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Evaluating Educational Game via User Experience (UX) and User Interface (UI) Elements

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Abstract

The user interface (UI) is an access point where users interact with applications and systems. It might be as simple as a visual display overlaying on a screen, controlled by a pair of analogue potentiometers. Nowadays, UI has become a crucial component in video games and a significant factor in the user experience (UX). Users judge designs quickly and care most about usability and appeal, for instance, the surface and overall feel of a design. This research proposes an approach for evaluating UI in existing educational games that can assist educational game designers in developing even more engaging and rewarding games. The critical analysis is based on the ten (10) UI elements connected to each selected game. Simultaneously, this study describes an educational game in terms of experience and its impact on players based on UI elements. To this end, a conceptual framework for designing and developing an educational gaming platform based on the UI elements identified has been explored and analysed for future development.

Keywords: user interface, Human-computer interaction, user experience, educational game, gam-based learning, educational technology

INTRODUCTION

There have been some revolutionary changes in pedagogy with the introduction of game-based learning (GBL). GBL refers to the use of games in teaching and learning. With games, lessons and assessments can be delivered and played to support traditional learning activities. Thus, designing an educational game provides a fun and immersive learning experience whilst facilitating learning and activity management at one's own pace and environment (Nagalingam & Ibrahim, 2015). According to Roslina and Azizah (2011), the potential of educational games is far more than expected, as per the digital interests and involvement of today's generation. The fun and exciting aspects of games also encourage students to learn even more to improve their learning environment. Indirectly, it exposes a new learning experience to the students in critical and creative thinking.

Nowadays, the educational game design process calls for many considerations, and these include complex algorithm development, design characteristics, behavioural change aspirations, psychological impact factors, pedagogical choices, and identifying suitable games based on the required evaluation techniques. Thus, the designer and developer should understand all the relevant knowledge, step-by-step, in developing educational games. Based on Czauderna & Guardiola (2019), developing an educational game is a challenging endeavour since there are two states of requirements involved: purely for commercial and entertainment purposes, or to provide players with learning experiences related to pedagogy and environment. Consequently, while developing educational games, two disciplines must be considered: 1) game design, and 2) instructional design, which takes a different approach from traditional learning (Becker, 2006). The merging of both disciplines leads to successful educational

game design, creating a formal approach of combining game and instructional design with new perspectives.

As a result of the earlier suggested requirements, as well as the rapid expansion in serious games production in general, and educational games production in particular, ideas from game design and instructional design formulated to form a new field, more specifically, an (inter)discipline known as *"Educational Game Design"*. According to Lameras et al. (2017), educational game design is a relatively new discipline that combines learning design with gaming elements and mechanics. They claim that a fundamental aspect of this approach is that it is based on educational need and theory rather than simply entertainment. Thus, designing educational games requires a unique methodology that addresses both instructional strategies and learning theories.

Therefore, there is a need for new methodologies in terms of designing an educational game. It is a complex process that involves design elements and instructional strategies. Thus, in this paper, we introduce the beginning of a process to understanding educational games interfaces. It required comparison with existing UI elements and guidelines based on user experiences. Next, we offer a closer look at the results for each UI element: connectivity, simplicity, directional, informative, interactivity, user-friendliness, comprehensiveness, continuity, personalisation and internal. All of these elements will be subsequently discussed. At the end of this paper, we provide a solution for developing a new educational game based on the UI elements approach, combining instructional design and pedagogy strategies.

User Interface Design (UID)

There is currently a wide range of gaming methodological approaches available to support game designers and developers, academics and practitioners, to begin to design and develop games. One of the crucial methodologies is designing a user interface (UI). User interface (UI) plays a vital role in guiding continuous user focus on the object and subject (Ayob et al., 2009; Vanderdonckt et al., 2019) for any application or game planned to be developed based on required specifications. It is essential to comprehend that any application or game should be designed and developed efficiently. Therefore, understanding the UI is considered crucial since it is the heartbeat of every game development and gateway to the information within. According to Lee & Benbasat (2003), every UI development needs high and consistent interaction like a non-repetitive menu, iconic design and layout to maximise user focus and usage to be an effective communication tool in shaping users' perception and objective. Hence, UI has two contexts to consider: technical context and psychological context, both fundamental in creating and developing a useful UI in Human-Computer Interaction (HCI) (Sabry & Baldwin, 2003).

In technical context, fast-paced interaction and social support are required to understand characteristics of relevant content displayed. Similarly, the utilisation of flexible UI design, independent of platform used, without modifications, makes for better user engagement. Based on *User Interface Design Principle* (Seraj & Wong, 2012) and *10 User Interface Elements* (Zamri & Al Subhi, 2015), every development UI must have clear and consistent navigation to avoid unnecessary information. Thus, in designing UI especially in game design, there is a need to refer to the existing guidelines, principles and theories such as *The Eight Golden Rules* (Shneiderman & Plaisant, 2009), *Additional Guideline* (Gong & Tarasewich, 2004) and *Seven Usability Guideline* (Warsi, 2007) to have a systematic development process whilst decreasing usability issues.

While, in psychological context, users' interaction and learning via application or game is vital, considering that interruption and distraction from the environment will influence the application or game use (Cecil, 2006). Indirectly, the learning process will be hampered due to the underestimation of the psychological elements. Honka et al. (Honka et al., 2011) stated that to strengthen the user interaction from the emotional, physical, and social point-of-view, designing the UI needs to have elements like consistency, user-friendliness and personalisation to balance user psychology (Zamri & Al Subhi, 2015). In addition, there is an implicit interaction between user and application or software, either tangible or intangible, with UI such as gesture, body language and voice. For example, the user

needs to touch one button to see the effect of colour based on the instruction given or move the head when following the direction. Poupyrev et al. (2002) stated that designing UI always needs as little and straightforward attention as possible to make users compatible during the learning process. Therefore, to design a good UI for an educational game, the research needs to focus on understanding both contexts. It will help user attention and interaction with the application or game. It is also to avoid users neglecting their primary task and interaction (Gorlenko & Merrick, 2003).

Educational Game

In the 1800s, kindergartens were established, born from Friedrich Fröbel's idea that children learn from the play. The military back then even used Chess to develop strategic thinking. Fast forward to the 20th Century, Vygotsky developed the theory called the Zone of Proximal Development (ZPD), in which learners, via the guidance of someone more knowledgeable than them, would be able to perform tasks that they otherwise would not be able to do unguided. Vygotsky argued that by playing, children could behave *"a head taller"* than themselves (p.102), and by playing with adults or a more capable peer, a ZPD is created. This *"proximal zone"* is the yet to be achieved potential of the child, which can be realised through play.

Similarly, Piaget (1973) developed the theory of cognitive constructivism, which states that knowledge and meaning are formed from experiences. Game-based learning has many similarities with Piaget and Vygotsky's theories, such as the use of ZPD for creating game challenges, playing to learn, experiential learning and hypothesis testing. Scholars like Gee (2005) and Squire (2013) observed that playing games could lead to learning, and thus the term game-based learning (GBL) came to be. GBL includes the use of purpose-made games for learning (known as serious games for learning) as well as commercial off-the-shelf (COTS) games created purely for entertainment purposes but incidentally, also contains learning elements. It should be noted that games for learning incorporate both digital as well as non-digital games to be equally effective for learning.

Digital GBL emerged as computers started being made available to the mainstream and included the innovative use of computer games to support learning, enhance teaching and assessment, and evaluating students (Tang et al., 2009). As far back as 1970, Seymour Papert introduced the *Logo* programming turtle as a fun and visual way to learn programming. Then in 1971, Kirriemuir (2006) stated that a learning game called *Oregon Trail* set the stage for digital GBL by teaching players about the experiences of the early North American settlers. Since then, numerous developments have occurred resulting in two main camps of digital GBL: the serious games for learning movement and the commercial off-the-shelf games being used for education.

Serious games, however, have been criticised for being uninspiring *("drill and kill")*, meaning they were nothing more than bland, repetitious learning materials with a game tagged on in an effort to make the learning less boring (Van Eck, 2006). Therefore, education that focused on assessment and performance was also at odds with games, which focused on fun and entertainment. Thus, a good user experience from playing GBL games becomes even more crucial if serious games overcome the limitations set forth by a formal learning curriculum within a serious game. With breakthrough research in the serious games movement, however, researchers like Arnab et al. (2015) are progressively deciphering the excellent game mechanics of COTS games for use in serious games. Hopefully, these developments will see better user engagement and motivation to learn via playing serious games in the future.

With well-made COTS games, user engagement is not an issue. Gee (2005) states that the effective feedback mechanisms of "good" COTS games make these games suitable tools for GBL. However, the learning to be had is questionable. As COTS games were never meant to educate or assess learners, there are issues with formal student assessment and the formal learning syllabus (Klofer et al., 2009).

In this study, eight serious games and two COTS games were examined. The serious games studied were *Duolingo, Quick Brain, English Planet, Memory Games: Brain Training, Words of Wonders: Search, Rabbids Coding*, and *Japanese Alphabet 50 Sound: Beginners Quest*, and the two COTS game studied were *Minecraft* and *Cooking Mama: Let's Cook*. It should be noted that the term *"educational game"* in this study denotes any game that is suitable for GBL.

User Experience (UX)

A fundamental objective for any game development is to design an enjoyable, engaging game that enables gamers to be challenged and apply their skills, provides aesthetically pleasing experiences, supports social interaction, or allows the player to identify with the game (Forlizzi & Battarbee, 2004). Numerous methods have been used to evaluate the various elements contributing to the entire game experience (Bernhaupt, 2015). The term user experience (UX) occasionally used in the games industry has become popular in HCI, and developers are beginning to learn to integrate this method into their development process (Bernhaupt et al., 2015; Jakubowski, 2015).

UX is a vibrant and time-dependent exposure for users. Therefore, it is essential to understand, explore, and identify the dimensions or aspects considered for the various application areas. The purpose of UX is to perceive the impression function as a predecessor, a result, and a technological mediator. UX also can also be centred on user perception and responses as a result of using or anticipating the use of a product, system, or service. From a psychological point of view, these responses, actively developed in psychological evaluation processes, determine which ideas can best represent the psychological categories, allowing for the measurement of user experience characteristics.

The UX approach extends usability technique (Lew et al., 2010) to remove obstacles from a technical perspective rather than providing engaging experiences. A UX is based on three fundamental components: users, artefacts, and tasks. The engagement of these factors offers a particular context of use in user experience. For example, actual settings under specific artefacts are frequently utilized, like emotions, values, experience, as well as users' characteristics. The interaction between users and an artefact determines an artefact's usefulness. It also influences how users interpret an artefact and the activities.

The design of an artefact, including the required elements, demand users to perform their activities successfully and effectively to achieve their goals (McGrenere & Ho, 2000). An artefact's design should transition from a cognitive artefact-interaction to a fluent one to maintain optimal cognitive resources for significant processing information. Such a change frequently implies that using an artefact to learn is quick and straightforward (Forlizzi & Ford, 2000). Not all playing, though, should be effortless. A learning task should impose the appropriate cognitive load for knowledge development (Sweller et al., 1998). If the task is enjoyable, the user is willing to put in more effort to achieve it. The notion of engagement as defined by Skinner and Belmont's (Skinner & Belmont, 1993) educational context may apply to user experience with the level and emotional quality of a user's involvement in starting and carrying out actions is referred to as engagement. Users who are engaged exhibit persistent behavioural and cognitive participation in activities, and have a positive emotional tone.

METHODOLOGY

This paper uses the applied Human-Centered Design Process (HCD) (ISO, 1999) model as reference and the HCD classification model by Maguire (2001). There are six stages involved, namely, 1) planning and scoping, 2) context of use, 3) requirements, 4) design, 5) evaluation and 6) meeting requirements. Only three stages were conducted in this paper: planning and scoping, context of use, and requirements. Meanwhile, the user experience analysis was conducted based on the UJMG1163 Perception Studies class at UTAR. The thirty-five (35) students who participated were divided into five (5) groups.

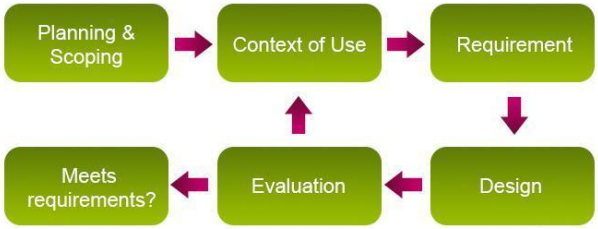

Fig. 1 – Human-Centered design process model

Students were required to identify educational games for each group in the planning and scoping stages and to discuss the games based on group perception and experience. In this stage, analysis based on technical environment categories proposed by Maguire (2001) is used to measure the game's ability and relation with the UI elements using a Likert scale of 1-5 (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree). Then, based on group discussion, the games are analysed based on the ten (10) UI elements proposed by Zamri & Al Subhi (2015) in the context of use-stage. The ten (10) elements are *connectivity*, *simplicity*, *directional*, *informative*, *interactivity*, *user-friendliness*, *comprehensiveness*, *continuity*, *personalisation*, and *internal use*.

In stage three (3), *requirement*, after identifying the relation and effectiveness of UI elements in educational games, Table 1 showed that applying UI elements in the educational game design based on user experience, is a point to consider. It would help the design and development process attain a clear direction and be more productive in attracting users to play and learn at the same time.

Table 1 – 10 educational games vs 10 UI elements

Game	U1	U2	U3	U4	U5	U6	U7	U8	U9	U10
Minecraft	3	4	4	3	5	5	3	5	5	4
Duolingo	4	5	4	4	5	4	3	5	5	4
Quick Brain	3	5	4	4	3	4	3	4	2	3
English Planet	3	5	4	5	3	5	3	4	2	3
Memory Games: Brain Training	4	3	5	4	3	3	3	4	3	2
Words of Wonders: Search	5	5	4	2	4	5	3	2	4	1
Rabbids Coding	4	3	2	3	3	2	3	4	4	4
Cooking Mama: Let's Cook	4	3	4	3	4	4	4	3	2	3
Japanese Alphabet 50 Sound	3	5	2	2	3	4	2	3	3	4
Turboprop Flight Simulator 3D	4	4	3	3	3	4	4	4	5	5

U1= Connectivity, U2=Simplicity, U3=Directional, U4=Informative, U5=Interactivity, U6=User Friendliness, U7=Comprehensiveness, U8=Continuity, U9=Personalisation, U10=Internal

RESULTS AND DISCUSSION

Based on the ten (10) educational games (Zamri & Al Subhi, 2015), the results showed an average rating for each element to be between 3.1 to 4.2. Clearly stated in Table 2, simplicity and user-friendliness average rating is 4.2 and 4 respectively, which means more than 70% of educational games are effective when UI elements are implemented in the design process. Games like *Minecraft, English Planet, Words of Wonders, and Duolingo* are rated high in both elements. *Simplicity* means straight-to-the-point information minus complex and insignificant information. This element simplifies and speeds up player decision-making, an element connected with user-friendliness and an excellent and dependable user experience. In addition, both elements will compel the player to continue to play and explore the game constantly and maintain their interest and interaction.

Table 2 – UI elements analysis

Game	U1	U2	U3	U4	U5	U6	U7	U8	U9	U10
Average rating	3.7	4.2	3.6	3.3	3.6	4	3.1	3.8	3.5	3.3
Percentage (%)	60	70	70	40	40	80	20	70	50	50
Minimum rating	3	3	2	2	3	2	2	3	2	1

U1= Connectivity, U2=Simplicity, U3=Directional, U4=Informative, U5=Interactivity, U6=User Friendliness, U7=Comprehensiveness, U8=Continuity, U9=Personalisation, U10=Internal

Connectivity element

The ability to access information quickly in a short time frame is vital in educational games since it enables the game to be disconnected when the learning process begins. In *Minecraft*, for example, the player who plays solo or in a group needs to create their server, and sometimes the network connection is inaccessible, forcing the player to retry, removing the information from the server. This can make the player lose interest in the learning activity. *Cooking Mama, Words of Wonders* and *Rabbids Coding* are examples of games with *connectivity* elements scores of 4 and 5. As evidenced, the impact of this element can indirectly improve the gaming experience.

Simplicity element

The highest average rating element for the majority of games in the design process was *simplicity*. It required a simple UI to engage the player with the learning environment and objective. *Duolingo* and *English Planet,* for example, provided simple directions and minimal information to reduce memory load~~,~~ and to ensure meaningful and focused player engagement. With a minimum rating (3), the *simplicity* elements must be applied in all educational games to balance game mechanics and elements.

Directional element

Over 60% of educational games have a minimum rating of 2 in terms of *directional* elements, indicating a lack of emphasis in this area. In Table 1, *Rabbids Coding* and *Japanese Alphabet 50 Sound* neglected these elements crucial in improving player experience while playing the game. This element is focused on navigating the user through a step-by-step process that requires related information. For example, through an in-game purchase, a few steps are required from the item selection until the checkout process. This will help the user identify their needs based on the information provided. Without information, a player will lose track, and it can affect their experience.

Informative element

In this study, 60% of the games did not well cover the *informative* element. It is a crucial requirement to convey necessary information, also the most valuable feature in UI design. Only the *English Planet* game rated five since the game provided simple instructions and beneficial information. They guide and engage the player through the game, steering the player away from forming flawed interpretations. This element needs to take into consideration future educational game development.

Interactivity element

Four out of ten (10) games have a relationship with this element: *Minecraft, Duolingo, Words of Wonders,* and *Cooking Mama.* The four (4) games which rated 4 and 5 have clear and straightforward navigation. *In Duolingo*, for example, a player can answer the question based on their ability and understanding. The game guides players through sound and colour notifications, indicating whether the answer is wrong or correct. Consistency UI and layout see player engage with this game frequently and shows how this element plays an essential role in shaping player activity and experience.

User friendliness element

It focuses on two characteristics, namely 1) layout and 2) gameplay. The layout requires attractiveness to manage user interaction and should have user's preferences such as an iconic design, colourful, animation and white space. Based on the analysis, 80% of the games have this element in their UI design. Without a user-friendly layout and gameplay characteristics, the player will no longer be effective, and this requires some consideration since the educational game is about an engaging learning environment and technology.

Comprehensiveness element

Comprehensiveness focuses on transformational content and allows the player to manage the game according to their ability and understanding. Only 20% of the games consider this element in their UI design. *Japanese Alphabet 50 Sound* rated the lowest in this analysis. Learning appears to be affected when players do not easily understand terms. With the emphasis on digital literacy, the *comprehensiveness* element becomes even more crucial in any UI game development.

Continuity element

This element refers to the consistency of designing UI. The navigation, action and position remain the same colour or concept to maintain player experience and avoid causing confusion for the player. It will make it easy to understand game concepts and stories no matter how complex the game is designed. To avoid instability of the UI, every position and action like menu, instruction manual, and time-in-game needs to introduce flexibility in UI design like *Minecraft* and *Duolingo*. *Words of Wonders* was the only game with the lowest rating for this element.

Personalisation element

This element is related to the *connectivity element*. Only 50% of the educational games allow the player to feel they have control in-game. Introducing this element in UI design will increase player engagement since players can customise the game style and experience. Indirectly, players can perform and organise their learning activities based on the environment.

Internal element

Error prevention is well executed in the majority of the games except for *Words of Wonders*. *Internal element is* the fundamental factor to examine when designing UI for an educational game. It would affect the game experience and the game objective. As an educational game, waiting time to connect and engage with information needs to be reduced to a minimum since it will break the learning momentum and activity entirely. The majority of UI elements in *Words of Wonders* are rated highly except *internal element*. Indirectly, this game sees a decrease in learners' attention since error prevention is not its priority.

CONCLUSION AND FUTURE WORK

With the ten (10) elements that have been studied and analysed in the ten (10) educational games, it can be concluded that each element has its significance. Therefore, developers cannot just focus on a few elements in developing UI for educational games. Instead, a consideration of the elements overall must be emphasised in every aspect of development. Examining the UI elements contributing to efficiency and relationship in the game design process is crucial. Implementing UI elements in educational game development can positively impact the users by indirectly establishing a better learning environment. Furthermore, this study argues that having this kind of information can assist and improve the game experience.

This study also discusses all UI elements related to UX and how they may help players have a better game experience. Advancement in UI design must be emphasised regularly, with thorough study and rigorous evaluation to ensure players engage and understand the learning activity and objective. Without a doubt, further study is required to confirm and comprehend the UX and gaming experience. An empirical study of UX and UI will form better results in the gaming and learning environment and will make a significant contribution to research and the community via a player-centred design (PCD) approach.

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