2. Demonstrate how the utilizations of digital platforms in energy education impacts the future critical thinking skills of secondary school students.

2.4 Research importance

The following highlights the significance of the present research:

1. Providing an enrichment program on energy concerns to individuals responsible for developing secondary physics curriculum so they can incorporate it into the content development of these curricula.
2. Staff members from the Ministry of Education (MOE) responsible for professional development initiatives and physics instructors could offer valuable guidance on digital platform physics education.
3. Provide a test to assess secondary school students' future thinking abilities for individuals responsible for evaluating physics instructors and curriculum.

2.5 Research terms

1. **Enrichment program:** The enrichment program is characterized by a variety of additional experiences and tasks within the physics course taught on the "Madrasati" platform. The program aims to assist secondary school students in becoming more future-focused and aware of energy-related challenges.
2. **Interactive digital platforms:** The Madrasati platform, an interactive learning environment connected to the MOE, is the operational definition of the interactive digital platform used in the current study. With this platform, secondary school students can delve into energy concerns in more detail during their physics class, as information can be accessed electronically over the Internet. It provides a range of interactive and solo exercises that make use of multimedia components such as audio files, pictures, videos, hyperlinks, assessments, and online homework.
3. **Future thinking skills:** The ability of secondary school pupils to anticipate future energy challenges, gain a thorough understanding of these challenges, and suggest appropriate solutions is known as future thinking skills. The student's performance on the future thinking skills exam, specifically designed for this purpose, is used to assess these abilities.

3 METHOD AND PROCEDURE

3.1 Research methodology

In order to teach energy-related topics, a physics enrichment program was created using the descriptive technique on the Madrasati platform. To establish a pre-dimensional measurement for two groups, a semi-experimental method was also employed. The aim of the study was to evaluate how the future thinking skills of secondary school students would be impacted by the utilization of digital platforms in energy education.

3.2 Participants

During the academic year 1443 AH, 47 students who attended King Fahd Secondary School in the Al-Baha area, who were in the second and third grades of the secondary school (course system), were selected as the research sample. The sample was purposefully selected because it represents the last batch of high school students who used the course system to learn physics. The control group, which included 25 students, and the experimental group, which included 22 students, were randomly selected from this sample.

3.3 Research materials and tools

1. **Preparing the enrichment program:** Utilizing interactive digital platforms, the proposed physics enrichment program aims to educate students on energy-related topics. The enrichment program aimed to assist secondary school students in becoming more aware of energy concerns (cognitive, emotional, and behavioral) and in developing future-oriented thinking skills (future

problem solving, future perception, and future forecasting). Communication theory served as the foundation for preparing and organizing the enrichment program. The interactive digital platform Madrasati was used for its implementation. Discussion, lectures, brainstorming, problem-solving, web inquiry, self-learning, and cooperative learning were some of the e-teaching techniques employed to deliver the enrichment program's content via the Madrasati platform.

Revised 2: A variety of instructional methods and resources, such as learning materials available on the Madrasati platform, were included in the enrichment program. With an emphasis on the Word and PowerPoint programs, these resources encompassed the entire Office 365 suite. The program also utilized the Microsoft Teams application, allowing group creation and the exchange of audio recordings, PDF files, and external links. Additionally, OneDrive, a cloud storage service that allows students to save and share files, was utilized by the software. OneNote, a note-taking application, was another tool used for recording and storing notes in OneDrive. In addition to creating electronic achievement files and portfolios, students can browse, examine, organize, and share their notes with others. Surveys and electronic tests with instant responses were also developed using the Forms program. Lastly, children can upload pictures and notes using the Padlet app. Second, the revised language is more reader-friendly and offers detailed information about the various tools and resources used in the enrichment program. On the Wordwall website, unique patterns and forms can be utilized to convey thoughts and ideas. With the ability to choose from pre-made activities and share the activity link through the Teams program, this website is dedicated to creating interactive educational activities.

A panel of specialists in curriculum design, science education, educational technology, educational supervision, and science teaching reviewed the enrichment program's materials to validate them. The experts confirmed the appropriateness of the program's goals, subject matter, instructional techniques, learning exercises, and assessment procedures. Certain modifications have been implemented based on advice from experts.

The finished version of the suggested enrichment program is shown in Table 1.

Table 1. An explanation of the completed image of the suggested enrichment program

Subject	Number of Hours	Number Activities	Number Brochures
Energy Sources	Two hours	3	3
Solar Energy	Two hours	3	3
Wind Energy	Two hours	3	3
Water Energy	Two hours	3	3
Nuclear Energy	Two hours	3	3
Thermal energy	Two hours	3	3
Electromagnetic energy	Two hours	2	2
Energy and the future	Two hours	3	3
Total	16 hours	23	23

The first research question was addressed when the final version of the suggested enrichment program was reached.

2. **Preparing the future thinking skills test of secondary school students:** The test is designed to assess secondary school students' future thinking abilities in areas such as energy-related problem-solving, forecasting, and visualization. The following abilities related to future thinking were identified based on a review of several previous studies on the subject [44], [45], [46], [47]:

   Future aptitude for solving-problems. Problem-solving is the capacity to evaluate and devise solutions for complex issues, intricate situations, or puzzles that hinder advancement in a specific aspect of life.

   Ability to foretell the future. It's a talent employed by those who use their expertise to predict future events.

   Ability to visualize the future. Science fiction is the art of envisioning fully developed future scenarios influenced by creative elements; it aims to depict a futuristic reality based on factual information.

   Following the identification of five energy-related concerns and issues, three assessments were developed, each measuring one of the three future-oriented thinking skills. The future-thinking exam originally had 15 items, with five vocabulary items evenly distributed among the three future-thinking skills. To estimate the responses to the rubric, a verbal scale was developed. It included the grade awarded to each description to be used in the correction as well as an explanation of the intended answers for each item. Subsequently, test instructions were developed for secondary school students, outlining the exam's objectives and how to respond to them. The instructions took into account the importance of clarity, simplicity in language, and time management.

   To enhance the test's psychometric properties, a sample of 25 secondary school students participated in the modification process. The discrimination coefficients of the vocabulary ranged from 0.40 to 0.61, while the difficulty coefficients of the test items ranged from 0.3 to 0.7. The test items exhibit adequate difficulty and discrimination coefficients, as indicated by these results.

   A satisfactory stability coefficient for the test was indicated by the Cronbach's alpha stability value of 0.74. Using the half-fractionation method and the Spearman-Brown equation, the test's stability coefficient was found to be 0.75, indicating a high level of test stability. The last exam assesses future thinking abilities.

4 RESEARCH RESULTS

1. **Results of the first question:** The first question is as follows: "What enrichment program in physics is suitable for teaching energy issues using interactive digital platforms for high school students?" This question was addressed in the previously explained in-depth procedures for creating the enrichment program, which included the program's philosophical underpinnings, sources of inspiration, objectives, content, instructional strategies, learning resources, and methods of assessment. These procedures also included presenting the program to a panel of experts and specialists in the fields of curriculum, science education, and educational technologies, making the necessary revisions, and ultimately creating the final version of the enrichment program.
2. **Results of the second question:** The second question is, "What is the impact of using interactive digital platforms to teach energy issues on secondary school students' development of future thinking skills?" Table 2 displays the results of the independent samples T-test conducted to examine the validity of the research hypothesis. The hypothesis aimed to answer the question: "Are there

statistically significant differences, at a significance level of 0.05, between the average scores of students in the experimental and control research groups in the dimensional application of the future thinking skills test?"

Table 2. Results of the independent samples t-test

Skills	Groups	N	Mean	Std. Deviation	df	T	Sig.	D Cohen	η^2
Solve future problems	Control	25	15.6	2.12	45	4.57	0.01	1.81	0.32
	Experimental	22	18.04	1.43					
Future prediction	Control	25	15.24	1.45	45	6.97	0.01	2.38	0.52
	Experimental	22	18	1.23					
Future visualization	Control	25	14.68	1.21	45	10.42	0.01	3.21	0.71
	Experimental	22	18	0.93					
All future thinking skills	Control	25	45.52	2.8	45	11.58	0.01	5.42	0.75
	Experimental	22	54.04	2.15					

Table 2 shows the results of the independent samples t-test which confirm the significance of the variations in the means of the experimental and control study groups after the future thinking skills exam was administered. The study hypothesis was rejected because Table 2 demonstrates statistically significant differences between the control and experimental groups' average scores in the dimensional application of the test of future thinking skills as a whole and its three skills, favoring the experimental group, at a significance level of 0.01. The alternative hypothesis posited the existence of statistically significant differences between the average student scores of the experimental and control research groups in the dimensional application of the upcoming thinking skills tests, with a significance level of 0.05, in favor of the experimental group.

The table further displays Cohen's value of (d) for the following future thinking talents: overall future thinking skills (5.42), future visualization skills (3.21), future prediction skills (2.38), and future problem-solving skills (1.81). Furthermore, the table demonstrates that the ETA square (η^2) for the following talents was calculated: 0.32 for future problem-solving skills, 0.52 for future forecasting skills, 0.71 for future perception skills, and 0.75 for the overall skills of future thinking. The aforementioned findings indicate that incorporating interactive digital platforms in energy education significantly enhances future thinking abilities among students in the experimental study group.

5 DISCUSSING THE RESULTS OF THE RESEARCH

It has been demonstrated that the use of interactive digital platforms, such as the Madrasati platform, in energy education has a significant impact on the development of future thinking capacities among pupils in the experimental research group. This is due to the vast array of educational resources, tools, and digital technologies that are offered on the Madrasati platform. Students were able to express their thoughts and proposals for potential future solutions to energy-related challenges in an engaging and dynamic learning environment that fostered critical thinking. Furthermore, the Madrasati platform offers numerous advantages that improve students' future capacity for critical thinking. These include allowing students sufficient

time to contemplate, express their opinions, and participate in online research, study, and investigation on topics related to energy. Set expectations, recognize potential future energy-related challenges and limitations, and focus the Madrasati platform's learning environment on student engagement and interaction. This is consistent with earlier studies [47], [48] that have shown the importance of digital strategies and tools in promoting forward-thinking abilities.

The enrichment program's coverage of energy-related concerns, combined with the students' personal experiences, helped them connect the dots. This enabled them to better understand the challenges facing their society and develop suitable responses. According to research by [49], this contributed to the development of the students' future thinking abilities. These studies demonstrated that the students' future thinking abilities were influenced by the relevance of the topics they studied to their lives and the needs of their society. According to [50], students' curiosity is piqued when they can relate the subjects they study to their lives and the societal challenges they face. As well as competing with one another to comprehend these problems and come up with solutions, they also develop their problem-solving abilities for the future.

The integration of energy-related subjects into physics courses has been crucial in establishing an engaging learning atmosphere that allows students to propose solutions and provide examples for upcoming energy-related problems. This is consistent with other study findings [51], [52], [53], [54] that highlight the significance of enrichment programs in fostering the development of critical thinking skills.

5.1 Research recommendations

In light of the study's findings, the investigator recommends the following:

1. A desire to teach science courses, particularly physics, to secondary school students using interactive digital platforms.
2. Training teachers to use interactive digital platforms for teaching science across various subjects.
3. The need for future issues, such as energy difficulties, to be covered in scientific curricula.
4. The need to focus on helping students at all educational levels develop their capacity for future thinking.

5.2 Research proposals

Based on the study's findings, the researcher suggests conducting further research:

1. How students' development in other cognitive domains, such as critical and creative thinking, is impacted by interactive digital learning environments for physics education in secondary schools.
2. A curriculum proposal is designed to help high school students develop 21st-century skills by incorporating communication theory.
3. The use of interactive digital platforms in teaching physics enhances the scientific reasoning abilities and deepens the understanding of secondary school students.
4. Explore how other digital tools, such as augmented reality, personalized learning platforms, and AI applications, could help secondary school students enhance their capacity for future planning and raise awareness of energy-related issues.

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8 AUTHORS

Dr. Asem Mohamed Ibrahim is a Professor of Curriculum and Science Education at Sohag University. He obtained Master's degree in Science Education, 2005, Sohag University. He obtained PHD in Science Education, 2009, Sohag University. Currently, he works at King Khalid University. His current research interests include curriculum design, evaluation and development, science teaching methods, digital platforms, mobile learning, artificial intelligence in education, the joy of learning, social-emotional learning, STEAM education, scientific and engineering practices, science standards for the next generation, and performance-based assessment (E-mail: amibrahim@kku.edu.sa).

Dr. Ibrahim Ahmed Al-Farhan is an Associate Professor of Curriculum in Science Teaching. He has completed Masters and PhD in Science Curriculum and Teaching Methods, and is working as Head of the Department of Specialized Curriculum in Chemistry. His research interests include curriculum evaluation and development, green education, integration with STEM, artificial intelligence, and science development (E-mail: ialfarhan@kku.edu.sa).

Dr. Eman Wefky Ahmed is an Associate Professor at Sohag University. She earned her Bachelor of Science and Education in 1992, followed by a Master's in Education in 1999. In 2004, she completed her Doctorate in Curriculum and Teaching Methods at Flensburg University, Germany. Her career spans teaching, research, and educational development, both locally and internationally (E-mail: e_wefky@yahoo.com).

Dr. Ahmed Sadek Abdelmagid is a Professor of Educational Technology at the College of Education, King Khalid University in Sohag. He obtained Master's degree in 1999 and Doctorate in 2003He is an advisor to the Deanship of E-Learning, and the Managing Editor of the *King Khalid University Journal of Educational Sciences*. His research interests include designing of electronic platforms, smartphone

applications, generative artificial intelligence applications, and big data analysis (E-mail: abdelmagid@kku.edu.sa).

Dr. Majed A. Al-Zahrani is a dedicated Physics Teacher at the Riyadh Education Administration in Saudi Arabia. With a passion for science education, Mr. Al-Zahrani brings his expertise and enthusiasm to inspire students and promote a deeper understanding of the fascinating world of physics (E-mail: alzhrani.majed@gmail.com).

Dr. Nusaibah J. Dakamsih is an Assistant Professor in English. Currently He works in the Department of English Language and Translation, Jadara University, Irbid, Jordan. His research interests include English language, literature, drama and theatre, feminist studies, and criticism. He worked as a representative of the Department of English in the Control and Assurance Quality Unit at Shaqra University and at Jadara University as well. He has published number of Scopus-indexed Articles and is a member of the Jadara University Journal editorial board (E-mail: n.dakamsih@jadara.edu.jo).