IJWR

$(DG)^2DP$: A New Process for Digital Game and Digital Gamification Development

Fakhroddin Noorbehbahani
Faculty of Computer Engineering, University of Isfahan, Isfahan, Iran; noorbehbahani@eng.ui.ac.ir

ABSTRACT

Although there are several development processes for creating entertainment games, serious games, and gamified solutions, there is a need for a new consolidated process capable of developing different types of computer games and digital gamified solutions. This study covers the topic of computer games and gamified solutions design and development processes. First, processes of computer entertainment game production are introduced and investigated. Second, the paper describes gamification and serious game development processes. Finally, this study presents a new process called $(DG)^2DP$ to develop entertainment and serious computer games as well as digital gamified solutions. Two methods have been employed to evaluate the proposed game development method. First, the proposed process is assessed by 42 game development practitioners through an 8-factors questionnaire. Second, 16 experts that have applied the process are requested to rate the extent to which they would recommend the $(DG)^2DP$ to other game developers. The evaluation results show a 28.39% higher score for $(DG)^2DP$ than other processes. Furthermore, in comparison with other development processes, 81.25% of respondents agreed and strongly agreed to recommend the $(DG)^2DP$ to other game developers.

***Keywords*— *Video game development, Serious game, Gamification, Game design, Design thinking*.**

1. Introduction

In 2021 the global video game market size reached $195.65 billion, and the predictions imply a compound annual growth rate (CAGR) of 12.9% from 2022 to 2030. Hardware and software progression, the advancement of smartphones, and the growing internet penetration rate contribute to the growth of the video game market [1]. The value of the serious games market by gaming platform (smartphone, console, PC, etc.) in 2020 was $5.94 billion, that reaches $32.72 billion by 2030 with a CAGR of 18.47% [2]. The global gamification market size is predicted to reach $58.8 billion by 2028, registering a CAGR of 26.8% [3].

While entertainment games usually have broader target audiences, serious games and gamification are applied in more specific contexts, consequently, they have more specific and narrow audiences. Hence projects corresponding to developing serious games and gamified solutions, require a lower budget and expect lower ROI (Return of Investment). Entertainment game markets are mostly B2C (Business-to-Consumer), whereas serious game and gamification markets are often B2B (Business-to-Business) [4].

The growth of the computer game industry increases the interest in how games are actually developed. In the game industry, there are several guidebooks for developing computer games, however, less academic research has been conducted regarding development processes [5].

Compared to software development, game development is more challenging due to the multidisciplinary nature of game production. The game production activities entail the cooperation of artists, animators, game designers, level designers, musicians, and programmers, whereas software product development includes activities focused solely on developing and testing software [5]. To produce purposeful games and gamified solutions, further cooperative work is required because domain experts should also be involved in the development process [6].

http://dx.doi.org/10.22133/ijwr.2024.448619.1209

Citation. F. Noorbehbahani, "$(DG)^2DP$: A New Process for Digital Game and Digital Gamification Development ", *International Journal of Web Research*, vol.7, no.1,pp.1-17, 2024, doi: http://dx.doi.org /10.22133/ijwr.2024.448619.1209.

**Coressponding Author*
Article History: Received: 14 November 2023 ; Revised: 3 January 2024; Accepted: 16 January 2024.

A literature review on video game production indicates that the existing frameworks and processes only considered limited aspects of game production, therefore, a holistic process is required that supports every aspect of video game development, including pre-launch and post-launch ones [7]. Likewise, developing serious games is not straightforward and different aspects should be considered that make the production complex [4]. Applying a proper formal process for gamification development is a vital success factor, and using ad hoc approaches might be unbeneficial [8].

Although there are several development processes for creating entertainment games, serious games, and gamified solutions, there is a need for a new consolidated process capable of developing different types of computer games (entertainment games, serious games, and gamified solutions). This process should be practical, learnable, straightforward, and flexible, while supporting collaborative work, complex problem solving, and creativity.

The practical values of such a process for those companies and developers that produce different types of computer games are as follows:

- The same process could be applied to develop different computer games, so managing the production projects become more straightforward, and there is no need to use multiple development processes.
- The production efficiency is increased, and the productivity of the development team is boosted because of less training required and less distraction for switching between multiple processes.
- The well-defined process specifies the steps required to develop computer games and define the project phases while allowing the development team to customize the details of implementing the steps.
- The process supports all stages of the computer game lifecycle (pre-production, production, and post-production).
- The consolidated process facilitates the collaboration of in-house and outsourced teams for developing computer games.
- The objectives of the presented study are as follows:
- Review and compare various development processes corresponding to digital entertainment games, serious games, and gamification.
- Disambiguate and clarify some terms, concepts, and definitions related to computer games, serious games, and gamification.
- Present a new process to design and produce computer games and gamification.

This study covers the topic of computer games and gamified solutions design and development processes. First, processes of computer entertainment game production are introduced and investigated. Second, the paper describes gamification and serious game development processes. Regarding the review results, some terms and definitions related to computer games and gamification are disambiguated and clarified. Finally, this study presents a new process called $(DG)^2DP$ (Digital Game and Digital Gamification Development Process) to design and produce entertainment and serious computer games as well as digital gamified solutions. The proposed process is evaluated and compared with other computer game development processes.

The paper is organized as follows. Section 2 describes the study methods, including literature search, design methodology of the proposed game development process, and experiment design. In section 3, a literature review is conducted in which terms and definitions, literature review results, and a comparison of development processes are explained. Section 4 describes the proposed game development process, the evaluation results, and a case of the proposed process application. Finally, section 5 concludes the paper and gives some perspective for future work.

2. Methods

In this section, methods related to literature search, designing the proposed development process and evaluations are described.

2.1. Literature search

To review existing computer game and gamification development processes, the following search query was employed to extract the related studies from Google scholar, Science direct, Springer, IEEE Xplore, Wiley, and etc.

Search query: (computer OR video OR digital) AND (game OR gamification OR serious game OR gamified solution OR purposeful game) AND (production OR development OR creation OR design OR generate) AND (process OR model OR method OR framework OR methodology).

The main criteria for the publications considered in the current review are as follows.

Inclusion criteria:

- Studies which have defined stages and activities related to game production.
- Studies should be written in English.
- Records should be retrieved utilizing the designed search query, and related cited work.
- Exclusion criteria:
- Studies that are related to analog, physical, and board games production.
- Low-quality studies (i.e., published by non-reputable publishers without peer review, too short review time, and so on, studies with poor theoretical background, experimental evaluation, or structure).

2.2. Design methodology of the proposed game development process

Before explaining the design methodology, it is necessary to clarify the process, phases, stages, and steps. As depicted in Figure 1, "process", "phase", "stage", and "step" terms are employed to represent first-level, second-level, third-level, and fourth-level processes, respectively.

To design the (DG)²DP, first, entertainment (general) computer game development processes are reviewed to extract phases and steps. Next, phases and corresponding steps are integrated to form a complete development process incorporating all game lifecycle phases. To integrate phases, some phases are merged, and the same term was employed for those phases having different names but similar concepts. Likewise, a list of all steps needed to develop entertainment computer games is determined. After investigating serious game and gamification development processes, the corresponding lists of steps were extracted and integrated. Then, all the resulting steps, together with author-designed ones, were consolidated, and assigned to the integrated phases. The steps were grouped into stages, if possible, and after multiple revisions and refinements, the (DG)²DP was defined. Figure 2 displays the design methodology of the proposed game development process.

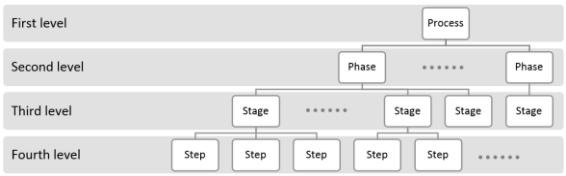

Figure. 1. process hierarchy

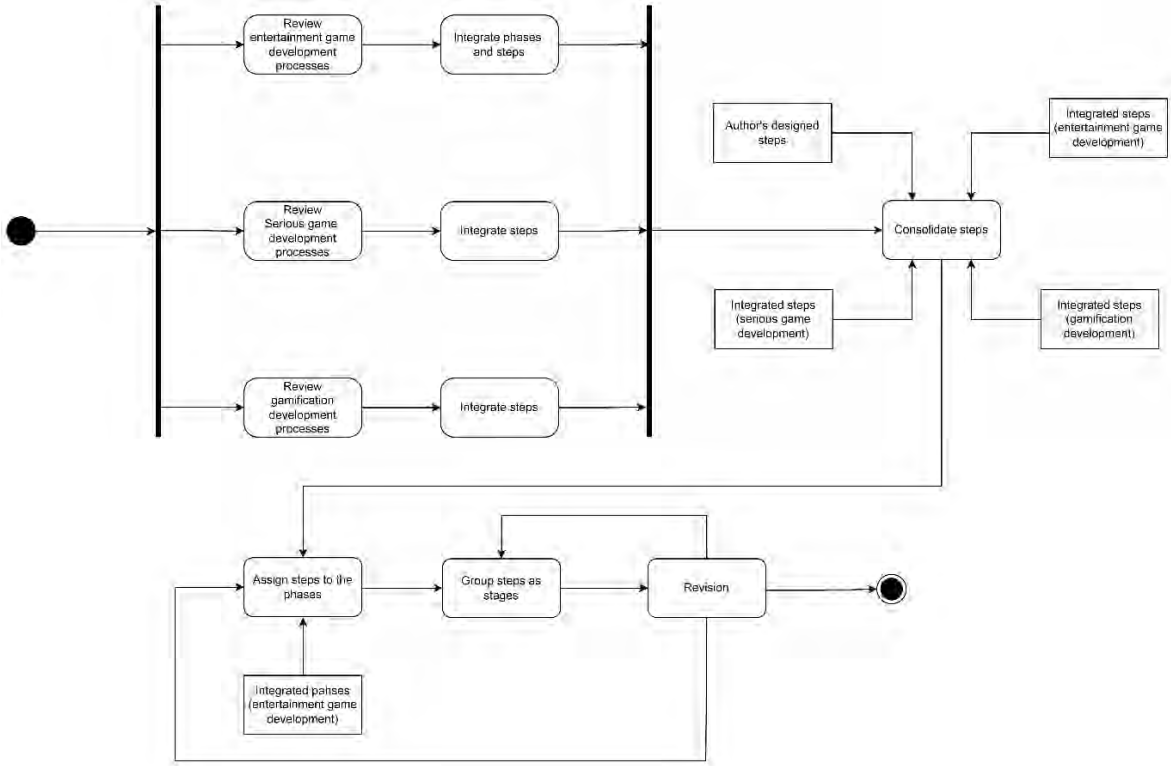

Figure. 2. Design methodology of the proposed game development process

2.3. Evaluation design

Two evaluations have been conducted to gauge the effectiveness of the proposed game development process. In the initial assessment, a group of game practitioners evaluated the $(DG)^2DP$ and their own development processes or recommendations using a 5-point Likert scale. The utilization of close-ended questions streamlined responses, making it easier and quicker to gather measurable and quantitative data. Furthermore, respondents displayed a higher inclination to engage with Likert scale questionnaires. A comprehensive list of candidates, all seasoned in computer game development, was curated. This list was initiated by consulting with game production experts to recommend candidates, which was then expanded based on further suggestions and outreach to game production companies. To solicit responses, candidates were provided with a questionnaire link and a 30-minute instructional video detailing the $(DG)^2DP$.

In the first evaluation, 8 factors were employed to evaluate the proposed game development process, explained in Table 1.

In the subsequent evaluation, experts who had implemented the process in developing computer games assessed its efficacy. They were prompted to rate their likelihood of recommending the $(DG)^2DP$ for various types of game development, including entertainment games, serious games, and gamification, compared to other development processes they were familiar with, using a scale from 1 to 5.

Table 1. Evaluation factors

Factor	***Description***
Learnability	The process capability to enable the user to learn how to apply it.
Flexibility	How easily the process handles changes during computer game development.
Effectiveness	The effectiveness of the process of developing computer games.
Clarity	To the extent to which the process activities and steps are clear and unambiguous.
Creativity-support	How far the process supports creativity and innovation in game development.
Complexity-support	The ability of the process to solve complex problems during game development.
Collaboration-support	The potential of the process to support collaborative work.
Comprehensiveness	The capacity of the process to develop different types of computer games, including gamification, serious games, and entertainment games.

3. Literature review

In this section, related terms and definitions of different types of computer games are clarified. Next, the literature review results and their comparisons are presented.

3.1. Terms and definitions

The terms “video games” and “computer games” are commonly used interchangeably by researchers such as Li [9] and Sardone et al. [10]. For instance, Li states the following definition: “video game: also called computer games or digital games, refers to a variety of interactive games played on different display platforms, for example gaming device, television, or mobile device” [9]. However, some game researchers and practitioners believe that computer game is a subtype of video game [11]. Video games include the games run on PCs (Personal Computers), consoles, arcade machines, and other platforms.

Because computers emerged in 1970, early games run on consoles and arcade machine platforms (with limited memory and processing power) were referred to as video games [12]. These platforms are types of computers; thus, it makes sense to consider both terms equivalent. Recently, other computer game platforms have emerged, such as, smartphones and smartwatches, tablet computers, virtual and augmented reality systems, smart TVs, web browsers, and remote cloud gaming.

As defined by Marczewski [13], game thinking is “The use of games and game-like approaches to solve problems and create better experiences”. Game thinking includes four categories: gamification (a.k.a gamified solution design), game inspired/playful design, serious and (entertainment) games. The categorization is based on two factors. The first factor is concerned with the principal objective of the game (sole entertainment vs. other primary purposes), and the second factor pertains to gameplay (incorporating gameplay vs. no gameplay). Both serious games and entertainment games contain gameplay, and they are complete games. Gamification and game-inspired/playful design, apply gaming elements to incorporate into products and services, they don’t include gameplay [13]. Serious games and gamification are both developed for primary purposes other than fun or entertainment [14][15][16], while games and game-inspired design aim to entertain players and users.

This study focuses on the production of computer games, and the game development processes for entertainment and serious computer games are investigated. Hence, analog and purely physical games, such as card games, board games, role-

playing games, group activities, and so forth, are not covered in this study. It is worth noting that gamification and game-inspired design could also be classified as digital and analog. Digital gamification refers to online gamification incorporated into websites or gamification applied to any computer software and mobile applications [17]. Like entertainment and serious games, only digital gamification development processes are discussed in this paper.

Deterding et al. [18], believe that gamification represents an unspecified group of phenomena complex of gamefulness, gameful interaction, and gameful design, however, it is different from playfulness, playful interaction, or design for playfulness concepts. The authors define gamification as follows: "gamification is the use of game design elements in non-game contexts". Gamification relates to games, not play (or playfulness), and there is a distinction between game and play in game studies. Gaming and games (in contrast to playing and toys) are conducted by explicit rule systems and characterized by the competition or strife of actors towards discrete goals or outcomes. Gamified applications are rule-bound and goal-oriented, with little space for open, exploratory, free-form play. The authors categorize gamification-related concepts based on gaming/playing and parts/whole dimensions. Table 2 displays game thinking categories based on four factors.

Nicholson [19], introduced the concept of meaningful gamification: "meaningful gamification is the integration of user-centered game design elements into non-game contexts". The author believes that user-centered design prevents designers from creating meaningless, or even harmful, gamification. The user-centered design ensures that the user's needs and goals are the primary consideration at every stage of the game development process. Instead of relying on points and external rewards as a gamification mechanism, the game design elements can be made meaningful to the user through information. Thus, internal motivation is enhanced, and there is less need to focus on external motivation.

Regarding computer game development, some expressions and terms have been inconsistently employed by researchers/developers, and there is no standard definition. The terms "framework", "model", and "process" are not applied uniformly in the computer game development context, which results in confusing the readers. Regarding computer game development, in this study, the following definitions are taken into account.

Table 2. Game thinking categories based on four factors

Categories	***Gameplay***	***Purpose***	***Whole/ Parts***	***Gaming /Playing***
(Entertainment) game	Yes	Fun	Whole	Gaming
Serious game	Yes	Primary purposes other than fun	Whole	Gaming
Gamification/ Gameful design	No	Primary purposes other than fun	Parts	Gaming
Game-inspired/ Playful design	No	Fun	Parts	Playing

Framework: a set of concepts, practices, and criteria that help develop computer games.

Model: the essential components, elements, and functions needed to design and develop computer games.

Process: phases, stages, activities, and tasks that should be accomplished to produce computer games together with their sequences and relations.

This study focuses on the processes of computer game design and production.

3.2. Literature review results

In this section, the results of the literature review related to entertainment games, serious games, and gamification development processes are explained. The search result included 98 studies, and 12 studies were chosen after applying inclusion and exclusion criteria.

Entertainment Computer Game Development Processes

Several game production processes could be applied to develop entertainment computer games. Chandler [20], emphasizes four phases in producing computer games, namely Pre-production, Production, Testing, and Wrap-up. In the pre-production phase, the game plan, including the game concept, the features and constraints that affect this concept, and the basic technical and design documentation for developing a game, is generated. Moreover, cost, time, and required teams should be determined in this phase. The pre-production consists of the following components: concept, game requirements, game plan, and risk assessments. The team starts to develop and

code the game in the production phase. This phase might be activated while the pre-production phase is still running. For instance, while some features are being produced in the production phase, other features might be analyzed and planned in the pre-production phase. The production phase comprises plan implementation, tracking progress, and task completion activities.

After production and code release, the game development process should be wrapped up to collect and record any experiences gained by running the current game development process. Learning from experience and archiving the plan are two activities of the post-production phase.

Another computer game development process has been presented by McAllister and White [21], consisting of concept, prototyping, pre-production, production, and Alpha-Beta-Gold phases. Game concepts could be ideated by a publisher or development studio. When both parties agree on the general concepts, the development team starts to prepare a game design document and produce a plan including milestones and financial commitment of the publisher, and the budget for the project. In this phase, incremental product delivery is determined to be evaluated corresponding to the feedback generated by the publisher. Prototyping is applied to assess concepts and different aspects of the game by gettering feedback from stakeholders during the early stages of development.

The pre-production stage starts after the approval of the design to select basic game mechanics and identify the problems. Moreover, in this stage, ideas are evaluated rapidly without getting stuck in the details of the final game to identify any risks. During the production phase, all the game features are fully developed, and QA (Quality Assurance) team tests the game to ensure a high-quality game. In this stage, testing, including functional, usability, and playability evaluation, are conducted.

After completion of the production phase, the Alpha version of the game incorporating all game contents will be generated. Although the contents and features of the game are not of final quality, the game should include all the necessary parts. In the Beta version, all content and features have been completed, however, further minor adjustments might be performed. To convert the Alpha version to the Beta one, the focus is on fixing the bugs and finalizing the game quality. Next, the Beta version is submitted to the QA team to ensure strict technical and presentation guidelines supporting brand recognition and HCI requirements. After the final approval of the QA team, the game is in the Gold version, ready for manufacturing and distribution.

Aktaş and Orçun have introduced six stages to develop computer games [12]. In the first, key features of the game are determined, such as genre, target audience, concept documents, platforms, references, and the development plan. The pre-production stage deals with game design issues, including story and scenario, mechanics, aesthetics, development principles, object-oriented specifications, and game world design (e.g., an island or a house).

In the production/development stage, all the elements and components of the game, including codes, models, sounds, videos, etc., are generated and integrated to form the unified game. The purpose of the post-production stage (also called validation and testing) is to evaluate and validate different aspects of the game, such as mechanics, gameplay, user interface, qualities of audio-visual content, and to what extent the market requirements are met. In the release and lunch stage, the release is delivered to the manufacturer, and the post-release (maintenance) stage pertains to developing patches and upgrades.

Computer game development phases corresponding to different development processes could be summarized as planning, pre-production (design), production (development), and post-production.

Fullerton has introduced a playcentric design process to develop games that could be applied for computer game development as well [22]. This process is based on involving the player in the design process from conception through completion. Iteration is crucial to the playcentric design process, which means designing, testing, and evaluating the results repeatedly throughout the game development to improve gameplay or features until the player experience satisfies the criteria. The game design process includes brainstorming, physical prototype, software prototype, design documentation, production, and quality assurance stages.

Serious Game Development Process

Braad et al. have discussed several methods for designing and developing serious games [4]. The design and development of serious games include several phases with different purposes. The ADDIE is an iterative process that discriminates between Analysis, Design, Development, Implementation, and Evaluation phases [23]. ADDIE incrementally enhances the design and production of a serious game to overcome design and development complexities. Another development methodology and toolkit to develop serious games in higher education is EMERGO relies on ADDIE [24].

Practically, the iterative and cyclic game development processes such as ADDIE are supported by a software development methodology such as Scrum [25] to benefit from incremental development and prototype evaluation throughout the development process.

Kirkley et al. [26], have proposed a Simulation-Games Instructional Systems Design process (SG-ISD) intended specifically for developing educational serious games. They designed game development phases by integrating the Waterfall-model of software engineering and information systems design methods based on the ADDIE model. In the analysis phase, an instructional theory is integrated into the game design. The design phase corresponds to integrating learning methodology and game features. Guidelines for formative evaluation, prototyping and playtesting, and summative evaluation are also provided by their process.

Another process for developing educational serious games based on interactive screenplays has been presented by de Lope et al. [27]. The process focuses on educational games incorporating narrative scripts organized into chapters and scenes. Various game elements are progressively added to the script (e.g., scenarios, characters, fun, educational challenges, etc.). Their proposed process includes pre-phases (design of the educational challenges, design of the type of game, and initial design of the story and main characters) and phases (chapter design, scene design, identification/labeling of educational challenges and assessment, Identification/labeling of emotions, adaptation design, and collaboration design).

Ávila-Pesántez et al. have reviewed several studies to analyze the main features of the serious game design processes in educational games and academic learning [28]. The results indicate 4 main phases and 31 integrated stages for developing educational serious games. This study has not investigated iterative design, user-centric design, or design thinking approaches in game development.

The ASGD framework aims to assist developers, especially in the concept development stage, by providing a practical step-by-step methodology tailored to the needs of multidisciplinary teams [29]. Through a mixed-method evaluation, multidisciplinary game design teams perceived positive effects of ASGD in enhancing efficiency, structure, usability, and team support.

Gamification Development Process

There are several gamification design processes, however, there is no consensus among researchers and practitioners on which process could outperform the others or which has been applied more widely [30]. Five known and most commonly used processes are described below.

The gamification design process presented by Marczewski [31], includes three main phases, namely, discovery/define, design/build and refine which, each phase contains iterative activities. The discovery phase aims to understand the users and their problems that are supposed to be addressed by gamification. This phase consists of the "define the problem", "define the people", and "define success" stages to elicit clients' needs, understand users, and identify success factors, respectively.

The design phase includes three steps: design the user journey, BMEM design, and action/feedback loops design. Discover, onboard, immerse, master, and replay are the stages of the user journey. For each stage, the concept of experiences should be designed and created. Next, BMEM (Behavior, Motivations, Emotions, and Mechanics) and action/feedback loop (call to action, user action, feedback, and state change) are designed and analyzed. Refine is the final phase to iteratively improve and refine the design until the desired design is completed.

Another practical gamification development process is the gamification project design process consists of 7 stages [32]. In the first stage, the objectives of the gamification project are defined, and the applicability of gamification to solve the problems is analyzed. Following stage deals with gathering information about the client for which gamified solution will be developed. In stage 3, the actions and behaviors of players that are required to achieve objectives together with metrics for monitoring behaviors are defined. This stage is iterative and performed until all business objectives and related behaviors are determined. Stage 4 is all about the users and their corresponding needs and motivations. It is also essential to analyze the user in terms of different player types (i.e., killer, achiever, explorer, socializer) and select proper mechanics to motivate different player types. The purpose of stage 5 is to design a prototype to analyze the gamification ideas. This stage includes finding themes, building prototypes, play testing, and creating a specification document. In stage 6, the right team for developing gamified solution is formed, and the production is started while testing/playtesting is performed during production. In this stage, after finishing production, the solution is rolled up and released. The final stage is called follow-up planning, in which the project is reviewed, and possible errors will be solved after project delivery. Furthermore, in this stage effectiveness of the gamified solution as a whole and each game mechanic individually are evaluated. Feature development and planning regular fresh

contents are two other activities performed in the final stage.

Paz has presented a set of steps applicable to any type of gamification project consisting of prepare, design, implementation, and maintain phases [6]. In the prepare phase, the organization's business goals are set up, and the problems that should be gamified are determined. Deciding if a gamified strategy is a correct solution, gathering the team members, deriving business objectives, and understanding the target users are the steps followed in this phase. In the second phase, the basic design and elements of the future application, target behaviors of users, game components, mechanics, and dynamics are determined. The last phase corresponds to implementing and deploying the gamified application. Moreover, the data is collected by measuring the activities on the system to analyze the effectiveness of the application. Maintenance should also be performed as long as the system is run.

Marache-Francisco et al. employ a user-centered approach to identify factors that should be considered in gamification design (intention, situation, task, users) [33]. The authors present a design guide comprising a design process and a toolbox. The design process consists of two significant steps: context analysis and iterative conception. The toolbox provides a context analysis guide to help the designer during the first phase and gamification core principles are to be taken into account during all the design phases. Moreover, in the second phase, the game elements are chosen through the proposed conception grid and the decision trees. Then, the iterative conception phase is conducted using mockups or prototypes and tested on users.

Bakhanova et. al explore the gamification of Participatory Modeling (PM), focusing on essential components and steps to integrate gamification into the PM process. The study reviews literature on gamification, stakeholder engagement, and problem structuring methods, particularly PM [34]. The framework emphasizes contextual analysis, including participant dynamics, group interaction, and modeling aspects within the gamified activity.

3.3. Comparison of development processes

Table 3 compares game development processes. The gamification project design process [32] supports the design thinking approach. Although the playcentric design process [22], does not apply the design thinking approach directly, it is an iterative and user-centric process similar to the design thinking process. Chandler's process [20], and game development processes presented by McAllister and White [21], and Aktaş and Orçun [12], support activities corresponding to the game life cycle (pre-production, production, post-production).

While Marache-Francisco et al. [33], present good guidelines and a helpful toolbox, the proposed process is too abstract, consisting of two phases, and the activities required to develop gamified solution have not been specified clearly. The processes introduced in Jenkin [32] Jenkin and Paz [6] are well-defined and valuable for managing game development projects because the phases and steps have been appropriately clarified. The gamification model proposed by Bakhanova et al. [34], is highly specialized and specifically tailored for participatory modeling.

Kirkley et al. [26], de Lope et al. [27], and Ávila-Pesántez et al. [28][29] studies have proposed more specific serious game development processes for educational objectives, and they don't support all game lifecycle phases. ASGD methodology exclusively addresses the pre-design phase [29].

Table 3. The comparison of game development processes

Process	*Computer game type*			*Design thinking support*	*Define activities*	*Determine activities order*	*Support all game lifecycle phases*
	Entertainment game	*Serious game*	*Gamification*				
[20]	✓	×	×	×	✓	✓	✓
[21]	✓	×	×	×	✓	✓	✓
[12]	✓	×	×	×	✓	✓	✓
[22]	✓	×	×	×	✓	✓	×
[23]	×	✓	×	×	✓	✓	×
[28]	×	✓	×	×	✓	✓	×
[26]	×	✓	×	×	✓	×	×
[27]	×	✓	×	×	✓	✓	×
[29]	×	✓	×	×	×	×	×
[31]	×	×	✓	✓	✓	✓	×
[32]	×	×	✓	×	✓	✓	×
[6]	×	×	✓	×	✓	✓	✓
[33]	×	×	✓	×	×	×	×
[34]	×	×	✓	×	×	×	×
$(DG)^2DP$	✓	✓	✓	✓	✓	✓	✓

Based on the investigation of game development processes, there is no process with the all following specifications:

- could be applied to gamification, entertainment, and serious game production.
- Applies design-thinking and iterative process.
- Supports different stages of the computer game lifecycle.
- Identifies the steps required to define and manage the game production project while it is customizable.

Applying such a process to develop games leads to efficient and effective game production. In the next section (DG)²DP, the proposed game development process is explained, incorporating all the specifications mentioned above.

4. The proposed game development process

This section describes the stages of the (DG)²DP process and a specific case of its application for developing a serious game. Furthermore, the evaluation results of the proposed process are presented.

4.1. The (DG)²DP process

Based on various computer games and gamification development frameworks, models, and processes, the author presents the (DG)²DP process to design and produce entertainment and serious computer games as well as gamified solutions displayed in Figure 3. (DG)²DP is an iterative and human-centered process for developing games and gamification focusing on the design thinking approach. The symbol denotes that the corresponding stage or phase employs the design thinking approach [35].

Design thinking is an iterative and human-centered approach to innovation and solution development. Design thinking was started, in the case of gamification in 2008 [30], but it has received great attention since 2009 when Tim Brown introduced this term in his book "Change by Design" [36]. Design thinking stages are Empathize, Define, Ideate, Prototype, and Evaluate. The first stage focuses on user-centric research to gain an empathic understanding of the problem that should be solved. The empathize stage help designer gain real insight into users and their needs instead of relying on their assumption about the world. In the define stage, the information gathered during the empathize stage is organized and analyzed to define the core problems from a perception of the users' needs (user-centric problem statement). In the third stage, the innovative solution is generated by designers through ideation techniques such as Brainstorm, Brainwrite, Worst Possible Idea, and SCAMPER [35]. The prototype is an experimental stage that aims to find the best possible solution for the problem identified during the first three stages. The solutions are implemented within the prototypes (small-scale models of the exact solution) that are tested, improved, rejected, and accepted based on users' experiences. In evaluate (also called test or execute) stage, the final solution or complete product is implemented when the prototype is refined enough. This is the stage where the final solution is tested on a full-scale basis. Although this is the final stage, the results generated are often applied to redefine one or more further problems. The straight arrows in Figure 3 indicate that it is possible to return to the previous stage if revision/refine is needed.

The (DG)²DP includes four phases as described below.

Planning

In the first phase, problems that a serious game or a gamified solution is going to solve are defined. Problem identification is only relevant for producing a serious game or gamified solution. Why and how will the gamification/serious game resolve the problem? Is gamification/serious game the best solution to the problem?

Next, the main goals of a serious game and gamification (e.g., engagement, education, health and therapy, psychometric instrument, user modeling, productivity, marketing, etc.) are determined. In the case of entertainment computer game development, the principal goals are fun and entertainment. Once goals are defined, they can be divided into objectives. For example, if the main goal is marketing, the related objectives could be increasing customers, enhancing retention, or building brand loyalty.

Understanding and discovering the target audiences and their needs are critical in producing computer games. Who are the players? What are their demographic and psychographic features? Will solving the problem be beneficial to the target audience? What rewards are appealing to them? To create a purposeful game, the desired player's actions and behaviors to achieve the objectives should also be defined. Furthermore, success factors and metrics need to be determined to evaluate to what extent the objectives are achieved.

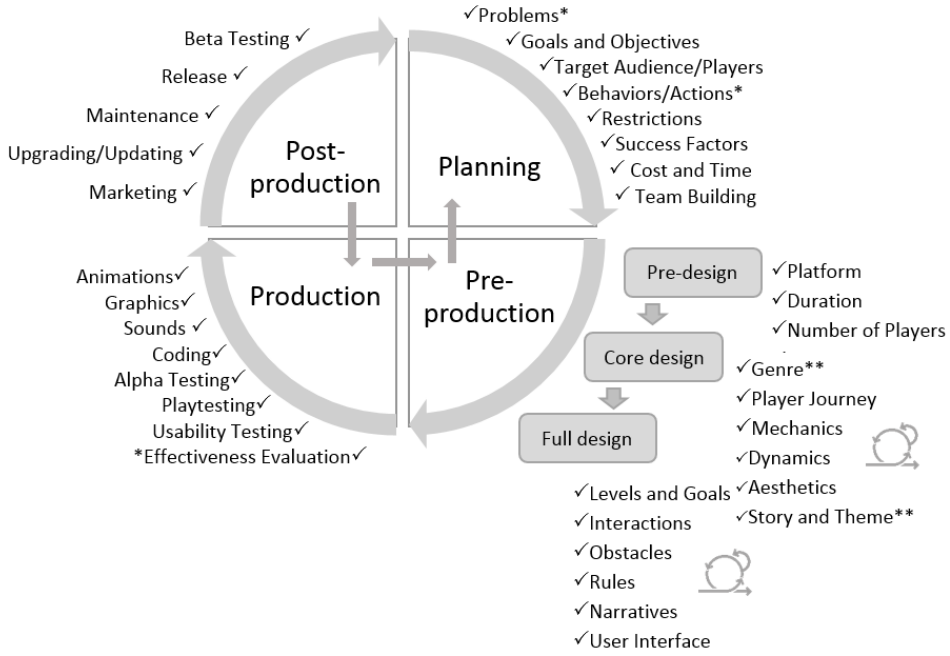

Figure. 3. The $(DG)^2DP$ process (* Only relevant for purposeful games, ** Only relevant for entertainment and serious games)

Some examples of desired behaviors are: signing up for an account, posting comments, working out for a minimum of half an hour, tweeting information about a brand, visiting locations or venues, and buying a specific product [37].

In the planning phase, restrictions and required time, and costs of the game development project are also identified. The final step is forming a computer game development team. What types of knowledge and skill are required on the team? What individuals have the needed expertise? Are the resources to assemble the right team available, or is it necessary to hire external service providers?

Pre-production

This phase consists of pre-design, core design, and full design stages. In the pre-design stage, the platform on which the digital game or the gamified solution will be run is decided. The platform could be PC, Console, Mobile, Virtual Reality, Web, etc. Game duration and the number of players are two significant factors that should be identified in the core design stage. To determine the game duration, the designers find the solution to the following questions. What is the average level length of the game? Do the players prefer long playtime (Casual players) or short playtime (Hardcore players)? How much should be the duration of the campaign game? Regarding the number of players, games are categorized as Single-player, Multiplayer, and Both-types games.

Games, like most other forms of media, may be categorized into genres based on gameplay, atmosphere, and other factors. In the core design stage, the proper genre for the game is selected. Notably, the genre is not identified for gamified solutions because they don't include gameplay. Some well-known digital game genres are Pong, Infinite running, Racing, MMO, Fighting games, RPG, Top-down Shooter, Puzzle, Adventure, Hyper-casual, Sports, Strategy, Turn-based, Stealth-based, etc.

Player journey designing pertains to designing the concept of the experiences for each of the five phases of the player journey; discover, onboard, immerse, master and replay. The MDA framework [38], divides game consumption into rules, systems, and fun that correspond to the counterparts in a game design process (i.e., Mechanics, Dynamics, and Aesthetics). Mechanics describes the particular components of the game at the level of data representation and algorithms. Dynamics describes the run-time behavior of the mechanics acting on player inputs and each other's outputs over time. Aesthetics describes the desirable emotional responses evoked in the player when she interacts with the game system. Examples of mechanics, dynamics, and aesthetics are as follows.

- Mechanics: Points, Levels, Missions and Challenges, Badges, Leaderboards, Unlocks, Event Feed, Notifications, Visual progress, Virtual goods and spaces, and Gifts and charity.
- Dynamics: Competition, Collaboration, Community, Collection, Achievement, Emotional

progress, Reward, Altruism, Status, and Exploration.

- Aesthetics: Sensation, Fellowship, Fantasy, Discovery and Curiosity, Narrative, Expression, Submission, Satisfaction, Surprise, Fun, Envy, and Trust.

Mechanics, dynamics, aesthetics, story, and theme are also designed in the core design stage. The story of a game refers to the overarching narrative or plot that unfolds as players progress through the game. It encompasses characters, events, conflicts, and resolutions that drive the gameplay forward and provide context for the player's actions. The story can be linear, branching, or open-ended, depending on the game's design. The theme of a game refers to the underlying concept, subject matter, or atmosphere that shapes the game's tone and aesthetic. Themes can evoke specific emotions, explore philosophical concepts, or reflect cultural influences. A game's theme sets the mood and provides a cohesive framework for the gameplay experience. Common themes in games include: Science Fiction, Horror, Adventure, Historical, Humorous, etc. Notably, all mentioned design activities in the core design stage apply the design thinking approach.

In the full design stage, the levels and corresponding goals of each level are defined. The goals are what the players must perform to get points and win. For example, getting to the finish line, protecting your town, saving the princess, killing the enemy, etc. Interaction design defines how the player can interact with the game to achieve the goals. In digital platforms, there are multiple ways to interact with the game, such as touch, click, press button, voice command, motion control, etc. The obstacles and challenges prevent the players from achieving the goals to make the game fun. Some challenges, including enemies, skill barriers, and level obstacles, are designed in the full design stage. The game rules (what players can do and can't do) and narratives (how the story is being told through the medium of the game through the plot, sounds, music, atmosphere, dialogues, and so on) are decided. In addition, user interface design, encompassing elements such as color, layout, typography, and information architecture, is developed to complete the full design stage. The Full design stage also apply the design thinking approach.

Production

During the production phase, developers create animations, sounds, graphics, videos, and other necessary elements to finalize the game. Coding and Alpha testing of the game are also done in this phase. This phase is the longest and most expensive stage of development at which the programmers write the code, the artists create all the art files and animation, and the sound designers produce sound effects and music. Furthermore, the writers generate dialogue and other in-game text. If Agile production is employed, smaller interdisciplinary teams of programmers, artists, and designers are built around particular feature sets to complete a specific part of the game. In this phase, Alpha testing is applied to discover potential errors and test the functionality of the game before the final product is released to the actual users. This type of test is carried out by in-house developers, the quality assurance team, or the product management team. Alpha testing is conducted multiple times through black box, and white box testing aims at evaluating the quality of the product. The outcome of the production phase is a completed "Alpha" code for supporting all features and functions of the game. Builds are versions of a project that will be continually assembled by the team and are identified with an incremental number. In an Agile setting, these builds are produced after each feature Sprint.

Another crucial test conducted in this phase is playtesting. Playtesting focuses on evaluating the gameplay experience, mechanics, and overall fun factor of a game. Playtesting involves having users play through a game to gather feedback on aspects like: Game mechanics and controls, Pacing and difficulty level, Overall enjoyment and engagement, Clarity of objectives and instructions, etc. [22]. Usability testing conducted during the production phase, evaluates how effectively users can navigate and interact with a product's interface and features to accomplish tasks [39]. Usability tests evaluate factors like: Learnability and intuitiveness of the UI, Efficiency and effectiveness of task completion, and User satisfaction and frustration levels. The aim is to uncover usability problems and optimize the product's design for better user experience. In purposeful game development, it is essential to assess the game's effectiveness in achieving its intended purpose. For example, if the goal is educational, it is necessary to evaluate the serious game or gamification system based on its educational objectives.

Usability and effectiveness evaluations can be conducted by players or experts [40], [41]. Expert-based evaluation, also known as heuristic evaluation, involves a group of experts assessing a software product/game using a set of predefined heuristics that guide best-practice design principles [42]. While a single evaluator can conduct a heuristic evaluation, involving multiple evaluators is recommended to identify a broader range of issues. There are several heuristics for evaluating game/gamifications such as [43]–[46]. While playtesting, usability testing, and

effectiveness evaluations were discussed in the production phase, these evaluation methods can also be utilized during the pre-production phase. This is because the pre-production phase incorporates design thinking, and testing is one step within this approach. The key difference is that during the production stage, evaluations are conducted using the actual game or gamified app, whereas in the pre-production phase, evaluations are performed using game or gamification prototypes.

Post-production

This is the final phase in which Beta testing is completed, and the game or gamified solution is released. Beta testing is carried out by actual players through a black-box approach. Beta testing takes less time than Alpha testing and aims to evaluate customer/player satisfaction. Based on Beta testing feedback, changes to the game are made to fix the bugs/errors, and the game is released to the public or clients. Maintenance, upgrading, and marketing are the other activities performed in this phase.

After game production, it is time to collect, measure, and analyze data to adjust and maintain the game. What tools are needed to track user activity data? How could the collected data be analyzed? How could the system be upgraded/adjusted and maintained after it is in place? Regarding computer game development, there are three forms of maintenance, namely corrective, perfective, and adaptive maintenance [47]. Corrective maintenance involves removing any bugs and errors from the game that are not uncovered through the testing phases. Perfective maintenance is related to improving and adding new features over the game's lifecycle. Adaptive maintenance includes adjusting a game to match changes made with the environment where the game run (for example, new Windows or Android OS updates, new firmware installation, etc.).

Upgrading a game incorporates major improvements and adjustments to form a new version of the game. New features and components would be added to the upgraded game. Alternatively, game updates (also called patches) fix minor errors and bugs or make small improvements in the game. Upgrades are less frequent, consisting of radical changes in the game, whereas game updates can be more frequent and are used to repair the game for free.

The $(DG)^2DP$ process could be applied to develop generic and custom computer games. Generic games are designed for many customers and the mass market, whereas custom games are produced to meet one client's specific needs, regarding the budget and requirements predefined by them. Marketing activities such as pricing, advertising, promotion, selling, social network marketing, etc., are crucial in the case of developing generic games. How will awareness about the computer game to the target users be raised? How players' onboarding (signing up and participating) with the game is planned?

4.2. Evaluation results

In the first evaluation, 70 game practitioners were asked to evaluate the $(DG)^2DP$ and the development process that they experienced or recommended through a 5-point Likert scale. A list of 92 candidates from Iran is prepared, all experienced in computer game development. To create the list, four game production experts are asked as a seed to recommend other candidates. The candidates were added to the list, and again, based on their recommendations, the list was extended. Furthermore, several game production companies were contacted to find more candidates. After an initial screening of the list, 22 candidates were eliminated because they were not familiar with any game production process or did not apply any process to develop games. Of the 70 candidates contacted through email, phone calls, and social network services, 42 participants completed the questionnaire. To collect the responses, the questionnaire link and 30 minutes video tutorial about the $(DG)^2DP$ were sent to the candidates.

In the second evaluation, the proposed process was assessed by 16 experts who have applied the process to develop computer games (five serious games, two gamified solutions, and two entertainment games). All 16 experts have collaborated with the author on developing computer games using the $(DG)^2DP$. They were asked to rate their answers on a scale from 1 to 5 to the following question. "In comparison with other game development process(es) that you experienced or know, how likely are you to recommend $(DG)^2DP$ for computer game development including entertainment games, serious games, and gamification?"

Regarding the first experiment, 18 respondents were females, 24 were males, and they were, on average, 29 years old. Figure 4 displays the distribution of respondents' primary expertise (the numbers indicate the percentage of each expertise). Table 4 shows the mean score, standard deviation, and 95% confidence interval of means (using a normal distribution) for each evaluation factor. The higher means belong to comprehensiveness, learnability, clarity, and effectiveness, respectively. The means of other factors are slightly lower because the respondents needed to apply the process for better evaluation. The average values of evaluation factors in the worst case (lower bond) and best case (upper bond) are 3.24 and 3.81, respectively. The minimum value of 2.74 belongs to the collaboration factor in the

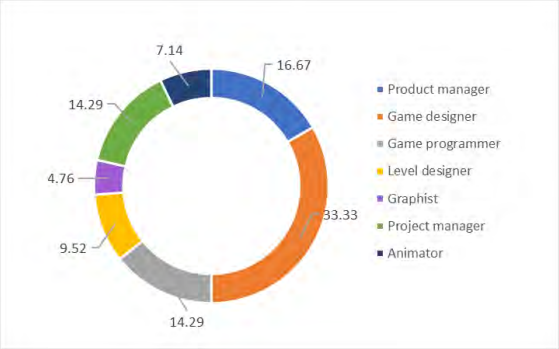

Figure. 4. The percentage of respondents per expertise

worst case, however, this value denotes that the collaboration score in the worst case is medium.

A paired t-test using a 95% confidence level was applied to compare the mean scores of (DG)²DP with the processes that respondents have experienced or are familiar with across 8 factors.

Table 5 displays the paired sample test results. Only in case of flexibility the difference is not significant (p-value > 0.05).

Table 6 compares the mean scores of (DG)²DP and the processes that respondents have experienced or known regarding 8 factors. The third column displays the percentage increase of development processes with respect to (DG)²DP. Except for effectiveness, and collaboration support, (DG)²DP scores are much higher than other development processes. Because the respondents in the first evaluation had not applied (DG)²DP to develop computer games and gamification, the effectiveness and collaboration support scores of (DG)²DP are slightly lower than other development processes. Evaluation results imply that creativity-support and complexity-support scores of (DG)²DP are, respectively, 17.36 and 18.26% higher than other processes. This might be because (DG)²DP is iterative and supports design thinking. The most percentage increase belongs to comprehensiveness (111.11%), since (DG)²DP could be applied to develop different types of computer games and gamification. Moreover, regarding clarity and learnability factors, (DG)²DP scores are 44.04% and 38.98% higher than other methods, respectively. The results of the first evaluation imply that the average percentage increase of scores regarding (DG)²DP and other processes is 28.39%.

The results of the second evaluation are displayed in Figure 5. As depicted in Figure 5, in comparison with the other processes the respondents experienced or knew, 81.25% of respondents agreed and strongly agreed to recommend the (DG)²DP to game developers.

Table 4. Evaluation results of (DG)²DP

Factor	*Mean*	*STDEV*	*Mean (95% Margin of error)*	*Mean (Upper bound)*	*Mean (Lower bound)*
Learnability	3.90	0.84	0.25	4.16	3.65
Flexibility	3.19	0.91	0.27	3.46	2.92
Effectiveness	3.60	0.95	0.29	3.88	3.31
Clarity	3.74	0.93	0.28	4.02	3.46
Creativity-support	3.38	0.90	0.27	3.65	3.11
Complexity-support	3.24	1.11	0.34	3.57	2.90
Collaboration-support	3.10	1.17	0.35	3.45	2.74
Comprehensiveness	4.07	0.77	0.23	4.30	3.84

A comparison was made between the median respondent score (4) and a neutral score of 3 using a one-sample Wilcoxon signed rank test, given the relatively small sample size of 16. The results of the hypothesis test indicate that the null hypothesis (median respondent score equals 3) was rejected with a p-value of 0.015 (confidence level = 95%). This finding suggests that (DG)²DP is highly recommended for developing video games and gamification by the respondents.

4.3. Treasure Island game: a case of the (DG)²DP process application

Treasure Island is a serious game for extraction of Hofstede's cultural dimensions at the individual level, which has been developed by exploiting the QSGD (Questionnaire-based Serious Game Development) process [48], and the (DG)²DP process. Figure 6 displays a few screenshots of the game.

To better understand the (DG)²DP, the specifications of the planning and pre-production phases of Treasure Island [48], are described as follows.

Planning

- Problems: some companies and businesses want to extract Hofstede's cultural dimensions at the individual level for better personalized targeting, user experience design, and recommendations. The current tool for collecting such data is a questionnaire, however, the users are not engaged in completing the questionnaire, and the data collected through a questionnaire might not be concise.
- Goals and Objectives: the goal is to extract Hofstede's cultural dimensions at the

Table 5. Paired t-test results of comparing (DG)²DP and other game/gamification development processes

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Learnability	1.095	1.322	0.204	0.683	1.507	5.370	41	0.000
Flexibility	-0.214	1.440	0.222	-0.663	0.235	-0.964	41	0.341
Effectiveness	-0.214	0.470	0.073	-0.361	-0.068	-2.952	41	0.005
Clarity	1.143	1.372	0.212	0.715	1.570	5.400	41	0.000
Creativity	0.500	0.944	0.146	0.206	0.794	3.434	41	0.001
Complexity-support	0.500	0.890	0.137	0.223	0.777	3.640	41	0.001
Collaboration-support	-0.214	0.645	0.100	-0.415	-0.013	-2.152	41	0.037
Comprehensiveness	2.143	0.977	0.151	1.838	2.447	14.213	41	0.000

Table 6. Comparison of (DG)²DP and other processes

Factor	(DG)²DP	Other processes	Percentage increase
Learnability	3.90	2.81	38.98
Flexibility	3.19	3.20	-0.45
Effectiveness	3.60	3.51	2.44
Clarity	3.74	2.60	44.04
Creativity-support	3.38	2.88	17.36
Complexity-support	3.24	2.74	18.26
Collaboration-support	3.10	3.21	-3.56
Comprehensiveness	4.07	1.94	110.02

individual level through a serious game. The objectives are to extract each Hofstede's cultural dimension through game levels and engage users to complete the game.

- Target Audience/Players: all potential customers of the business that are familiar with the Internet and interested in online games.
- Behaviors/Actions: watch the video, read content, recommend the game.
- Restrictions: it is crucial to get feedback from experienced psychologists and linguistic experts.

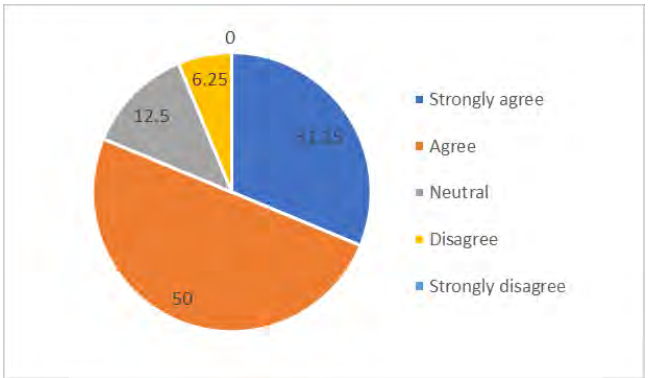

Figure. 5. Experts' recommendation rates of the (DG)²DP

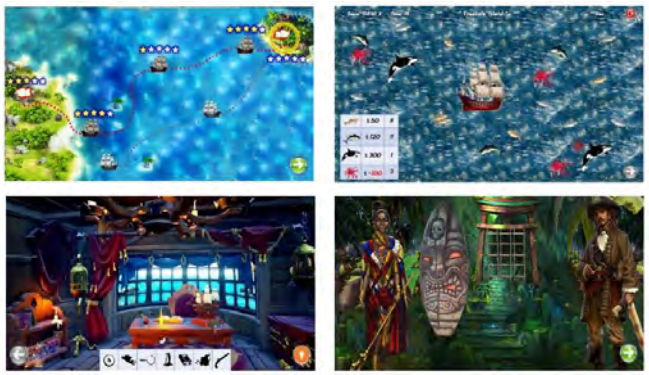

Figure. 6. Treasure Island [48]

- Success Factors: portion of target customers who play the game, portion of target customers who recommend the game, and player satisfaction.
- Cost and Time: maximum 1000$ budget and 18 months production.

- Team Building: 2 serious game experts, one graphist, one animator, and 2 programmers.

Pre-production

- Pre-design
  - Platform: web-based
  - Duration: maximum one hour
  - Number of Players: single player
- Core design
  - Genre: role-playing and adventure
  - Player Journey: discover, onboard, immerse, master and replay
  - Mechanics: points, levels, missions and challenges, leaderboards, and unlocks
  - Dynamics: achievement, emotional progress, reward, and exploration
  - Aesthetics: discovery and curiosity, narrative, and fun
  - Story and Theme: the mission of the game is to find the treasure and bring it to the beach. The game theme is adventure.
- Full design
  - For more details, please see [47].

5.Conclusion

Unfortunately, some concepts and terms in the computer games and gamification domains are not defined clearly, and several inconsistencies exist. For example, mechanics, dynamics, and aesthetics are not conceptualized uniquely and consistently in the literature resulting in misunderstanding and confusion of the concepts. In this study, processes of developing computer games and gamified solutions are described and reviewed. Subsequently, some terms, concepts, and definitions related to video games, serious games, and gamification are clarified.

There are various computer game development processes reported in the literature that makes it difficult for game practitioners to choose the proper process. It is unlikely to determine which process is the best or is being applied more frequently. Designers could employ a process or combine multiple processes or even customize a process to develop their games. There is room for a new process capable of developing different types of computer games (entertainment games, serious games, and gamified solutions). This is because such a process could facilitate managing production projects and boost production efficiency.

In this study, a new process to design and produce entertainment and serious computer games, as well as gamified solutions called (DG)²DP is presented. The (DG)²DP employs design-thinking and iterative process, and supports different stages of the computer game lifecycle. Applying the design thinking approach and user-centered design methods are critical in developing computer games and gamification to overcome the complexity of the design and better understanding players through an iterative process. The (DG)²DP identifies the steps required to define and manage the game production project while it is customizable.

Companies, developers, and practitioners that only produce serious games, gamified solutions, or entertainment games, might choose more specific development processes, however, the application of the (DG)²DP is beneficial to those developers that produce different types of computer games. Until now, the (DG)²DP has been applied to develop five serious games, two gamified solutions, and two entertainment games effectively. However, further investigation is required to examine the effectiveness of this process in computer game production.

To evaluate the proposed process, a questionnaire with the 5-point Likert scale has been applied. The average values of evaluation factors in the worst case (lower bond) and best case (upper bond) are 3.24 and 3.81, respectively. The evaluation results indicate that there is an average percentage increase of 28.39% in scores for (DG)²DP and other processes. Moreover, 81.25% of respondents agreed and strongly agreed to recommend the (DG)²DP to game developers. One limitation of the (DG)²DP evaluation is that all the participants are from Iran. So more extensive assessment through collecting responses from other nationalities and cultures is crucial. It is also helpful to give a more in-depth understanding of the experts' perspectives through open-ended questions and interviews to improve the (DG)²DP in future work. Furthermore, a game development project management software specially designed based on the (DG)²DP could be built to facilitate game production.

Declarations

Funding

This research did not receive any grant from funding agencies in the public, commercial, or non-profit sectors.

References

[1] "Video Game Market Size, Share & Trends Analysis Report," 2022. [Online]. Available: https://www.grandviewresearch.com/industry-analysis/video-game-market.

[2] V. Gaikwad, R. Rake, and V. Kumar, "Serious Games Market by Gaming Platform, Application, Industry Vertical, and Region: Global Opportunity Analysis and Industry Forecast, 2021–2030," Allied Market Research, 2022. [Online]. Available:

https://www.alliedmarketresearch.com/seriousgames-market.

[3] Analysis Report By Component, By Application, By End-User, By Deployment Type, By Organization Size, By Regional Outlook and Forecast, 2022 – 2028," 2024. [Online]. Available: https://www.reportlinker.com/p06289248/Global-Gamification-Market-Size-Share-Industry-Trends-Analysis-Report-By-Component-By-Application-By-End-User-By-Deployment-Type-By-Organization-Size-By-Regional-Outlook-and-Forecast-.html?utm_source=GNW.

[4] E. Braad, G. Žavcer and A. Sandovar, "Processes and models for serious game design and development," in *Entertainment computing and serious games*, Springer, 2016, pp. 92–118, https://doi.org/10.1007/978-3-319-46152-6_5.

[5] H. R. Ruonala, "Agile Game Development : A Systematic Literature Review," *Computer Science*, 2017.

[6] B. M. De Paz, "GAMIFICATION : A tool to improve Sustainability Efforts," University of Manchester, 2013.

[7] N. B. Ahmad, S. A. R. Barakji, T. M. A. Shahada and Z. A. Anabtawi, "How to launch a successful video game: A framework," *Entertain. Comput.*, vol. 23, pp. 1–11, 2017, https://doi.org/10.1016/j.entcom.2017.08.001.

[8] A. Mora, D. Riera, C. González and J. Arnedo-Moreno, "Gamification: a systematic review of design frameworks," *J. Comput. High. Educ.*, vol. 29, no. 3, pp. 516–548, Dec. 2017, https://doi.org/10.1007/s12528-017-9150-4.

[9] J. Li, "A Systematic Review of Video Games for Second Language Acquisition," in *Handbook of research on integrating digital technology with literacy pedagogies*, 2020, pp. 472–499, https://doi.org/10.4018/978-1-7998-0246-4.ch021.

[10] N. Sardone, R. Devlin-Scherer and J. Martinelli, "Game-Based Instruction in a College Classroom," in *Handbook of Research on Instructional Systems and Technology*, IGI Global, 2008, pp. 463–475.

[11] G. Galehantomo P.S, "Platform Comparison Between Games Console, Mobile Games and PC Games," *SISFORMA*, vol. 2, no. 1, p. 23, Nov. 2015, https://doi.org/10.24167/sisforma.v2i1.407.

[12] A. Aktaş and E. Orçun, "A survey of computer game development," *J. Def. Model. Simul. Appl. Methodol. Technol.*, vol. 13, no. 2, pp. 239–251, Apr. 2016, https://doi.org/10.1177/1548512914554405.

[13] A. Marczewski, *Even Ninja Monkeys Like to Play: Gamification, Game Thinking and Motivational Design*. CreateSpace Independent Publishing Platform, 2015.

[14] K. Larson, "Serious Games and Gamification in the Corporate Training Environment: a Literature Review," *TechTrends*, vol. 64, no. 2, pp. 319–328, Mar. 2020, https://doi.org/10.1007/s11528-019-00446-7.

[15] M. Raftopoulos, S. Walz and S. Greuter, "How enterprises play: Towards a taxonomy for enterprise gamification," *DiGRA 2015 Divers. Play*, no. April, pp. 1–17, 2015.

[16] I. Caponetto, J. Earp and M. Ott, "Gamification and education: A literature review," *Proc. Eur. Conf. Games-based Learn.*, vol. 1, no. October, pp. 50–57, 2014.

[17] A. Marczewski, "Analogue vs Digital Gamification," 2020. [Online]. Available: https://www.gamified.uk/2020/01/17/analogue-vs-digital-gamification-2/. [Accessed: 01-Jun-2022].

[18] S. Deterding, D. Dixon, R. Khaled and L. Nacke, "From game design elements to gamefulness: Defining 'gamification,'" *Proc. 15th Int. Acad. MindTrek Conf. Envisioning Futur. Media Environ. MindTrek 2011*, September, 2011, pp. 9–15, https://doi.org/10.1145/2181037.2181040.

[19] S. Nicholson, "A User-Centered Theoretical Framework for Meaningful Gamification," in *Games+Learning+Society 8.0*, Madison, WI, 2012.

[20] H. Chandler, *The Game Production Handbook (Game Development Series)*. Charles River Media, Inc., 2005.

[21] G. McAllister and G. R. White, "Video game development and user experience," in *Game user experience evaluation*, Springer, 2015, pp. 11–35, https://doi.org/10.1007/978-3-319-15985-0_2.

[22] T. Fullerton, *Game Design Workshop: A Playcentric Approach to Creating Innovative Games*. CRC Press / Taylor & Francis Group, 2019.

[23] M. Molenda, "In search of the elusive ADDIE model," *Perform. Improv.*, vol. 42, no. 5, pp. 34–37, 2003, https://doi.org/10.1002/pfi.4930420508.

[24] W. Westera, R. J. Nadolski, H. G. K. Hummel and I. G. J. H. Wopereis, "Serious games for higher education: a framework for reducing design complexity," *J. Comput. Assist. Learn.*, vol. 24, no. 5, pp. 420–432, 2008, https://doi.org/10.1111/j.1365-2729.2008.00279.x.

[25] C. Keith, *Agile game development with Scrum*. Pearson Education, 2010.

[26] S. E. Kirkley, S. Tomblin, and J. Kirkley, "Instructional design authoring support for the development of serious games and mixed reality training," in *Interservice/Industry Training, Simulation and Education Conference (I/ITSEC)*, 2005, pp. 6–9.

[27] R. P. de Lope, N. Medina-Medina, P. Paderewski and F. L. G. Vela, "Design Methodology for Educational Games based on Interactive Screenplays," in *CoSECivi*, 2015.

[28] D. Ávila-Pesántez, L. A. Rivera and M. S. Alban, "Approaches for serious game design: A systematic literature review," *ASEE Comput. Educ. J.*, vol. 8, no. 3, 2017.

[29] N. Djafarova, A. Dimitriadou, L. Zefi and O. Turetken, "The Art of Serious Game Design: A Framework and Methodology," *AIS Trans. Human-Computer Interact.*, vol. 15, no. 3, pp. 322–349, 2023, https://doi.org/10.17705/1thci.00193.

[30] E. Villegas, E. Labrador, D. Fonseca, S. Fernández-Guinea and F. Moreira, "Design Thinking and Gamification: User Centered Methodologies," in *International Conference on Human-Computer Interaction*, 2019, pp. 115–124, https://doi.org/10.1007/978-3-030-21814-0_10.

[31] A. Marczewski, "A Revised Gamification Design Framework," *Gamified UK*, 2017.

[32] P. Jenkin, "Gamification Project Design Framework," 2017. [Online]. Available: https://gamificationplus.uk/gamification-project-design-framework/. [Accessed: 01-Apr-2022].

[33] C. Marache-Francisco, E. Brangier and E. B. Perseus, "Process of Gamification. From The Consideration of Gamification To Its Practical Implementation," *Sixth Int. Conf. Adv. Hum. oriented Pers. Mech. Technol. Serv.*, 2013, pp. 126–131.

[34] E. Bakhanova, J. A. Garcia, W. L. Raffe and A. Voinov, "Gamification Framework for Participatory Modeling: A Proposal," *Gr. Decis. Negot.*, vol. 32, no. 5, pp. 1167–1182, 2023, https://doi.org/10.1007/s10726-023-09838-w.

[35] R. F. Dam, "Design thinking: a quick overview," Interaction Design Foundation, 2020.

[36] T. Brown, *Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation*. HarperBusiness, 2009.

[37] K. Werbach and D. Hunter, *For the Win: How Game Thinking Can Revolutionize Your Business*. Wharton Digital Press, 2012.

[38] R. Hunicke, M. G. LeBlanc and R. Zubek, "MDA : A Formal Approach to Game Design and Game Research," in *Proceedings of the AAAI Workshop on Challenges in Game AI*, 2004.

[39] J. Rubin and D. Chisnell, *Handbook of usability testing: How to plan, design, and conduct effective tests*. John Wiley & Sons, 2008.

[40] E. Fokides, P. Atsikpasi, P. Kaimara and I. Deliyannis, "Let players evaluate serious games. Design and validation of the Serious Games Evaluation Scale," *ICGA J.*, vol. 41, no. 3, pp. 116–137, 2019, https://doi.org/10.3233/ICG-190111.

[41] P. Caserman *et al.*, "Quality criteria for serious games: serious part, game part, and balance," *JMIR serious games*, vol. 8, no. 3, p. e19037, 2020, https://doi.org/10.2196/19037.

[42] S. Pohjolainen, J. Mattila, J. Tuovinen, M. Rajanen, L. Arhippainen and P. Alavesa, "Heuristic evaluation of a mobile game developed to help battle the pandemic," in *2021 IEEE Conference on Games (CoG)*, Copenhagen, Denmark, 2021, pp. 1–8, https://doi.org/10.1109/CoG52621.2021.9619103.

[43] H. Desurvire and C. Wiberg, "Game usability heuristics (PLAY) for evaluating and designing better games: The next iteration," in *Online Communities and Social Computing: Third International Conference, OCSC 2009, Held as Part of HCI International 2009, San Diego, CA, USA, July 19-24, 2009. Proceedings 3*, 2009, pp. 557–566, https://doi.org/10.1007/978-3-642-02774-1_60.

[44] N. Jerzak and F. Rebelo, "Serious games and heuristic evaluation--the cross-comparison of existing heuristic evaluation methods for games," in *Design, User Experience, and Usability. Theories, Methods, and Tools for Designing the User Experience: Third International Conference, DUXU 2014, Held as Part of HCI International 2014, Heraklion, Crete, Greece, June 22-27, 2014, Proceedings, Part I 3*, 2014, pp. 453–464, https://doi.org/10.1007/978-3-319-07668-3_44.

[45] R. Yanez-Gomez, J. L. Font, D. Cascado-Caballero and J.-L. Sevillano, "Heuristic usability evaluation on games: a modular approach," *Multimed. Tools Appl.*, vol. 78, pp. 4937–4964, 2019, https://doi.org/10.1007/s11042-018-6593-1.

[46] G. Fortes Tondello, "Dynamic Personalization of Gameful Interactive Systems," 2019, UWSpace, http://hdl.handle.net/10012/14807.

[47] A. A. Jarman, "Testing and Maintenance in the Video Game Industry Today," Senior Honors Theses, 128, pp. 1–36, 2010, https://digitalcommons.liberty.edu/honors/128.

[48] F. Noorbehbahani and F. Salehi, "A serious game to extract Hofstede's cultural dimensions at the individual level," *User Model. User-adapt. Interact.*, vol. 31, no. 2, pp. 225-259, 2020, https://doi.org/10.1007/s11257-020-09280-6.

Fakhroddin Noorbehbahani is an Assistant Professor of Computer Engineering at the University of Isfahan. He received his B.Sc. and M.Sc. in Computer and IT Engineering from, respectively, Isfahan University of Technology and Amirkabir University of Technology, Iran, in 2007 and 2010. He obtained his Ph.D. degree in Computer Engineering from Isfahan University of Technology, Iran, in 2016. His research interests include Human Computer Interaction, Gamification, Serious Games, E-business, Machine Learning, and Data Science.