Dental Research Today

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Review

View Article Online

Received 14 September 2024
Revised 16 September 2024
Accepted 18 September 2024
Available online 20 September 2024

Edited by Mohmed Isaqali Karobari

KEYWORDS:
Game Based Learning
Synthesis matrix framework
Gamification
Gamify dentistry
Digital games
GBL & SMF in dentistry

Dental Research Today 2024; 1 (1): 38-44
https://doi.org/10.53365/drt/193486
eISSN: XXXX-XXXX

A Concept Centric Synthesis Matrix Framework (SMF) on the application of Game-based learning (GBL) as an emerging paradigm in the curriculum of dentistry

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ABSTRACT:

Background:The advancements in digital technologies and globalization in dentistry demands for anew innovative way of teaching learning methodologies to shape our students to perceive high intellectual skills & critical learning abilities in Indian education system. Few empirical studies have contextualizedGame Based Learning (GBL) to achieve this herculean task. This review aims to offer a concept centric synthesis matrix framework (SMF) to synthesize few evidence-basedstudiesongame basedlearning&gamification, to conceptualize theories and understand the hypothesis involved in game dynamics for increasedstudents'involvementinlearning.

Methods : The search strategy was initiated using PRESS in databases such as Pubmed/Medline, Embase, Scopus & was conducted with language restriction (English) & time restriction (2010-2020). Publications included in the review spanned to original studies in domain of teaching module applying game-based learning (GBL), excluding article with language other than English & review articles

Results: All the studies synthesized by SMF inferred higher cognitive outcomes using GBL with excellent understanding of the subject & increased academic scores.

Conclusion: Game-based learning (GBL) & gamification can be a new platform that can create an extra level of motivation and increase learners' cognitive development. The application of SMF can act as a guiding tool to identify the knowledge gap from the existing literature for future scope in research & hence should be considered as a preliminary exercise prior to the conduction of SLR or scoping review.

1. INTRODUCTION

The rapid advances and revolutionary change during the 21^{st} century with digitalization & globalization have changed how the students learn and think differently. Today's students have grown up with digital technologies that have broken traditional boundaries, thereby demanding a change from traditional lecture-based unilateral passive learning methodology to active techno-savvy experimental learning methodology (Cheng & Su, 2012; Deterding et al., 2011; Kanthan & Senger, 2011). Based on the present milieu of ongoing reform in dental education, it is of paramount importance to shape our students as critical thinkers with profound knowledge to perceive high order thinking intellectual abilities to develop curious minds leading to an innovative ecosystem in Indian education. This can be achieved by contextualizing games in academic curriculum with an entirely new approach of game-based teaching learning (GBL) methodologies. In this review, we have applied a concept centric synthesis matrix framework (SMF) to synthesize few evidence-based studies on game-based learning (GBL) & gamification in the discipline of health education with the aim to conceptualize theories and understand the hypothesis involved in game dynamics for increased students' involvement in learning. The application of SMF can act as a guiding tool to identify the knowledge gap from the existing literature for future scope in research. Before initiating this framework, a brief summary on terminologies on game based learning & gamification, components of game pyramid, canonical theories involved in game dynamics are discussed for basic understanding on interlink between students learning abilities and their involvement.

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2. WHAT IS GAME-BASED LEARNING (GBL) & GAMIFICATION?

Game-Based learning is defined as a new innovative method of teaching educational material in a playful lucid way. Contextualizing games in the academic curriculum can create an extra level of motivation and increase the learners' cognitive development (Bigdeli, 2016; Jui-Mei, 2011). GBL in dental education can be part of behavior change gamification wherein the students, being the players, are involved in learning by increasing their involvement in institutional libraries, thus solving the problem of most of the librarians who could not raise the student's attendance in using the library. In 2011, Sukovic et al. inferred that the application of games and its various tools used in library websites could improvise the more efficient functioning of libraries (Sukovic et al., 2011). Radhakrishnan et al. in 2013 also inferred that utilizing gamify services in the library websites can increase and boost a greater number of students involvement. Hence, the institutes should now recognize its potential and incorporate them as "library gamification tools" (Radhakrishnan, 2013). The basic principles on which GBL works are intrinsic motivation, contextualized learning, and autonomy. The game mechanics involved should be simple with rules and clear goals and should have specific interactions (items) with progressively difficult levels and constructive feedback (Blascomolla et al., 2015).

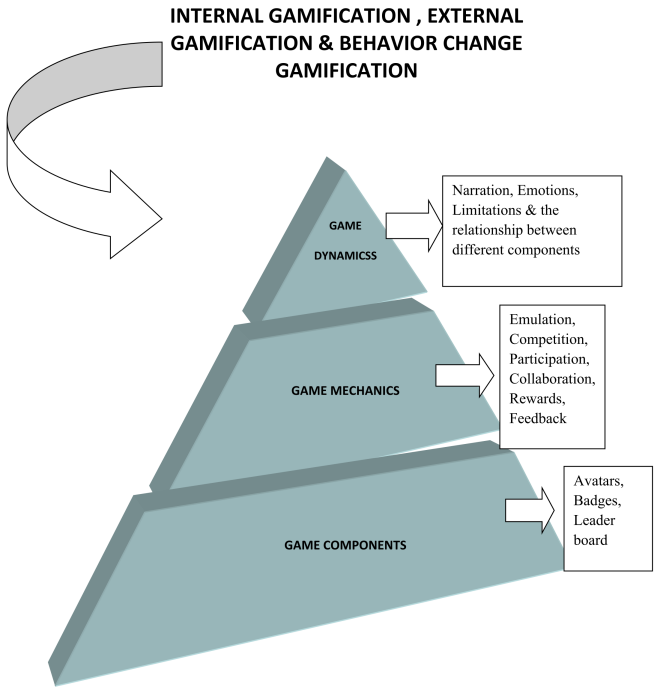

Figure 1. Depicting the different forms ofgamification and their associated components.

Deterding et al. in 2011 defined gamification as "a use of online and video game elements in non-game contexts to improve users' experience and increase their engagement" (Deterding et al., 2011). Nick Pelling first described this notion of gamification in 2002 (Kuutti, 2013). There are three types of gamifications: internal gamification, external gamification, and behavior change gamification. Internal gamification involves small organizations where games are designed to improve the efficiency of the organization. It is also known as "Enterprise Gamification." External gamification involves organizations' marketing goals, thus improving the relationship between the users & offered services. Behavior change gamification involves games that create useful atomic habits for the players, such as education systems, libraries, and health services (Bigdeli, 2016). To achieve these three forms, gamification experts Werbach & Hunter in 2012 have introduced the Game Pyramid.

3. GAME PYRAMID & ITS COMPONENTS

It involves three major elements, i.e., Game Dynamics, Game Mechanics, and Game Components. Game dynamics are located at the top area of the pyramid and forms the essential core of each gamified operation based on developing games' mechanics. It includes narration, emotions, limitations, and the relationship between different components (Kuutti, 2013; Schönen, 2014; Wu, 2011). Game mechanics lead to players' uniqueness and include emulation, competition, participation, collaboration, uncertainty, rewards, feedback, and interactions. Wu (2011) Game elements include the competencies such as levels, avatars, badges, leader board, points, etc., used by the game users (Kuutti, 2013) (Figure 1).

4. CANONICAL THEORIES ON GBL

4.1. Self Determination Theory

Ryan and Deci (2000) put forth the theory of self-determination (SDT). Based on three main characteristics, i.e., amotivation, intrinsic motivation, and extrinsic motivation. This concept emphasizes the idea that all humans are proactive and have a sincere wish to develop internally (our core self). However, external factors, like money or competition, lead to a separable outcome. Additionally, this theory also focuses on three basic physiological needs- autonomy, competence, and relatedness. The individual's tendency to do his/her activities freely is called autonomy, whereas competence alludes to the individual's ability to do a task. Relatedness is the beseech to interact with others as a form of social influences (Brühlmann, 2013; Csikszentmihalyi, 1990; Ryan & Deci, 2000) (Figure 2).

4.2. Flow Theory

In 1990, a psychologist named Csikszentmihaily proposed a theory based on flow. He defined flow theory as "an operation in which a person performing an activity is fully immersed in a feeling of energized focus, full involvement, and enjoyment in the process of that activity." He observed the work of painters who got immersed in their activity in depth who eventually ignored their need for food, water, sleep, etc (Csikszentmihalyi, 1990).

Table 1
The SMF is to synthesize evidence based empirical studies on Game based learning (GBL) & Gamification in discipline of health education. The framework involves rows and columns. Each row represents Source information (SI) element timecentred (Year of Publication), Role Centred (Author, Source/Citation) & Outcome of Each Paper. The column represents the Argument Matrix (AM) element.

ARGUMENT MATRIX ELEMENT (AM)	**"SMF FRAMEWORK" SOURCE INFORMATION ELEMENT (SI)**		
	Year	**References**	**Study Outcome**
The unilateral knowledge acquisition using the traditional power point method has failed to understand how the present generation students learn and think differently. As per the ongoing reforms in dental education, the need to develop critical thinkers is the need of an hour. Contextualizing games in academic curriculum can be one of the best solutions to achieve this herculean task.	2019	Friedrich et al. (2019)	An randomized experimental pilot study was conducted among students admitted in the first semester of Dentistry at Goethe University Frankfurt am Main. A total 0f 25 students (9 –M; 16 –F) with an average age of 23.8±2.02. The learning module was named "Jeopardy." The sample was divided into two groups, i.e., an active participant (players group) and passive participants (listeners group). The player group was subdivided into four groups, and two consecutive quiz show sessions were held wherein a buzzer that emitted acoustic and visual signals was provided. The participants had the opportunity to choose 30 sequential questions. These were further divided into categories of varying difficulty (increasing points for correct solutions). The listener group passively watched as spectators. Pre /post-test with 39 MCQ questions were formulated. The pre-test was given one day before the game. A time duration of about 15 minutes was given for the task. One day after intervention, a post-test was conducted with 15 minutes duration. Statistical analysis was done using SAS 9.1 (SAS Institute Cary, NC, USA). The pre-test score of group 1 was 23.07±6.61, and group 2 was 20.58±4.38) inferring an improved overall performance score of about 2.08 points.
	2016	Malik et al. (2017)	A study was conducted to assess the knowledge about oral health education and oral hygiene status using a game-based method and conventional method among school children admitted at elementary school in Lucknow, Uttar Pradesh, India. A sample of about 150 children of 8-12 years was selected, applying the table of random numbers. The sample were divided into 2 groups- Group 1/ conventional method (n=75) and group 2/ game-based method (n =75). Conventional /group 1 implemented the PowerPoint presentation on oral health education taken once daily for seven days. Game-based /group 2 was implemented using a quiz or crosswords using PowerPoint presentation. The knowledge assessment was done using a 15-item structured questionnaire, and Cronbach's alpha and split-half reliability values were found to be 0.81 and 0.88, respectively, for validation. The knowledge cores of 10.32 and 9.98 were found in group 2 at one and 3-month intervals, respectively, inferring the high improved knowledge score using the game-based method.

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Table 1 continued

	2013	Boeker et al. (2013)	An RCT study was conducted as per the guidelines of CONSORT 2010 statement, applying game-based e-learning method on winter semester 2008/9 among 145 third-year medical students in Department of Urology at the University Medical Center Freiburg, Germany. After approval from the ethical committee, the study sample was divided into two groups: the GbEl group (82 participants) and the Script group (69 participants). For the script group, the topic designated as – "Phase-contrast microscopic urinalysis on native urine," and for the GbEl group, an electronic game named Uro-Island was developed using open source Wintermute game engine under the GNU Lesser General Public License. Informed consent was taken from each participant, samples were randomly divided using the lottery method, and power analysis was applied for allocation concealment. The students in the script-based approach were provided with three exemplars of 8-page writing that included the following learning objectives: Introduction on the sampling of native urine, application of phase-contrast microscope, morphology of micro-organisms, and microscopic findings of diseases like cystinuria, hematuria, sterile leukocyturia, etc. that are important to know as general practitioners. The game player had to control and navigate the game character and engage in dialogues with non-player characters and complete the quests. The learning measures/outcomes were measured with 34 item single choice test questions, and the internal consistency of each item was calculated using Cronbach's α. Statistical analysis was done using Cohen's Kappa and regression analysis. The means and standard deviations for the script group were 26.0 (3.99), and the GbEl group was 28.6 (3.53). Cohen's d effect size was about 0.71. Likert scale was used to measure students' attitude towards the game-based learning that showed higher cognitive learning outcomes.
	2012	Creutzfeldt et al. (2012)	A quasi-experimental transfer study design was conducted among thirty-six medical students at Karolinska Institute and Hospital, Stockholm, Sweden. After approval from the ethics committee, the study sample was divided into three groups. Among these groups, two groups were pre trained (6 and 18 months) before assessing the topic selected, i.e. Multiplayer Virtual World - cardio-pulmonary resuscitation. The control group had no training on this topic. They divided the study into 2 phases, in which the first phase focused on a rehearsal lecture of 10 mins duration. The second phase was training about the game model using various avatars of 20 mins duration. Pre and post-test, consisting of 10 items, were formulated to assess the knowledge, and the data collected were subjected to statistical analysis. The six-month group showed more excellent CPR related understanding than the 18 months and control group.

Continued on next page

Table 1 continued

2011	Cendan and Johnson (2011)	An RCT study was planned to teach Shock Physiology (medical curriculum) based on web-based and mannequin simulators with the aim to see the association between the latest technologies and their impact on learning outcomes objectively. The samples were divided into two groups – web-based group and mankin based group. This technology was made available in a beta version by its developer, Dr. Craig Knoche, at http://www.physiosim. org/. Students used newer applications like slide bars, self-guided tools, etc. Scripts were given on the topic selected. The study was assessed using 30 items MCQ s using survey money, and the attitude of the student's perception towards the study was done applying the Likert's scale. Statistical analysis was done using Mixed-model ANOVA & IBM SPSS/PASW Statistics 18. The study results concluded that the educational impact observed from these novel approaches could improve the human cognitive architecture with excellent fidelity.

Csikszentmihaily stated this flow as a buoyed experience, i.e., doing something for its own sake that was in concordance with Brühlmann in 2013 defined it as "the optimal experience, a state of mind and body with absorption and enjoyment" so when everything comes together, and we feel focused and involved in the task, we experience flow (Brühlmann, 2013). He hypothesized the theory based on three factors Personal factors based on causality orientation ; Situational factors based on rewards & Contextual factors based on goals (Figure 3).

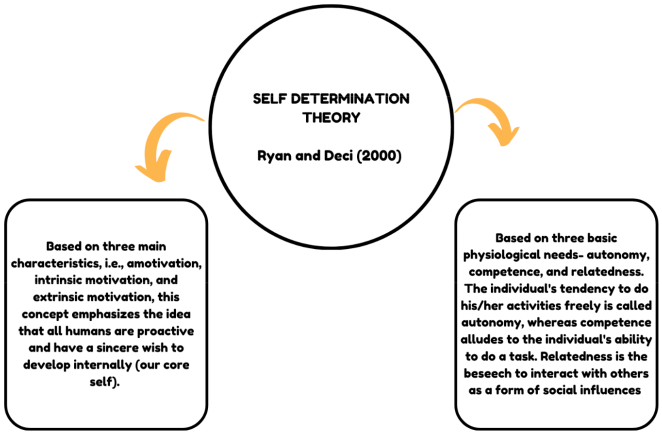

Figure 2. Concept Mapping on Self Determination Theory (SDT).

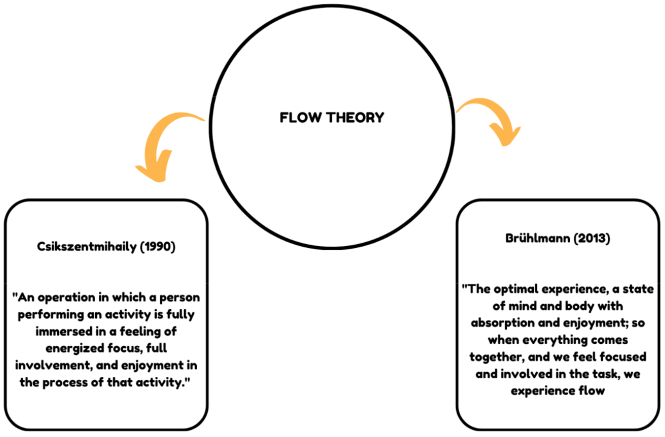

Figure 3. Concept Mapping on Flow Theory.

We applied Synthesis Matrix Framework to synthesize evidence-based studies on game-based learning & gamification in the discipline of health education with the aim to conceptualize theories and understand the hypothesis involved in game dynamics for increased students' involvement in learning (Table 1). The importance of applying this framework is to identify the research gap on existing literature so as to develop a conceptual framework based on the argument matrix (AM) element by accurately scoping empirical studies in an organized and systematic approach. This can lead to hypothesis generation and hypothesis testing and hence it should be considered as a preliminary exercise prior to the conduction of SLR or scoping review.

5. CONCLUSION

This SMF review can help researchers to explore the GBL as a new innovative teaching method that can be contextualized in the academic curriculum, thus creating a new platform for learning dentistry in a fun way. However, more experimental randomized control trial or quasi-experiment design should be conducted using various software, and its subsequent impact on learning performances should be evaluated.

CONFLICTS OF INTEREST

All the authors associated with the present manuscript declared no potential conflicts of interest concerning the research, authorship, and publication of this article.

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FUNDING

The author received no specific funding for this work.

AUTHOR CONTRIBUTIONS

Both authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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