Insights into Design of Educational Games: Comparative Analysis of Design Models

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Abstract. The study reports on an ongoing research that intends to identify and validate the core dimensions for Game-Based-Learning (GBL) and further explore the shift in dimensional focus between different phases of educational game development life cycle: pre-production (design), production (development) and post-production (testing and maintenance). Hence, this paper presents the initial work focusing on design phase by presenting a comparative analysis of educational game design models using GBL attributes, validity and framework attributes as analytical lens. The main objective is to analyze the fundamental GBL attributes in existing design models; to identify the common attributes which demonstrate their importance for design phase and highlight any need for further research in terms of attribute validation and framework improvement. This study also highlights the strengths and weakness of existing design frameworks. The results of analysis underline learning/pedagogical aspects and game factors as the most essential attributes for design phase of educational games. Comparative analysis also guides researchers/practitioners to better understand GBL through various properties of different existing design models and highlights the open problems such as lack of tool support, empirical validation, independent evaluations, adaptability and absence of concrete guidance for application to make more informed judgments.

Keywords: Educational games; game-based learning; serious games; design models; frameworks; comparative analysis; design attributes

1. Introduction

Over the past decade, educational games or game-based learning systems have greatly impacted the learning industry. However, it has been a constant challenge for educational game designers to understand the different aspects embedded in game-based learning [1]. Lately, several researchers have proposed design frameworks/ models/ guidelines to guide educational game design [2-16]. According to Neil [17] usually all proposed design models tend to communicate some core foundational elements, yet they differ in their approach and results. As there is a lack of dialogue between researcher and practitioners and also among researchers themselves. Therefore, also at completely theoretical level, there is a lack of work providing comprehensive comparative analysis in the field [17]. To the best of our knowledge, we found only two such attempts of comparison studies for learning game design frameworks. Dos Santos et al. [18] presented a comparison of 5 digital learning game design methodological frameworks and highlighted their differences and similarities to

identify selection criteria for guiding framework choice and promote methodological frameworks as a way to encourage principled educational games design. However, the framework selection is not explicitly stated. Likewise, Ahmad et al. [19] presented a survey of different educational design frameworks; against criteria such as well-designed games, effective video games, four learning theories and key elements of a games and analyzed them from software engineering perspective for the development of effective educational games. However, the keywords are not specifically focused on educational games. Malliarakis et al. [20], however, did not present a comparative analysis but studied existing frameworks for educational game design to document the features supported by current educational games to teach computer programming in order to establish a framework for the design of their computer programming specific educational game.

Often the underlying purpose of comparison entails valuing one model over another. However, this is not the sole focus of this study. Rather, the approach here is to analyze the existing design models/frameworks against core GBL dimensions to pinpoint elements specifically focused for the design phase based on similarities in analyzed frameworks. The GBL dimensions selected as analytical lens comes from our previous research results [33]. Although all core dimensions are considered important for an effective educational game product but dividing them in different phases might help education game designer and developers to emphasize the focus in that phase and ease the process. Further, the design frameworks are also compared in terms of validation of used dimensions and exploring framework attributes to highlight strengths and weaknesses which would aid researchers and designer in better understanding the issues in educational game design. The objectives of this study are the following:

1. Exploring game-based learning attributes used in existing design models.
2. Validation of game-based learning attributes by existing models and frameworks: Support for being theoretically grounded and empirically sound.
3. Comparison of existing GBL frameworks using analytical lens to identify open issues and highlight their strengths and weaknesses.

The paper is organized into following sections. Section 2 describes background by presenting an overview of educational game design frameworks/models, section 3 describes the method, section 4 illustrates the comparative analysis, section 5 presents discussion and finally, section 6 concludes the study with conclusion and future work.

2. An Overview of Educational Game Design Frameworks/ Models

Our previous research study examined the state of the art in game-based learning by conducting a systematic literature review. The work reported in [21] highlighted the existing design focused approaches for educational games and these frameworks/models were selected for the comparative analysis described in this paper. In this section, the existing educational game design models/frameworks are presented, and their objectives are briefly described.

2.1 Level Up

The goal of Level Up [6], is to build new modes to design and evaluate the future game-based learning systems. The author hypothesized that the framework will increase the production speed of educational games, increase the quality and offer scientific evaluation of educational content of the games. According to the author Level Up framework will make use of a collection of empirical experiments as well as log-data driven analyses using empirical learning curves for understanding learning in educational games. The aim is to model learning of students and identify gaps to improve game development by using educational data mining on game-log data of students. The learning models could be dual fold: assessing the quality of learning in educational game and identifying the exact spots for applying in-game feedback (e.g. hints on more difficult problems). The author makes use of game-log data for evaluating learning in an educational game. The evaluations and logging system together are considered to provide foundation for developing design principles for an effective educational game.

2.2 Experiential gaming model

The experiential gaming model [8] is developed based on the idea of integrating experiential learning theory, flow theory and game design. Experiential gaming model emphasizes the importance of clear goals, providing immediate feedback, and matching challenges to skill level of players. The model comprises of an experience loop, ideation loop, and a challenge depository. The model uses the operational principle of human blood-vascular system as metaphor. The heart of the model is formed by challenges based on educational objectives. The flow theory is applied and factors contributing to flow experience are discussed in the model to enhance positive user experience and maximize educational game impact.

2.3 Framework for the analysis and design of educational games

This framework for design of educational game [2] is developed based on existing components including a method for specifying the educational objectives, principles for instructional design supported by empirical research in learning sciences and a framework for linking game dynamics, mechanics and aesthetics. The framework directs the levels which are essentials for an educational game to be effective. The framework discusses the three components: Learning objectives, MDA and Instructional principles highlighting the support they can provide to game designer by the analytical angle. The author highlights that success of educational game is more prospective when learning objectives of educational game are clearly established early in development process and if designers carefully think about linking the desired game aesthetic in game mechanics, via proper game dynamics observing the proven instructional design principles.

2.4 RETAIN Model

Zhang et al. [16] presented the RETAIN model consisting of six elements (relevance, embedding, transfer, adaptation, immersion and naturalization). The model is

constructed on instructional design principles and describes the notorious concepts between instructional design and game, providing a common framework for educators and game designers by comprehending the effective integration of game and learning content to even them out.

2.5 Adaptive Digital Game-Based Learning Framework

The author [13] has identified essential components and features of best practice to be considered for the design of games-based learning environments based on existing models and frameworks. The author discusses four frameworks/models in this paper: The Design Framework for Edutainment Environment, Adopted Interaction Cycle for Games, The Engaging Multimedia Design Model for Children and Game Object Model. Based on analysis the developed framework focuses on the learners and the game design. The framework also highlights some important features such as challenge, goals, story and objectives not included as part of the framework.

2.6 A Theoretical Framework for Serious Game Design

Rooney [10] investigated a triadic theoretical framework consisting of the elements of pedagogy, play and fidelity for the design of serious games. The author points out that the inherent inconsistencies between pedagogy, game design and fidelity make it difficult to balance these elements during serious game design process and integrating them in one coherent framework. Another challenge is the multidisciplinary nature of serious game that require collaboration between members from different disciplines bringing in the conflicting interests, priorities and from diverse backgrounds can complicating the process of "balancing".

2.7 The "I's" Have It (A Framework for Serious Educational Game Design)

The framework "I's have it" for the design of serious educational games is a nested model of six elements: identity, immersion, interaction, increased complexity, informed teaching and instructional [4]. The elements of the framework are derived from studies on design and development of games from Grade 5 to graduate level. The elements are grounded in theory and research within education, instructional technology, psychology, and learning sciences. According to the framework educational games contain these six elements that come into view in the order of magnitude staring from the element identity and ending at instructional. According to the author the backbone of his work is based on the research in constructivist viewpoint which shows that people learn based on discovering prior schema and eventually building the new knowledge by connecting their new experience with prior ones.

2.8 e-VITA framework for SGs

The framework for serious games developed as a part of e-VITA project [9] focuses on three key dimensions including technical verification, user experience and pedagogical aspects (learning outcome). The project highlights serious games as a game, an IT product, and a learning instrument. It argues that with respect to development and evaluation, an educational game should have three critical dimensions to be effective

(1) it should be easy-to-use and technically sound (2) it should be engaging and fun game and (3) it should be an effective learning instrument providing desired learning outcomes. To improve motivation and learning, all the three dimensions should be targeted, the failure to meet any one dimension could compromise the effectiveness of serious games.

2.9 Educational Games (EG) Design Framework

The focus of Ibrahim et al. [7] was to develop an educational game design framework for higher education. This author compared few available frameworks and recommend the required criteria based on his analysis both from pedagogy and game design viewpoint. The idea behind this framework is to combine three factors that include pedagogy, game design and learning content modelling into the educational game design. The focus of game design is on multimodality and usability. As usability studies in educational games are not much focused by researchers. Similarly, the focus of pedagogical factor is learning outcomes and motivation theory. The factors of fun, problem solving, and syllabus matching are also highlighted.

2.10 Game Factors and Game-Based Learning Design Model

Shi et al. [11] underlined the fact that prior models are designed based on specific game genres making them difficult to use when target game genre is different from default game genres applied in research. Therefore, the author presents macro level design concepts comprising of 11 key factors for game-design. The factors include game goals, game fantasy, game mechanism, game value, narrative, interaction, challenges, freedom, sociality, sensation, and mystery. The author verifies the usability of the model and performance of identified factors for designing educational games by analyzing two applications.

3. Method

The methodology used in this paper is the comparative analysis of educational game design models/frameworks using appropriate analytical tools. The Quasi-formal comparison technique proposed by [22] and used by many researches [23-25] for comparative reviews is employed in this study.

The comparison of existing frameworks and models with one another is useful to get an insight into a specific area and identify the gaps for future research. Although, it is a very difficult task, but the result is often considered to have some sort of researcher bias as it is based upon the subjective judgment of the researcher. Two alternative approaches have been proposed for comparative analysis, informal and quasi-formal comparison. However, informal comparison lacks a systematic framework to direct the analysis and therefore is more likely to have a subjective bias. Quasi-formal comparison on the other hand attempts to subdue the subjective limitations by presenting a strategy and creating a baseline for comparison in the form of an analytical tool. Quasi-formal comparisons can be conducted using different techniques. One technique is to select a set of critical perspectives or attributes and then compare the objects against them and this is considered closer to a traditional scientific method [22]. This approach is adopted

for conducting the quasi-formal comparison in this study. For this purpose, appropriate analytic tools are needed to make analysis and comparison. Although many researchers have proposed and used analytical tools for comparative analysis [26-29] but not all fit for the purpose and specific area of this research. The analytical lenses seen as appropriate for the research objective of this study are classified as: GBL/educational game attributes; validity and framework attributes. The GBL attributes were selected based on our earlier research study which categorized game-based learning into six fundamental dimensions using directed content analysis [33] of GBL literature selected through a systematic literature review [21]. The analytical lenses of validity and framework attributes are taken from [23, 26, 27]. These analytical lenses are described along with the references in Table 1. The research study outlines three research questions, which are as follows:

RQ1. Which GBL attributes are essential for design phase of educational game development life cycle. (comparison of attributes covered in each model/framework).

RQ2. To what extent are the attributes being used in existing models validated? Are they theoretically grounded? Is empirical evidence available?

RQ3. What type of characteristics are provided by existing design models to operationalize and use them and their strengths and weaknesses?

Table 1. Analytical lens for comparative analysis of existing educational game design models/frameworks.

Analytical lens	**Description**	**Reference**
GBL Attributes	How many and which GBL attributes are covered by the educational game design model/framework?	[21][33]
Learning/pedagogical	Does the model/framework consider learning/pedagogical attribute, or any elements related to it?	
Game factor	Does the model/framework consider game factor attribute, or any elements related to it?	
Affective Reactions	Does the model/framework consider affective reaction attribute, or any elements related to it?	
Usability	Does the model/framework consider usability attribute, or any elements related to it?	
User	Does the model/framework consider user attribute, or any elements related to it?	
Environment	Does the model/framework consider environment attribute, or any elements related to it?	
Validity	Does the model/framework have support for its claims?	[18, 23, 26]
Theoretical evidence (Development basis)	Is the model/framework grounded in appropriate theory? (author provide development basis for the model/framework).	
Empirical evidence (Validation/application)	Does the model/framework have empirical support for its claims? (details of application/validation of framework/model: game name, sample size, validated elements).	
Framework attributes	What type of attributes are provided by the model/ framework?	[18, 23, 27, 28]

Tool/ instrument Support	Does the model/ framework offer tool/instrument support for its artefacts?	
Assessment and stakeholders	What types of assessment approaches are used for the model/framework? Which groups of stakeholders are required to participate in assessment?	
Applicable Stage	What is the most appropriate educational game development lifecycle phase(s) to apply the model/framework?	
Application domain	In which application domain(s) the model is mostly applied?	
Guidance for application (abstract principles vs concrete guidance)	Does the model/framework rely only on abstract principles or it provides concrete guidance? (offer guidelines on how to practically use it for educational game design).	
Target/adaptability	Is the model/framework fit for all educational games (universal/ generic) or is it situation appropriate (specific)? Does it offer adaptability in actual use?	
Strength/weakness	What are the strengths and weaknesses of the model/framework?	

4. Comparative Analysis

The frameworks described above aimed at establishing guidelines and patterns for designing effective educational games. A comparison of these models, highlights not only the fundamental common characteristics to be considered during GBL design phase but also highlights the distinct aspects and approaches of each framework plus bringing forward the open issues that still needs to be addressed in GBL design research. In this section, 15 existing educational design models/guidelines (including 10 models/frameworks and 5 design guidelines/principals) are compared and analyzed using the three categories of analytical lenses (GBL attributes, validity and framework attributes) described in Table 1.

4.1 Key GBL Attributes

Among the most significant comparison features is the number of key attributes a model/framework deal with [26]. Six fundamental GBL elements were selected for comparative analysis of design frameworks (see Table 2). These include learning/pedagogy, game factors, affective reactions, usability, user and environment. The reason for selecting specifically these six attributes as analytical lens is because they are identified as core dimensions of GBL in our earlier research study [33]. Therefore, the aim here is to identify if any of these six attributes should be more focused or particularly essential for the design phase of effective educational games.

Learning/pedagogical entails the elements related to pedagogy and learning such as learning objective, strategy, content and outcome. Game Factors include the features of a game world that encompass every perspective of game environment (game definition, mechanics, narrative, aesthetics, resources). Affective Reactions depict the emotions and feelings stimulated during interaction with educational game such as

(flow, engagement, motivation, enjoyment). Usability signifies how usable is the educational game by its users in achieving its goals (learnability, satisfaction, interface). User is the learner/player playing the educational game and their characteristics such as profile, cognitive and psychological needs. Lastly, environment describes the technical and context-related aspects of educational game. Table 2 presents the comparative analysis based on these GBL attributes.

Table 2. Comparative analysis of educational game design models/frameworks based on key GBL attributes.

Design-focus frameworks	Learning/ pedagogy	Game Factor	Affective Reactions	Usability	Users	Environment	Tot-al
Game-Based Learning Guidelines [3]	**X** (learning objectives)	**X** (game req.)		X (User Interface)	X (child req.)		4
Level Up [6]	**X**(learning)						1
Experiential gaming model [8]	**X** (experiential learning)	**X** (Game design)	X(flow)				3
Usability guidelines for mobile educational games [14]				**X**(Usability)		X (Context)	2
Framework for analysis and design of educational games [2]	**X** (learning objectives, Instructional design)	**X** (MDA					2
RETAIN Model [16]	X (Relevance, Embedding, Transfer, Adaptation, Naturalization		X(immersion)				2
Adaptive Digital Game-Based Learning Framework [13]		X (Game design)			**X** (Learner)		2
A Theoretical Framework for Serious Game Design [10]	**X**(pedagogy)	**X**(fidelity)	**X**(play)				3
"I's" have it [4]	**X**(instructional)	X(identity)	X(immersion)				3
User Experience for Mobile Game-Based Learning [12]	X (learning content)	X (game play)		X(usability)		X(mobility)	4
EGameDesign [15]	X (Knowledge enhancement)		X(Enjoyment)				2
e-VITA framework for SGs [9]	X (Pedagogical aspects)		**X** (affective aspects)	X(usability)		X (Technical verification)	4

Educational Games(EG) Design Framework [7]	**X**(pedagogy, learning content)	**X** (Game design)					2
Design principals for serious game [5]		**X**(design principal)					1
Game Factors and Game-Based Learning Design Model [11]		**X** (Game Factors)					1
Total models:15	**11**	**10**	**6**	**4**	**2**	**3**	

*Bold **X** is used when all factors of that attribute are covered by a framework and X when only some are covered.*

4.2 Validity: Theoretical and Empirical Evidence

This section analyzes the design frameworks in terms of their validity, examining the theoretical and empirical support available for each framework. The theoretical validity is examined to explore the development basis and foundations of these design frameworks/models. Empirical support is required to see if the existing design models are grounded in empirical evidence or applied to any educational game. It is important to see if the existing educational game design models have strong practical orientation in real life educational game design and development using empirical studies or just present in research work. Table 3 details the models/frameworks with their development basis, empirical validation or application, educational games on which the model is applied, sample size of empirical study and the elements of model/framework validated in the study.

Table 3. Comparative analysis of educational game design models/frameworks based on validity.

Model Ref	Theoretically grounded (Development basis)	Empirical validation/ application	Educational game(s)	Sample Size	Validated elements
[3]	Reviewed literature* (not specified)	No validation			
[6]	Intelligent tutoring system literature	Yes (empirical study)	Wu's Castle video game	61	Learning curve
[8]	Experiential learning theory, flow theory and game design	Yes [31, 32]	IT-Emperor game, Day Off	221	Flow antecedents
[14]	Interviews with educational game developers, game design theory, and game analyses	No validation			
[2]	Existing components: method for specifying educational objectives, framework for relating game's mechanics, dynamics, and aesthetics, and principles for instructional design	Yes*(case study), applied framework to analyze the game	Zombie Division	NI	

[16]	Game and instructional design principals (Keller's ARCS Model, Gagne's events principles of Bloom's scaffolding)	Yes*(case study), applied for evaluation of educational game	Knowledge Discovery	NI	Relevance, Embedding, Transfer, Adaptation, Immersion, Naturalizatio n
[13]	Four models: Design Framework for Edutainment Environment, Adopted Interaction Cycle for Games, Engaging Multimedia Design Model for Children and GOM	No validation			
[10]	NI	No validation			
[4]	Experience of developing and testing educational games and using research from commercial video games	No validation (example only)	The Great Entomologist Escape	NI	
[12]	NI	Case study	1Malaysia	64	
[15]	Four-dimensional game-design evaluation framework and Bloom six levels of knowledge	Yes* (case study), applied to design a learning game	VIEW		
[9]	NI	Yes* (preliminary validation of game (results not provided)	e-VITA-European life experience	NI	
[7]	Compares a few frameworks: Adaptive Digital Game-Based Learning Framework, Three Layered Thinking Model, Experiential Gaming Model and Model for Educational Game Design	No validation			
[5]	Literature review of related work* (not specifically stated)	Yes *(case study), applied in 2 Math video games but no evaluation performed	Gem Game, Grandma's Garden Game	NI	
[11]	Literature search of studies whose primary concerns were game factors	Yes	Slice it, Xiao-Mao	31	All 11 factors

*NI=Not identified. * is used when it is stated but not explained, not empirical validation or when results are not provided*

4.3 Framework Attributes

The existing design frameworks are also analyzed with analytical lens of framework attributes mentioned in Table 1. The comparative analysis of educational game design frameworks in terms of tool support, assessment and stakeholders, application stage, domain, guidance for application and target /adaptability is presented in Table 4. Table 5 highlights the strengths and weaknesses of each mentioned framework. For this part of analysis, we have only included the design frameworks/models and not design principals/guidelines. Therefore, a total of 10 frameworks are compared here.

The framework attributes are briefly described here: a tool support facilitates to capture the design artefacts together with evaluation outcomes, decision rationales and measurements that are invaluable assets [23]. A stakeholder is any representative or person having interest in the system [23]. A perspective of abstract versus concrete guidance allows to assess guidance for application, whether the frameworks offer any concrete guidance for their application in designing educational games or just rely on abstract rules e.g. to illustrate this "respect people" without providing any guidelines on how to perform it is an abstract principle [23]. The target of analyzed design models can be categorized as general or specific based on whether model can be used for the design of any kind of educational game and for any target audience or they focus on any specific platform, audience or game genre, providing specific guidelines for their target. Design models are used for the design process of educational games therefore, the application stage is the design phase. However, some of these models claim to be equally applicable to other stages of development lifecycle.

Table 4. Comparative analysis of educational game design models/frameworks based on framework attributes.

Model Ref	Tool support	Assessment/ stakeholder	Assessment method	Guidance for application	Target/ adaptability	Applicable stage	Domain
[6]	NO	Mixed (user &model)/students, user	Qualitative	Partial guidance	Specific/ NI	Design and evaluation	Computer science
[8]	NO	NI	NI	Abstract	General/ NI	Design and analysis	IT
[2]	NO	Expert assessment/ designer	Qualitative	Concreate/ application and use of components	General/ NI	Design	Math
[16]	Yes/ Specified design and evaluation criteria	Expert assessment/ Teachers and instructional designers	Quantitative	Concreate/ criteria and case study to apply it	General/ NI	Analysis, design, development and evaluation	Chinese, math, foreign languages
[13]	NO	NI	NI	Abstract	General/ NI	Design	NI
[10]	NO	NI	NI	Abstract	General/ NI	Design	NI
[4]	NO	NI	NI	Abstract	General/ NI	Design	NI
[9]	NO	Mixed approach/ expert and users	Quantitative and qualitative	Abstract	Specific/ Yes (used based on game scope &characteristics)	Evaluation and design	Intergenerational and intercultural learning
[7]	NO	NI	NI	Abstract	Specific/ NI	Design	Higher education
[11]	Yes	User-based/ player	Qualitative	Concreate	General/ Yes (macro	Design	Geometry/history,

					elements for different genre)		geography, culture

Table 5. Strength and weakness of existing educational game design models/frameworks.

Model Ref	Strength	Weakness
[6]	Uses data-driven analysis of learning experiences through visualizations, educational data mining, and statistical techniques applied to game logs. Game-log data are used to model learning and identify places of improvements.	The steps in the process of designing educational games are not clearly defined.
[8]	Model links gameplay with experiential learning to facilitate the flow experience.	It only provides a link between game design and educational theory not guiding the whole game design project. Several issues such as engaging storyline, appropriate graphics and sounds, and game balance are not included. Only good gameplay cannot save learning game.
[2]	Useful analytical tool and also assist to improve the creativity of educational game designer by guiding the brainstorming of game ideas from both game design and educational angles. Encourage thinking across components rather than individual approach.	The framework is descriptive and difficult to apply. It does not offer any tool or instrument support as well.
[16]	Offers a common framework for educators and game designers by comprehending the effective integration of curriculum and game. The model also aids in evaluating the effectiveness of games used in educational settings as well as to select valuable games for use in classrooms.	The model provides guidance to assess already developed games for classroom use. However, does not provide practical guidelines to structure the design process for educational game development. The criterion for design and evaluation should be refined further to be perfect for educational game design in practice.
[13]	Emphasize the pedagogical aspects in designing educational games.	key features presented for designing educational games are based on four frameworks and not all are specific for educational games. No guidance is provided on practical application of framework.
[10]	The triadic theoretical framework provides a rich theoretical basis and present serious game design elements by outlining underpinning theories and associated challenges.	Does not provide any concrete guidance on steps to integrate them in design process or how to operationalize them in serious game design
[4]	Provides a hierarchy with identity as core foundational element. Includes informed learning concept as an important element in hierarchy. It exhibits a game concept to demonstrate learning game design process.	Model does not provide design steps and practical application of these concepts in design process with reference to their magnitude.
[9]	Framework emphasize the threefold nature of educational game and include technical verification and user experience along with pedagogical dimension, highlighting critical aspects of each.	The framework does not focus on game specific dimensions and doesn't provide practical guidelines to educational game design.
[7]	The model emphasizes on higher education with game design, pedagogy and learning content modelling as main factors and is designed specifically for student self-learning with incorporated self-assessment modules.	The model does not provide concrete guidance for application. Although model focuses on higher education, but the compared frameworks used as development basis are not specific for higher education.

[11]	Presented macro game design concepts that can be adapted to different game genre. To build a GBL design model it defines all factors and also analyze the relationships among them.	GBL combines game and education but the model only discussed the game factors.

5. Discussion

A comparison among existing models/frameworks clarifies the underlying common features and distinctive aspects. Mainly such comparison provides two benefits: first to help educational game designer/researchers understand and contrast the alternative approaches available for selecting an appropriate one, and second to highlight the open problems for future research. However, this study has a third key benefit of guiding educational game designers in design phase by highlighting the essential attributes for design of educational games. This study performs the comparative analysis of educational game design models/frameworks through the perspective of important GBL features that in our viewpoint could be considered as the core dimensions and are fundamental for an effective GBL product. Although all of these attributes are important for educational game development life cycle, but the view or focus may change in different phases of design, development and evaluation; leading to some attributes more important in one phase than the other. Therefore, the idea is to explore this shift and focus.

RQ1: The comparison among existing models/frameworks in terms of GBL attributes clarifies the underlying common features for design phase. 11 design models included learning attribute mostly focusing on learning objectives, learning content, instructional design, knowledge enhancement/transfer and pedagogical aspects. 10 frameworks focused on game factors with emphases on game design including factors such as goals, mechanics, dynamics, aesthetics, narrative and fidelity. However only 6 design frameworks focused on affective reactions such as experiential gaming model emphasized on flow experience, RETAIN and I's focused on immersions, EGameDesign focused on enjoyment. Although it is a common feature of digital games and considered equally important in educational games as well, but in design models it comes after learning and game factors. Usability is approached by 4 frameworks/guidelines including e-VITA, experience for mobile game-based learning, usability guidelines for mobile educational games and game-based learning guidelines. Environment is covered by three frameworks [9,12,14] focusing on context, mobility and technical verification. User attribute is only focused by adaptive digital game-based learning framework and game-based learning guidelines that included learner and children requirements respectively. Majority of analyzed frameworks focus on two attributes (learning and game design) highlighting their importance in design phase. None of the design frameworks or even guidelines covered all six attributes.

RQ2: The analytical lens of validity highlighted that all analyzed frameworks to some extent cited some theory or literature to justify their development. The selection of a theoretical basis for development of framework is based on the specific objectives and approach of each framework towards game-based learning. The knowledge of

underlying developmental base is also important for educational game designer to select the framework appropriate to their objectives. Most frameworks are theoretically grounded in literature for a pedagogical base and game design principals. Some of the pedagogical theories used include Blooms taxonomy, Piaget's schemes and Gagne's events of instruction, Vygotsky zones of proximal development, experiential learning theory and instructional design principals [4, 15, 16, 31].

Some frameworks (Adaptive digital game-based learning framework and Educational Games(EG) design framework) compared existing models as developmental base of their framework. Moreover, "I's" combined the practical experience from field with research from commercial games as the development base. When it comes to empirical validation or application of design frameworks, only two frameworks level up and experiential gaming model had empirical evidence of their validity with sample size of 61 and 221 respectively. Learning curve, flow antecedents and game factors in [11] were the only elements validated by empirical study. However, the frameworks are validated by the authors who proposed them, and no other educational game so far reported to use these frameworks in its design. All the other mentioned frameworks were not empirically validated, only mentioning it as a future work. However, four frameworks: Framework for analysis and design of educational games, RETAIN, EGameDesign and design principals for serious game illustrated the application of framework on educational game as a case study without actual implementation.

RQ3: The comparison on the basis of framework attributes highlighted some open problems. Surprisingly, no tool support is available by existing educational game design frameworks except Game Factors and Game-Based Learning Design Model that provided an instrument called "Game factor questionnaire" and RETAIN model which provided design and evaluation criteria in terms of level points, higher the points, better is the designed educational game. The studied models also differ in terms of assessment and stakeholders involved. Framework for analysis and design of educational games and RETAIN model focused on expert-based assessment with teachers and designers as stakeholders, e-VITA framework for SGs focused on mixed approach of both expert and user assessment and Game Factors and Game-Based Learning Design Model emphasized on user-based assessment. While the authors of remaining frameworks and models did not provide any information.

Based on comparative analysis, six frameworks (Experiential gaming model, Adaptive digital dame-based learning framework, A theoretical framework for serious game design, "I's", e-VITA framework for SGs and Educational Games(EG) design framework) emphasized on abstract principles rather than concrete guidance and are limited to high-level concepts without providing any procedural guidance to structure the design process of educational games. The other three frameworks provided some form of concrete guidance to support educational game design. Framework for analysis and design of educational games provided guidance on each of the three components by illustrating their application on a zombie game and also guided how to think across component during brainstorming. RETAIN provided a criterion with level points to assess already developed educational game and a case study to illustrate it. However, it did not provide guidance for designing a new educational game. Game Factors and Game-Based Learning Design Model suggested macro elements and represented a

thinking process with a model to help educational game designers incorporate it in their game along with an instrument (game factor questionnaire) for assessment.

The comparative analysis also illustrated that most of the models are general for any educational game design and audience. However, there were three specific models, two of these focused on a specific domain (computer science games in level up, intergenerational in e-VITA framework) and one focused on specific audience (higher education students in Educational Games(EG) design framework). The framework attribute of "adaptability in use" is addressed by only two models: e-VITA framework which emphasized that framework should be employed depending on the characteristics and scope of game and Game Factors and Game-Based Learning Design Model that not only emphasized but also provided the opportunity for adaptation by offering macro elements that can be adapted for different genre. According to the comparative analysis, most of the analyzed frameworks focused only on design stage but three models (Level up, Experiential gaming model and e-Vita) can be used for evaluation or analysis as well along with design stage. Moreover, RETAIN model claims to be applicable for all stage (Analysis, design, development and evaluation) of educational games development life cycle. However, no practical usage is available. The educational game design models are applied in various educational domains such as computer science, math's, geography, culture, language and history are particularly mentioned among the compared models.

6. Conclusion and Future Work

This paper particularly focuses on design of educational games and reports on the comparative analysis of design models/frameworks for game-based learning. The study analyzes the use of GBL dimensions and validation in existing frameworks to identify essential elements for design stage. Secondly it also highlights the differences and similarities between different GBL design frameworks/models by exploring framework attributes to guide educational game designer/ researchers in making more informed decisions and also to underline the open research issues in this area. The results of comparative analysis conclude that: Learning/pedagogy (Learning objective, instructional design, learning content and knowledge enhancement/outcome) and game factors (mechanics, dynamics, narrative, aesthetics, goals) are the most essential attributes for the design of educational games. The attributes of affective reactions (flow, enjoyment, immersion) comes after learning and game factors. Whereas, usability (user interface), user (learner requirements) and environment (including technical and context related aspects) are less emphasized by the analyzed educational game design models. Therefore, the design phase of educational game should emphasize more on linking learning objective with game objective in an efficient way to facilitate the affective reactions such as flow in order to engage and immerse the player [8, 10]. The importance of these three attributes in the design of educational game is also evident from the developmental basis of these models, most of which are theoretically grounded in learning and game design theories with focus on ARCS models and flow theory. However, there is a scarcity of evidence for empirical validity and practical application of educational game design models for educational game development. A few empirical studies and developed educational games that exist for

framework validation are conducted by the same researchers who developed the framework in order to validate it and few elements such as learning curve, flow antecedents and some game design factors are empirically validated. A bigger community of educational game designers and researchers is needed who are willing to apply these models for designing educational games to bring useful insights from industry and go beyond the researchers who developed these frameworks.

Therefore, the analysis brings forward two extremely important issues which are in line with the results of [18]; lack of independent evaluation and absence of practical application of these design models in educational game industry for designing effective educational games. This lack of usage and assessment can also be seen as a result of absence of tool support, lack of adaptability and concreate guidance for practical application of framework concepts in the design process of educational game development. However, one aspect could also be that most of industry work is not published in research community and a collaboration between industry and research is important for thorough insights. Also, most of the frameworks do not provide any information on assessment approach, method or stakeholder(s) that are required to participate in assessment.

For overcoming these issues, future research should focus on providing concreate guidelines and steps to use the framework's principals for educational game design in practice for example if a framework focuses on linking gameplay and learning so researcher should provide practical insights about how certain learning objective such as problem solving can be seamlessly embedded in game mechanics or if focus is challenges then how to increase learning complexity along with increasing game challenges and mapping learning content to game tasks and narrative. The future research should also guide the game designers on assessment of the design principals (that the models provides) embedded in their educational game as part of design phase. Finally, there is an extreme lack of tool support for available educational game design models which need to be addressed to make ways for framework-based educational game design by providing tool support for practical application. The future work will focus on the development and evaluation models for educational games to investigate and compare the shift in dimensional focus between different stages of educational game development lifecycle.

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