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The Impact of Serious Games on Learning User Interface Design Guidelines

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Abstract: The increasing popularity of serious games in education as a method for learning and teaching has led to a growing body of literature on their effectiveness in various fields of study. However, there is a lack of empirical studies evaluating the impact of serious games on learning user interface design guidelines. The work presented in this paper aims to explore this effect by answering two research questions: (i) do serious games have an impact on learning the user interface guidelines? and (ii) to what extent do serious games affect the learning of user interface guidelines? In particular, it examines the current state of serious games in education and their impact on learning user interface design guidelines by comparing the performance of two groups of university students. The first group uses the traditional PowerPoint slides to learn four guidelines, whereas the other group uses a proposed serious game called UiDGame for the same purpose. The study found promising results regarding using serious games to learn user interface design guidelines, which could be used to improve the design of such serious games and provide a better learning experience for students.

Keywords: Serious Games, User Interface Guidelines, Game Design

1. INTRODUCTION

The use of serious games in education has become increasingly popular in recent years as a method for learning and teaching. These games, designed for educational or training purposes, have been shown to be effective in various fields and subjects (Almeida & Simoes, 2019; Laamarti et al., 2014). Several authors explored the impact of games on education (Krath et al., 2021). However, there is an apparent lack in the literature of empirical studies evaluating games' effectiveness on learning (Dicheva et al., 2015). Designers have used user interface design guidelines to ensure a consistent user interface design across platforms and users (Johnson, 2020). Learning user interface design guidelines at a university level has been a challenge for several reasons (Cheng et al., 2019; Johnson, 2020; Miller, 2021). Firstly, such guidelines continuously evolve as new technology, and design traits are often rising. Secondly, the design of user interfaces based on guidelines calls for a combination of technical and creative skills, which makes it difficult for designers to master all of the necessary skills and knowledge. Finally, understanding user interface guidelines requires excellent attention to visual details (Johnson, 2020).

The work presented in this paper explores the impact of serious games on learning user interface design guidelines. It aims to answer two research questions: (i) do serious games have an impact on learning the user interface guidelines? and (ii) to what extent do serious games affect the learning of user interface guidelines? In particular, we aim to examine the current state of serious games in education and their impact on learning user interface guidelines. This research holds significance due to the fact that as the use of serious games in education continues to grow, it is essential to understand the effectiveness of such games on learning user interface guidelines. By understanding the impact of serious games on learning these guidelines, we can improve both the design of these games and the learning experience for students. The scope of this paper will cover the current state of serious games in education and their impact on learning. It will also cover the key factors that determine the effectiveness of these games in learning existing user interface design guidelines. The experimental study of this work compares the performance of two groups of participants in learning four specific user interface design guidelines. One group learns the guidelines using

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traditional PowerPoint slides, whereas the other group uses a proposed serious game (UiDGame) to learn the same guidelines. UiDGame is a simple, serious game with multiple-choice questions and several photo cards as answers. The player, or student, needs to pick the correct answer. Whether the player selects the correct or incorrect answer, they will receive immediate feedback with a brief description of the user interface design guideline.

The paper is organized as follows: Section 2 provides a background description of serious games in education and user interface guidelines. It also provides a detailed description of the current related work on using serious games for learning and teaching. Section 3 provides details of the process used to design and develop the serious game, including the phases of analysis, design, implementation, and evaluation. Section 4 describes the experimental study and details of its design. Section 5 presents the results of the study and discusses them. Finally, Section 6 concludes the paper and introduces a couple of future work directions.

2. BACKGROUND AND RELATED WORK

A. Serious Games in Education

A serious game is one of the game genres where the game is designed for a purpose other than entertainment (Abt, 2002). Serious games have been used in education to enhance the achievement of learning objectives. These games are designed to teach players or students a specific set of skills or knowledge (Daoudi, 2022). Professional training, primary and secondary schools, and higher educational institutes use serious games to teach various subjects, including math, science, history, and languages. Serious games can take many forms, including video games, simulations, and interactive scenarios. They can be used in a classroom setting and for self-directed learning. The main goal of these games is to make learning more engaging and interactive and to help students retain information better than traditional methods. Additionally, serious games develop students' abilities of problem-solving, critical thinking, and decision-making (Gurbuz & Celik, 2022). In (Young et al., 2012), the authors reviewed trends and challenges of serious games for education and the effectiveness of such games in attaining a course's learning objectives. However, studies have shown that more research is needed to get more insights on the effectiveness of these games (Hammady & Arnab, 2022) and to identify the best practices for designing and implementing them (Young et al., 2012).

Serious games in education typically include several key elements that are designed to make the game playable and effective for learning (Dorner et al., 2018; Hookham & Nesbitt, 2019; Martin et al., 2021). Firstly, the serious game should be designed to serve a specific educational objective or course learning outcome. Such games should also be interactive and engaging for students. The game should also provide feedback to players on their progress and performance and assess their understanding of the material. Moreover, a serious game for education should balance difficulty and knowledge to keep the students engaged.

B. User Interface Design Guidelines

User interface design guidelines are sets of best practices and principles that designers and practitioners often follow to design usable interfaces for mobile apps, websites, and software applications (Johnson, 2020). In 1983, Norman presented a list of system design principles to minimize the errors that can occur while interacting with these systems (Norman, 1983). These principles have evolved since then based on the advancement of technology and human behavior studies in interacting with computers. In his book (Shneiderman, 1986), the author introduces his eight golden rules of interface design, which are being used by many designers today. The authors in (Reed et al., 1999) also presented a set of user interface guidelines and described guidance for incorporating these guidelines into the process of software design and development. Recent research studies have focused on user interface design guidelines for specific systems. In (Fath & Henneman, 1999), for example, the authors presented a set of user interface design guidelines for e-commerce websites. Maguire provided another review of such guidelines (Maguire, 1999). More specific user interface design guidelines have been studied in healthcare (Johnson et al., 2005), electronic learning (Muhanna & Jaser, 2014), mobile commerce (Ahmad & Ibrahim, 2017), the elderly (Dodd et al., 2017), interactive machine learning (Dudley & Kristensson, 2018), among other domains.

A user interface design guideline is essential for several reasons. Firstly, it provides a consistent design, which helps users feel more comfortable and confident when interacting with the interface, as they know what to expect and where to find information. They will find the interface easy to use, easy to learn, accessible, and visually appealing (Dudley & Kristensson, 2018). Adhering to user interface guidelines could also ensure that the design is consistent across different platforms and screen sizes. Additionally, design guidelines can help reduce development time and costs, as developers and designers would be speaking the same language.

Because of their foreseen benefits, several organizations in the industry have adapted sets of user interface design guidelines. The Human Interface Guidelines by Apple provide guidance and best practices for designers to create interfaces for Apple products, including patterns, components, input, and technologies. Google provides a guideline for its Material Design, an open-source design system that includes three main sections: Foundations, Styles, and User Interface Components. Each section consists of design guidance for designers and developers that can be used for Android and the Web. Fluent Design System by Microsoft is another

open-source, cross-platform design system that provides guidelines for multiple platforms, including the Web, Windows, iOS, Android, and macOS. IBM Carbon is another open-source design system consisting of code, design tools, resources, and interface guidelines.

C. Related Work

There is a growing existing work on using games in education (Dicheva et al., 2015; Kara, 2021). The focus has been on investigating the potential benefits of games for learning. However, these studies have not been rigorously evaluated using experimental methods. Consequently, there is a shortage of conclusive evidence regarding the effectiveness of games in educational contexts. More rigorous empirical studies are needed to determine the potential benefits of games for education.

In (Kara, 2021), the authors presented their results of studying articles to review the use of serious games in science education. They based their review on what each article discusses regarding the examined topics, research methodologies, data collection tools, sampling and data analysis methods, and game types. The authors of (Sabri et al., 2022) presented statistical insights on using serious games in higher education based on a literature survey of four hundred articles. In particular, they used a machine learning technique to analyze a dataset of scholarly articles and identify key themes and trends in the literature. The study aimed to provide a comprehensive overview of research on serious games in higher education and identify areas for future study. Their findings were summarized into three main topics: exploring the importance of making an educational game, utilizing serious games for teaching science, and a systematic review and meta-analysis of digital games.

Examining the work of (Zain et al., 2011), the authors analyzed two eye tracking patterns to assess the effectiveness of user interface design in an educational game. Utilizing Tobii T60 remote eye tracking system and ManGold software suite, the authors conducted experiments on users while playing an educational game to understand the different behaviors of users. Results of their study indicated a correlation between eye-tracking patterns, including metrics like 'number of fixations' and 'heat map separation,' and user interface design problems and reduced productivity.

In (Shabbir et al., 2019), the authors presented a set of six design principles for serious games, aiming to support and enhance cognitive learning among dyslexic children. These proposed guidelines encompassed various factors related to application design, such as user-friendliness, interactive enjoyment, and aesthetic appeal.

To explore the role of serious games in user experience, a comprehensive analysis was conducted on three surveys using exploratory factor analysis. The findings shed light on players' preferences regarding three game elements and four game mechanics (Ferro, 2021). These results formed the foundation of the Game Elements and Mechanics (GEM) framework. In order to assess the real-world implementation of the framework, the GEM framework was employed to adapt and align a game design tool named GamiCards. This undertaking broadened the existing comprehension of players' favored GEMs and fostered dialogues regarding utilizing the GEM Framework alongside GamiCards and player modeling techniques (Ferro, 2021).

The author in (Tao, 2005) introduced an approach that involved incorporating usability evaluation into behavioral modeling for interactive systems. The author suggested incorporating usability evaluation early on to enhance students' comprehension of usability and motivate them to pursue usability throughout the development process.

Examining the application of serious games, the researchers in (Gounaridou et al., 2021) introduced an educational computer game that aimed to promote awareness of traffic behavior. The game underwent analysis, design, development, and evaluation stages, with a specific focus on investigating the impact of gamification on traffic safety. Players were tasked with navigating a virtual city, completing missions, adhering to road safety regulations, and experiencing journeys as pedestrians or vehicle drivers. The findings demonstrated that a well-designed educational game had the potential to be highly engaging, enjoyable, and effective, thereby enhancing understanding of traffic concepts through experiential and mediated learning approaches.

3. GAME DESIGN PROCESS OF UIDGAME

Most unsuccessful games fail because their software life cycle does not follow a formal design process (Mora et al., 2015). Several studies have investigated the existing literature on game design processes and gamification frameworks. In (Mora et al., 2015), the authors analyzed eighteen frameworks to design and develop games based on nineteen items in economics, logic, measurement, psychology, and interaction. The study concludes that existing literature needs a complete and generic framework for an effective gamified process. In (Morschheuser et al., 2017), the authors proposed a comprehensive method to design and develop games. Their approach consists of seven phases: preparation, analysis, ideation, design, implementation, evaluation, and monitoring. They evaluated their method with experts based on semantic quality, pragmatic quality, and utility. Other studies have introduced design guidelines for serious games for learning purposes, which focus on experience-based learning, learner motivation, and the scoring system (Westera, 2019). Furthermore, authors of (Young et al., 2012) emphasized the significance of adopting a user-centered design approach when creating serious games.

The authors in (Herzig et al., 2015) described how to design games as a software development process. In particular, they presented an adopted gamification development process, which includes business modeling, requirements, design, provisioning, implementation, testing, deployment, and monitoring. Moreover, the Game Development Process (GaDeP) was recently introduced in (Antonaci et al., 2018; Klemke, et al., 2020) and consisted of six phases to design and implement gamification for Massive Open Online Courses (MOOCs). These phases include: (i) analyzing the scenario for the context, (ii) defining the problem, (iii) identifying the theoretical framework, (iv) selecting game elements, (v) implementing them, and (vi) evaluating the effectiveness of the intervention (Klemke et al., 2020). GaDeP combines the phases introduced by other models into a comprehensive, more flexible process. In addition, GaDeP is tailored to gamification in MOOCs. Therefore, we based the design and development of UiDGame on GaDeP with minor adjustments.

Figure 1 shows the modified process of designing and developing UiDGame. As the figure shows, the process is based on four main phases: analysis, game design, implementation, and evaluation. In the analysis phase, users and context of use were analyzed to understand the user needs and the game context, resulting in several user stories that were the base to start the game design phase. Following an incremental process, user stories were prioritized and fed incrementally into an iterative design, implementation, and evaluation process. In the game design phase, the theoretical framework of the game was defined, and the game elements were selected, resulting in a low-fidelity screen prototype that was then implemented and evaluated using formative evaluation and a usability study. Assessing UiDGame as a game on one hand and a learning tool on the other was essential.

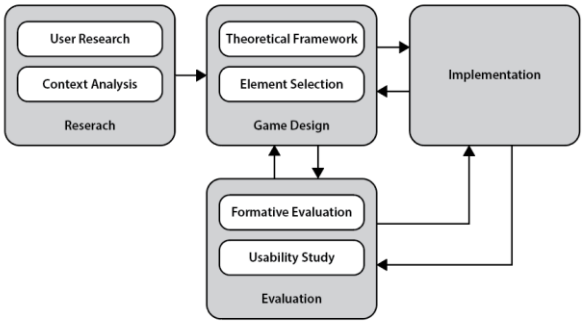

Figure 1. The Design and Development Process of UiDGame

A. Phase 1: Analysis

In this phase, we analyzed the users and the context of use. In user analysis, we followed the contextual inquiry approach (Hwang et al., 2015), where we conducted a semi-structured interview with students to understand their needs in games similar to the UiDGame and how they play such games. Fifteen students were selected to play a visual card connection game. OuiSi Original: Game of Visual Connection was given to each student in separate sessions to find a visible pattern in cards. OuiSi Original is a set of visually connected photo cards. Players should find a match between connected cards to form one pattern, one shape, one color, etc. No guidance was given to students to play the game. Each student should learn how to play the game and connect cards.

The outcome of this phase included user personas and stories. The following lists three examples of these user stories:

- As a university student, I want to see a list of photos of good and bad UI designs, so that I can recognize which guidelines to follow.
- As a university student, I want immediate feedback on whether I answered a game question correctly or not, so that I can read more about the topics I wrongly answered.
- As a university student, I want to know my progress in the game, so that I can pace myself and not lose interest in the game.

Figure 2. OuiSi Original: Game of Visual Connection (OuiSi, 2023).

B. Phase 2: Design

Based on the analysis of the first phase, several brainstorming sessions were conducted to define the theoretical framework and game elements of the UiDGame. The UI components of Google Material Design were selected as the game's material. For each UI component, Google Material Design defines a set of guidelines to follow for designers that support the best practices of user interface design. Four UI components were selected for the game: UI Cards, Floating Action Buttons (FABs), Checkboxes, and Sliders. These components are considered some of the essential components in the design of user interfaces for mobile apps or websites. Moreover, photo cards were selected as the main game elements, where the user is provided with a list of photo cards to decide which one fits the required criteria. In particular, the UiDGame is a serious game that

presents a list of multiple-choice questions to the user. Each question consists of a narrative question and a list of photo cards as answers. Only one card represents the correct answer. Once the user picks a photo card, they receive immediate feedback that includes if the answer was correct or incorrect, as well as a description of the guideline that was followed or violated.

The user stories of the first phase were the base for sketching several screens for the game. Figure 3 shows two examples of the wireframes of the UiDGame. The Balsamiq tool was used to create these mid-fidelity prototypes. The wireframes were evaluated against Nielson's ten usability heuristics to produce a simple and usable game.

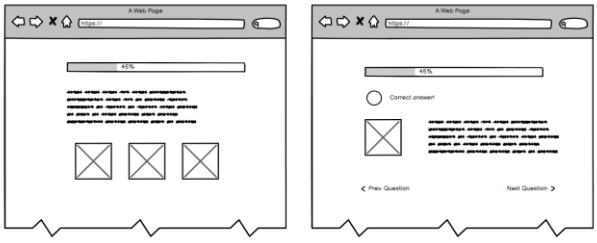

Figure 3. Two Examples of the Mid-Fidelity Prototypes of UiDGame

Figure 4 and Figure 5 show two of the high-fidelity prototypes of the game. In particular, Figure 4 shows a game question where the student is asked to pick the photo card representing a wrong use of FABs. Figure 5 shows how immediate feedback is provided to the student if an incorrect card is selected. Both figures also show the progress bar, which helps the student determine the length of the game, the correct and incorrect answers, and the percentage of correct answers. The student can also click on any of the dots provided by the progress bar to jump back to any previous question.

Figure 4. Example of a UiDGame Question

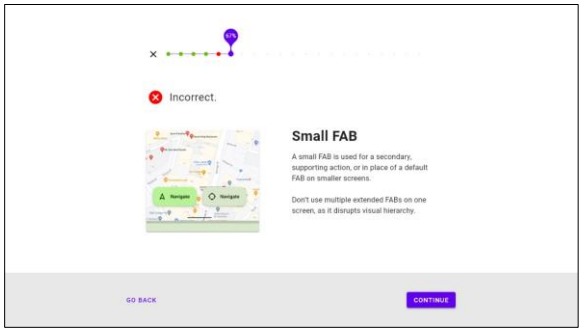

Figure 5. Example of the Immediate Feedback for a UiDGame Question

C. Phase 3: Implementation

The UiDGame was implemented using HTML5, Cascading Style Sheets (CSS), and JavaScript. The game consists of multiple pages, with each page representing a question. The narrative question is displayed at the top of the page, and the photo cards representing the possible answers are displayed below, as shown in Figure 4 and Figure 5. The student would select one photo card as the answer, and JavaScript is used to check if the chosen card represents the correct answer. If the answer is correct, the student receives a message indicating that the answer is correct and a description of the guideline that was followed. If the answer is incorrect, the student receives a message indicating that the answer is incorrect and a description of the violated guideline. CSS was used to style the game and make it visually appealing. The game was developed to be responsive so that it can be played on different devices and screen sizes. Figure 6 shows the game being played on a student's laptop.

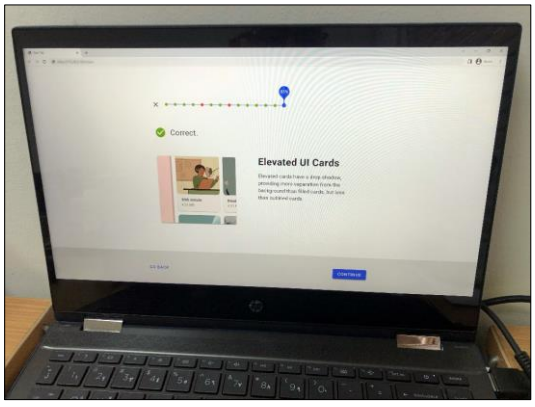

Figure 6: The UiDGame as Seen on a Student's Laptop

D. Phase 4: Evaluation

As discussed earlier, evaluating UiDGame was performed over several sessions. In its early stages, UiDGame was evaluated using Nielson's ten usability heuristics as a formative evaluation. UiDGame showed no severe usability issues. UiDGame provides clear and timely feedback to students on the status of their answers

(visibility of system status). It uses language and concepts familiar to students enrolling in the HCI course (match between the system and the real world). It also provides students with the ability to navigate freely between questions (user control and freedom). Additionally, UiDGame focuses on photo cards instead of textual descriptions (recognition rather than recall) and allows the use of keyboard shortcuts to answer questions and continue to the next question (flexibility and efficiency of use). UiDGame has a clean and visually pleasing design with no unnecessary clutter (aesthetic and minimalist design).

A usability study of UiDGame was conducted as well. A group of seven third-year students, who were not enrolled in the HCI course, was recruited and asked to complete a series of tasks while using the game. The tasks were designed to test specific aspects of the game's usability, such as navigation, understanding of instructions, and ability to identify answers. During the study, the participants were observed and asked to speak aloud while using the game. They were also asked to provide verbal feedback on their experience with the game. The data collected from the usability study was analyzed to identify any usability issues with the game. No severe issues of usability were identified.

4. EXPERIMENTAL STUDY

It is essential to assess UiDGame as a game and learning tool. To achieve this, we designed an experimental study to answer several research questions, detailed in the following subsections.

A. Participants

All participants of the study were students of a Human-Computer Interaction course at [removed for review] The course is a third-year course of a BSc in Computer Graphics curriculum, which covers several aspects of the interaction between humans and computers, including understanding the user and task analysis, human behavior, user interface design, evaluation, and usability, among other topics. In the Fall of 2022, 43 students were enrolled in the course. All enrolled students were invited to participate in the study if they met the inclusion criteria. The inclusion criteria included availability after class, willingness to play serious games, an adequate understanding of English, and no impairment that could affect the ability to play a video game. Students willing to participate in the study were asked to provide more information about themselves in terms of age, gender, year of study, years of experience in playing video games, and years of experience in playing serious video games. Additionally, students were asked to write a small paragraph in English about their experience with university life during the pandemic. The goal of the writing was to evaluate students' level of English needed to complete the tasks of the study.

Thirty-nine students (90.6%) out of the total enrolled students were recruited to participate in the study. All participants were in their third or fourth year of study ranging in age between 19 and 21 years old. 64% of the participants were female (n = 25). The course instructor evaluated the levels of English in each student's writing. All 39 students passed the required English level on participating in the study. Participants reported an average of 8.2 years (SD = 1.1) of playing video games ranging from 7 to 10 years. They also reported an average of 0.4 years (SD = 0.6) of playing serious video games ranging from 0 to 2 years. Moreover, students' GPAs ranged from 2.72 to 3.76, with an average of 2.95 (SD = 0.27).

B. Design of the Study

All 39 students were given instructions about the study and its goal. They were then semi-randomly divided into two groups (between-subjects) while ensuring a similar average GPA for each group. The control group (CG) included 19 students (average GPA = 2.95), while the rest of the participants (20 students) took part in the experimental group (EG) (average GPA = 2.95). Participants in the CG were provided with 35 PowerPoint slides explaining the guidelines for designing four user interface components based on Google Material Design. These components include UI Cards, Floating Action Buttons (FABs), Checkboxes, and Sliders. The PowerPoint slides are part of the original material of the course. Members of the CG were given 35 minutes to study the slides and familiarize themselves with the guidelines of these UI components. On the other hand, the EG participants were provided with the UiDGame. They were allowed to play the game for 35 minutes.

When the time was up, participants from both groups were asked to take their first test (T1). The test included multiple-choice questions regarding the guidelines of the UI components, which evaluates student understanding of such guidelines. Students were given 15 minutes to complete the test and instructed to continue studying the material for another week using the PowerPoint slides for the CG and playing with the UiDGame for the EG. After one week, all 39 participants (no absences) sat for another test session (T2). Additionally, all experimental group participants were asked to evaluate their experience with UiDGame using the System Usability Scale (SUS) (Brooke, 1995) of a slightly modified questionnaire.

C. Research Questions, Variables, and Hypotheses

As mentioned earlier, the main goal of the experiment is to study the impact (if any) of using serious games on learning user interface guidelines. This develops two research questions that state:

- RQ1. Do serious games have an impact on learning the user interface guidelines?
- RQ2. To what extent do serious games affect the learning of user interface guidelines?

To answer these research questions, we defined two independent variables (IV) and measured four dependent ones (DV) as the following:

- IV1. Study Tool: PowerPoint Slides (CG) and UiDGame (EG).
- IV2. Test Time: First Test (T1) and Second Test (T2).
- DV1. Grades of CG Students in Test 1 (CGT1)
- DV2. Grades of EG Students in Test 1 (EGT1)
- DV3. Grades of CG Students in Test 2 (CGT2)
- DV4. Grades of EG Students in Test 2 (EGT2)

Table 1 lists the hypotheses developed to answer the research questions using the independent and dependent variables.

5. Results and Discussion

Both independent and dependent t-tests were carried out to explore any significant difference between the results of the measured variables with a standard significance level = 0.05. Furthermore, the System Usability Scale (SUS) was used to report user satisfaction with UiDGame as a digital game.

A. *Results*

To study the impact of the study tools (PowerPoint Slides vs. UiDGame) on learning user interface guidelines right after the intervention, two independent t-tests were performed. Results of the first test (T1) show that students who used the UiDGame performed better than those who used the PowerPoint Slides. In particular, the 20 students who used UiDGame (M = 66.6, SD = 7.4) compared to the 19 students who used the PowerPoint Slides (M= 60.9, SD = 7.6) performed significantly better in T1, t(37) = 2.29, p = .03. Figure 7 shows the distribution of grades (out of 100) of students of the CG and those in the EG for the first test (T1).

TABLE 1. HYPOTHESES DEVELOPED TO ANSWER THE RESEARCH QUESTIONS

No.	Type	Description	Goal
H1	Null	Grades of students in the first test (T1) are not affected by the study tool they used (CG or EG)	To study the impact of study tools (PowerPoint Slides vs. UiDGame) on learning user interface guidelines right after the intervention
	Alternative	Grades of students in the first test (T1) are affected by the study tool they used (CG or EG)	
H2	Null	Grades of students in the second test (T2) are not affected by the study tool they used (CG or EG)	To study the impact of study tools (PowerPoint Slides vs. UiDGame) on learning user interface guidelines in one week after intervention
	Alternative	Grades of students in the second test (T2) are affected by the study tool they used (CG or EG)	
H2	Null	The difference between the grades of students in the first test (T1) and the second test (T2) is not affected by the study tool they used (CG or EG)	To study the impact of the test time (one extra week of study) and study tools (PowerPoint Slides vs. UiDGame) on the performance of students in learning user interface guidelines
	Alternative	The difference between the grades of students in the first test (T1) and the second test (T2) is affected by the study tool they used (CG or EG)	

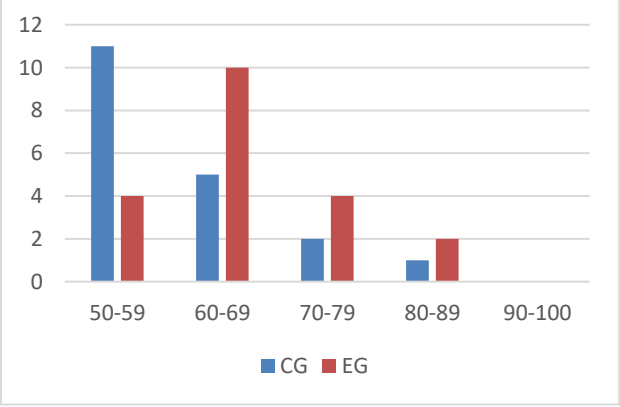

Figure 7. Distribution of Grades of CG and EG after Immediate Intervention (T1)

Another two independent t-tests were used to explore the impact of the study tools (PowerPoint Slides vs. UiDGame) on learning user interface guidelines one week after the intervention. Results of the second test (T2) show that students who used the UiDGame performed better than those who used the PowerPoint Slides. The 20 students who used UiDGame (M = 75.7, SD = 8.9) compared to the 19 students who used the PowerPoint Slides (M= 68.7, SD = 7.1) performed significantly better in T2, t(37) = 2.61, p = .01. Figure 8 shows the

distribution of grades (out of 100) of students of the CG and those in the EG for the second test (T2).

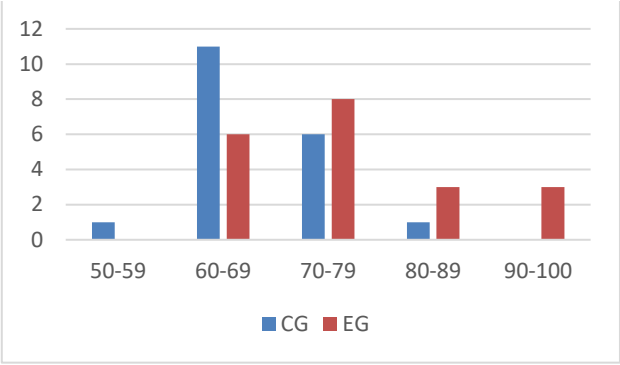

Figure 8. Distribution of Grades of CG and EG, One Week after Intervention (T2)

To investigate the impact of allowing all participating students to learn about the given UI design guidelines, we studied if there was a significant difference between the grades of the first exam (T1) and those of the second exam (T2) for the two groups separately. Results from the first dependent t-test of the CG show a significant improvement between grades of T2 (M = 68.7, SD = 7.1) and T1 (M= 60.9, SD = 7.6), $t(18) = 9.5$, $p < .001$. Moreover, results from the dependent t-test of the EG also show a significant improvement between grades of T2 (M = 75.7, SD = 8.9) and T1 (M = 66.6, SD = 7.4), $t(19) = 8.8$, $p < .001$. Figure 9 depicts the improvement in student performance within one week for those who used UiDGame (left) and those who used the traditional PowerPoint Slides (right) to learn more about UI design guidelines.

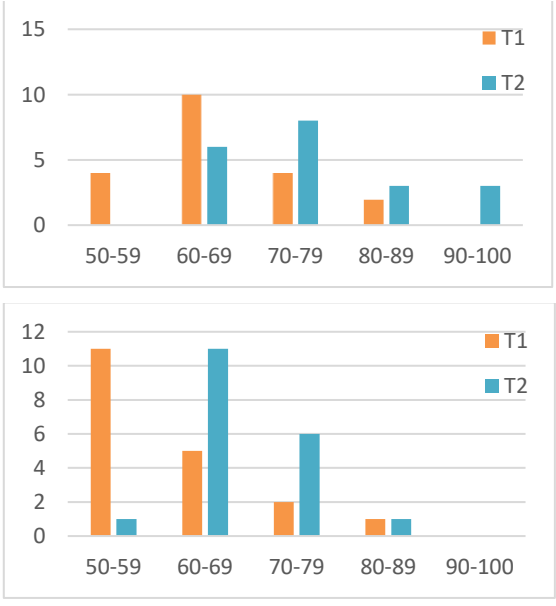

Figure 9. Distribution of Grades of T1 and T2 for the EG (top) and the CG (bottom)

To evaluate user satisfaction with the UiDGame, students of the EG were asked to fill out the System Usability Scale questionnaire. We slightly modified the standard SUS questions by replacing the word 'system' with 'UiDGame.' Moreover, an adjective-rating scale was added to the SUS to understand better and discuss its results (Bangor & Kortum, 2009). Figure 10 shows participants' SUS score of UiDGame with an error margin of 4.4% (CL = 95%). UiDGame (EG) users reported an average usability score of 86.4 (SD = 6.4). According to (Bangor & Kortum, 2009), a SUS score above 85.5 and below 100 is considered excellent in terms of usability.

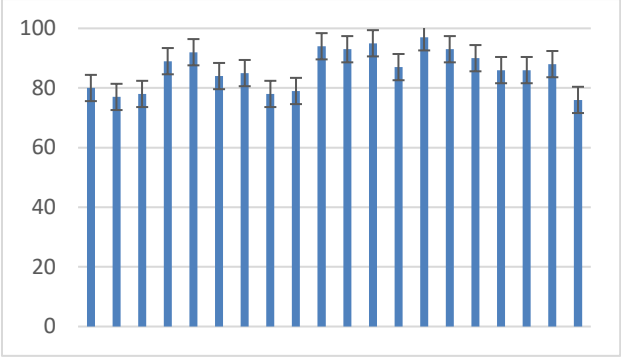

Figure 10. System Usability Score by Participants of the UiDGame

B. *Discussion*

The findings of this study indicate that the utilization of UiDGame as a study tool has a positive impact on the immediate learning of user interface guidelines following the intervention, compared to using traditional PowerPoint Slides. This was demonstrated using two independent t-tests, with the first test (T1) results showing that students who used the UiDGame performed better than those who used the PowerPoint Slides. Therefore, the null hypothesis of H1 is rejected. Moreover, results of the second test (T2) indicate that using the UiDGame as a study tool also positively impacts learning user interface guidelines even after one week of the intervention, compared to using PowerPoint Slides. Therefore, the null hypothesis of H2 is rejected.

The results also highlight the importance of providing students with opportunities to learn about UI design guidelines, regardless of the study tool they used. In particular, the results of T1 and T2 indicate that both the control and experimental groups improved their understanding and retention of the material within one week. This suggests that mere exposure to UI design guidelines can help students understand and retain the material, regardless of the specific study tool used. The results also indicate that the game-based tool (UiDGame) and the traditional method (PowerPoint Slides) can improve the understanding and retention of the material. However, the results from the first two independent t-tests

suggest that the UiDGame was more effective in improving the understanding and retention of the material.

We believe there are several potential reasons why students who used the UiDGame performed better than those who used the traditional PowerPoint Slides. One possibility is that the interactive and game-based nature of the UiDGame made the learning experience more engaging and motivating for students. As discussed earlier, several studies have shown that interactive and game-based methods can increase student engagement and motivation, leading to better learning outcomes. Another possibility is that the UiDGame provided students with an immersive platform that allowed them to apply and practice what they were learning actively. This active learning approach can help students better understand and retain the material, compared to passive methods like reading slides. Moreover, the game-based nature of the UiDGame may have enabled students to learn in a more authentic and realistic context, which can help to increase understanding and retention of the material. UiDGame also provides a way for learners to get instant feedback on their performance and adjust accordingly, which may have helped them improve their understanding of the UI design guidelines. We also believe that the UiDGame was designed to align better with the learning objectives and the way of understanding the students, making it more effective than the traditional slides.

It is worth noting that while the results of this study are promising, there are also limitations to consider. For example, the study only evaluated the immediate impact of the study tools on learning user interface guidelines, and it is unclear if the results would be sustained over a more extended period. This is an important consideration, as it is possible that the benefits of the tools may not be maintained if they are not used or practiced regularly. Therefore, it is essential to conduct further research to determine the long-term effectiveness of these tools. Additionally, the study only used one specific game-based tool, and it is unclear if the results would generalize to other game-based tools or interactive methods. Results of the system usability scale showed that UiDGame is a usable tool with excellent user satisfaction. This might be due to the game's careful design, the game designers' experience in user experience design and evaluation, and the motivation the game brings to students.

6. Conclusion and Future Work

The study presented in this paper aimed to evaluate the effectiveness of a developed serious game (UiDGame) on learning UI design guidelines. The study used independent and dependent t-tests to compare the grade results of two tests taken by two student groups. The first group used traditional PowerPoint slides, whereas the second used UiDGame. The goal of each group was to learn the guidelines for designing Google Material Designs' UI Cards, Floating Action Buttons (FABs), Checkboxes, and Sliders. Overall, the study's results suggest that game-based tools can be an effective and engaging way to learn user interface guidelines. In particular, using the UiDGame as a study tool has been shown to be more effective than PowerPoint Slides. The study proves that interactive and game-based learning methods can effectively teach user interface guidelines. Educators and instructional designers should consider incorporating interactive and game-based elements in their teaching and training materials. The game's design, the way it presents information, the way it engages the learner, and the type of feedback provided might have an impact on the effectiveness of the learning experience and the presented results. These results indicate that the positive impact of UiDGame on learning user interface guidelines is not only immediate but also sustained after one week, which makes it even more valuable. This highlights the serious game's effectiveness in helping learners retain and retrieve information in the long term. Moreover, the UiDGame showed excellent usability scores, and it may be a valuable tool for educators and designers to consider when teaching user interface guidelines in the future.

However, it is essential to consider the study's limitations and the need for further research to replicate these findings and evaluate the long-term impact and generalizability of the results. It is also important to consider other factors, such as the type of game, the level of complexity and engagement, the target audience, and the specific user interface guidelines being taught. All these elements can influence the effectiveness of serious games. Therefore, it is essential to consider different scenarios to understand better the serious game's impact on learning user interface guidelines. It is also necessary to remember that games should not be the only way to teach a particular subject or topic; they should be used as a complementary tool and not the only teaching method until further research studies are performed.

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