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The Effectiveness of an Innovative Mobile Application in Self-Regulation and Metacognitive Awareness Among Eighth Grade Students in the Sultanate of Oman

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Abstract: The study aimed to evaluate the effectiveness of a gamified mobile application in enhancing self-regulation and metacognitive awareness among eighth-grade students in Oman during the COVID-19 pandemic. Using a quasi-experimental design, the study involved 63 students, divided into an experimental group (33 students) and a control group (30 students), with pre- and post-tests conducted. The researchers designed an innovative mobile application based on the gamification approach, which focuses on providing students with scientific concepts in various fields of science, and which was called (Dr.Electron). The self-regulation and metacognitive awareness scales used had reliability coefficients of (0.91) and (0.95), respectively. Results indicated significant improvements in the experimental group for both self-regulation and metacognitive awareness compared to the control group. However, no significant interaction between teaching method and gender was found for self-regulation, while a significant interaction was observed for metacognitive awareness. The study recommends the use of gamified educational apps to enhance student engagement, especially during crises like the COVID-19 pandemic.

Keywords: Gamification Self-regulation, metacognitive awareness, Mobile application, COVID-19.

فاعلية تطبيق هاتفي إثرائي مبتكر قائم على منحى التلعيب (Dr. Electron) في التنظيم الذاتي والوعي لما وراء المعرفة لدى طلبة الصف الثامن بسلطنة عُمان خلال جائحة كوفيد- 19

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المستخلص: هدفت الدراسة إلى استقصاء فاعلية تطبيق هاتفي اثرائي قائم على منحى التلعيب في التنظيم الذاتي والوعي لما وراء المعرفة لدى طلبة الصف الثامن الأساسي بسلطنة عمان في ظل جائحة كوفيد- 19، وقد تم استخدام المنهج شبه التجريبي المعتمد على التصميم ذي المجموعتين الضابطة والتجريبية والتطبيق القبلي والبعدي، و تكونت عينة الدراسة من (63) طالبًا وطالبة في الصف الثامن الأساسي انقسموا إلى (33) في المجموعة التجريبية و (30) في المجموعة الضابطة، و قام الباحثون بتصميم تطبيق هاتفي مبتكر قائم على منحى التلعيب، ويركز على اكساب الطلبة للمفاهيم العلمية في مختلف أقسام العلوم والذي أطلق عليه اسم (Dr.Electron)، كما تم استخدام مقياس التنظيم الذاتي والذي بلغت قيمة معامل الثبات له (0.91) ومقياس الوعي لما وراء المعرفة والذي بلغت قيمة معامل الثبات له (0.95) وأظهرت النتائج وجود فروق ذات دلالة إحصائية في التطبيق البعدي بين المجموعتين الضابطة والتجريبية تعزى لطريقة التدريس لصالح المجموعة التجريبية، وعدم وجود أثر دال إحصائيًا للتفاعل بين طريقة التدريس ومتغير النوع الاجتماعي في التطبيق البعدي لمقياس التنظيم الذاتي في حين كان هناك تفاعل ملحوظ بين طريقة التدريس والنوع الاجتماعي في مقياس الوعي لما وراء المعرفة لصالح الإناث، وتوصي الدراسة بضرورة توجيه القائمين على تدريس العلوم إلى أهمية تصميم واستخدام التطبيقات الاثرائية القائمة على مبادئ منحى التلعيب وذلك لتنمية التنظيم الذاتي وتنمية الوعي لما وراء المعرفة لدى الطلبة.

الكلمات المفتاحية: منحى التلعيب، التنظيم الذاتي، الوعي لما وراء المعرفة، جائحة كوفيد- 19.

1- Introduction

The rapid technological advancement in various fields of life and the emergence of global crises, both economic and health-related such as the COVID-19 pandemic, are among the most influential factors leading many educational institutions to employ modern technological means, strategies, and applications such as the use of gamification in education. This is with the aim of continuing the educational process, keeping up with developments in all fields, and preparing a generation capable of directing its behavior, organizing its knowledge, and relying on itself in all aspects of life.

Self-regulation is one of the concepts associated with self-learning and significantly influences an individual's behaviors, actions, and competence. The foundations of self-regulation go back to Albert Bandura's theory of social cognitive learning, which refers to the reciprocal relationship between the individual, the environment, and behavior (Al-Yousef, 2020). Self-regulation is defined as "student's ability to acquire and develop new strategies and methods to assist them in the learning process and knowledge acquisition (Jaber et al., 2014, p. 506)."

This can bring many academic and social benefits (Jaber et al., 2014, p. 506). Several studies indicate the importance of equipping students with self-regulation skills due to their high impact on guiding individual behaviors, stimulating motivation, and raising academic performance (Bakracevic &Licardo, 2010; Mega et al., 2014). It also helps students acquire decision-making skills and self-confidence (Khader, 2015; Al-Yousef, 2020), and contributes to increasing students' ability to plan, self-monitor, and self-evaluate their performance (Al-Absi, 2018; Al-Taibani & Younis, 2020; Schraw et al., 2006). A study by Junaidi (2015) pointed out that some students' weakness in self-regulation skills leads to the emergence of socially, scientifically, and psychologically unacceptable behaviors and it affects their academic level.

To overcome the low academic level, weak organization of cognitive and behavioral structure, and the low ability to plan, self-monitor, and evaluate among some students, some studies have suggested the necessity of training students on self-regulation skills (Mottaleb & Hashem, 2017). Additionally, some studies have also suggested the necessity of employing appropriate teaching strategies aimed at equipping students with self-regulation skills (Khalil, 2021; Al-Absi, 2018) which include scientific inquiry, cooperative learning, problem-solving, building mental models, and utilizing technology to support education. Self-regulated learning strategies play an effective role in enhancing students' ability to organize knowledge by retaining it in memory and recalling it and by linking prior knowledge with new knowledge (Al-Absi, 2018). Self-regulation strategies such as planning and goal setting, rehearsing and remembering, helping others, and using cognitive maps can be employed to improve students' academic achievement levels (Mega et al., 2014).

The concept of metacognitive awareness is one of the most recent topics in the field of educational psychology which appeared at the hands of the American scientist Flavell at the beginning of the seventies of the last century through investigation and research in memory processes (Talafha & Al-Tal, 2019). Metacognitive awareness is defined as "the individual's knowledge of their own thinking strategies and processes and the ability to organize these processes and control them. This concept includes two types of cognitive activities: the individual's awareness of the knowledge and the organization of knowledge" (Ahmed, 2013, p. 367).

At present, it has become necessary to prepare a generation for the future by preparing it for conscious understanding of the successive changes in the external environment surrounding it with the aim of facing problems and obstacles and trying to find suitable solutions and alternatives for them (Abdul Nabi, 2020).

Arab and foreign studies indicate the necessity of equipping students with metacognitive awareness through the application of appropriate strategies such as self-regulation of learning (Lee et al., 2010; Schraw et al., 2006), self-questioning, thinking out loud, modeling, concept maps, metacognitive learning cycle, V-shape maps, mind maps (Al-Sayed, 2021; Al-Ghamdi, 2019), active learning and blended learning (Nababan et al., 2019). These strategies have a basic role in raising the academic level of students and equipping them with problem-solving skills and innovative and critical thinking. These strategies increase the ability of students to make a conceptual change and overcome learning difficulties (Rahab et al., 2010). Metacognitive awareness plays a basic role in helping students to self-organize their learning process and determine their short and long-term goals (Ahmed, 2013). However, the decrease in some students' motivation for academic achievement is due to their low metacognitive awareness (Mohammed, 2004). So, several studies have suggested the necessity of employing the learner for methods and educational strategies to raise their metacognitive awareness including brainstorming, summarizing, and self-questioning (Abdul Nabi, 2020).

Some studies (Al-Dajani & Al-Mashqih, 2021; Alhalafway et al., 2019; Safapour et al., 2019; Su & Cheng, 2015; Tamtama et al., 2020; Xu et al., 2016) have agreed on the importance of employing technology in education, especially in light of the COVID-19 pandemic, to support the educational process and achieve the desired educational outcomes. The use of technology in education contributes to enhancing the learning process and making it more effective and enjoyable. It provides various educational resources and tools that help in explaining and simplifying the educational content. It also contributes to developing students' skills in self-learning and independent thinking and enhancing their motivation towards learning. The use of technology in education also contributes to overcoming the challenges and obstacles facing the educational process especially during the COVID-19 pandemic which imposed a new reality on the educational process. The pandemic led to distance education that required the use of various technological tools and applications. Therefore, many educational institutions have resorted to employ and integrate technology into the educational process to ensure the continuity of the educational process and achieve its goals considering the current circumstances. The use of technology in education has become a necessity not a luxury considering the rapid technological development and the changes and challenges it imposes on various fields of life including the field of education. Therefore, it is necessary to pay attention to employing technology in education and integrating it into the educational process. It is also necessary to train teachers and students on how to use it effectively to achieve the desired educational outcomes.

The use of gamification in education plays an active role in the self-regulation of student learning as it provides enjoyment and increases student participation and self-motivation. A study by Al-Hosni and Al-Balushi (2023) showed the effectiveness of teaching using a mobile application based on the gamification approach in the attitudes towards self-learning among fourth-grade students during the Corona pandemic. Therefore, this study aimed to investigate the impact of teaching science using the gamification approach in self-regulation and awareness of metacognition among eighth-grade students in Oman during the COVID-19 pandemic using an innovative mobile application called Dr. Electron. Given the limited studies that have dealt with self-regulation and awareness of metacognition and their relationship to gamification, to the best of the researchers' knowledge, this study hopes to benefit teachers, educators, and those in charge of continuously developing the educational process with the aim of creating a generation capable of self-learning in all areas of life.

Due to the COVID-19 crisis, most educational institutions have turned to employ the remote online learning system through virtual classrooms to continue the educational learning process. To ensure the engagement and interaction of students in the remote learning system, some teachers and educators have resorted to employ educational games and the gamification approach to stimulate students' motivation towards learning, to achieve the best expected performance (Al-Qahtani et al., 2016; Su & Cheng, 2015), and to develop scientific concepts among fourth-grade students (Al-Hosni and Al-Balushi, 2023). Despite the diversity of gamification employment in various fields of life such as marketing, sports, health, tourism, media, customer service, and education (Xu et al., 2016), most previous studies and literature have agreed on a precise and comprehensive definition. Ismail (2019) defines gamification as "designing educational game incentives electronically using game elements and characteristics in an educational activity in educational contexts in order to reach an educational goal or stimulate learning motivation among students consisting of four dimensions; arousing interest, challenge, providing opportunities for choice, fun, with a focus on educational and cognitive tasks that are beneficial" (p. 204). It is defined by Al-Dajani and Al-Mishqih (2021) as "using the principles and elements of the game outside the play environment" (p. 91). Some studies agree with the previous definition (Hanus & Fox, 2015; Safapour et al., 2019). It is necessary to apply the elements and principles of gamification when employing gamification in education to ensure the active participation of the student and to express its positive impact on the entire educational process (Hitchens & Tulloch, 2018).

Despite the difference in the employment of gamification in several areas of life and the multiplicity of its use goals, most educational literature has agreed that it contains fixed elements that enable it to create an educational environment that stimulates students' motivation and attitudes towards learning everything new. The elements of gamification are represented in the points that the students collect (Points), the level they reach (Level), the leaderboard and the students' ranking among the players (Leader-boarder), the challenges that the students face in the game (Challenges), the prizes they get (Rewards), and the badges that the students win when achieving the achievement (Badges) (Al-Hosni & Al-Balushi, 2023, Hitchens & Tulloch 2018). Therefore, activating the elements of gamification contributes significantly to achieve the planned educational goals through interaction and integration of students in educational activities (Al-Mahmoud et al., 2019).

Gamification is one of the modern electronic activities in the field of assistive technology that affects the educational process by stimulating the student to interact with the educational content, developing communication skills with the surrounding environment, and providing the opportunity for them to express themselves within a specific social framework (Hitchens & Tulloch, 2018). In addition, it is one of the evaluation tools that provides immediate feedback to the student to realize their strengths and weaknesses (Al-Mahmoud et al., 2019). The importance of gamification in education lies in stimulating students' motivation towards learning, raising their academic level, motivating them to participate and interact in education (Su & Cheng, 2015). Gamification is essential for developing students' ability to work as a team, analyze and solve problems, enhancing planning skills with the aim of reaching their goals, enhancing self-confidence, developing their cognitive structure, enhancing self-confidence, and developing their self-efficacy (Safapour et al., 2019).

1-2-Self- Regulation

Self-regulation is one of the basic components upon which e-learning is built because of its ability to provide opportunities for the student to plan, control, and rely on themselves in the learning process. Self-regulation also enables the student to employ appropriate learning strategies with the aim of achieving their educational goals (Ibrahim, 2020).

Self-regulation is considered an indicator of the decrease or increase in scientific and academic achievement among students due to its fundamental role in enabling students to plan their goals, achieve them, and evaluate their performance with the least possible effort (Khader, 2015). Self-regulation has a significant impact on the cognitive and behavioral structure through its ability to enable the student to monitor their behaviors and actions and organize their time to reach the planned goal (Al-Yousef, 2020, Bakracevic & Licardo, 2010; Mega et al., 2014; Schraw et al., 2006).Self-regulation is defined as "a complex construct that includes the ability to control the individual's behaviors, manage them, and organize them by directing them towards performing actions and activities according to the requirements of a specific situation in order to modify behaviors that allow them to harmonize with the surrounding social environment" (Bakracevic & Licardo, 2010, p.159). Ibrahim (2020) also defines self-regulation as "a set of steps or actions or behaviors that the learner practices in order to acquire information, store it, retain it, and retrieve it when needed through e-learning" (p.346). It is also defined as "a set of processes that learners use to enable them to control their cognitive structure and organize their efforts while performing their school tasks. Self-regulation is a metacognitive strategy that helps to coordinate the learning process through three general processes represented in: planning, monitoring, and evaluation, so that they can review, examine, monitor, and evaluate their behavior while performing their school tasks" (Radadi, 2002, pp. 178-179). It is defined by both Al-Taibani & Younis (2020) as "self-guidance from within the individuals themselves, through which they practice self-monitoring, perseverance, attention, conscious management, and the ability to control behavior and emotions to achieve the desired goals" (p.8). Mega et al. (2014) define self-regulation as "the individual's organization of knowledge, experiences, internal motivations, and behaviors according to pre-determined standards with monitoring the level of their progress towards achieving the goals they aspire to" (p.122). The theories that support and explain self-regulation (Khader, 2015) are:

1- Theory of Cognitive Development (Piaget): Self-regulatory cognition occurs through the processes of representation, accommodation, and adaptation to the external environment by integrating new knowledge with the individual's previous knowledge to achieve cognitive equilibrium.
2- Cyclic Self-Regulation Theory (Zimmerman): It requires the individual to make successive efforts to reach a level of mastery in self-regulating learningwhich is done through self-processes in organization, regulation, and strategic guidance of behavior in the surrounding environment.
3- Behavioral Theory (Skinner): The self-regulation of an individual's learning occurs due to external factors such as training and influences of the surrounding environment which affects the strength of behavior and its repetition. So, the external environment that surrounds the individual affects their behavior more than their experiences.
4- Social Cognitive Learning Theory (Bandura): The social cognitive learning theory of the world Bandura (1997) is of great interest to many researchers in the educational field which has contributed to the development of the theory of self-regulation of learning. Self-regulation of learning consists of three basic and overlapping components which are cognitive awareness, awareness behind knowledge, and motivation. The theory of self-regulation of learning also asserts that self-organized individuals go through four successive levels until they reach self-regulation of learning. These levels are

observation, imitation, self-control, self-organization. The observation is affected by modeling and the imitation is affected by social guidance and feedback which has greatly contributed to the emergence of multiple strategies for self-regulation represented in self-monitoring, self-enhancement, self-evaluation (Al-Taibani &Younis, 2020). Radadi (2002) indicates that self-regulation strategies are classified into cognitive strategy and self-regulation. Also, Schraw et al. (2006) indicates the effectiveness of employing teaching strategies in the classroom in developing self-regulation skills among students represented in inquiry-based learning, cooperative learning, problem-solving strategy, building mental models, personal beliefs such as self-efficacy, employing technology to support student learning.

Self-regulation skills for learning are defined as "the processes and procedures that the learner employs during their learning to be active and direct it towards achieving their goals.It includes a set of skills: planning and setting goals, self-efficacy, detail, asking for help, self-monitoring, self-evaluation, searching for information, and time management" (Mohammed, 2018, p.35). Self-regulation skills include processes that the individual performs and represents in cognitive processes that contribute to defining the goal, attention, cognitive flexibility, behavioral processes that contribute to the ability to control the individual's behaviors, and social processes that help the individual learner to monitor and organize social interaction with the surrounding environment. (Al-Taibani& Younis, 2020). Ziyada mentioned in Al-Absi (2018) that self-regulation skills are classified into five basic skills represented in planning and setting goals, self-monitoring, self-evaluation and self-enhancement, and controlling external stimuli.

According to Al-Taibani & Younis (2020), self-regulation has four dimensions represented in self-monitoring, planning and setting goals, behavioral organization, and self-evaluation. Self-organized learning strategies include writing, asking for help, organization, peer learning, time management, self-dialogue, control of motivation, monitoring understanding, searching for information, summarizing, detailing, task strategies, and self-evaluation (Mohammed, 2018). Several studies have indicated the ability of self-regulation of learning to predict the academic level of students (Bakracevic&Licardo, 2010; Mega et al., 2014; Schraw et al., 2006; Vrieling et al., 2010). Arab and foreign studies have indicated that a lack of self-regulation of learning leads to a decrease in the academic level and a decrease in motivation to learn among students (Khader, 2015; Al-Taibani & Younis, 2020). To treat the weakness of self-regulation among students, several studies have recommended the necessity of training students on self-regulation skills, especially in the early and middle childhood period because it has a fundamental role in developing the cognitive, behavioral, emotional, and social aspects (Al-Taibani & Younis, 2020; Al-Absi, 2018; Al-Yousef 2020).

Researchers have found a trend in recent educational literature to study the effectiveness of gamification in developing self-regulation among learners including a study of gamification across digital platforms (Al-halafawy & Zaki, 2022), gamification in e-learning (Li et al., 2022) and gamification based on the local old story (Pramana et al., 2020).

1-3-Metacognition Awareness

The term metacognition emerged in the early 1970s by the American psychologist Flavell. The term is based on the development and improvement of the learning process for learners through thinking and training them through effective activities and exercises that help them think (Hamza et al., 2020; Talafha& Al-Tal, 2019). The importance of developing metacognition in students is considered a basic indicator of the level of understanding and self-organization of their learning.It helps to organize the behaviors of students through awareness and self-monitoring of what they have learned and provides them with the opportunity to take responsibility for their learning. It is also a way to achieve success and academic achievement (Hamza et al., 2020). Teaching students thinking skills at various levels and types has become a basic requirement in many educational institutions at various stages due to its active role in equipping students with problem-solving skills and awareness of contemporary issues. It is one of the most important learning strategies based on the principle of "thinking about thinking" "Metacognition strategy" that gives students self-organization skills and awareness of their learning and provides them with the opportunity to employ what they have learned in other similar educational situations (Abdul Nabi, 2020). Metacognition strategies are defined as "a set of actions that the learner performs to know the activities, mental processes, learning methods and self-control that are used before, during and after learning to remember, understand, plan, manage, solve problems, and other cognitive processes" (Rahab et al., 2010, p.164). Some examples of metacognition strategies that can be employed in the educational environment are brainstorming, self-questioning, KWLH, summarizing and concept maps (Abdul Nabi, 2020; Rahab et al., 2010). Mohammed (2004) classifies them into strategies of reading, motivation for academic achievement and self-esteem protection. Metacognition strategies are also classified into nine strategies which are self-questioning,

thinking out loud, planning and self-organization, concept maps, cooperative learning, modeling, asking questions, I know I want to learn and brainstorming (Al-Sayed, 2021).

Metacognition skills appear in the learner at the first stage of their education. They appear more prominently as they progress in age during the educational stages through training and experience based on various activities, effective exercises and programs. Therefore, the middle school stage is the most appropriate stage for developing metacognition skills until the learner can develop them more and employ them in the secondary education stage (Hamza et al., 2020). Also, Metacognition skills are defined as "a set of mental processes that the learners perform while they are at a degree of awareness during their practice of the cognitive process, their use of appropriate strategies for the subject of learning and their knowledge of the goal to be reached. This is done through their performance of planning, monitoring and continuous evaluation processes to know the extent of their progress and gradually towards the goal as well as their ability to contemplate the methods and strategies they perform during their acquisition of knowledge" (Sweidan & Al-Zuhairi, 2015, p.374). Hamza et al. (2020, p.420) define it as "mental skills that make the student aware of their thinking and their ability to self-evaluate through their ability to plan, monitor, control and evaluate". Talafha and Al-Tal (2019) define metacognition experiences as "cognitive experiences that help the individual to choose the appropriate strategies when facing a task, so that they differentiate between a group of strategies to reach the correct solutions such as looking at the problem from several angles to see if there is something that may contribute to removing ambiguity or asking for help from others" (p. 769). The researchers in this study define metacognition awareness as the process of thinking about thinking, enabling the learner to realize, be aware and control their way of thinking before, during and after the learning process through several successive and repeated steps represented in planning, monitoring, control, and evaluation.

The results of several studies have indicated the positive impact of metacognition skills on various learning outcomes, the academic level and academic achievement (Rahab et al., 2010; Al-Sayed, 2021; Mohammed, 2004), thinking skills, problem-solving and awareness of contemporary issues (Abdul Nabi, 2020; Al-Issa, 2014), self-organization of student learning (Talafha & Al-Tal, 2019), self-efficacy (Hamza et al., 2020), and motivation for achievement (Manoukh & Saeed, 2009). Kartika (2019) indicated the effectiveness of blended learning in developing metacognition skills and positive attitudes towards learning.

The term metacognition emerged in the early seventies of the twentieth century by the American psychologist Flavell. The term is based on the development and improvement of the learning process for learners through thinking and training them through effective activities and exercises that help them to think (Hamza et al., 2020; Talafha & Al-Tal, 2019). The importance of developing metacognition among students is considered a basic indicator of the level of understanding and self-organization of their learning. It helps to organize the behaviors of students through self-awareness and monitoring of what they have learned and provides them with the opportunity to take responsibility for their learning. Several studies have indicated the positive impact of metacognition skills on various learning outcomes and processes such as academic achievement (Rahab et al., 2010; Al-Sayed, 2021; Mohammed, 2004), thinking skills, problem-solving and awareness of contemporary issues (Abdul Nabi, 2020; Al-Issa, 2014), self-organization of student learning (Talafha & Al-Tal, 2019), and self-efficacy (Hamza et al., 2020). Metacognition skills are defined as "a set of mental skills that make the student aware of their thinking and ability to self-evaluate through their ability to plan, monitor, control and evaluate their learning" (Sweidan & Al-Zuhairi, 2015, p.374).

In conclusion, the need called for research into teaching methods and strategies that would raise the level of self-organization and metacognition among students. Several studies have pointed to the effectiveness of gamification in stimulating students to build knowledge and retain the impact of learning by transferring what they have learned in other similar situations. Gamification also creates an atmosphere of enthusiasm, fun, and competition in learning science which raise the level of student performance and academic achievement (Su & Cheng, 2015).

Using gamification by employing smartphone applications has an active role in developing thinking skills among students (Al-Juhani, 2019), raising the level of academic achievement (Su & Cheng, 2015) and self-learning (Ismail, 2019; Al-Hosni & Al-Balushi, 2023; Mohammed, 2018).

The current study aims to investigate the impact of teaching science using a gamification approach on self-organization and metacognitive awareness among eighth-grade students in Oman during the COVID-19 pandemic using the Dr.Electron application. The main question of this study is what is the impact of an innovative gamification-based mobile application (Dr.Electron) on the

development of self-organization and metacognitive awareness among eighth-grade students in Oman during the COVID-19 pandemic? This main question has the following four sub-questions:

1- What is the impact of an innovative gamification-based mobile application (Dr.Electron) on the development of self-organization among eighth-grade students in Oman during the COVID-19 pandemic?
2- What is the nature of the interaction between the teaching method (gamification/traditional method) and the gender (male/female) in the level of self-organization among eighth-grade students?
3- What is the impact of an innovative gamification-based mobile application (Dr.Electron) on the development of metacognitive awareness among eighth-grade students in Oman during the COVID-19 pandemic?
4- What is the nature of the interaction between the teaching method (gamification/traditional method) and the gender (male/female) in the level of metacognitive awareness among eighth-grade students?

1-4-Significance of the Study

This study derives its importance from the novelty of using gamification in education which is one of the most important modern trends in the field of technology-based learning. Given that many students own smartphones, we find that gamification by employing phone applications plays an effective role in developing students' thinking skills (Al-Juhani, 2019) and raising their level of academic achievement (Su & Cheng, 2015) and self-learning (Ismail, 2019; Al-Hosni and Al-Balushi, 2023; Mohammed, 2018). The use of educational games is one of the main motivators that arouse students' motivation and enthusiasm for learning (Osatuyi et al., 2018; Tamtama et al., 2020).Therefore, it is hoped that the current study will contribute to narrowing this gap in educational literature. Its importance also lies in its attempt to draw the attention of teachers in the Arab world to the employment of gamification in science education and the interest in integrating learners in learning. The results of the study are expected to encourage more researchers to conduct research on the effectiveness of gamification-based mobile applications and study their impact on various aspects influencing learning in general and science learning in particular. The importance of the current study is further enhanced by the fact that it was conducted during the COVID-19 pandemic at a time when students were alternating attendance at schools in Oman, week after week. The period when the student stays at home for a full week was exploited to encourage them to use the activities and questions in the mobile application (Dr. Electron). This study also provides an innovative mobile application available on Google Play equipped with interactive questions for science curriculum topics for grades 1-9 in an engaging and interactive way.

2- Method

2-1-Study Design

The current study adopted a quasi-experimental design with two groups: experimental and control, and pre and post application. Also, self-organization and metacognitive awareness scales were applied to both groups in the pre-application. Then, the experimental group was taught using the mobile application (Dr.Electron) based on gamification and the control group was taught using the usual method. Then, the scales were applied.

2-2-Population and Sample

The study sample was purposely selected from the study population represented by the eighth grade in Muscat Governorate in Oman in the academic year 2021/2022. A male school and a female school were chosen due to the cooperation of the school administration and the presence of an online environment suitable for implementation and use of the mobile application. Four classes were chosen from the eighth grade, with two classes from the male school and two classes from the female school. The sample size at the beginning of the experiment was about 120 students. However, several reasons led to the withdrawal of students among which are the surrounding environmental conditions and the emergency weather conditions represented by Shaheen Cyclone that hit Al Batinah North Governorate. The subsequent psychological and material damage represented by the loss of electronic devices among students, long periods of power outage, significant material, financial, psychological losses in homes led to the withdrawal of students. Thus, the number of students remained with a total of 63 students as shown in Table 1.

Table 1 Distribution of sample members according to the number of branches and social type.

The Group	Male	Female	Total
Experimental	18	15	33
Control	18	12	30
Total	36	27	63

2-3-Tools and Materials

The current study measured two variables which are self-organization and metacognitive awareness using an online questionnaire distributed to the study sample. The researchers also designed a mobile application based on gamification named Dr.Electron in collaboration with one of the programming companies. This mobile application was used by the experimental group. The research team prepare a teacher's guide that includes the theoretical and scientific framework for using the mobile application in the educational process. Here is a detailed explanation of the study tools and materials.

2-4-Self-organization scale

The current study adopted the self-organization scale (Motivated Strategies for Learning Questionnaire) by Pintrich & de Groot (1990). The scale was built according to the five-point Likert scale (strongly agree, agree, neutral, disagree, strongly disagree). The researchers chose this scale due to the clarity of its phrases and its suitability for the age group of the target sample which is eighth-grade students. The scale phrases were developed to suit the study conditions. The scale included 20 statements distributed over four dimensions: goal orientation, control of learning beliefs, review and repetition, and test anxiety. Table 2 shows the distribution of phrases on the axes of the self-organization scale.

Table 2 Distribution of statementson the axes of the self-organization scale.

No	Dimension	Number of statements	Statement numbers
1	Goal orientation	6	1,3,11,17,19,20
2	Control of learning beliefs	5	4,5,6,7,10
3	Review and repetition	6	12,13,14,15,16,18
4	Test anxiety	3	2,8,9

- Scale validity: The validity of the scale was verified by presenting it to faculty members in curricula and teaching methods department and psychology department at the College of Education, Sultan Qaboos University. It was also presented to specialists from the Ministry of Education. Based on their observations, the scale statements were reduced from 55 to 20 statements to suit the nature and level of eighth-grade students.
- Scale reliability: To verify the reliability of the scale and determine the time it takes during the application; the research team piloted the scale and calculated the end of the first student's answer the test and the end time of the last student's answer to the test. Then, the research team extracted the average of the two times, and it reached approximately 40 minutes; therefore, this period was determined as a suitable time to answer the test. The scale was applied to a sample consisting of 542 ninth-grade students. The reliability coefficient was calculated using the Cronbach Alpha method and it was 0.91. This indicates that the scale has a suitable degree of reliability (Deliou, 2014).

2-5-Metacognitive awareness scale

The metacognitive awareness scale by using Schraw and Dennison (1994) was used to evaluate metacognitive awareness among students. 22 statements were quoted from a total of 55 statements to suit the levels of eighth-grade students. The scale was built according to the five-point Likert scale (always, sometimes, unsure, rarely, never) and it was adapted from the previous study with four dimensions (planning, information management strategies, error correction strategies, evaluation) in which the statements were distributed on the four dimensions as shown in Table 3.

Table 3 Distribution of the statements on the dimensions of the metacognitive awareness scale

No.	Dimensions	Number of statements	Statement numbers
1	Planning	5	1-2-3-4-5

No.	Dimensions	Number of statements	Statement numbers
2	Information management strategies	6	6-7-8-9-10-11
3	Error correction strategies	6	12-13-14-15-16-17
4	Evaluation	5	18-19-20-21-22

- Scale validity: The validity of the scale was verified by presenting it to 7 specialists from faculty members in curricula and teaching methods department and psychology department at the College of Education, Sultan Qaboos University. It was also presented to specialists from the Ministry of Education. Based on their observations and opinions, appropriate modifications were made.
- Scale reliability: The scale was applied to a sample consisting of 542 ninth-grade students. The reliability coefficient was calculated using the Cronbach Alpha method and it was 0.90 which indicates that it has a suitable level of reliability (Deliou, 2014).

To determine the response time of the study sample on the scale, the average time of the end of the first student's answer to the test and the end time of the last student's answer to it was calculated. The average time reached approximately 40 minutes. Therefore, one period was determined as a suitable time to answer the scale.

2-6-Mobile application

To achieve the objectives of the study, a mobile application for teaching science named Dr. Electron was designed. The general model for designing education (ADDIE Moodle) was adopted. The design included five planning components: Analysis, Design, Development, Implementation, and Evaluation. Here is an explanation of these components:

- Analysis: This stage includes defining the general goal of the proposed application which is to provide an innovative mobile application aimed at acquiring students in the scientific homeland the correct scientific concepts. This stage also included defining the educational goals after analyzing the study units in all developed science curricula. This stage also included analyzing the characteristics of learners who are students whose ages range from 7-15 years. This age stage is classified as a stage of adolescence and this stage is characterized by instinctive instincts represented in the love of exploration and play.
- Design: This stage included the application content and interaction interfaces which included defining the technical and educational standards that must be available, the number of interfaces, stages, levels, and questions posed in each stage and level, the number of badges and pictures. It also included the way of designing it and its components, as well as preparing a scenario and preliminary design for the interaction interfaces for the mobile application Dr. Electron to guide programmers on how to design and implement. Here is a detailed explanation for each interface:

The application has four interfaces: The main application interface, the main components interface, the room selection interface and the character selection interface.The four interfaces at the beginning of the application allow the learner to define the nature of the application, its components, and its main topics with the freedom to choose the room and the character that suits them. Figure 1 below shows the main interface of the application.

Fig. 1.The main interface of the application

The scientific stages interface: The mobile application includes a number of 600 scientific questions classified into 20 scientific stages represented in: Discover your body, our beautiful environment, the world of creatures, I am a scientist, the lung of the earth, my food is my health, the blue planet, listen, the science of movement, the vast space, attraction and repulsion, bright light, the chemical village, the city of chemistry, the world of materials, the shining sun, the materials around me, behind the light, the energies of the universe, charge and cat, with the possibility of increasing the number of stages and the questions included in them in the future.

Question interfaces: Each level (Diligent - Persistent - Majid) contains 10 consecutive questions of the multiple-choice type. For example, in Figure 1, the first level (Diligent) includes 10 consecutive questions. Each question includes three choices. The questions were graded from easiest to hardest, and the student can retry to answer 3 times.

In addition to that, there are many different sections and interfaces that were designed creatively such as the "Race Field" interface which represents the leaderboard in the gamification approach. In addition, there is the points store interface where students exchange points for motivational products like the Diamond Lion and the Golden Eagle. Also, there is the personal file interface where the student chooses their room, their personal picture, and the badges. The titles interface where a set of badges and titles were identified that have a certain significance (Persistent, Majid, Leader, Amazing, Expert, Explorer, Dr. Electron is proud of you) which the student gets in return for a certain work or achievement. Figure 2 shows one of the surprises that accompany the player getting a certain badge which is rare and exciting information about one of the Muslim scientists.

Fig. 2. The badges interface and the surprise

Preparing the application questions: The questions were formulated according to the global science learning standards (NGSS). They were reviewed and checked for their validity and ensured that they were free of scientific and linguistic errors over five months in cooperation with four science teachers who have a master's degree. Also, the pictures for the application and the questions were designed. The drawings were prepared for all the questions to increase the fun and excitement and they were reviewed and checked for their suitability for the age group of the students, the Arab context, and their accuracy.

- Development: At this stage, the interaction interfaces were collected and merged into an integrated mobile application. Then, the application was run and the transition across the interfaces, stages, and levels was tested.
- Application: The application was tested by presenting it to experts specialized in the technical field, supervisors, teachers, and workers in science education to judge its validity and suitability for the purpose for which it was prepared. In addition, it was presented and tested by students whose ages range from 7-15 to receive their observations and record their opinions about the application. Finally, it was uploaded to the Android play.
- Evaluation: At this stage, the scientific content was evaluated by specialists in science education and assessment. The research team collected the application survey data and feedback from users and used the data in developing the application. The research team also researched the application to measure its effectiveness in a number of achievement and psychological variables.

2-7-User guide for the Dr. Electron application for teachers

A guide was prepared for teachers to learn how to use the Dr. Electron mobile application. The guide included a precise and comprehensive description of each part of the application. A comprehensive file was distributed to the teachers that includes the questions included in the application with their model answers.

2-8-Equivalence between the Two Groups

To verify the equivalence of the experimental and control groups in the pre-measurement of the self-regulation scale (Self-Regulation) and the metacognition awareness scale (Metacognition Awareness), the "t" test for independent samples was used as shown in Table 4.

Table 4 Results of the independent samples t-test for differences between the experimental and control groups in the pre-test measurement of self-regulation and metacognitive awareness.

Variable	Group	N	SMA	SD	t Value	Sig.
Self-regulation	Experimental	33	3.09	0.19	0.28	0.779
	Control	30	3.07	0.26		
Awareness of metacognition	Experimental	33	3.29	0.21	0.73	0.257
	Control	30	3.25	0.21		

As shown in Table 4, there are no statistically significant differences between the control and experimental groups in the pre-measurement of self-organization and metacognitive awareness, the "t" probability value was greater than the significance level (α=0.50). Thus, it is concluded that the two groups are equivalent in the pre-measurement.

2-9-Study Procedures

- After completing the preparation of the theoretical framework and the actual version of the application, a workshop was prepared for teachers to train them on using the application over three consecutive days. A male teacher from the male school and a female teacher from the female school. The strength of the internet network was ensured and a tablet device was provided for each student in the experimental group. They were trained for two days on using the mobile application.
- The two study scales were applied pre-application to the control and experimental groups before implementing the gamification-based mobile application on the experimental group.
- The implementation of the study extended for 12 weeks during the first semester of the academic year 2021/2022. It included the pre and post applications of the self-organization scale and the metacognitive awareness scale. The experimental treatment took 9 weeks. Since the study was applied during the COVID-19 pandemic, the study began when blended learning was applied where half of the students of one class attend school for a week and the other half attend the other week. This took six weeks from the experimental application of the current study. Then, all students returned to normal education in the last three weeks of the study application.
- During the first six weeks, the teacher was explaining the lesson to the students presented in the school during the first part of the period, then asked the students to apply what they learned during the second part of the period using the Dr. Electron application. For the students at home, they were asked to answer the questions in the Dr. Electron application as a kind of review, modify their points, complete the remaining tasks and share those completed works with the teacher. This method provided the opportunity for students at home to use the Dr. Electron application intensively. The teachers implementing the study were urging students to answer the questions. As for the remaining three weeks of the application period, the application was used during and after classroom time.
- After completing the application of the study, the two study scales were applied to the two study groups once again.

3-Results and Discussion

3-1-Research Question 1

The results of the first question which states: What is the impact of an innovative gamification-based mobile application (Dr. Electron) on the development of self-organization among eighth-grade students in Oman during the COVID-19 pandemic?

To answer the first question, a two-way ANCOVA (Analysis of Covariance) was used to determine the differences between the experimental and control groups in the post-measurement of self-organization after adjusting for the effect of the pre-measurement. Table 5 illustrates the actual and adjusted means and standard deviations for self-organization according to the variables of teaching method and gender after adjusting the effect of the pre-measurement.

Table 5 Actual and adjusted means and standard deviations for self-organization according to the variables of teaching method and gender after adjusting the effect of the pre-measurement.

Teaching method	Gender	No	SMA	SD	Adjusted Mean
Gamification	Male	18	3.86	0.22	3.86
	Female	15	3.95	0.25	3.93
	Total	33	3.90	0.23	3.90
The traditional method	Male	18	3.14	0.46	3.13
	Female	12	3.30	0.28	3.32
	Total	30	3.20	0.40	3.23

Table 6 summarizes the results of the covariance analysis accompanying the differences between the experimental and control groups in the post-measurement of the level of self-organization after adjusting for the effect of the pre-measurement.

Table 6 Results of the two-way analysis of covariance for the differences between the experimental and control groups and their interaction with gender in the post-measurement of self-organization after adjusting the effect of the pre-measurement.

Source of variance	Sum of squares	Df	Mean squares	F	Sig.	Eta effect size(η^2)
Pre-measurement	1.36	1.00	1.36	16.61	0.000	0.22
Teaching method (A)	6.86	1.00	6.86	83.77	0.000	0.59
Gender (B)	0.28	1.00	0.28	3.38	0.071	0.06
Interaction (A ×B)	0.06	1.00	0.06	0.68	0.415	0.01
Error	4.75	58.00	0.08			

Table 6 shows that there are statistically significant differences in the post-measurement of the level of self-organization after adjusting for the effect of the pre-measurement according to the teaching method variable where the "F" probability value was less than the significance level (α=0.50). Referring to the adjusted means in Table 5, these differences were in favor of the group of students who studied using the gamification method. It is also clear that the effect size eta (η^2) value is 0.59. According to this value, the effect size is considered large according to Cohen's classification (Cohen, 1988) which indicated that the effect size is considered large if the eta value exceeds 0.14. This indicates that the gamification approach has made a significant contribution to raising the level of self-organization among the students of the experimental group.

This result is consistent with the results of the study of Al-halafawy & Zaki (2022) which was applied to tenth-grade students and showed the effectiveness of digital platforms based on gamification compared to digital platforms that are not based on gamification. It also agreed with the results of the study of Li et al. (2022) which was conducted on third-grade students and indicated the positive impact of gamification in learning English. The results of the study of Pramana et al. (2020) indicated that the gamification approach leads to improving self-organization among fifth-grade students in productive skills. This result is attributed to the mobile application (Dr. Electron) which was designed in a way that allows the learner the opportunity to plan, control, and understand the learning environment through the excitement that drives them to desire to discover different game scenes (learning environment) independently. As it was prepared in a way that helps them to define their goals and monitor their implementation and evaluate them through seeing the achievement they achieve in the early levels. In addition to that, they watch the progress of their competing peers and they see their position compared to them. This gives them an indicator to evaluate the extent of their achievement of learning

goals. This interpretation is supported by the study of Hassan et al. (2020) which indicated that the good design and preparation of gamification help in self-organization. Also, it is supported by the study of Hanus and Fox (2015) which concluded the importance of being cautious when applying gamification in educational environments because the application mechanism affects self-motivation, social comparison, satisfaction, effort, and academic performance.

3-2-Research Question 2

The second question which states "What is the nature of the interaction between the teaching method (gamification/traditional method) and the gender (male/female) in the level of self-organization among eighth-grade students?", sought to know whether there is a statistically significant effect of the interaction between the teaching method and the gender in developing self-organization among eighth-grade students. It is clear from Table 5 that there is no statistically significant effect of the interaction between the teaching method and the gender on self-organization. This indicates that the gamification approach has contributed to the development of self-organization among male and female students almost equally.

Through reviewing the educational research, the researchers did not find any study that examined the detection of the interaction between the teaching method (gamification / traditional method) and the gender (male / female) in developing self-organization. The study of Al-Hosni and Al-Balushi (2023) concluded that there is no difference between the teaching method (gamification / traditional method) and the gender (male / female) in self-learning and through looking at the performance of learners in the (Dr. Electron) application and after referring to the control panel on the application site, the researchers noticed that both genders were competing to reach advanced levels in the application since both genders got close points. This reflects the convergence of their ability to plan, control, and rely on themselves during learning which is an indicator of the growth of self-organization.

The researchers attribute this to the clarity and ease of use of the mobile application in displaying topics; as the mobile application provides an icon for the student's personal file that shows him his progress, the medals he has received, the points store, and the topics he has passed. It also contains a race track that allows him to see his position compared to his colleagues; which was reflected on the player in terms of his ability to accurately define his goals, monitor himself, organize his behavior, and evaluate himself; it helped him to control and modify his planning at any time and depend on himself in that.

3-3-Research Question 3

To answer the third question which states what is the impact of an innovative gamification-based mobile application (Dr.Electron) on the development of metacognitive awareness among eighth-grade students in Oman during the COVID-19 pandemic?, a two-way ANCOVA (Analysis of Covariance) was used to determine the differences between the experimental and control groups in the post-measurement of metacognitive awareness after adjusting for the effect of the pre-measurement. Table 7 shows the actual and adjusted means and standard deviations for metacognitive awareness according to the variables of teaching method and gender after adjusting for the effect of the pre-measurement.

Table 7 Actual and adjusted means and standard deviations for metacognitive awareness according to the variables of teaching method and gender after adjusting for the effect of the pre-measurement.

Teaching method	Gender	No.	SMA	SD	Adjusted Mean
Gamification	Male	18	3.99	0.29	4.01
	Female	15	4.11	0.40	4.08
	Total	33	4.05	0.35	4.05
The traditional method	Male	18	3.50	0.22	3.52
	Female	12	3.26	0.21	3.24
	Total	30	3.40	0.25	3.38

Table 8 summarizes the results of the covariance analysis accompanying the differences between the experimental and control groups in the post-measurement of the level of metacognitive awareness after adjusting for the effect of the pre-measurement.

Table 8 Results of the two-way analysis of covariance for the differences between the experimental and control groups and their interaction with gender in the post-measurement of metacognitive awareness after adjusting for the effect of the pre-measurement.

Source of variance	Sum of squares	Df	Mean squares	F	Sig.	Eta effect size)η^2(
Pre-measurement	0.11	1	0.11	1.27	0.264	0.02
Teaching method)A)	6.73	1	6.73	78.01	0.000	0.57
gender(B)	0.12	1	0.12	1.43	0.237	0.02
Interaction(A ×B)	0.47	1	0.47	5.46	0.023	0.09
Error	5.00	58	0.09			

Table 8 shows that there are statistically significant differences in the post-measurement of metacognitive awareness according to the teaching method variable where the "F" probability value was less than the significance level (α=0.50). Looking back at the adjusted means in Table 8, these differences were in favor of the group of students who were taught using the gamification method. It is also clear that the effect size eta (η^2) value is 0.57. According to this value, the effect size is considered large according to Cohen's classification (Cohen, 1988) which indicated that the effect size is considered large if the eta value exceeds 0.14. This indicates that the gamification approach has made a significant contribution to metacognitive awareness among the students of the experimental group.

This result is consistent with the results of many studies that pointed to the effectiveness of online education in general and gamification in particular in raising the level of metacognitive awareness among students (Sweidan & Al-Zuhairi, 2015; Al-Sayed, 2021; Kartika; 2019). This result can be explained considering the theory of metacognitive awareness that focuses on the learner's way of self-learning which enables them to learn and modify their educational practices in specific educational environments which helps to develop them academically, socially, and behaviorally (Talafha& Al-Tal, 2019). According to the concept of metacognitive awareness, the badges and titles in the mobile application are a basic indicator that expresses the learner's progress in learning after accomplishing a certain task (Abdel-Ati et al., 2010). In light of the dimensions of metacognitive awareness as dimensions of error correction strategies and evaluation, the mobile application (Dr. Electron) includes the correct answers interface and the wrong answers interface which are based on the principle of evaluation and immediate feedback for the answers. This is to consolidate scientific concepts and raise metacognitive awareness through trying and repeating games. In addition to the dimension of information management strategies, it is found that the application includes a question interface with three levels which are Diligent, Persistent and Majid. Each level includes a set of graded questions from easiest to most dificult. The student can retry the answers 3 times (Schraw & Dennison,1994). The researchers attribute this result to the design of the mobile application which is characterized by creativity and attractiveness. In addition, it is attributed to enrichment, cognitive organization, acquisition and consolidation of scientific concepts (Al-Hosni & Al-Balushi, 2023).

3-4-Research Question 4

To answer the fourth question which states What is the nature of the interaction between the teaching method (gamification/traditional method) and the gender (male/female) in the level of metacognitive awareness among eighth-grade students?, a two-way ANCOVA (Analysis of Covariance) was used to determine whether there is a statistically significant effect of the interaction between the teaching method (gamification / traditional method) and the gender (male / female) on the level of metacognitive awareness among eighth-grade students. The results shown in Table 8 revealed a statistically significant effect of the interaction between the teaching method (gamification, traditional method) and the gender on self-efficacy where the "F" probability value was less than the significance level (α=0.50). Figure 4 illustrates the effect of the interaction between the teaching method and gender on the level of metacognitive awareness.

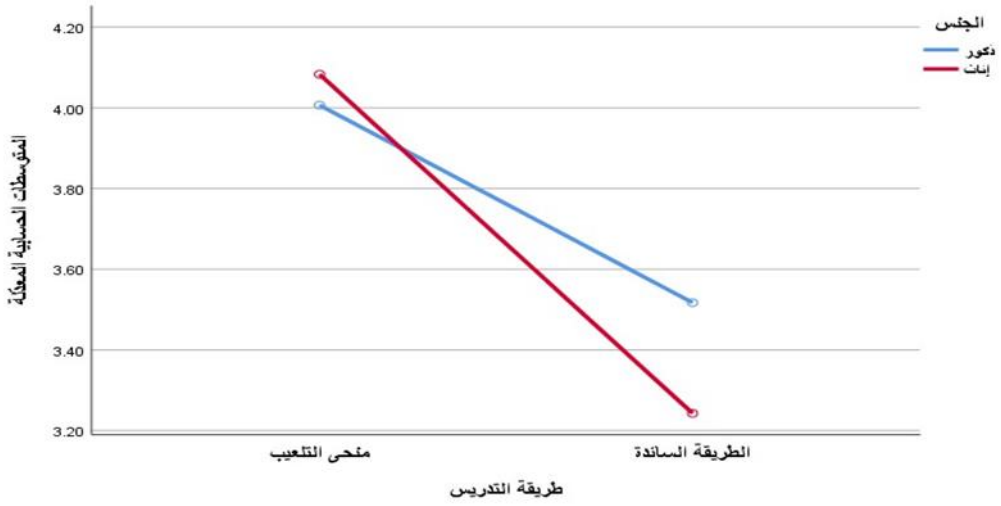

Fig. 4.The effect of the interaction between the teaching method and gender on the level of metacognitive awareness

As shown in Figure 4, there is an effect of the interaction between the teaching method and the gender on the level of metacognitive awareness. It is noticed there is an increase in the level of awareness among female students when using the gamification method compared to the traditional method. This indicates that this method had a greater impact on female students compared to male students. A study by Manoukh and Saeed (2009) indicated that there are no statistically significant differences between male and female in the level of metacognitive awareness. Additionally, to the best of the researchers' knowledge, there is no study that has investigated the effect of gamification on the level of metacognitive awareness among male and female.

This result can be explained considering some principles on which gamification is based such as the principle of active learning which enhances the learner's participation in the learning and exploration process. In addition, gamification is based on the evaluation principle that enables the learner to evaluate the acquired knowledge or skill. Through gamification, the learners integrate with all their senses as they hear, see, touch, and interact which contributes to raising the level of facts and acquired knowledge. In addition, it contributes to raising the level of motivation, achieving learning and fun (Hitchens & Tulloch, 2018). Given the general characteristics of female students that attract them to music, pictures, colors, and drawings more than male students, this may be a reason why metacognitive awareness of female students was better than male students in the experimental group.

4-Conclusion

The current study aimed to investigate the effectiveness of an innovative visual mobile application based on gamification (Dr. Electron) in developing self-organization and in developing metacognitive awareness among eighth-grade students in Oman during the COVID-19 pandemic. The study had a set of results including the superiority of the experimental group that studied using gamification over the control group that studied with traditional methods in both self-organization and metacognitive awareness. Also, the study found that the relationship between gamification and self-organization does not differ by gender. Finally, the study indicated that the relationship between gamification and metacognitive awareness differs by gender in favor of female students as gamification affects metacognitive awareness for female students more than male students in the experimental group while metacognitive awareness for male students is greater in the control group.

The researchers attribute this to the unique creative design of the application as it deviates from the usual design. It is characterized by attractive elements such as badges, race fields, points store, the information, facts, and scientific concepts that the application includes. This contributed to the continuance of students' learning for the longest possible period and acquiring them many scientific information and concepts in an interesting way. In addition, it contributed to developing students' skills and attracting them to learn different methods that are in line with their feelings and break the monotony and routine. Also, it contributed to the ease of access to information and created an atmosphere of enthusiasm, interaction, fun, competition, and enjoyable learning. This raises the level of

students' motivation and greater involvement in the educational process (Al-Ghamdi, 2019; Hanus & Fox, 2015; Hitchens & Tulloch, 2018).

The study recommends paying attention to programs and electronic applications based on gamification which may contribute to keeping students busy learning outside the schoolenvironment. It also recommends paying attention to gamification as a successful means of continuing learning especially during crises such as the COVID-19 pandemic. In addition, it recommends preparing workshops and tours for teachers and teachers before service and around the mechanism of integrating and managing gamification in the educational process. Furthermore, it recommends using the innovative visual mobile application (Dr. Electron) to conduct other studies and at different curricula, educational stages and sample sizes. Finally, it recommends encouraging the design of applications based on gamification and focusing on raising the level of self-organization and awareness of metacognition among students.

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