



The Third Information Systems International Conference

User Experience of Educational Games: A Review of the Elements

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Abstract

Over the recent years, the study on User Experience (UX) have been an area of discussion among Human Computer Interaction (HCI) researchers. User Experience is a branch of HCI which focus on interaction between products and users thus in the era of growing digital games, UX plays an important part in identifying the appropriate or suitable variable in order to evaluate the UX design. This study explore about the UX elements for the purpose of evaluation and design of educational games (EG). EG have captivated most students with the idea of mixing fun with learning. A good framework of UX for educational game will help EG designer to evaluate the UX of their games in order to ensure that they have produced the effective game. Therefore, it is essential to identify the suitable elements in order to model the right UX framework for educational games.

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Peer-review under responsibility of organizing committee of Information Systems International Conference (ISICO2015)

Keywords: User Experience; Human Computer Interaction ; Educational games.

1. Introduction

Game industry alone have been generating billion dollars of revenue globally which simultaneously showing sign of the industry to sustain its growth as part of the human civilization [1]. In addition to that, the fast growing technology world have given the users unlimited access of games anywhere and anytime through smart phones, mobile phones, PDAs or handheld devices. According to a study [2], for the past 40 years, computer games have become a very favorable past time activity and lately there has also been interest in using serious games to aid in attitude, behavior change and skill acquisition as well as learning. Thus education researchers are in search of discovering the pedagogical potential of computer games [3]. Most researchers believe that educational games could be learning aids to be used as reinforcement to support traditional learning because such games can lower anxiety and make learning acquisition more likely [4]. Since game based education offers a chance for learning in a natural environment [5] thus students are able to adapt easily to the subject of learning with their own environment.

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Educational games can be defined as game technology for learning and teaching purposes which includes specific subject intended to meet desired learning results for students [6]. Besides that, educational games have also opened a new door of learning with fun and excitement. Studies on educational games show that the fun factor of a game inspires students to believe that they will learn better, at the same time they are captivated with educational games idea itself [7]. The evaluation and development of a game involves many complex criteria as the designer should be able to understand the relevant knowledge behind the subject, the design, behavior change, motivation, pedagogy as well as able to identify the suitable game based on the required evaluation techniques and behavioral outcomes or learning [2]. The boundaries between functionality and experience are completely unclear as games are usually only “used” to produce enjoyment or positive emotions [8].

From the early game development period, there have been user experience evaluations performed [9]. Even though UX is still sometimes just viewed as an extension of usability, its future may really correspond to a paradigm evolution rather than simply a buzz word [10]. As much as it is important to model user experience, it is important to identify the elements or criteria that shape the effective or appropriate game design according to individual players’ affective response patterns, not certainly noticeable, yet the game version should be fast as well as prepared with adjustable game elements and finally the affect-based contact should be rich in terms of game context and player input [11]. In addition, there is a need to help game designer and academicians in identifying the proper elements in modelling user experience framework that could help them produce effective and productive educational design in future since there are still issues pertaining to UX modelling remain to be fixed [12]. Besides that, a suitable UX model will help designer’s dream to come true by encouraging users to use the designer’s products more than one time as well as introduce it to others [13].

The goal of this paper is to review the related elements that involves in modelling user experience frameworks for the purpose of educational games UX design evaluation. This section includes the background of the present research, research approach and its aim. Section 2 describes User Experience in terms of usability followed by section 3 which focuses on the discussion of some of the available user experience models and elements that supports them. This section is divided into two parts which focus on general user experience model and educational user experience model. Section 4 discusses on the related works in the previous section followed by an analysis of the elements involved. Finally, the conclusion and future work will end this paper.

2. Defining User Experience

The term ‘user experience’ is linked with a different range of meanings [14], ranging from traditional usability to hedonic, beauty, affecting or experiential features of technology use. Another researcher [15] discussed hedonic experience (Mentally stimulating or entertaining, a source of enjoyment and pleasure) and usability experience (Quality of human–computer interactions) in their research on second life design which is a virtual world game design. The “user” part of UX is the key driver towards achieving UX; although, the product itself has to be well designed to enable the user to achieve his pragmatic and hedonic goals [16]. Meanwhile, experience is a general concept referring to both immediately-perceived events and the wisdom gained. In the context of UX, it is a sequence of events for a user’s interaction with the software product [17].

Based on ISO 9241-110:2010 (clause 2.15)[18], user experience is explained by means of a person’s responses and perceptions that resulted from the use and/or anticipated use of a system, product, or service (for brevity’s sake, hereafter the word “product” refers to system, product, and services)[19]. User experience idea incorporates factors like effectiveness and efficiency with extra criteria like attractiveness, aesthetics or joy-of-use [20]. Based on the variety of user experience meanings, user experience goes beyond ordinary functionality and usability aspects of products by combining the users’ emotions and feelings in the direction of these products during or before interaction [21]. Hence, user experience is an interaction between users and products or systems they are engaged with and this interaction is depending on the surrounding elements.

3. Related Works

3.1 Existing User Experience Modals

Modelling user experience calls for user centred designs (UCD); designs that take into account traditional user needs as well as those that are abstract and subjective in nature [16]. The first framework that will be discussed is The Product Ecology. This framework is based on social ecology theory, and is suitable for identifying valuable detailed data on the interaction between human and products. Several aspects in the social environment and the physical environment influencing human experience [22]. Fig 1 shows the schematic diagram of Product Ecology which outlines the relationships or connection between users, products and places, as well as routines and social norms. Four types of key ideas about the Product Ecology are listed below:

- Each product has its own ecology which can results in different individual experience and affected by other factors in the ecology.
- The factors in the Product Ecology are dynamic, and interconnected in several ways such as activities are modified and new ones are developed, or in extreme cases cause the ecology to break down.
- Changes in product use cause changes in other factors of the Product Ecology.
- The factors in the Product Ecology are the same whether the people using the product are close to or far away from each other.

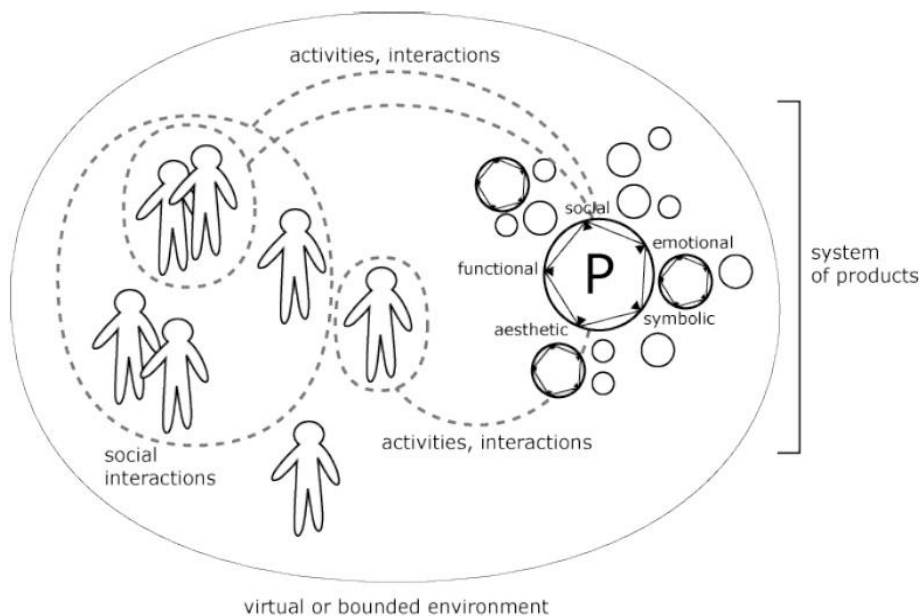


Fig. 1. Product Ecology[22]

However, the concept of these variances in agential capacities has not been theorized within the ecology framework [23].

In 2012, [17] have proposed a user experience based on the recent ISO 25010 which stress on the quality of product (PQ) and quality in use (QinU) which is in alignment with recent related research contributions as well. The proposed framework and its model is known as 2PHT whereby 2P stands for Product and Pragmatics, H for hedonics and T for temporal (Fig 2). Eventually, the main objective of this model is to model temporal aspects of UX and to develop a flexible and unified framework for modelling UX. There are eight characteristics of PQ and five characteristics of QinU modelled under the recent ISO 25010(as shown in table 1).

Table 1. Characteristics of ISO 25010[17]

No of characteristics	Product Quality (PQ)	Quality in Use (QinU)
1	Functional Suitability	Effectiveness
2	Performance efficiency	Efficiency
3	Compatibility	Satisfaction
4	Usability	Freedom from risk
5	Reliability	Context Coverage
6	Security	
7	Maintainability	
8	Portability	

In their User Experience Temporal Requirements (UXTR) model they have introduced two concepts of appeal and brand association as well as characterized the concept of appeal into adoption and retention sub-characteristics and described their importance according to the current research. The following are the characteristics' included into the models:

- Adoption: Defined as the scale that indicates how many users start using a certain product or application in a given time period.
- Retention: Defined as the scale that indicates how many of the users from a given time frame are still using a certain product or application in some later time period
- Brand Association: Defined as personal liking or attachment with a certain service provider or an organization that manufactures certain product(s), and has certain popularity rate in the market and among various user groups.

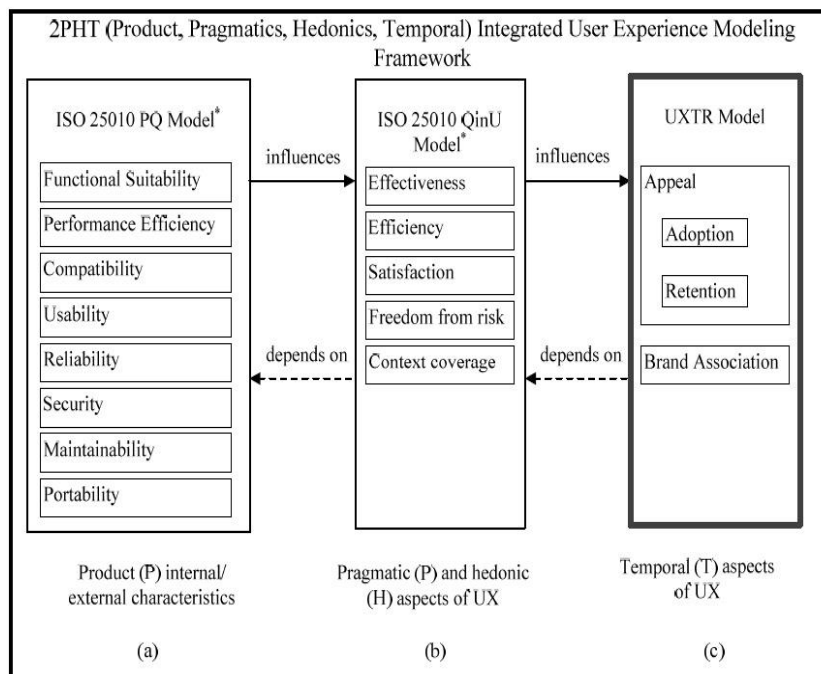


Fig. 2. 2PHT[17]

[24] have developed the Presence-Involvement-Flow framework (PIFF) which encompasses both technical game components and psychological determinant of UX. This model was evaluated using a factor analytic study.

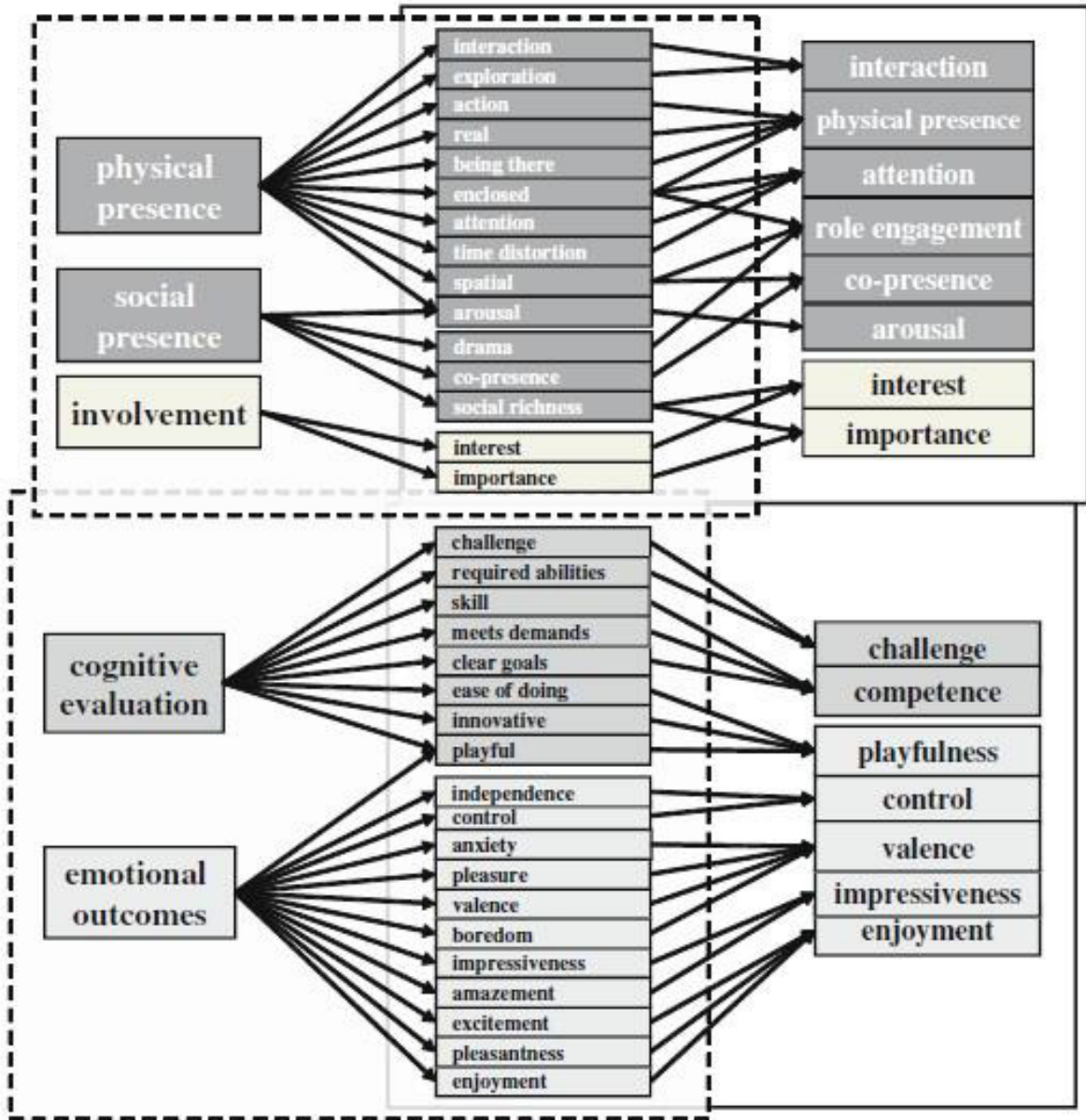


Fig. 3. The two measurement models that form the PIFF2 [24]

The final questionnaire was assessed by comparing two different groups of gamers in two different games. In addition, the profile for games was compared to Metacritic (user ratings provided by theMetacritic.com) scores and user ratings. The results were promising, with results of PIFF accounting for the important differences between games and illuminating the learning curves of different users during the first hour of play. PIFF is very broad in scope and shows potential to evaluate user experience at different stages of development. Fig 3 shows the refined version of PIFF which is the PIFF2 developed based on bigger data sets. The measured latent elements in five boxes are on the left and in the middle, 139 measured questionnaire items (observed elements) represented in 34 boxes. On the right, displays the 15 factor-analytically (PFA) extracted subcomponents of UX in games. This multidimensional framework is

helpful in defining the preferred psychological qualities for the UX. However, there is still lack of exposure on the studies on the social and story-related subcomponents of the PIFF2 in order to deal with socially rich game contents, such as massively multiplayer online role-playing games

On the other hand, [11] developed a generic approach known as Experience-Driven Procedural Content Generation (EDPCG), which is applicable to various subareas of HCI. In this model, the content of the game was given importance. Following are the components of the model:

- Player experience modelling: Player experience is modelled as a function of player and game content.
- Content quality: Modelled experience of the player is evaluated with the quality of the generated content.
- Content representation: Content is characterized accordingly to maximize performance, robustness and efficacy of the generator.
- Content generator: The generator searches through content space for content that enhances the experience for the player according to the developed model.

Besides that, another model known as Long-term UX model was created by [13] in respect of the designers' hope of wanting their products to be used for longer term and at the same time being recommended to others. It is essential to understand how UX and subsequently the assessment of a product are changing over time as some products are used for months and years. This model (Fig 4) highlights the importance of the person's background as expert or novice besides the experiential aspects that are changing over time. This Long Term UX model was more involved with meanings and emotions than users' experience throughout the use, and points to the connection between experience and memories.

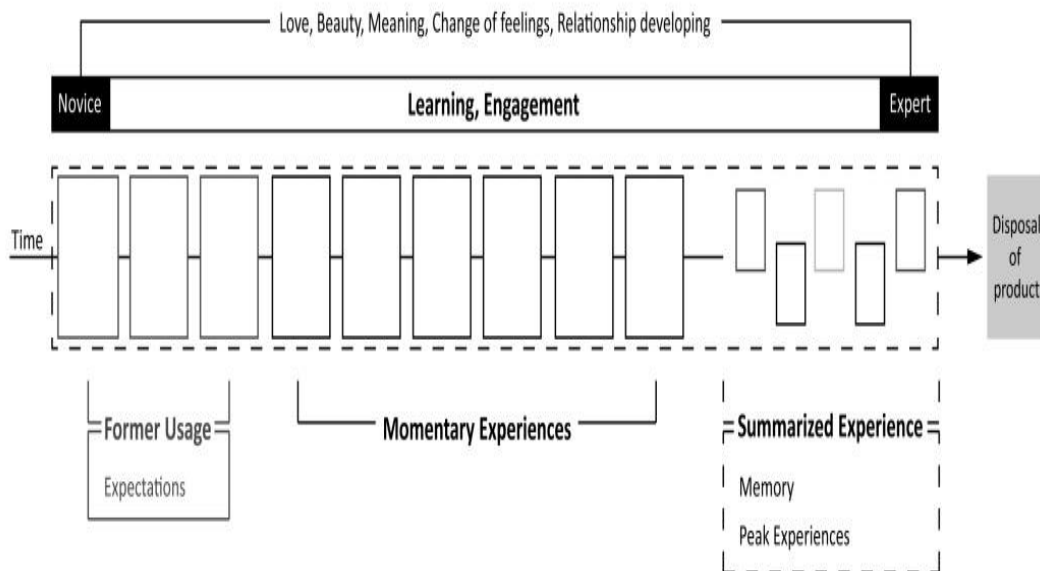


Fig. 4. Long Term UX Model [13]

As discussed in this section, there are many important aspects or elements that are taken into consideration when modelling user experience model. In the next section, more UX frameworks will be reviewed which mainly focus on educational games. These elements will be further discussed in section 4.

3.2 Existing User Experience Models in Educational Games

A recent study on user experience of educational game have highlighted five motivating factors in user experience modelling which are type of control, update, challenge, content and fun that provoke students to be constantly engaged with the digital games[1]. In this paper they have recognized that these elements encourage students to play the educational games. However, the study was only conducted in a small scale and with basic interview analysis.

Apart from that, [8] introduced a user experience in the specific context of digital games known as player experience (PX) framework. This framework is based around three layer aspects which are the technical game system experience (including the operational and perceptive effect of experience), reaction of the player and the perspective of the game. Currently, there is no model to explain in details of these components interaction since the psychological components of PX, and corresponding psycho-physiological indicators of these components is still growing. Although it is challenging to determine future experiences, it is possible to build upon prior experiences thus they have to handle the PX framework as a black box of values that retrace the activities that applied at the current point of time.

Apart from that, [25] have developed mobile game based learning (mGBL) engineering model which described an organized method that contains methods and processes for the progress of mGBL (Fig 5). The development of the game was divided into three phases (Pre-Production, Production and Post-Production). The design phase which is the production phase included processes such as learning content development, game assets development, coding and core mechanic development and game feature interactions. In order to fulfil the needs of user experience evaluation, the authors have used a demographic approach as the game was developed with the 1Malaysia concept with Malaysian cultural aspects. Heuristics evaluations are used to evaluate the application with 64 respondents completed the 5-point Likert scale questionnaires. The four main characteristics that was evaluated was Game Play (GP), Mobility ((MO), Game Usability (GU) and Learning Content (LC) with 4.025 average score. However, this framework was merely focusing on mobile application rather than overall digital application.

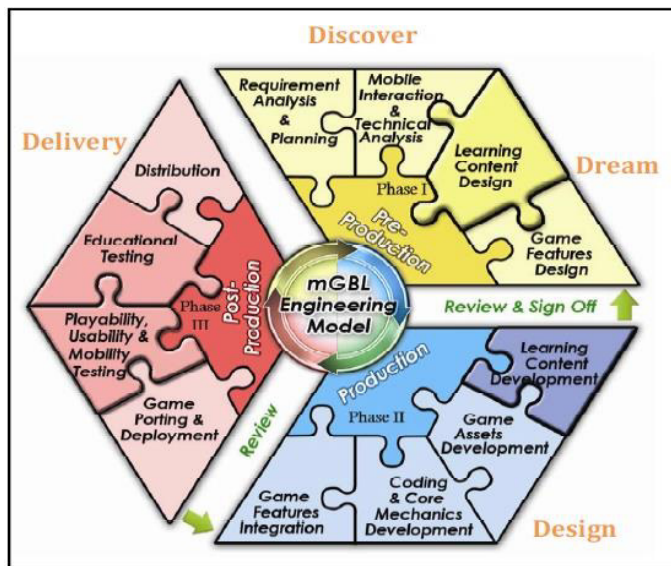


Fig. 5. Mobile Game Based Learning [25]

On the other hand, [26] introduced three layers framework of Game Experience (GX) for serious gaming which include learning games (Fig 6). Game experience is known as the player-game interaction and their focus was put on the technical metrics and physiological aspects of the game evaluation. Three methodological categories for experiences that frame digital games are identified: the quality of the product (game system experience), the quality of human-product interaction (individual player experience), and the quality of this interaction in a given social, spatial, temporal or other context. Game system experience is the overall functional level of the game system, in the meantime, game engine and player experience methods focus on evaluating the emotional or cognitive effect that a game have on a player. Apart from that, this context experience methods are suitable for studying the interaction of player in a co-present or co-located game environment. This framework basically covers all aspects and suggested all available testing to be conducted. Cost and testing equipment availability will be a few of the concerned part whether this framework will be a favourable framework.

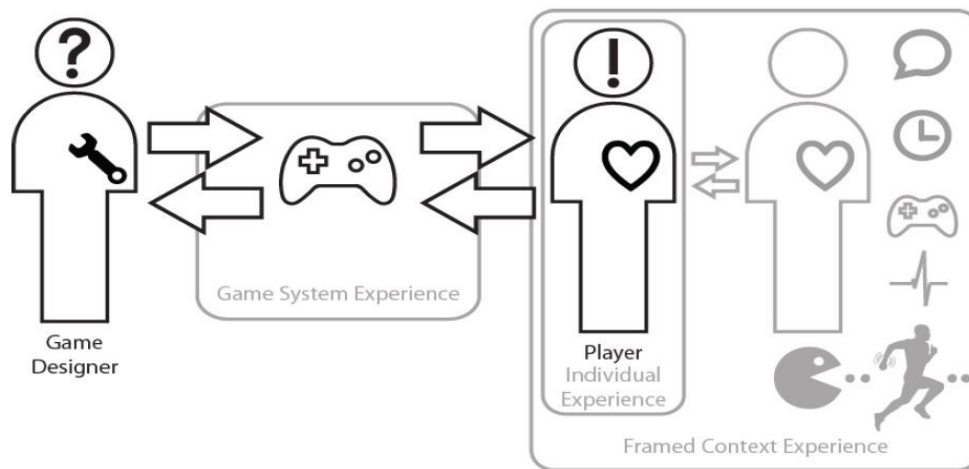
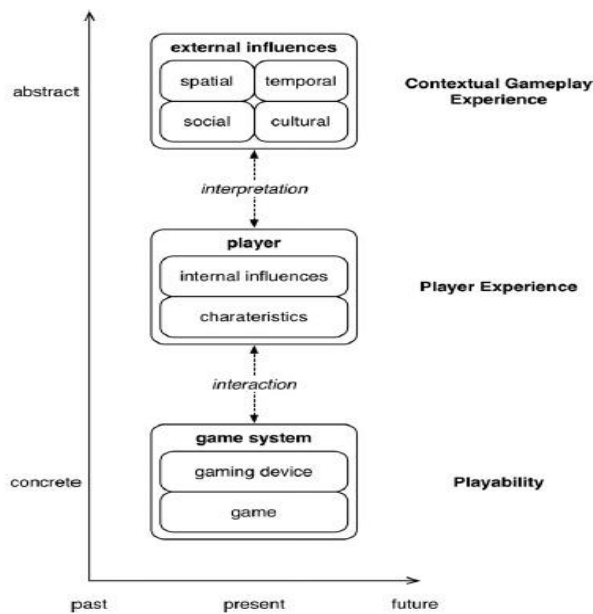


Fig. 6.
Game
Experience
(GX) [26]

Fig. 7. Gameplay Experience Model [27]

A similar approach was made by [27] in proposing three layers of abstraction game experience model with the game system's playability, the player experience emerging over the connection with the game system and the related gameplay experience formed by the interpretation of external and internal influences (Fig 7).

This model give enough room for future extensions by integrating with previous research. The authors believe that in future there is a way to build a refined model by using more mixed-method data on player experience in different situations. This was supported by [28] whereby they believe that a multi-measure approach allows a fuller description of game experience than any single inaccessible measure, hence preparing us to the rich scale of experiences allied with digital games.

Besides that, a study by [29] have presented nine attributes to characterize the educational playability:

- Satisfaction: It is depends to individual expectation in gaining the pleasure or satisfaction from playing the game.
- Learnability: The ability of the player to understand the content of the game and how to handle or play the game.
- Effectiveness: To identify if the objective of the game is achieved.
- Immersion: To engage player with the game world and indirectly expose the educational aspects.
- Motivation: The excitement that drives the players need in order to play the game until the last level.
- Emotion: It is involving the player's feeling towards the game they are playing. It is important because the positive feeling towards the game will motivates players to continue to play the game.

Last but not least, [30] have developed a flow framework as shown in Fig 8 below. Flow is known as being in “the Zone” or an optimal experience, which represent the subjective experience of player as they play games with a high level of enjoyment and fulfilment [31]. The framework is divided into three groups: Flow antecedents (factors that contribute to the flow), flow state (state of the player where there are completely unaware of their surroundings) and lastly the flow consequences (the results of the flow including learning and exploratory behavior). The factors that involved in flow antecedents are clear goals, cognitive feedback, immediate feedback, sense of control and playability. Recently an experiment was done based on the flow framework and they have concluded that clear goal and sense of control are essential in developing and designing serious games [31]. Thus these factors is considered as an important aspects to create an effective learning process.

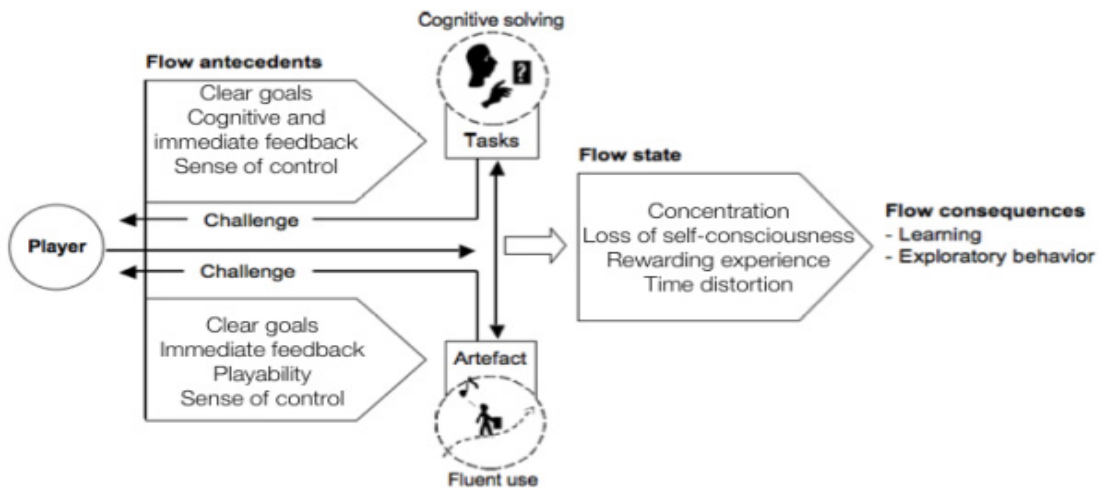


Fig. 8. The Flow Framework [30]

4. Discussion

Based on the reviews from all the previous user experience models and frameworks, the elements involving in the user experience design evaluation are summarized in the Table 2. The most obvious elements are the social and physical elements. Social elements involves political, cultural, economics and etc. meanwhile physical elements involves technology, geography, demographic, architecture and etc. Both this elements are given equal importance in user experience evaluation. The next highly noted element is time. Time in this concept is look in as the future or something unpredictable beyond some period of time. Besides that, game developer need to ensure that the game they produce can be used for certain time period thus time is needed to observe the value of the game. Next element is the involvement which holds the players attention towards the game. This element is closely related to appeal and time since involvement of the player towards game involves engagement thus the appeal factor which include adaptation and retention is playing the same concept of holding the players attention for certain period of time without creating boredom or lack of interest.

Other than that, the emotional and cognitive elements also included in few of the user experience evaluation models. This elements involves in studying the inner emotional level of the players when engaging with the game. There are few measurement can be done to evaluate the emotional level of a

game players but it have been done with few lab test thus cost and availability of the right equipment's can be a limitation. Next element is the game content. Content of the game in educational games plays an important role in carrying out the goal of the game. This involves the learnability aspects as the content of the game must be in a right educational level in order for the players to understand the educational aspects of game and at the same time able to have fun.

Fun was not given much attention as most of the researcher was listing the other aspects besides fun which is a well-known and essential factor for people to handle or work with any products without hesitation [8]. Lastly, the important of flow factors in designing educational game was reviewed as well. Based on table 2, it is known that there are a few important aspects or elements that need to be given attention in order to build a suitable User Experience framework for educational games UX evaluation.

Table 2. Elements from Previous User Experience Models/Frameworks

Frameworks/Models	Elements
The Product Ecology	Social Environments Physical Environments
User Experience Temporal Requirements (UXTR)	Appeal Brand Association
Presence-Involvement-Flow framework (PIFF)	Physical Presence Social Presence Involvement Cognitive evaluation Emotional Outcomes
Experience-Driven Procedural Content Generation (EDPCG)	Content of the game
Long-term UX	Time
Player Experience (PX)	Time
Mobile Game Based Learning	Demographic
Game Experience (GX)	Emotional/Cognitive Physical Environment Social Environment
Gameplay Experience Model	Time
The Flow Framework	Flow antecedents

5. Future Work & Conclusion

This paper reviewed the earlier UX framework for game UX design evaluation. As for the future work, there is a need to design a proper single framework which incorporate all the important elements discussed in this paper for an ideal evaluation of educational game's User Experience. Besides that, there should be a practical investigation or experiment to support the theory of the finding in this paper as well as to identify any new elements to model the framework.

This paper aims to identify the relevant elements that support or suitable in modelling User Experience framework for educational games. This framework will not only aid game designers in developing effective educational games in future but also ease game designers' work in evaluating their game with the right framework. Based on the review of previous User Experience Models, there are many elements contributed for the models. This aspects not only covers on the fun, challenge and entertainment but as well as overall social aspects such as branding, environmental in the sense of students background, culture, content of the game and so on. Another aspects that the researchers concentrated was on the time factors. They believe that as time pass by, the users response towards the product would change as well thus the model should covers future expectation as well as current trend to attract the users' attention.

Acknowledgements

The authors would like to thank Universiti Teknologi Malaysia for sponsoring the research under university grant (RUG vote number 10J05), Advanced Informatics School (UTM AIS) and Ministry of Education Malaysia for the support.

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