

A Gamified e-Learning Framework for Teaching Mathematics to Arab Deaf Students: (Supporting an Acting Arabic Sign Language Avatar)

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Abstract: Gamification is an exploitation of game design elements and game mechanics in non-game scenarios. It can be used as a web-based education tool to increase student engagement and motivation. According to World Federation of the Deaf (WFD) in addition to our past research with hundreds of Arab deaf-muted people over nine years, we reached a conclusion that most are undereducated or semi-literate. This is due to poor ways of communication with the society, and lack of means that support lifelong learning. Since, parity in life and self-learning systems are a right to everyone regardless of their ability. From this point, the aim of this project is to develop an e-learning system for teaching a difficult subject, such mathematics, to the Arab deaf students. Gamification technique will be followed and different gamification components will be included through the process of system development to motivate the deaf students. This framework is supported with an Arabic Sign Language (ArSL) acting avatar to support more clarity, interactivity and integration for the deaf-muted students. Therefore, the proposed framework will fulfill the psychological satisfaction needs of the intended users.

Keywords: E-learning; Gamification, Gamification in learning, Deaf learning; E-learning tools, Human Computer interaction (HCI), Designing for deaf, Psychological need satisfaction, Motivation, Self-determination theory

Introduction

Gamification in education and game-based learning are two different terms and they have different definitions.

Gamification in education is “A serious approach to accelerating the experience curve of learning, teaching complex subjects, and systems thinking” (Kapp 2012).

On the other hand, in game based learning, clear goals are presented by games. These goals are divided into several achievable short-term objectives that give the players a seamless sense of advancement by providing much recompense that act as extrinsic motivators.

Advances in communication technology and information have consolidated games by bestowing them with immediate connection with other players and instant feedback. Videogames are leading and growing industry attracting talented programmers, artists and designers (Chatfield 2010). Utilizing the ability of videogames to promote masterly productivity and thinking to be able to lead to new slipways of facing real problems in the world. Videogame proponents suggest that videogames can have the potential to make a better world and effects on everyday activities (McGonigal 2011). Also, game-based learning has already shown the strength of videogames to integrate disadvantaged target groups and broaden audiences, thus making the education process more accessible (Kam et al. 2008; Kapp 2012) Some studies on gamification in education concluded that it is effective and important in terms of engaging students in non-curricular activities (Walter et al. 2012) and promoting behavior changes in order to increase involvement in peer tutoring sessions (Figure 1). That is mainly reflected as a growing in success percentage (Decker, Lawley 2013).

According to the WFD (WFD 2003) in addition to our past research with hundreds of Arab deaf-muted people along nine years (Riad et al. 2012; Riad et al. 2013; Riad et al. 2014; Abo El-Soud, Shohieb 2010; Shohieb et al. 2015; Shohieb 2016; Shohieb et al. 2012; Shohieb et al. 2009; Shohieb et al. 2010)we have reached that approximately 80% of the deaf-muted people are undereducated, illiterate or semi-literate. Thus, they have low education levels due to the lack of accessibility in the current education system. The proposed framework aims at developing a gamified based e-learning

system for teaching a difficult subject, such mathematics, to the Arab deaf students. Many researchers have (Shohieb et al. 2010; WFD 2003; Riad et al. 2012; Riad et al. 2013; Riad et al. 2014; Abo El-Soud, Shohieb 2010; Shohieb et al. 2015; Shohieb 2016; Shohieb et al. 2012; Shohieb et al. 2009) concluded that deaf people have many difficulties regarding accessing written information on the web and difficulties in understanding the general context. This framework is supported with an acting Arabic Sign Language (ArSL) acting avatar to support more clarity, interactivity, accessibility, motivation and integration for the deaf-muted students with the system. Therefore, the proposed framework will reach to fulfilling the psychological satisfaction of the intended users. The question that may emerge to minds that why an avatar is needed as text is the predominant mode on such systems, and that is still accessible? The answer to this question is that the advanced content of mathematics contains some expressions which may be impossible to understand alone without assist of an agent (in our case the ArSL acting Avatar).

This paper is formatted as follows; section II presents the literature review for both gamification in education and some available learning systems for the deaf. Section III contains the proposed e-learning framework for teaching mathematics to deaf Arab students design. After that, we will deep into the psychological need satisfaction in section IV. Then, we will match psychological needs to game design elements in section IV. Finally, the conclusions will be presented.

Literature Review

The following subsections will present two types of research conducted according the area of interest. The first is research on gamification in education in general. The second is the narrative of some available classical learning systems for deaf.

A. *Gamification in Education*

Maněnová and Chadimová studied the effect of utilizing elements of the gamification process on teaching, especially 3D models. They were able to achieve successful increase in motivating the level 1 of the primary school students (Maněnová, Chadimová 2015). Simoes et al (2013) proposed the main features and guidelines of a social gamification framework that were used in a K-6 social learning environment.

Moreover, De-Marcos et al. (2014) compared the effects of a social networking site to those of a gamification plugin that were applied in Learning management system (LMSs) in the same educational setting. They found out that both presented techniques have better effect than a traditional e-learning technique regarding the academic accomplishments for practical assignments, and students' attitudes were positive. However, this study reported a problem in assessing the information. Bíró (2014) studied gamification as the 5th learning theory by drawing an analogy with the cognitivist, constructivist, connectivity and behaviourist approaches over every element of the learning process. He found that gamification from all the mentioned factors was successful in learning process.

In a set of studies Yigal and Meirav (2015) examined the effects of points, a main element of gamification, on performance in a computer based assessment of mastery and fluency for the basic mathematics concepts. They found good results of students especially those of grades 6-8. Also, Vassiliki et al. (2014) designed a game based application for Law students. This application was successful to in motivating students for studying the subjects of law. Furthermore, Alham et al. (2013) tested two different systems on 38 students from different high schools. The results show that removing gamification caused significant decrease on student participation. Concilio and Pacheco (2013) proposed more exciting e-learning practices in terms of developing emotional engagement through experience design, games, and interaction. They merged the gamification with the game-based learning concept in their proposed system. The results show that integrating the gamification technique in the learning environment increases the interaction and the excitement of students. Finally, Wongso et al. (2014) designed a framework that can be used as a guideline for the implementation of Web 2.0 technology and gamification in e-learning systems.

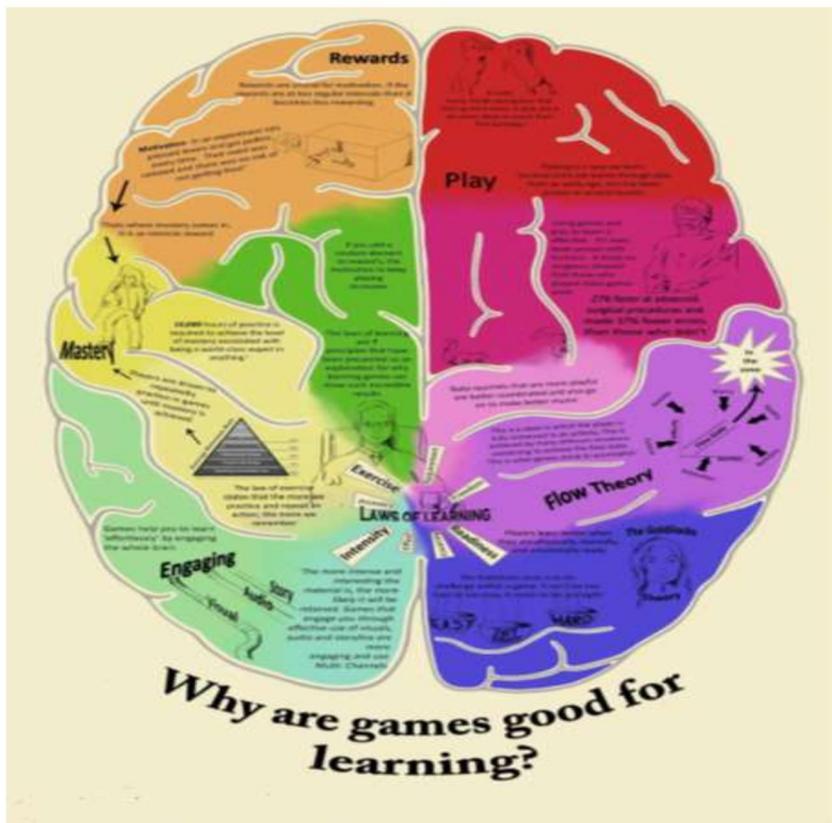


Figure 1. Gamification importance in learning process (Bradbury 2017)

B. E-learning Systems for Deaf

There are many classical e-learning systems for deaf. For example, Khwaldeh et al. (2007) proposed a centralized based learning system that facilitates learning, teaching and communications for both deaf people and teachers. However, that system still has limitations in its use. Chee Kyun Ng et al. (2008) proposed an e-Learning framework and created a platform for both disabled and normal students that enable them to share the same effectiveness of academic achievement. The deaf students were able to send and receive messages over chat rooming system to communicate with instructor and other students. However, this system did not maintain SL learning in general and needed training on its use. To motivate the deaf children to learn the American Sign Language (ASL), a PHP scripting language based system was proposed by Shirali-Shahreza et al. (2008). When a deaf-muted person wanted to log into the website, a word is shown as a movie using SL. He/she should recognize and select the word from a list. This system is used for web browsing only. Straetz et al. (2002) proposed a Learning Management System (LMS) that offers a German SL video for each text in the learning environment. The system was designed mainly for deaf adults who need to improve and to maintain their reading, writing and mathematical skills. This system required large bandwidth for video downloading resulting in low reliability. Stewart et al. (2007) proposed a library for teaching the ASL. This library was available on the ASL website. Although it supports small-sized movies, the reliability is still low. Also, Shohieb et al. (2009) proposed an e-learning system for deaf Arab students to give them equal rights in learning. Also and Abo El-Soud, Shohieb (2010) proposed a web accessibility framework specified for many disabilities and its case study for the deaf. Moreover, Shohieb et al. (2010) proposed a dictionary system specified for the deaf students to provide them with lifelong learning. Additionally, Carrillo-

Ramos et al. (2008) presented the functional prototype of such a system that organizes and the content of a course.

As a result, to the best of our knowledge, there is no available system that makes use of the gamification techniques to build a learning system for teaching the Arab deaf.

The Proposed E-Learning Framework for Teaching Mathematics to Deaf Students Design

In "Human Computer Interaction" (HCI) field, to design a gamified system, we should follow the "Player Centered Design" steps (International Design Foundation 2016; Anderson 2011)

- 1) Identify your player
- 2) Identify the task
- 3) Recognize motivation technique for the human
- 4) Perform mechanics
- 5) Manage, audit and measure



Figure 2: The general components for the proposed Gamified E-learning System for deaf students

To design the proposed "Gamified" learning system for teaching mathematics to deaf, there are many components that will collaborate together and are integrated with the "Player Centered Design" steps. The general components are shown in Figure 2 and followed with explanation for each component in details.

Component 1. Content

That contains the mathematics course specification, course structure, quantity, depth, and activities. In our proposed framework, the content will range from components of numbers (ex; five consists of 3&2, 4&1, or 5&0) to proportionality (ex; $\frac{3}{4} = \frac{9}{12} = \frac{12}{16} \dots$ etc).

Component 2. Arabic Sign Language Avatar

Many research (Shohieb et al. 2010; WFD 2003; Riad et al. 2012; Riad et al. 2013; Riad et al. 2014; Abo El-Soud, Shohieb 2010; Shohieb et al. 2015; Shohieb 2016; Shohieb et al. 2012; Shohieb et al. 2009) concluded that the deaf people have many difficulties regarding accessing written information on the web. Consequently, we designed an attractive avatar acting SL that can be used in some context to facilitate the explanation and demonstration process for the users. The designed ArSL avatar was designed as a girl with simple clothes and simple haircut. Also, it was designed to support more clarity, interactivity, accessibility, motivation and integration for the deaf-muted students with the system. The intention to add such avatar is that the advanced content of mathematics contains some expressions which may be impossible to understand alone without assist of an agent (in our case the ArSL acting Avatar). Therefore, the proposed framework will reach to fulfilling the psychological satisfaction of the intended users. Table 1 shows some animated mathematical Arabic signs that our avatar performs.

Table 1: Some Animated Mathematical Arabic Signs That Our Avatar Performs

			
الارتفاع / <i>height</i>	العرض / <i>width</i>	نصف / <i>half</i>	المثلث / <i>triangle</i>
			
الطول / <i>length</i>	الضلع / <i>side</i>	استمرار / <i>continuouse</i>	المستطيل / <i>rectangle</i>
			
يساوي / <i>equal</i>	هي / <i>she</i>	هو / <i>He</i>	القاعدة / <i>base</i>
			
سم مربع / <i>Cm Square</i>	عربي / <i>Arabic</i>	مساحة / <i>area</i>	مربع / <i>Square</i>

Component 3. Quality Standards

We will base on quality matters rubric standards (Maryland 2013) that contains the next general standards; "course overview and introduction, learner interaction and engagement, learning objectives (Competencies), assessment and measurement, instructional materials, course technology, learner support, and accessibility."

Component 4. Learner Support

This consists of grading, guidance and feedback. All of these components are supported also in the other components. The grading and feedback are supported in points and continual and immediate feedbacks respectively that are included in the gamification component (is described later). The guidance is supported in the ArSL avatar .

Component 5. Learner Characteristics

That contains the learner goals, prior knowledge of the learner and learning context. It also contains the personalized preferences such as themes, preferred language, and preferred avatar.

Component 6. Gamification Components

The main gamification components that will be used in the proposed learning system for deaf students and activities are shown in Figure 2.

1. Points & Performance Graphs

Points & performance graphs are often used in a reward system to encourage students through exercises and activities. They can be used to drive desired behaviours, reward learners, signify status and even unlock access to new learning stages or rewards. Figure 3 shows the points performance graphs screen designed (in Arabic) to be used in the proposed framework.



Figure 3: Points & performance graphs designed in the proposed framework

2. Challenges, Badges and Achievements

Challenges, achievements and badges can be motivated to innovate faster, do more and work smarter than other competitors. Challenges that are meaningful and difficult for learners with visible recognition will motivate them to reach higher and higher. Figure 4 shows some badges designed (in Arabic) to be used in the proposed framework.



Figure 4: Badges designed in the proposed framework

3. Leader boards

Leader boards motivate learners to pass their peers and excel in addition to boosting repeat visits. Leader boards are in essence, scoreboards that visually display ranking of learners and their progress to help them gauge their performance against their peers. Figure 5 shows the leader board design (In Arabic) that will be used in the proposed system.

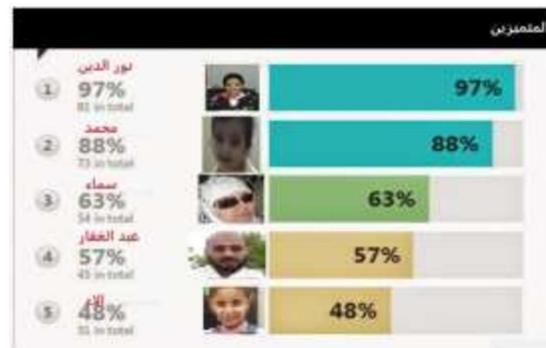


Figure 5: The leader-board design (In Arabic) that will be used in the proposed system.

4. Levels

Levels are a tool to assist a learner in understanding when he has reached an accomplishment or a milestone. Levels can be as an opportunity to provide areas for improvement and meaningful feedback. Figure 6 shows an example from the diagrams level (in Arabic). The question is "which of the following is a triangle?".



Figure 6: An example from the diagrams level (the question is: which of the following diagrams represents a triangle? “in Arabic”).

5. Time-based Activities

By creating scenarios with artificial time pressures like quizzes and countdowns, learners can be motivated to tackle challenges under real-life time constraints. Figure 7 shows a question designed based on time.



Figure 7: A question designed based on time.

6. Continual and Immediate Feedback

It is important for learners to be provided with feedback when they are unsuccessful. This does not only help to motivate learners when there is clear direction for improvement, but it also solidifies the learning.

7. Stories and Characters

Creating characters and stories around learning challenges will help to relate to the learners decisions as the story parts, and how the learning elements fit into the overarching story must be clear. Figure 8 shows the character designed to help the player in his/her journey and acting the questions in the Arabic Sign Language (ArSL).



Figure 8: The character designed to help the player in his/her journey

8. Freedom to Fail

Providing learners with the chance to fail by giving them second chances multiple lives, or alternative methods to succeed is extremely engaging particularly when a learner is motivated to work through a challenge for points or rewards. Figure 9 shows that the user can try again if he/she gave a wrong answer.



Figure 9. An example from the diagrams level (The question is: which of the following operations equals 1?"in Arabic" The button beneath means "try again" and appears when the user gave a wrong answer).

The integration between the proposed e-learning system components and the “Player Centered Design” steps to form the gamified e-learning framework is shown in the following figure.

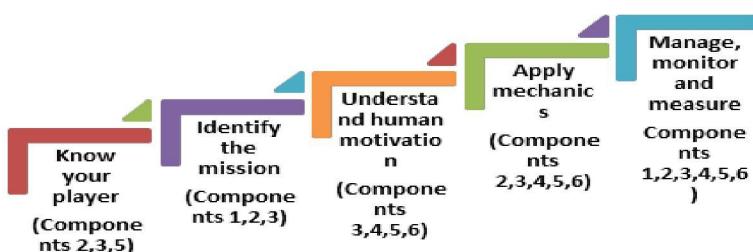


Figure 10: The integration between the proposed e-learning system components and the Player Centered Design steps

Psychological Need Satisfaction

With a view to investigate and analyze the motivational strength of our game design elements, here author is going to take a deeper scan at the motivation research. In this domain, six main perspectives will be featured, to a confirmed stage, that they are pertinent to gamification context; the perspective of self-determination, the trait perspective, the behaviourist learning perspective, the emotional perspective, the cognitive perspective, and the perspective of interest (Astleitner 2000; Krapp 1993).

All these perspectives have inclusions according to the possible effects and functions of gamification (Hense et al. 2014; Sailer et al. 2013), however, it seems convenient to concentrate on a certain perspective for the empirical study. In this research, the self-determination perspective has been chosen, to study the impact of the game-design elements applied in gamification. This option has been based on the truth that the self-determination perspective covers a wide ambit of encouragement techniques that, to some extent, meets several of the other perspectives (Przybylski et al. 2010; Przybylski et al. 2009; Przybylski et al. 2009; Rigby, Przybylski 2009)

In addition to the truth that self-determination perspective was utilized successfully in case of games (Przybylski et al. 2010; Przybylski et al. 2009; Przybylski et al. 2009; Rigby, Przybylski 2009; Męarz et al. 2011; Ryan et al. 2006). It as well asserts the environmental importance in spurring motivation (Deci; Vansteenkiste 2004) fructifying our proposed environment including game design elements, as gamification does, promptly adjust that environment. Consequently, that affects the psychological and motivational user experiences.

Three basic intrinsic and psychological needs that have been presupposed within self-determination theory; the autonomy need, the social relatedness need, and the competence need (Deci, Ryan 1985; Ryan 1995; Ryan, Deci 2002). (1) The competence need refers to feelings of success and efficiency whilst he/she interacts with the environment (Vansteenkiste, Ryan 2013; White 1959). It is presumed that each individual militates to feel competent while affecting the environment he/she interacts with. (2) The autonomy need points out to the strong wish and the psychological freedom to fulfil a particular task (Broeck et al. 2010; Vansteenkiste et al. 2012). While psychological freedom points out to feel of making decisions based on person's own interests and values (Ryan, Deci 2002), the strong wish (volition) points out to the feeling of working without extrinsic enforcement or pressure (Vansteenkiste et al. 2010). Thus, autonomy refers both to (a) task meaningfulness, which includes that the trajectory of action at hand stratified with user's goals and attitudes. (b) Decision freedom, that denotes being able to pick out between several scenarios of action. (3) The social relatedness need points out to human's attachment sensation of care, in relation to a set of considerable others, and belonging. This symbolizes the main willingness of the individual for strong consolidation with the social environment (Deci; Vansteenkiste 2004; Deci, Ryan 1985). Those three intrinsic psychological needs are resources of motivation that would be modified by adjusting the environment. Consequently, motivational behaviour patterns can be corroborated to a considerable degree by mainly addressing one's need for competence, autonomy, and social relatedness (Ryan 1995).

Corresponding Game Design Elements With Psychological Needs

As the elements of game design are used to modify non-game contexts (the proposed learning environments), that can intently direct techniques of motivation. "Psychological need satisfaction theory" (Vansteenkiste, Ryan 2013; White 1959) can be utilized to study the impacts of those modifications. From an abstract point of view, subsequently, the emanating question is which particular elements of game design can address specified psychological needs which. Based on the list of game design elements examined before, author supposes that the competence need can be addressed by badges, leader-boards, points, or graphs of performance (Hense et al. 2014; Sailer et al. 2013). Badges and leader-boards consider a series of player actions to furnish cumulative feedback. Points give the player granulated feedback, that will be directly joint with the actions of him/her. Performance

graphs show the player's progress visually over time, that way providing validated feedback (Vansteenkiste et al. 2010). Thus, mainly, it is the feedback function of those elements of game design that can summon competence up feelings, as that conveys a player's actions success directly.

The autonomy need implies two parts: experiences of task meaningfulness, and experiences of decision freedom. In the 1st part, (autonomy regarding task meaningfulness), stories play a substantial role. Stories encourage player to try his/her own actions as volitionally and meaningful engaging (Rigby, Ryan 2011) In the second part (autonomy regarding decision freedom), avatars can be pertinent, because they can offer the player choice freedom (Rigby, Ryan 2011; Peng et al. 2012; Annetta 2010; Sailer et al. 2017; Diana et al. 2011). Ditto, the social relations need should be influenced by a story if it offers a narrative scope in which players are given significative roles. A summary of the previous evidences regarding the question of how specific elements of game design can be utilized in different psychological needs, is shown in *Table 2*.

Table 2: Elements of Game Design With Matching Psychological Needs

Psychological need	Technique	Element of Game design
Competence Need	Sustained feedback	Performance graphs
	Granular feedback	
	Cumulative feedback	Points
	Cumulative feedback	Badges
		Leaderboards
Autonomy Need(decision freedom)	Choices	Avatars
Need for autonomy (task meaningfulness)	Volitional engagement	Meaningful stories
Social relatedness Need	Sense of relevance	Meaningful stories
	Shared goal	Leaderboards

Conclusion And Future Work

According to the WFD (WFD 2003) in addition to our past research with hundreds of Arab deaf-muted people along ten years (Riad et al. 2012; Riad et al. 2013; Riad et al. 2014; Abo El-Soud, Shohieb 2010; Shohieb et al. 2015; Shohieb 2016; Shohieb et al. 2012; Shohieb et al. 2009) we have reached that approximately 80% of the deaf-muted people are undereducated, illiterate or semi-literate. Ditto, deaf people have many difficulties regarding accessing written information on the web and difficulties in understanding the general context. Thus, deaf have low education levels due to the lack of accessibility in the current education system. Consequently, the proposed framework aims at developing a gamified based e-learning system for teaching a difficult subject, such mathematics, to the Arab deaf students. Our framework is supported with an acting Arabic Sign Language (ArSL) acting avatar to support more clarity, interactivity, accessibility, motivation and integration for deaf-

muted students with the system. Therefore, the proposed framework will reach to fulfilling the psychological satisfaction of the intended users. The designed framework will be implemented to deaf-muted community; therefore the framework will be modified as required.

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