OGrES Welcome! Toward a Systematic Theory for Serious Game Design

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ABSTRACT

Despite the vast scholarship around serious games, there is still no consensus methodology for how to best go about designing them. This paper presents work-in-progress toward synthesizing an actionable, systematic serious game design theory. We introduce *mIBO* as a computational model to aid in thinking about game design processes and rationales, and *OGrES* as a method for defining the function of a serious game.

CCS CONCEPTS

• Human-centered computing → HCI design and evaluation methods; **Interaction design theory, concepts and paradigms**; **• General and reference → Design**; **• Software and its engineering → Software design techniques**; **• Applied computing → Computer games**.

KEYWORDS

serious game design, serious games, taxonomy, games beyond entertainment, meaningful play, design theory, design science

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1 INTRODUCTION

Several studies have shown serious games to be useful tools. For example, a meta-analysis on educational games and interactive simulations [36] demonstrated that these educational technologies produced greater positive attitudes toward the subject matter, had "significantly higher cognitive gains. . . versus traditional teaching methods," and when given a choice, users preferred the interactive simulations and games over traditional studies. Interestingly, this meta-analysis also found that the technologies need not be high fidelity in order to be effective, but that there was a positive correlation between increased realism and increased learning. Other analyses broadly converge on the same findings [9, 12, 16, 28].

We are interested in improving serious game effectiveness through a study of their design. However, while several methodologies exist [5, 7, 33], there are no converged-upon recommendations for serious game design. This leaves designers wondering how to design serious games to achieve the positive effects reported in the literature: what tools should be employed and when? where does one start in the design process?

To us, lack of convergence is due to the serious game design process being under-defined. Such a process ought to accommodate (at least) various genres of games—*e.g.* puzzle, role-playing (RPG), platformer. The process should also accommodate the various objectives one might use serious games for—*e.g.* awareness, education, training. We posit that better understanding serious game design activities will lead to more effective achievement of our serious objectives. That is the end goal of this work: to build a systematic theory that guides designers toward achieving a serious game's intended function reliably, predictably, and with maximum impact.

We seek to make the serious game design process more clear by rooting it within the *situated Function-Behavior-Structure* (sFBS) design activity framework [14]. This framework defines domain-independent activities that occur during design. It also conceptually models how designers move between these activities. While the activities do not need to happen in any particular order, they are deemed necessary to every design process. In this paper, we discuss these activities in the context of serious games, and define one activity's *Input* and *Output* within a more precise serious game design computational model for our *systematic Serious Game Design Theory* (sSGDT).

Contributions: This paper presents three theoretical contributions. First, we explain how sFBS is useful to serious game design. Second, we make sFBS more computationally precise via *mIBO* through which we modeled serious game design activity. Third, we use *mIBO* to help us articulate *OGrES*—our proposal for the dimensions needed to define the *Function* of a serious game.

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2 RELATED WORKS

Here, we review literature closest to our efforts in identifying or articulating a serious game design methodology. While excellent, current literature focuses on too fine of a detail of one aspect of the design process, without ever relating it to the other intertwined parts. We wish to address the design process in specific as well as in general.

For example, the work by Murphy-Hill et al. [30] covers differences between video game software development and other kinds of software development. There is no discussion of software-agnostic design concerns, nor serious game-relevant design concerns. Other work by Khaled et al. [20] focuses on how to document the design process, indirectly chronicling one design case study. Their work could refine the theory we synthesize here, but does not directly synthesize a design theory *per se*. Similarly, O'Donnell [31] presents extended grounded research on how video game developers work within the industry, including extensive details of their environment, and creative and collaborative process. We view our theory as consistent with more-grounded accounts, which have not yet been synthesized into a more general theoretical framework. More recently, El Arroum et al. [11] created a "generic game-based design model" based on a thematic synthesis approach. This model addresses one way a designer could approach designing the structure of an educational game. Their model is rooted in the game elements of *time* and *score*, and speaks more specifically to the practice of *gamification* [6] rather than broader ideas of what games could be. Indeed, many games do not even have a time or a score [38], leaving games without said facets unclear in the design activity.

Serious game design in particular has received considerable attention, due to the perceived conflict between *serious*- and *game*-centric design goals. Within serious games for education, this tension was orginally termed *chocolate-dipped broccoli* [3]. The term arises because *broccoli* (education, which we extend to other serious objectives) is healthy but not delicious and seemingly needs to be dipped (or smothered!) in delicious but not healthy *chocolate* (game and game-like features), for the purpose of making broccoli more appetizing. However, we—like others [3, 10]—posit that *chocolate-covered* (in any amount) *broccoli* need not be a fundamental tension in serious game design (education focused or otherwise).

Within education, Moreno-Ger et al. [29] examined several situated pedagogical factors that may impact the design of serous games. They created a design methodology for online education by taking into account interactions the game has with students, the Learning Management System, teachers, within the classroom, and with parents. They did not comment on other types of serious games. Further, their process is rooted in starting with the game genre in order to bring education and game elements together, whereas in our work this need not be the case.

Beyond education, Rau et al. [32] defined a "subgoaling" methodology that can be used throughout the design process to resolve conflicts within serious game design. Our work is consistent with theirs, and subgoaling can readily be an activity carried out within our framework. Relatedly, Altizer and Zagal [2] defined *The Design Box* methodology for ideation with an emphasis on *pitching*—the practice of trying to convince others to support the development of a (game) project. The Design Box argues for articulating constraints on the design process up front, prior to articulating game ideas to be pitched (and subsequently, developed). Some of these constraints reflect the intent of the game's design, which includes the potential for serious games. We subsume their work as one way in which a designer can formulate their design within a broader design activity.

3 THEORETICAL BACKDROP FOR DESIGN

We posit that serious game design is a wicked design problem [4]: there is an infinite solution space and many contributing factors that are often incomplete, dynamic, and/or difficult to define. This makes intentionally creating a desirable outcome deeply complex. We propose that *computational models*—computationally-precise mathematical abstractions—can help us deal with the complexity.

3.1 *mIBO*: Magic Input-Behavior-Output Model

A computational model is in essence a mathematical function— *e.g.* $f(x)$—that describes a phenomenon on the basis of three concepts that define a system: *Input* (I), *Output* (O), and *Behavior* (B). The Input (in $f(x)$, the x) describes facets of an environment relevant to the phenomenon but external to it. The Output (in $f(x)$, the resulting value itself) describes facets of an environment that the phenomenon bears relevance to. The Behavior (in $f(x)$, the f) describes how Inputs are mapped onto Outputs. When applied to model *design* phenomena, we posit that I, B, and O primarily refer to *information* that is mentally (*e.g.* via brainstorming) or physically (*e.g.* via prototyping) manipulated and enacted.

As discussed, serious game design relies on information that is challenging to articulate. Further, design *behaviors* (*i.e.* acts in designing) have many methodologies. To acknowledge this, we refer to our computational model as the *magic Input-Behavior-Output model*, or *mIBO* (pronounced "my-bow"). Our model is primarily a theoretical tool, and is illustrated in Equation (1).

$$\text{I:Input} \rightarrow \boxed{\text{B:Behavior}} \rightarrow \text{O:Output} \tag{1}$$

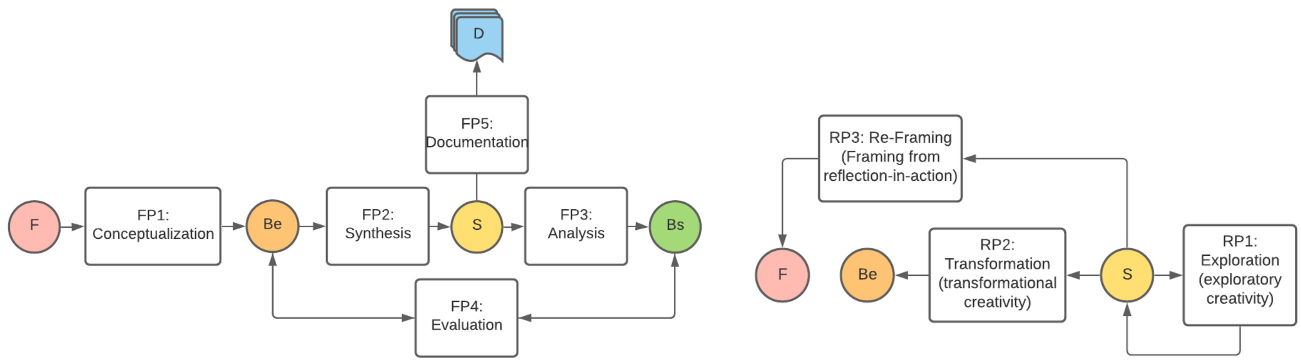
This theoretical tool is a fundamental axis of our work: for a given design activity we hypothesize that the better we understand the *m* behind the *I* and the *B*, the better we will be able to intentionally bring about our desired *O*.

Our work-in-progress is to employ the *mIBO* model to help us more precisely understand the behavior of various design methodologies and the flow of information as we design. At the same time, we note an important caveat: in mathematics, functions are well-defined. In other words, if we input x into $f(x)$ and $h(x)$ and they yield the same y for all x within our domain, then $h(x)$ is equivalent to $f(x)$. We posit this may not always be the case for *behavior* knowledge representations outside of well-defined mathematical functions, particularly for wicked problems [17].

3.2 sFBS in terms of *mIBO* Applied to Serious Game Design

The sFBS framework is a theoretical tool that was developed in the design sciences to better understand the *process* of design. The FBS part is made up of five kinds of design information (originally termed *variables*) and eight processes that transform information (Fig. 1). The kinds of information we manipulate during serious game design are:

- *F*: *Function*, *i.e.* what we want to accomplish with our serious game.
- *B*: *Behavior*, of two kinds: 1) *Be*: the expected Behavior, or gameplay we hope will lead to achieving *F*, and 2) *Bs*: the Behavior from structure, or gameplay that actually results when people play our serious game.



(a) FBS formulation processes drawn in terms of *mIBO*.

(b) FBS reformulation processes drawn in terms of *mIBO*.

Figure 1: The FBS elements of the sFBS framework, drawn in terms of *mIBO*. Nodes encapsulate design information, and directed edges transform information from source to sink. While drawn as separate for clarity, the graphs are connected via shared nodes.

- *S*: *Structure*, *i.e.* the composed serious game artifact that results from design (*e.g.* associated code, art assets).
- *D*: *Design Description*. Describes the artifact's structure.

The processes model how designers flow between the variables. Per *mIBO*, each is a *behavior*; the variables they transform are either input or output as appropriate. The first five *formulation* processes (FP) are (Fig. 1a):

FP1: *Conceptualization*. Transforms design requirements of F into Be.
FP2: *Synthesis*. Transforms Be into an S intended to exhibit Be.
FP3: *Analysis*. Derives Bs that follows from S (e.g. play testing).
FP4: *Evaluation*. Compares Bs to Be to check if S is acceptable.
FP5: *Documentation*. Provides a D to construct or manufacture artifact.

The last three *reformulation* processes (RP) are utilized when the Structure is deemed unacceptable to the designer, and typically occurs via *FP3: Analysis* or *FP4: Evaluation*. These are (Fig. 1b):

RP1: *Exploration*: changes S only. This is *exploratory creativity* [25].
RP2: *Transformation*: changes Be, but not S. This is *transformational creativity* [25].
RP3: *Re-Framing*: changes F, re-conceptualizing goals/purpose of artifact, as in *Framing* from reflection-in-action [8].

While FBS is useful to think about serious game design activities, designers do not operate in a vacuum; they are *situated*. That is, FBS activities are contextualized by the various worlds in which they take place (Fig. 2). This contextualization results in sFBS, which models three worlds: 1) the *external* (W_e) or material world in which a design is to be deployed, 2) the *interpreted* (W_i) or mental world the designer is using to enact design solutions, and 3) the *expected* (W_e^i) or idealized/imagined world made different through an envisioned design. These worlds situate the FBS variables; *i.e.* sFBS contains $F_e, F_i, F_e^i, Be_e, Be^i$, *etc.* Our computational model is the interface of sFBS and *mIBO*, which we term the *systematic Serious Game Design Theory* (sSGDT).

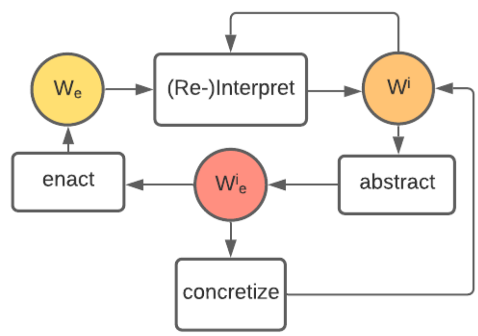


Figure 2: Illustration of situatedness in terms of *mIBO*. Arrows illustrate the flow of information between nodes, which themselves represent *worlds*: contexts that qualify the FBS variables (Fig. 1). Designers *interpret* the *external world* W_e to mentally model it as W^i, the *interpreted world* (itself subject to *(re-)interpretation*). Abstraction of W^i allows for theorizing solutions the designer wishes to effect, which results in an *expected world* W_e^i. Solutions are *concretized* for deliberation in W^i and/or *enacted* in W_e.

4 SSGDT PART ONE: FUNCTION → CONCEPTUALIZATION → EXPECTED BEHAVIOR

Articulating all of our proposed sSGDT is too broad to tackle in one paper. Instead, we aim to model how we transform Function (F) into expected Behavior (Be). That is, we aim to be more precise about the following *mIBO* model:

$$\text{F:Function} \rightarrow \boxed{\text{FP1: Conceptualization}} \rightarrow \text{Be:Expected Behavior} \quad (2)$$

Specifically, we propose a methodology to identify the information that constitutes F. Our methodology is called *OGrES*, as it asks designers to define four aspects of their game: 1) O: Objective(s) of Meaningful Play, 2) Gr: Game Rationale, 3) E: Enforced Constraint(s), and 4) S: Subject Domain. We offer a typology for each dimension, to help designers articulate the respective aspects. *OGrES* and its typologies were distilled from an inductive synthesis, which includes: case examples, several serious game taxonomies and typologies [15, 34], and the first author's game design experience. *OGrES* is summarized in Table 1.

4.1 *OGrES*: A Methodology to Define a Serious Game's Function

OGrES is an in-progress conceptual tool that offers one way to explicitly state a serious game's Function. It answers "what should the game do?" in parts; each part focuses on a different dimension of the game that we estimate will drive the conceptualization of the Behavior expected to accomplish said Function. Per prototype theory [21], we acknowledge our distinctions have fuzzy boundaries and expect our ideas will be refined. We discuss the dimensions in turn.

4.1.1 Objective (of meaningful play). The Objective is what the game is *for*. We liken this to learning objectives from instructional design [24]. While not all serious games have *learning* objectives we posit they do have at least one objective. We also suspect more than 3 objectives would lead to tension: designers may be unsure of what to focus on, potentially resulting in the artifact not meeting some or all of its objectives. Our Objectives typology includes:

Learning. Where the primary objective is to develop new concept understanding and/or skills within a Subject Domain. These games are commonly referred to as "educational games" or "games-based learning." Further, many games have a learning aspect (*e.g.* tutorials and on-boarding to teach players how to play the game), which we do *not* include in this Objective. *Learning* games have a set instructional design (whether implicit or explicit) and will frequently employ scaffolding and/or intelligent tutoring system-like algorithms, among others, to support player learning. An example of an educational game is *DragonBox* [22], which aims to teach children algebraic principles.

Training/Conditioning. Where the objective is to practice, rehearse, and/or improve skill(s) within a Subject Domain. These games are commonly referred to as "edutainment" or "simulation" [9]. We include "conditioning" in the title because these games can be thought of as helping to improve a player's "condition" (or "fitness") in a domain. Examples of training games include: typing games [13, e.g.], dance games, exergames, and pilot simulations [27, e.g.].

Awareness. Where the objective is elicit introspection, reflection, and/or extrospection in the player about something (*e.g.* implicit bias, gender inequality) in a Subject Domain. An example of an awareness game is *Papers, Please* [23].

Persuasive. Where the objective is to elicit a change in belief in the player, based on a particular viewpoint reflected in the game. Examples of these types of games would be advertisement or political campaign games.

Medicinal. Where the objective is designed for improving physical well-being, by making players better doctors (in terms of applying health science for a population) or patients (in terms of managing their own afflictions). While it can be thought of as *Learning* and/or *Training* in a medical Subject Domain, it also includes games whose objective is to improve physical well-being *through* playing. For example, better managing pain by playing during surgery.

Therapeutic. Where the objective is as in *Medicinal*, but where the focus is on mental (as opposed to physical) well-being. An example is an exposure therapy game in virtual reality for overcoming arachnophobia [28].

Research. Where the objective is to increase or refine the body of knowledge in a Subject Domain. They may be form of crowdsourcing games to improve data collection [35], or help with space exploration [1].

Assessment. Where the objective is to measure some aspect of the game's player during gameplay. For example, a game that assesses a player's skill level for therapy [18], or their personality based on in-game activity [26].

4.1.2 Subject (domain). The Subject Domain is what the game is *about*. Each example within the Subject Domain box of Table 1 can be more specific than listed, and the designers can select as narrow a version of their domain as is necessary. For example "Change" can include social, political, ethical, public opinion, and the like.

4.1.3 Game rationale. The Game Rationale addresses the question: "why make this a game?" This question subtly reveals a theoretical orientation to our work: that serious games need to be perceived as games by their audiences.

Serious games are often distinguished from non-serious games in that their objective transcends "entertainment," with some scholars arguing that serious games need not be "fun" [11]. Paradoxically, we—like others [3]—have also observed scholars justify why they sought to treat a Subject Domain through a serious game by appealing to qualities that stem from their entertaining nature. These qualities are thus different potential rationales for seeking to make a serious game, which include improving *effectiveness* in achieving the Objective [9] (*e.g.* because of their cognitive demand, and constructivist interaction/learn-by-doing [36]), as well as *engagement* and *motivation* to engage the Subject Domain [9]. Rationales presume a baseline method to achieve the same Objective, which suggests a default success criterion for a serious game's design.

4.1.4 Enforced (constraints). Enforced Constraints are (internal or external) conditions that must be met as part of every acceptable design solution in order to achieve our design goals. Examples include, but are in no way limited to, *audience* (*e.g.* accessible to children 5-8 years old), or *accessibility* (*e.g.* specific controllers required).

4.2 Expected Behavior: A Game Pitch

The aim of *FP1:Conceptualization* is to conceptually understand the expected Behavior of our serious game. This encompasses the

Table 1: *OGrES,* a method for defining a Serious Game's Function; *i.e.* the combination of *OGrES*' elements into one statement.

Objective (of meaningful play)		**Subject (domain)**
Learning	*Introduce new concept(s) and/or develop new skills.*	Education Subjects
Training / Conditioning	*Practicing, rehearsing, improving skills.*	Complex Skills (e.g. pilot)
Awareness	*Make the player(s) aware of something.*	Health
Persuasive	*Persuade or influence the player.*	Change (Public Relations)
Medicinal	*Help increase physical health and/or wellbeing.*	Entertainment
Therapeutic	*Help improve mental health and/or wellbeing.*	Advertising, Market Analysis
Research	*Increase human knowledge. (e.g. crowdsourcing)*	I/O Psychology
Assessment	*Assess the player in some manner.*	Sector (private/public)
Game rationale		**Enforced (constraints)**
Engagement	*think deeply about the domain*	Specific Controllers (e.g. Sip & Puff)
Motivation	*replayability (keep coming back)*	Specific Platforms (e.g. PC, mobile)
Effectiveness	*improve over base means along a metric*	Aesthetic

experience(s) the designer wants the player to have, including: emotions elicited, gameplay experienced, and (for serious games especially) the accomplishment of the Objective.

We propose that at minimum, one such output may be a game *pitch* [2]. Of course, beyond pitching lies significantly more work with different transformation of design information (*i.e.* the rest of the sFBS processes). Defining these is beyond the scope of this paper and will be addressed in future work.

4.3 The Design Box: A Tool for Conceptualization

With the serious game's input Function and output expected Behavior defined, we move on to *FP1:Conceptualization* itself—the mapping of input to output. As we have noted, there may be many ways to go about this conceptualization. Given our stated input and output, we propose that the *Design Box* (DB) [2] methodology is a reasonable candidate. While we cannot fully describe it due to space, we restate the critical elements below.

$$\text{Input:Serious Game Function} \rightarrow \boxed{\text{Behavior:Design Box}} \rightarrow \text{Output:Game Pitch} \quad (3)$$

The DB is a game ideation tool. It relies on four walls, or constraint kinds, that define its contour. These constraints are properties our design solution must meet.Once defined, game ideas that satisfy all constraints are pitched, and placed inside the box. The four kinds of constraints are: 1) *Technology*—Platform, software, licenses, etc., 2) *Aesthetic*—The emotional/cognitive experience the designer wants the player to have, 3) *Audience*—Who the game is intended for, and 4) *Theory*—Which fills in the blank in "The game is supposed to (blank)."

A previously defined Function will fill in the theory wall with the exception that enforced constraints may fill in other walls as well. For example, an enforced constraint of a "Sip and Puff" – a controller for disabled persons that allow them, through a series of sips and puffs, to control various apparatuses such as skis and sail boats—goes on the Technology wall. While during pitch meetings other walls may vary, the Theory wall for sSGDT should mostly remain the same. If the Function needs to change because it has been too loosely or too strictly defined, then designers should consider restarting to define the Function.

5 CASE EXAMPLE AND FUTURE WORK

We briefly discuss a serious game created by the first author, called *Family Photo Fun.* This serious game is about teaching children how to make correct ethical decisions in real life. The child would pick a family photo, and a quick story and ethical dilemma would be presented to them. They would then get to choose what to do between a "right" and "wrong" choice. If they chose "wrong," the narrator would gently tell them what would happen (the consequences of their choice for them and their family), were they to actually make that decision. The game would then allow them to pick the "right" with similar effect, leading to a family picture being added to their album. This game was part of the Waterford Institute's pre-Kindergarten curriculum learning app, used in schools throughout the United States [37].

The Function for *Family Photo Fun* would be defined as follows:

- *O*: 1) The primary objective was *learning*: to teach children correct ethical behaviors in various situations. 2) A secondary objective then was to *persuade* the children to make correct ethical decisions in real life.
- *Gr*: *Engagement*: we wanted the kids to think deeply about the consequences of their choices in the game. The aim was that it would effectively persuade the children to make correct ethical decisions in real life.
- *E*: The game had to work on both iPad and WebGL.
- *S*: pre-Kindergarten ethics.

While we did not employ the DB in Conceptualization when designing *Family Photo Fun*, our pitch's details can be detailed as follows:

- *Pitch*: A young narrator learns about ethics by recalling family events and presenting ethical dilemmas to the player who then chooses what to do. The player is rewarded for correct decisions, and allowed to pick the right choice after learning about the consequences of the wrong one.
- *Technology*: iPad and WebGL (Given by the *function* definition above).
- *Aesthetic*: A positive experience. This was achieved by rewarding the player with the correct choice, and by letting the player know the consequence of the incorrect choice but allowing the player to then choose the right choice afterwards and receive the positive reward.
- *Audience*: pre-Kindergarten students.
- *Theory*: The game's purpose is to teach children about the consequences of unethical decisions which will then help children make correct ethical choices when faced with an ethical dilemma in real life.

What we have talked about thus far is an examination of only a small part of design activity within serious games. There is much left to do for this theory; the next step in the process is examining the next parts of the design activity within sFBS and how they apply to serious game design. Future work would also include a critical analysis of sSGDT as a tool for design; we intend to do so as part of a serious game artifact we are currently developing.

We also posit that sSGDT offers an interesting lens for critically examining serious games, and their design methodologies and frameworks. Our discussion thus far offers a glimpse of sSGDT's utility in that respect.

Finally, we revisit our earlier point that serious game design is a wicked design problem. Designers face far too many decisions to be absolutely certain they are making the right ones. We propose that sSGDT may be useful as a general *design rationale tool* [19], potentially as a critical part of game design documents.

These points merit more discussion, which will be the emphasis of our future work.

6 CONCLUSION

The *OGrES* framework is our first step in formulating a *systematic Serious Game Design Theory* (sSGDT); there is still much work to do. *OGrES* offers one way to define the Function of serious games, and it was articulated by thinking of serious game design in terms of *mIBO*; *i.e. OGrES* defines the *Input* to the serious game design process of *FP1:Conceptualization*.

REFERENCES

[1] European Space Agency. 2014. Astro Drone Crowdsourcing Game. https://www.scientificamerican.com/citizen-science/astro-drone-crowdsourcing-game/

[2] Roger Altizer and José P Zagal. 2014. Designing Inside the Box or Pitching Practices in Industry and Education. *DiGRA '14 - Proceedings of the 2014 DiGRA International Conference* 8 (Aug. 2014), 16.

[3] Amy Bruckman. 1999. Can Educational Be Fun. In *Game Developers Conference*, Vol. 99. California, USA, 75–79. https://www.cc.gatech.edu/fac/Amy.Bruckman/papers/bruckman-gdc99.pdf

[4] Rogelio E Cardona-Rivera. 2020. Foundations of a Computational Science of Game Design: Abstractions and Tradeoffs. *Proceedings of the AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment* 16, 1 (2020), 8. https://ojs.aaai.org/index.php/AIIDE/article/view/7426

[5] Maira B. Carvalho, Francesco Bellotti, Riccardo Berta, Alessandro De Gloria, Carolina Islas Sedano, Jannicke Baalsrud Hauge, Jun Hu, and Matthias Rauterberg. 2015. An activity theory-based model for serious games analysis and conceptual design. *Computers & Education* 87 (Sept. 2015), 166–181. https://doi.org/10.1016/j.compedu.2015.03.023

[6] Sebastian Deterding, Dan Dixon, Rilla Khaled, and Lennart Nacke. 2011. From Game Design Elements to Gamefulness: Defining "Gamification". In *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments* (Tampere, Finland) *(MindTrek '11)*. Association for Computing Machinery, New York, NY, USA, 9–15. https://doi.org/10.1145/2181037.2181040

[7] Roberto Dillon. 2011. The 6-11 Framework: a new approach to video game analysis and design. *GAMEON-ASIA 2011 Proceedings* 2011 (2011), 25–29.

[8] Donald A Schon. 1984. *The Reflective Practitioner: How Professionals Think in Action*. Vol. 5126. Basic Books.

[9] Mary Jo Dondlinger. 2007. Educational Video Game Design: A Review of the Literature. *Journal of Applied Educational Technology* 4, 1 (2007), 12.

[10] Kees Dorst. 2011. The core of 'design thinking' and its application. *Design Studies* 32, 6 (2011), 521–532. https://doi.org/10.1016/j.destud.2011.07.006 Interpreting Design Thinking.

[11] Fatima-Zohra El Arroum, Mostafa Hanoune, and Youness Zidoun. 2020. Serious Game Design: Presenting a New Generic Creative Reflection Framework. *International Journal of Emerging Technologies in Learning (iJET)* 15, 19 (Oct. 2020), 247. https://doi.org/10.3991/ijet.v15i19.15603

[12] Fernando Fernández-Aranda, Susana Jiménez-Murcia, Juan J. Santamaría, Katarina Gunnard, Antonio Soto, Elias Kalapanidas, Richard G. A. Bults, Costas Davarakis, Todor Ganchev, Roser Granero, Dimitri Konstantas, Theodoros P. Kostoulas, Tony Lam, Mikkel Lucas, Cristina Masuet-Aumatell, Maher H. Moussa, Jeppe Nielsen, and Eva Penelo. 2012. Video games as a complementary therapy tool in mental disorders: PlayMancer, a European multicentre study. *Journal of Mental Health* 21, 4 (Aug. 2012), 364–374. https://doi.org/10.3109/09638237.2012.664302

[13] Fishing Cactus. 2016. *Epistory - Typing Chronicles*. PC, Linux, Mac.

[14] John S. Gero and Udo Kannengiesser. 2004. The situated function–behaviour–structure framework. *Design Studies* 25, 4 (July 2004), 373–391. https://doi.org/10.1016/j.destud.2003.10.010

[15] Mohammad Mehedi Hassan, Mohammod Shamim Hossain, Atif Alamri, Mohammad Anwar Hossain, Muhammad Al-Qurishi, Yousuf Aldukhayyil, and Dewan Tanvir Ahmed. 2012. A cloud-based serious games framework for obesity. In *Proceedings of the 1st ACM multimedia international workshop on Cloud-based multimedia applications and services for e-health - CMBAS-EH '12*. ACM Press, Nara, Japan, 15. https://doi.org/10.1145/2390906.2390912

[16] Christoffer Holmgård, Georgios N. Yannakakis, Héctor P. Martínez, Karen-Inge Karstoft, and Henrik Steen Andersen. 2015. Multimodal PTSD characterization via the StartleMart game. *Journal on Multimodal User Interfaces* 9, 1 (March 2015), 3–15. https://doi.org/10.1007/s12193-014-0160-5

[17] Horst WJ Rittel and Melvin M Webber. 1973. Dilemmas in a General Theory of Planning. *Policy Sciences* 4, 2 (1973), 155–169.

[18] Institute for the Future. 2012. Innovations in Games: Better Health and Healthcare. In *Institute for the Future*. Washington D.C., USA, 6. https://www.healthit.gov/sites/default/files/IFTF_SR-1494_Innovations_in_Games.pdf

[19] A.P.J. Jarczyk, P. Loffler, and F.M. Shipmann. 1992. Design rationale for software engineering: a survey. In *Proceedings of the Twenty-Fifth Hawaii International Conference on System Sciences*. IEEE, Kauai, HI, USA, 577–586 vol.2. https://doi.org/10.1109/HICSS.1992.183309

[20] Rilla Khaled, Jonathan Lessard, and Pippin Barr. 2018. Documenting trajectories in design space: a methodology for applied game design research. In *Proceedings of the 13th International Conference on the Foundations of Digital Games*. ACM, Malmö Sweden, 1–10. https://doi.org/10.1145/3235765.3235767

[21] George Lakoff. 1999. Cognitive models and prototype theory. *Concepts: Core Readings* (1999), 391–421.

[22] Yanjin Long and Vincent Aleven. 2017. Educational Game and Intelligent Tutoring System: A Classroom Study and Comparative Design Analysis. *ACM Trans. Comput.-Hum. Interact.* 24, 3 (April 2017), 20:1–20:27. https://doi.org/10.1145/3057889

[23] Lucas Pope, 3909 LLC. 2013. *Papers, Please*. PC, PS Vita.

[24] M. David Merrill and Leston Drake and Mark J. Lacy and Jean Pratt and the ID_2 Research Group. 1996. Reclaiming Instructional Design. *Educational Technology* 36, 5 (1996), 5–7. http://www.jstor.org/stable/44428356

[25] Margaret A. Boden. 2003. *The Creative Mind: Myths and Mechanisms* (2nd edition ed.). Routledge.

[26] John-Luke McCord, Jason L. Harman, and Justin Purl. 2019. Game-like personality testing: An emerging mode of personality assessment. *Personality and Individual Differences* 143 (June 2019), 95–102. https://doi.org/10.1016/j.paid.2019.02.017

[27] Microsoft. 1985. *Microsoft Flight Simulator Series*. https://en.wikipedia.org/wiki/Microsoft_Flight_Simulator DOS, Classic Mac OS, PC-98, Windows, Xbox Series X/S.

[28] Alexander Miloff, Philip Lindner, William Hamilton, Lena Reuterskiöld, Gerhard Andersson, and Per Carlbring. 2016. Single-session gamified virtual reality exposure therapy for spider phobia vs. traditional exposure therapy: study protocol for a randomized controlled non-inferiority trial. *Trials* 17, 1 (Feb. 2016), 60. https://doi.org/10.1186/s13063-016-1171-1

[29] Pablo Moreno-Ger, Daniel Burgos, Iván Martínez-Ortiz, José Luis Sierra, and Baltasar Fernández-Manjón. 2008. Educational game design for online education. *Computers in Human Behavior* 24, 6 (Sept. 2008), 2530–2540. https://doi.org/10.1016/j.chb.2008.03.012

[30] Emerson Murphy-Hill, Thomas Zimmermann, and Nachiappan Nagappan. 2014. Cowboys, ankle sprains, and keepers of quality: How is video game development different from software development?. In *Proceedings of the 36th International Conference on Software Engineering*. 1–11.

[31] Casey O'Donnell. 2014. *Developer's dilemma: The secret world of videogame creators*. MIT press.

[32] Martina A. Rau, Vincent Aleven, Nikol Rummel, and Stacie Rohrbach. 2013. Why Interactive Learning Environments Can Have It All: Resolving Design Conflicts between Competing Goals. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Paris, France) *(CHI '13)*. Association for Computing Machinery, New York, NY, USA, 109–118. https://doi.org/10.1145/2470654.2470670

[33] Sabrina Culyba. 2018. *The Transformational Framework*. ETC Press. https://press.etc.cmu.edu/index.php/product/the-transformational-framework/

[34] Ben Sawyer and P. Smith. 2008. Serious Games Taxonomy. https://thedigitalentertainmentalliance.files.wordpress.com/2011/08/serious-games-taxonomy.pdf

[35] Barbara Strobl, Simon Etter, Ilja van Meerveld, and Jan Seibert. 2019. The CrowdWater game: A playful way to improve the accuracy of crowdsourced water level class data. *PLOS ONE* 14, 9 (Sept. 2019), e0222579. https://doi.org/10.1371/journal.pone.0222579

[36] Jennifer J. Vogel, David S. Vogel, Jan Cannon-Bowers, Clint A. Bowers, Kathryn Muse, and Michelle Wright. 2006. Computer Gaming and Interactive Simulations for Learning: A Meta-Analysis. *Journal of Educational Computing Research* 34, 3 (April 2006), 229–243. https://doi.org/10.2190/FLHV-K4WA-WPVQ-H0YM

[37] Waterford Institute. 2014. *Waterford Early Learning*. https://www.waterford.org/teacher-tools-apps/ iPad, WebGL.

[38] José P Zagal, Michael S Debus, and Rogelio E Cardona-Rivera. 2019. On the Ultimate Goals of Games: Winning, Finishing, and Prolonging. In *Proceedings of the 13th International Philosophy of Computer Games Conference*. St Petersburg, Russia, 11.