CHAPTER 7

GAPS OF UNCERTAINTY

A CASE FOR EXPERIMENTATION IN SERIOUS GAME DESIGN FRAMEWORKS

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Using serious game design frameworks, designers can more rigidly and faster proceed through a serious game design process by following predefined design rules or heuristics. Deen and Schouten (2011, p.344), for example, introduce a six step framework in order to increase player motivation in serious games, and propose heuristics such as "explicitly communicate the learning regulations to players" and "use progressive feedback." Such heuristics are undoubtedly valuable, yet they simultaneously discount the individuality of design situations. They risk formalizing the serious game design process to a degree where design becomes only following rules, instead of exploring novel design possibilities. In this chapter, we argue that design frameworks should incorporate a self-critical experimental step in which designers momentarily forego the framework's rules in order to reveal unexpected design possibilities. A case study of a completed PhD project on the design of physical rehabilitation games (Quinten, 2015) is presented in order to discuss the advantages and disadvantages of this approach.

THE ROLE OF EXPERIMENTATION IN DESIGN

In this text, we seek to examine the role of experimentation as a critical component of serious game design frameworks. Before we address this role however, it is critical to first understand how experimentation relates to the practice of design itself. We believe Schön's (1983; 1992) seminal theory of the reflective practitioner provides a solid base for this understanding. Though this theory does not fully reflect the complexities of real-life design scenarios, it accurately peers into the basic tasks of what designers do. As such, Schön (1992, p.11) describes design as a reflective conversation with the materials of a design situation, in which he observes that the designer constructs design solutions and simultaneously "invents the moves by which he/she attempts to find [those] solutions". This happens through a repetitive pattern of seeing-moving-seeing as displayed in Figure 1, in which each segment of this pattern reflects a fundamental action required to progress through the design process.

To explain this pattern, Schön (1983; 1992) describes a situation where an architectural design student under supervision of her teacher is presented with a specific design scenario. The design goal in the scenario is to create a teaching space with the use of six classroom units. As a first step, seeing in the box on the left in figure 1, the student sees or inspects the design scenario and the materials (classroom units) at hand. This inspection not only concerns the visual registration of information, but, more importantly, the active construction of meanings relating to the scenario and the materials. The student identifies a (subjective) problem in the design scenario: the units are too small for the purpose of teaching. In an attempt to solve this problem, she continues to the second step of

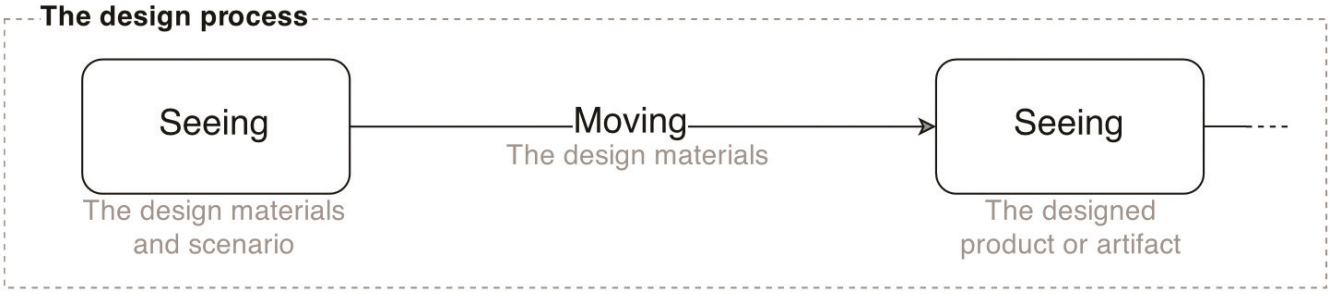

Figure 1. The seeing-moving-seeing pattern according to Schön (1983; 1992).

moving—displayed in the between the two boxes of seeing—and changes or rather reshapes the classroom units. In the example, the student rearranges the classroom units into attached spaces, aiming to create a larger total space. The student, thirdly, reflects on the changes made again by seeing, the box on the right in figure 1. If the new arrangement does not address the problem as expected, the second and third steps are repeated until a satisfied design solution has been reached.

Schön's (1983; 1992) theory of the reflective practitioner is a clear departure of the impression that designers ideate in advance of executing the design itself. If designers do not interact with the materials during the ideation phase, they may become trapped in their own thinking by disassociating themselves from the design situation. Schön's concept of design is thus rather a process in which both the designers and the materials perform a dialectical process in which they inform one another of the possibilities and constrains of the design situation. Critical within this concept is that the reflective conversation should not be viewed at from a distant third-person perspective in which the conversation has already unfolded. Instead, in order to fully comprehend the intricacies of the design process one must imagine the conversation from the designers' point of view. As in a real conversation, it is not determined in advance which sentences are going to be said at what time, the sentences are rather constructed during the conversation on the basis of others their responses.

GAPS OF UNCERTAINTY IN DESIGN

Following from its constructive nature, design is thus not a process where one linearly moves from point A to point B, but rather whereby one moves repetitively forward and backward again, exploring different pathways in a design space (Kruger and Cross, 2006). Schön (1992) asserts that the seeing-moving-seeing pattern permits designers to "recognize more in the consequences of their moves than they have expected or described ahead of time." Schön refers to the fact that the created artefact allows designers to gain knowledge they did not have before it was created. This is done through the act of reflection (Schön, 1983; 1992) or, in other words, by looking back on the design result in relation to the initial configuration. As is seen in figure 2, this reflection is on the designed artefact, which may contain materials that behaved in an unpredictable manner. Reflection is vital in design research because the material configuration is, to a degree, unpredictable (Schön, 1983; 1992). The act of moving involves creativity and thus may contain unexpected outcomes (Scrivener, 2000), and reflection allows designers to see this unexpectedness and respond accordingly in subsequent phases (Goodman, Stolterman and Wakkary, 2011).

To aid designers in this process of exploration, prototypes can be used. Lim, Stolterman and Tenenberg (2008, p.7:2) define prototypes as "the means by which designers organically and evolutionarily learn, discover, generate, and refine designs." Prototypes can be considered as low

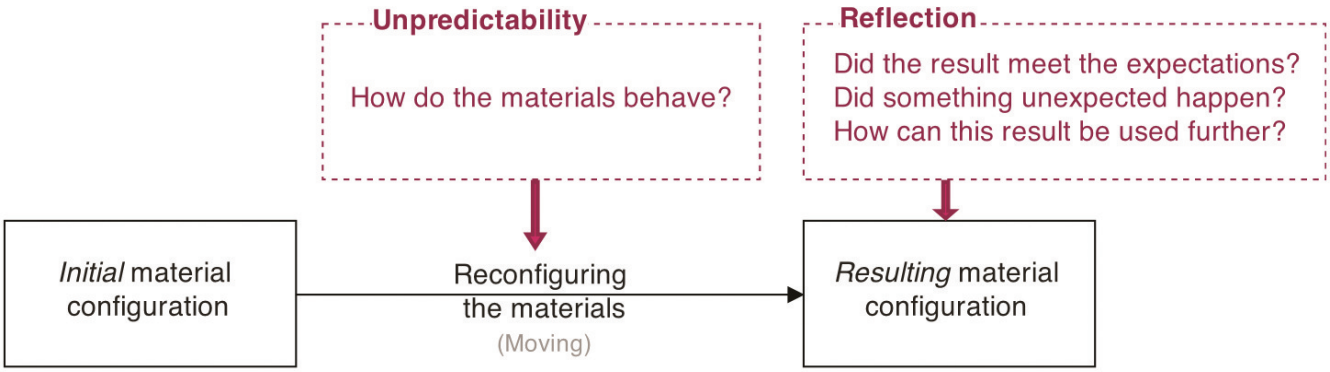

Figure 2. Reflection and unpredictability in the design process.

fidelity artifacts used to explore specific parts of the design space while leaving other parts (perhaps momentarily) aside. Lim, Stolterman and Tenenberg (2008) argue that prototypes are often regarded as means to evaluate designs in a resource-efficient manner, but more importantly, to stimulate the generation of design solutions. In this regard, the term prototypes is not understood as an early product model, but more as processes similar to sketching on a piece of paper in order to generate ideas fast and inexpensively (Agustin, et al., 2007). Of course, if we follow Buxton's (2007) discussion on prototypes and sketching, we cannot actually interchange prototypes and sketching. However, the beauty of Lim, Stolterman and Tenenberg's contribution is in fact that they do translate the exploratory and idea generating nature of sketching to other materials than pen and paper. As a result, they open a whole new range of possibilities for prototyping, as different materials have the capacity to generate different ideas based on that material (Lim, Stolterman and Tenenberg, 2008). In this way, Buxton's main component of sketching even becomes a prerequisite for prototyping: employing the ambiguity of the materials (Buxton, 2007) to discover opportunities and problems not thought of before (Edelson, 2002). Thus, in design research, prototypes serve as a material catalyst for inspiration during the exploration process.

TACKLING GAPS OF UNCERTAINTY THROUGH EXPLORATION

According to the constructivist philosophy, "[r]ealities are apprehendable in the form of multiple, intangible mental constructions [which] depend for their form and content on the individual persons or groups holding the constructions" (Bryman, 2012, p.111). It holds that people constantly (re)interpret the world and, as a result, reshape the meanings of and the perspectives on how that world works (Bryman, 2012). Important within this consideration is that there can exist multiple realities, as individuals and groups of people can interpret the world differently through their interactions with it. The goal of research within this paradigm is not to seek out a single objective 'true' reality, but to create a deeper and more informed understanding of how these diverse realities come about and work together (Guba and Lincoln, 1994).

The aim of design research in this sense is to generate, or construct, a (part of) particular reality through the act of designing (Fallman and Stolterman, 2010; Eckert, Stacey and Clarkson, 2003). Thus, following the constructivist philosophy, it is vital to create a deeper and more informed understanding of that particular reality or, in terms of Schön (1983; 1992), Cross (1982; 2006), and Frayling (1993), of the design process and its resulting artefact. The act of exploration can thus be considered as a manner to move towards a future which could not have been envisioned in advance.

This emphasis on the future is a critical aspect of design research (Stolterman, 2008). Designers do not direct their attention towards the now, but towards the construction of new futures (Goel and Pirolli, 1992). However, they do not know what they can or should create before they have actually created it. Therefore, through the act of design, and building upon what exists today, designers explore parts of the future in the now. This exploration does not necessarily result in a specific future, but presents concrete alternatives, and as such it can contribute to a more preferred one (Gero, 1990; Forlizzi, Zimmerman and Stolterman, 2009).

The exploration of a design space is not easy because of the design complexity and the insights and creativity required of the designers (Dorst, 2008). These elements submerge designers in the now and inhibit them from working towards new futures. Consequently, designers need to actively explore what is possible and desirable to create (cf. Norman and Verganti, 2014). As Schön (1992, p.11) observes, the designer constructs solutions and simultaneously "invents the moves by which he/she attempts to find [those] solutions." In this fashion, designers gradually discover the requirements, opportunities and limitations of a particular project (Ho, 2001), and direct both the problem and the solution towards one another (Dorst and Cross, 2001).

GAPS OF UNCERTAINTY IN CURRENT SERIOUS GAME FRAMEWORKS

In the previous section, we argued that design processes contain gaps of uncertainty. These gaps arise between the phases of *looking* at the design situation and *acting* on the design situation, during which time designers may manipulate designs in unexpected and innovative manners. As such, uncertainty in this sense should not be considered a negative aspect of design. Instead, uncertainty is always present and represents opportunities to create more fitting or novel designs.

In the following section, we argue that the developers of serious game design frameworks often fail to include these gaps of uncertainty in favor of depicting more predictable frameworks. These more predictable frameworks suggest increased time and cost efficiency as well as less expertise needed to use them. While these are undoubtedly critical components of a successful design project, the avoidance of the basic design component of uncertainty might likewise create missed opportunities that may otherwise positively influence the design outcome. After discussing these serious game design frameworks, we describe how we welcomed the gaps of uncertainty within our own design process and which advantages and disadvantages it brought with it.

THE RELEVANCE OF SERIOUS GAME DESIGN FRAMEWORKS

Within the field of serious game design, one of the major difficulties is combining the structure of digital games with the structure of education or training. In response to this difficulty, design researchers wish to generate information on how to design serious games in order to develop these games with reduced cost, time, expertise, or effort. One popular manner to address this issue is by developing design frameworks that guide designers through the design process. While these may be in the form of practical tools (e.g., the Unity3D [Unity Technologies, 2016] game engine is in itself a framework), we here wish to only go deeper into the theoretical frameworks created by researchers similar as in our own project (Quinten, 2015). The underlying assumption about these frameworks is that parts of a particular design process may be generalizable to other design projects as they contain similar challenges, situations, and solutions (Gericke, 2011). As is addressed in more detail below, this assumption needs to be balanced with the idea that each project also needs gaps of uncertainty.

Game researchers such as Prensky (2001) and Gee (2004) began to popularize the notion of game based learning early in the 2000s. Van Eck (2006) then wrote a seminal piece describing that as the field had finally caught attention, it should deliver what it had promised (an integrated combination of education and training, and games). This view is reflected in the works of, for instance, Gunter, Kenny and Vick (2006) who developed a standard formal design paradigm which merged educational and training theories and game design processes in order to build effective and interesting educational and training games. Important to highlight here is that researchers began call for standardized approaches through which all educational and training games could eventually be developed.

CURRENT SERIOUS GAME DESIGN FRAMEWORKS

Gunter, Kenny and Vick (2006) construct their framework by analyzing three existing educational theories and map these onto practices of game design. The result is a nine-step process in which they provide suggestions on how design researchers can combine instructional content with video games. For example, step one focuses on game design by suggesting to insert dramatic elements that gain the players' attention, while step two emphasizes instructional design by saying this attention can be applied to underscore the didactic choices to players. In relation to the seeing-moving-seeing of Schön (see above, The role of experimentation in design), Gunter, Kenny and Vick (2006) give suggestions on how to *move* from *seeing* a specific problematic situation (e.g. a separation of education/training and games) to *seeing* this situation resolved (e.g., education or training and games integrated together). In other words, this type of framework thus predefines the moving steps for creating educational/training games. A number of other researchers create same kinds of frameworks as Gunter, Kenny and Vick (2006). Deen and Schouten (2011, p.344), for example, introduce a six step framework in order to increase player motivation in serious games, and propose heuristics such as "explicitly communicate the learning regulations to players" and "use progressive feedback." Clearly, these investigations offer a valid and practical contribution to the area of educational/training games. Nevertheless, if these frameworks are interpreted as only following a set of rules, users of the framework might in practice actually miss opportunities in combining education or training with digital games. As seen in the section above, the role of experimentation in design, the steps of moving encourage designers to explore and innovate, which might be mitigated if the steps become predefined.

The observation that frameworks can hinder exploration is not entirely new. In his investigation into what designers know, Lawson (2009) examined a number of (non-game related) design frameworks and concluded frameworks are often too general or too detailed to reflect actual design practice. Lawson argues that design projects can involve a wide variety of designers and stakeholders whom all share different approaches and goals depending on the project. In view of this, frameworks may thus not translate from one situation to the other as one expects. Similarly from a game design perspective, Dormans (2012) argues that frameworks are not always accepted in the game industry, as some designers believe they restrict the productivity and creativity of the design process. Dormans here hints at the uncertainty factor in Schön's (1983; 1992) theory of design and that game designers actually wish for such uncertainty in order to design. Having said this, Dormans simultaneously underscores the relevance of frameworks provided they are used in the proper context.

Within the sphere of educational and training games, researchers have addressed the above issue with different types of frameworks. For example, the goal, audience, game and environment (GAGE) model (Lepe-Salazar, 2015) does not focus specifically on a step-by-step guideline of how to design an educational game. Rather, it acknowledges the complexity of game design and presents a set of

concerns designers need to take into account (e.g., *who are the stakeholders* and *what is the goal of the game?)*. One main advantage in this approach is that there is no prescribed step-by-step way of designing and designers thus have more creative freedom. Of course, one major disadvantage of this approach is that it requires a lot of design expertise to combine these concerns. Conversely, Roungas and Dalpiaz (2015) argue that most educational frameworks fail to structure the design process according to game design conventions. They therefore propose a *digitalized game design document* (GDD) tool that could aid researcher to design educational games. Although their evaluation of the tool was inconclusive, the idea shows promise as it would help design researchers iterate over each game element in sequence and manner they wish. Nevertheless, the disadvantage again would be that a lot of expertise would be needed to tie together all these game elements.

Winn (2009) makes an interesting contribution by extending the existing and popular *mechanics, dynamics* and *aesthetics* (MDA) framework (Hunicke, Leblanc and Zubek, 2004) in order to include a layer of learning on top of the normal game layers (storytelling and gameplay). However, his resulting *design, play* and *experience* (DPE) framework is perhaps foremost an analytic tool or a language tool between the different stakeholders in a serious game design process. As such, it highlights the links between game design and instructional design on the same abstract and useful level as the popular MDA framework, but it does not say much about what to do practically with these links as it is up to the designers to fill them in.

Hung and Van Eck (2010), on the other hand, focused on the types of gameplay that would fit best with specific learning goals and objectives. For example, starting from Jonassen's (2010) topology of problem types, Hung and Van Eck suggest that logical problems might best be solved in an *adventure puzzle* type of game, while decision-making might best be practiced within action games or strategy game. The model itself goes into more detail as to which specific features (declarative, high-order thinking, etc.) would be relevant in each choice. The model could be very useful in the beginning of the design process, where one can decide which type of game they will build in order to accommodate the learning objectives.

Finally, Kelle, et al. (2011) provide an insightful discussion on the standardization of educational game design. Specifically, they analyzed two approaches of creating frameworks and models in educational game design. The first approach appropriates learning models as a foundation and then adapts the game components to these models. Kelle, et al. (2011) conclude that the educational aspects in these types of frameworks can often be easily repurposed in other projects, yet also often lack an interesting resulting game experience. The second approach was the opposite, starting from game design characteristics and adapting these to the educational and training setting. While Kelle et al. argue this often results in a more convincing game experience, it conversely lacks the reusability of the educational aspects for other projects. They conclude that more harmonization is needed between both perspectives.

We conclude that educational game design frameworks often provide a good guidance during the design process, yet often do not take fully into account the importance of uncertainty in this process. We believe that in order to enjoy both clear guidance as well as uncertainty, there should be more focus on creative experimentation within the steps of a framework. We perceive that in many of the discussed frameworks the balance is currently directed towards filling in the gaps of uncertainty, while we believe we should sometimes replace this by helping designers navigate through the uncertainty in order to find the solution that befits their particular project.

THE EXPERIMENTAL SERIOUS GAME DESIGN FRAMEWORK

In this section, we present the *experimental serious game design framework*. This framework is one of the results of a PhD research project on the creative design of physical rehabilitation games (Quinten, 2015). The aim of this project was to explore the concept of physical rehabilitation games primarily from the perspective of the game designer. More specifically, our goal was to explore how a rehabilitation game style could encompass the particular characteristics of physical rehabilitation exercises as well as stroke and multiple sclerosis patient disabilities in the medium of digital games. In order to address this issue, four digital game prototypes were developed, tested accordingly, and reflected upon. The *experimental serious game design framework* presented below encompasses the rationale and goals of these prototypes in four phases, and has a particular focus on experimentation. Each phase is presented in the same structure: a short introduction which explains why we believe the phase was necessary and the general rationale behind it, then a clarification of how we aimed to address the issue presented in the introduction, and finally what the actual result of the phase was. Where relevant, we also added information on how we evaluated each phase, as evaluation is a critical factor in serious game design.

PHASE 1: SELECTING PRELIMINARY GAME ELEMENTS

In research on training games, researchers generally first draw a clear outline of the literature on a theoretical level. This outline provides information on the relevant issues and components within the field. Yet, it often does not provide practical design directions based on the particular features of the project. We therefore propose that preliminary elements should initially be defined in the design of training games (cf. the notion of a primary generator [Darke, 1979, cited in Lawson, 1990; Cross, 2006]). These elements assist to guide and structure the formation of the succeeding design process. To be clear, preliminary elements are not the training goals or characteristics, but rather elements that reflect the core idea of how the game will be developed. For example, in our project the close integration of educational characteristics and the digital game world was critical. Through the development of and reflection on an early game prototype, we explored which preliminary game elements would reflect this core idea.

Approach

Based on the works of Prensky (2001), Gee (2004), and Van Eck (2006), we shifted our initial focus of creating *fun* rehabilitation games to creating well-integrated rehabilitation games. Isbister, Flanagan and Hash (2010, p.2043) state that learning games need to contain *deep content,* referring to content that is closely integrated into the structure of a game and can consequently be experienced as an integral part of the game. As a detailed description of our rational can be found elsewhere (Quinten, Malliet and Coninx, 2015), it is important to note here that this helped us avoid developing only from a training perspective or game design perspective. Instead, finding a common ground between both worlds became our main goal in this prototype.

Of course, there are certain rehabilitation characteristics that eventually need to be included to deliver a successful rehabilitation. Our approach was thus to define these characteristics (see Table 1) and then generate three game concepts which we believed took these characteristics into consideration. Out of these three concepts, one concept was developed into a functional game prototype named *Flowers* (see Figure 3). In this game, patients grow and maintain flowers by performing simple rehabilitation exercises and can later display these flowers in a community garden. The goal of the

Rehabilitation exercises	Impairments	Contextual Factors
Horizontal motion	Reduced dexterity	Multiple sessions
Vertical motion	Visual difficulties	5-10 minutes of play time
Circular motion	Reduced memory	Sitting position
	Slow cognitive processing	
	Play with worse hand	
	No use of fingers	

Table 1. The rehabilitation exercises, patient impairments and contextual factors relevant to the project

game is to be creative and keep the flowers as healthy as possible, which is directly affected by how well the predefined exercises are performed. Each time players perform a task they receive visual, textual, and acoustic feedback as well as points. They automatically collect the points in a progress bar, and can thereby unlock new levels which include new types of flowers, colors and even new virtual spaces to plant seeds.

In line with the theory of design research (e.g., Schön, 1992; Cross, 2006), we reflected on our own design practice and process based on this prototype, and used these insights to uncover the rationale underlying the design decisions we made. This reflection was intended to support the discovery of possibilities and constraints in the design space (Edelson, 2002) which we hoped to translate into preliminary game elements. It was not our intention here to uncover all possibilities and constraints regarding our aim to create a common ground, but to expose some that could be useful in the subsequent design process. As such, we defined two preliminary elements we believed would be important:

1. use game mechanics (rather than narrative, visuals, etc.) to connect real-life exercises with virtual actions
2. avoid that unforeseen and unwanted genre conventions slip into the design process and conflict with the abilities of potential players (Quinten, Malliet and Coninx, 2015).

Result

Preliminary game element 1: use game mechanics (rather than narrative, visuals, etc.) to connect real-life exercises with virtual actions. Reflecting on *Flowers*, we noticed that game mechanics are a relevant link between the rehabilitation world and the virtual world, similar to the relevance of game mechanics in general educational games (Lacay and Casey, 2011). For example, *Flowers* includes three main mechanics: planting seeds, growing and healing plants, and coloring flowers. Game mechanics encompass several properties such as actions, attributes, and dynamics which, accordingly, mirror rehabilitation therapy features such as exercises, parameters, and the situational context. The rehabilitation motions as well as their parameters have been implemented in the game actions the player performs and, consequently, in the attributes of these actions. The notion of a common ground is reflected in the mechanics of the game as they link the actions in the virtual play environment to the rehabilitation exercises in the real world on multiple levels.

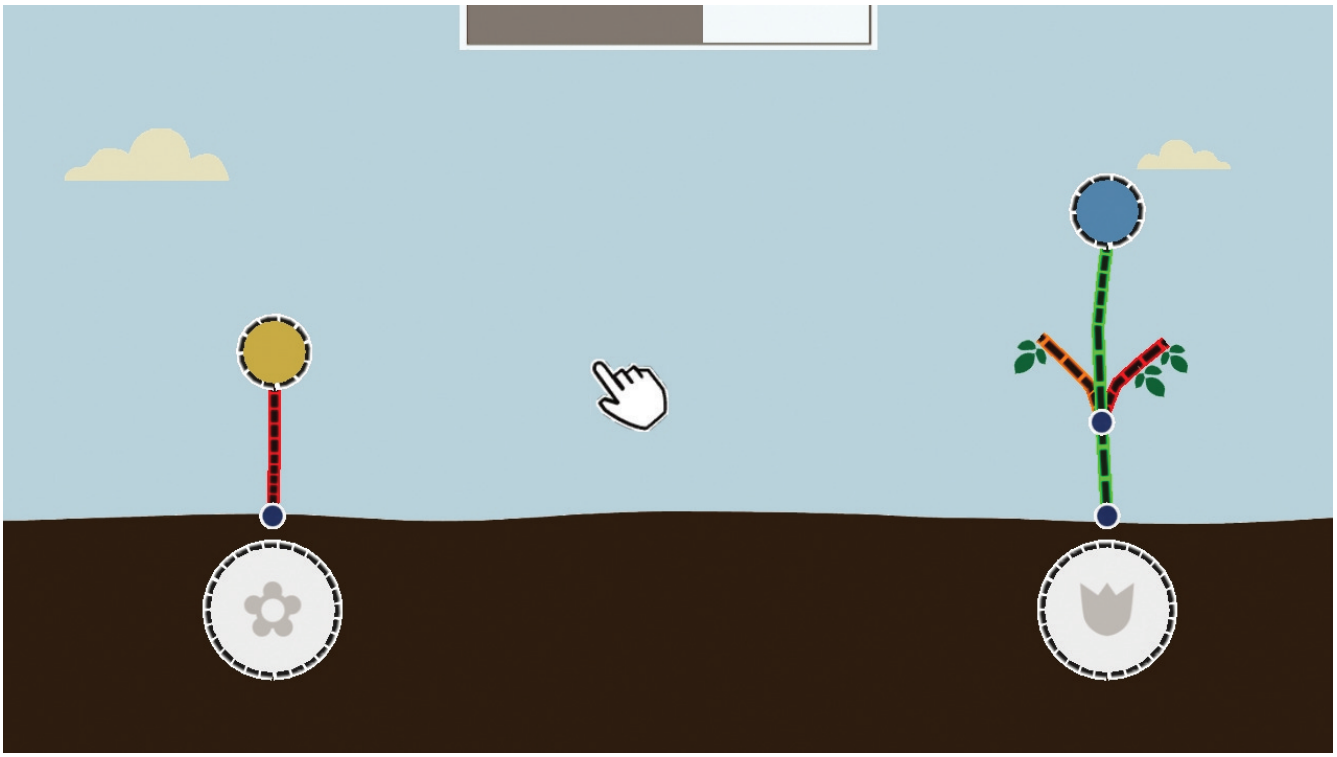

Figure 3. A screenshot of the game prototype Flowers in which players can traces lines in order to create a flower garden.

Preliminary game element 2: avoid that unforeseen and unwanted genre conventions slip into the design process and conflict with the abilities of potential players. In the concept phase, we spent attention on patient impairments (see table 1) by for instance using simple graphic representations. In spite of these precautions, the resulting prototype still included unwanted elements of visual and gamic[1] complexity which could not be removed as they were an essential part of the prototype's game genre. For example, an important part of construction and management games such as *Flowers* is the interface of the game which needs to communicate the underlying game world to the player (cf. Adams, 2009). This communication is often done through inventory systems that allow players to store and retrieve virtual items when appropriate, thereby avoiding the need to always have these items at hand (i.e. comparable to a real-life backpack). However, such inventory systems contain many small, selectable items, which increase the visual complexity of the screen as well as the difficulty of the hand-eye coordination needed. While we attempted to build the inventory in different manners, a conventional inventory system seemed one of the better solutions in the end for this concept, despite of its potential conflict with the abilities of potential players.

PHASE 2: PRELIMINARY GAME ELEMENTS CAN CATALYZE THE EXPLORATION OF DESIGN POSSIBILITIES.

The previous prototype helped us define preliminary elements that embodied our aim to integrate the rehabilitation world and game world. Unfortunately, these elements did not bring us much closer to actually creating a rehabilitation game. Because our game *Flowers* exhibited some fundamental issues (see preliminary element 2), we decided to create a new prototype that would take root in

1. We follow Kirkpatrick's (2011) use of the term gamic in order to highlight gameplay as a quality of games, in the same way games have, for example, visual, acoustic or haptic qualities.

a combination of both preliminary elements and avoid these issue. Consequently, the goal for the second prototype was to retain the element of game mechanics while removing as many genre conventions as possible. We approached this goal from an experimental point of view, meaning that we did not constrain ourselves to any rehabilitation characteristics, nor playability and user experience issues. The core goal was to embody the preliminary elements. With this in mind, the resulting prototype may appear a priori unsuitable as it fails to integrate specific rehabilitation characteristics and perhaps not even being playable. This observation is correct, yet this phase is only to further delineate the design space and reveal an overall design direction. In the next phase of the framework the prototype is adapted to specific constraints.

Approach

In order to achieve the goal of retaining the element of game mechanics while removing as many genre conventions as possible, we decided to reverse the typical game design approach according to which game elements are gradually added to a game concept (cf. Fullerton, 2008). We took our inspiration from abstract minimalist art and removed as many game elements as possible from an existing game while retaining its core game mechanics. Our focus was on the pictorial and fictional qualities of the game as well as the quantity of game elements in order to reduce the cognitive and physical load that is imposed on rehabilitation patients. Specifically, we deconstructed and minimalized the game world of the commercial game *Quake live* (Id Software LLC, 2010) gamically and visually. We chose *Quake Live* for its prominent tactile aesthetic (Smith, 2012) which we believed could potentially suit well the tactile nature of rehabilitation therapy. As there was no predefined method available for the abstraction and minimalization of entertainment games, we experimented with and changed the game's form. Specifically, we removed most of its genre conventions (e.g. using a gun to shoot) and represented the rehabilitation exercises through only its remaining core mechanics. While the limited space here prevents us from going into detail about this process, the important point is that we adapted the game form to our preliminary game elements through trial and error, rather than simply integrating the features presented in Table 1 into the existing game form.

Result

This resulted in the game prototype *Two circles and a line* (see figure 4). Compared to *Quake live* (Id Software LLC, 2010), the resulting game contains considerably less representational qualities to exteriorize the formal identity. In a similar fashion the spatial qualities of *Quake live* were significantly reduced in the experimental design process. The objects and challenges of the game were abstracted and minimalized. For example, opponents were represented by red cubes and moved on a constraint path instead moving freely in a 3D environment. Overall, the prototype contained less genre conventions yet still had simple mechanics which could represent the rehabilitation exercises.

Evaluation

Though the resulting game met the prototyping goals, the ensuing real-life arm movements were too restricted for rehabilitation and the gameplay was difficult to understand. Nevertheless, two informal play sessions were held with a number of rehabilitation therapists to assess whether the game and its abstract minimalist style warranted further development and testing with actual patients. The first session was organized during the development process, and revealed that the therapist had a generally positive impression of the game in relation to the goal of the prototype. She stated that the game

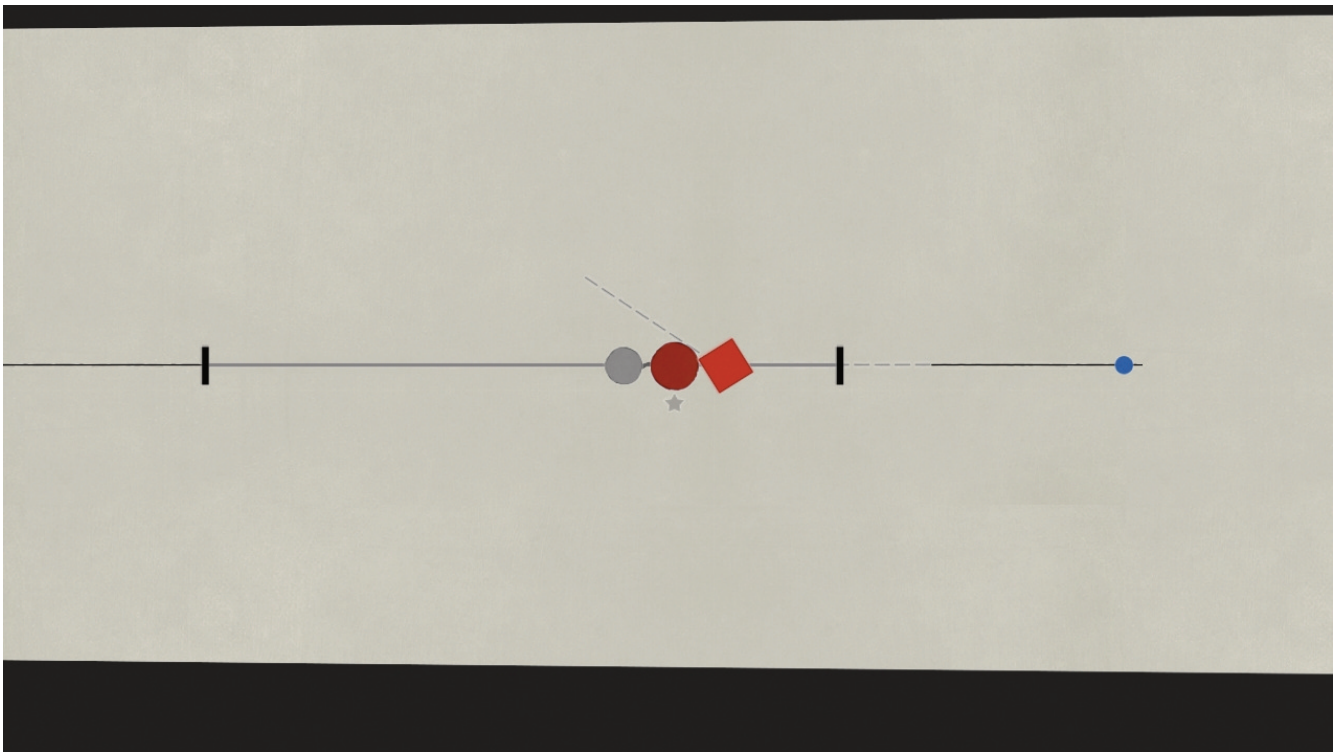

Figure 4. A Screenshot of the game prototype Two circles and a line where players push two circles over a line to the right while avoiding obstacles. The game world is abstract and minimalist to address the insights from the first prototype.

could potentially be relevant to a physical rehabilitation therapy (if further tests with patients were positive) and made some extra suggestions and remarks for future development. The second session was organized at the end of the design process. The therapists' general impressions were also positive, although they made three suggestions for improvements. These suggestions were taken into account in the further development of the game as described in the next phase.

PHASE 3: ADDRESSING THE PLAYABILITY, THE USER EXPERIENCE, AND SERIOUS ASPECTS

The experimental game prototype of the previous phase contained a number of features that reflected our preliminary game elements (e.g. abstraction and minimalism). However, adding new game elements or fine-tuning present ones in the experimental game would allow us to transform it into a more playable, pleasurable, and useful game. The aim here was not to simply revert it slightly back to the original game concept of *Quake live* (Id Software LLC, 2010), but to reimagine the game in a novel manner in relation to the physical exercises and patient disabilities defined in the first phase (see table 1). Qualitative player tests could then be used to determine the playability and pleasure of the transformed game, and provide incentive to adjust the game further.

Approach

We redesigned the abstract minimalist style according to concepts such as visual feedback (Crawford, 2003) and meaningful choice (Salen and Zimmerman, 2003; Schell, 2008). As such, a novel game prototype called *Collider* was created (see Figure 6) which aims to be usable and interesting to patients. Below are two examples of how this was achieved.

- *Visual feedback:* The graphical style of the previous game resulted from the abstract minimalist process, and therefore did not take into account how potential players will use and experience the game. To address this, changes were made to the current game's graphics. Graphics have to effectively communicate the gameplay (Crawford, 2003: Rouse, 2004), but at the same time should also create an interesting atmosphere to strengthen the play experience. In an attempt to achieve this, consistent changes in colors, gradients, lighting, and details were added to the graphical style, as described below.
- *Meaningful choice:* The horizontal lines in the previous game restricted players in their physical freedom and meaningful choices. As the player-character was completely attached to the line, players could only move forward and backward. To accommodate partial freedom, one half of the player-character has been detached from the guiding line so that the player can move freely about the game world, but still needs to follow the line in order to progress through the game world. In this manner, the player can feel free in the game world, while still being guided by a predefined line.

Result

In the described game, the concept of representing real-life rehabilitation exercises by means of virtual lines is maintained. However, the redesign resulted in four adjusted game mechanics: moving the player-character, pushing the square, passing a triangle, and collecting a point. Furthermore, notable similarities as well as differences can be observed between the described game and the abstract minimalist game introduced. The most noteworthy similarity is that players simultaneously have to guide two objects over a line, and at the same time have to avoid other objects.

Figure 5. The third game prototype, Collider, incorporating the game concept of the second prototype (Two circles and a line), yet with adapted game elements (e.g., graphics and meaningful choice) in order to accommodate playability, user experience and rehabilitation therapy.

Evaluation

Qualitative player tests with patients (n=8) in a participating rehabilitation center had been performed on the game in order to determine how the patients played and experienced the game. In reference to the MDA framework (Hunicke, Leblanc and Zubek, 2004), these tests were divide into three distinct topics, each reflecting a critical component in game design on a functional as well as an experiential level. The first two topics relate to the usability of the game, the first on the level of game mechanics and if patients could properly execute them, and the second on the conceptual level of the game and if players could properly understand the meanings and purposes of the virtual world. Finally, the third topic involves not the game itself, but rather the experience of patients while playing the game. This was done through structured observations based on play heuristics (Desurvire, Caplan, and Toth, 2004) as well as in-game as post-game interviews based on the *game experience questionnaire* (GEQ) (de Kort, Ijsselsteijn and Poels, 2008). In general, the game was well received by patients to support their rehabilitation process not only in terms of play experience, but also in relation to its style and usability. Several playability and user experience issues were also uncovered, mainly in relation to the controls of the game and how and at what points the players (mis)understood the gameplay.

PHASE 4: THE DEVELOPED CONCEPT MAY BE FURTHER EXTENDED.

The result of the previous phase may already be usable for the specific design assignment. Of course, this does not mean that this result is the final one. In principle, design spaces can always be further explored and novel insights can always be achieved. Therefore, in this fourth and final phase, which may be considered an optional one, designers integrate a new perspective and adapt the design result to that perspective. Having developed the game prototype in the previous phase, novel insights on the design space may have been gained with which to further integrate the game world and the rehabilitation world. In this project, the abstract minimalist elements were adapted to the physical space in which patients perform rehabilitation exercises, resulting in the translation of the style into a new context. This phase may be followed by phase three and four again, and continue until the requirements of the specific project are met.

Approach

Outside of the context of digital games, the attention of stroke survivors and individuals with MS following rehabilitation therapy is directed towards the qualities of the physical world (e.g. manipulating a non-virtual physical object). We therefore started exploring the concept of space in a real-life rehabilitation setting by performing small-scale observations in a rehabilitation center participating in our research project. We did this through observations, which are valuable to gain insights into the context and physical environment in which multiple actors operate during a certain activity (Mulhall, 2003; Lowe and Zemliansky, 2010). Emphasizing the physical world in the context of digital games is markedly different than dividing the attention between the physical world where exercises are performed and the virtual world on a display screen where feedback on these exercises is provided. Simultaneously, in general game design, the concept of game play is often extended outside the virtual world to also include the physical real world (Montola, Stenros and Waern, 2009). We therefore perceived an opportunity to investigate how the prototype can be extended towards the physical world where rehabilitation exercises are actually performed in order to integrate digital feedback in that world. As such, three additional physical game elements were introduced based on an analysis of experimental indie games (e.g., *Bounden* [GameOven, 2014]):

- spatially configure display screen(s) to reflect the physical rehabilitation space in the game's hardware
- use the physical materials as an essential part of the game
- integrate virtual feedback into real objects.

Result

The result is a game called *Shapes* (see figure 6), which consists of a collection of physical interactive objects with simple geometrical forms. The outline of these objects is shaped by polygons or plane surfaces. The overall goal of the game is to combine the individual objects in a wide variety of arrangements. This is done by performing basic physical actions such as lifting, rotating, dragging or pushing these objects in order to bring them together. Whenever a different combination is formed, the color and brightness of the interactive polygons is altered, and whereby new courses of action are suggested. In the current setup, there are three different objects: a cube, a sphere, and a cylinder. All three objects have different shapes and sizes, as well as different sizes of interactive segments. These shapes and sizes affect how patients perform physical actions in order to spatially configure the objects.

Figure 6. The fourth and final game prototype (Shapes) in which the style of the third game prototype (Collider) were transformed into the physical space.

Evaluation

Preliminary play tests were performed (n=4) in order to determine if patients could physically use the above presented game *Shapes*, and if they would be willing to play it in their own scheduled therapy commissioned by therapists. These tests were divided into three tasks: physically manipulating the objects 1) without any digital feedback, 2) in response to rudimentary digital feedback, and 3) in response to more complex feedback. Structured observations during the tasks were applied to get an indication of how the patients handled the objects, while post-test interviews based on the GEQ (de Kort, Ijsselsteijn and Poels, 2008) were done to get information on how the patients perceived their own handling of the objects. While the objects were well received overall, the patients encountered problems during the tests. For instance, holding the cubical object could be difficult for one patient, while another had more difficulties with getting familiarized with the feedback of the game.

DISCUSSION

At the start of this chapter, we discussed the relevance of creative experimentation in design practice. We argued that experimentation is necessary to bridge gaps of uncertainty which are inherent in design practice. Following this line of reasoning, we investigated the use of uncertainty and experimentation within current serious game design frameworks. We determined that a number of frameworks mitigate uncertainty by providing information on which actions to take in which sequence. In relation to Schön's (1983; 1992) theory of the reflective practitioner we can say that these frameworks suggest how to *move* between two phases of *seeing*. On the other hand, we also established that other frameworks highlight more the *seeing* phase by focusing for example on which game aspects are important in educational and training games. In the former case, a high degree of guidance is available, yet experimentation is rarely or not at all encouraged. It therefore seemed relevant to discuss our own design approach in a completed PhD research project on the creative design of physical rehabilitation (Quinten, 2015) as it situates itself between both cases. We believe our approach offers interesting advantages as well as disadvantages to both cases.

Our design approach was presented in a four-phase framework. In the first phase, preliminary design elements were defined that should guide the formation of a physical rehabilitation game. Two aspects are especially interesting in this phase. First, we acknowledged that in the beginning of a particular project, design researchers might not be aware of all the possibilities and problems further in the design process. For this reason, we refrained from, for example, immediately defining a game concept that would serve as the end product of the project. Instead, we explored game elements that provide a *direction* to what we wish to embody in our end product. In this sense, this phase shares a resemblance with, for instance, Hung and Van Eck's (2010) work who also wish to provide direction by deciding on a game genre before creating an actual game concept. Second, and different to Hung and Van Eck, a working game prototype was created to find these elements. This helped us to practically consider the serious characteristics of our specific project. For instance, by designing the prototype and actually being able to play it, it was much easier to envision the strong connection between game mechanics and rehabilitation exercises which later became critical in our project. A suggestion in hindsight would be to opt for a lower fidelity prototype (e.g., paper prototype) to save time and costs.

The second phase of our framework perhaps diverged the most from other existing frameworks. In this phase, design researchers are explicitly encouraged to momentarily forego the rehabilitation characteristics and context, and instead focus on the game elements identified in the phase one. In order for this to work, these game elements should adequately represent the main serious

characteristics without explicitly referring to them. To give an illustration, if our second game concept applied game mechanics as an integral connection to physical movements in the real world (preliminary game element 1) and had as little genre conventions as possible (preliminary game element 2), we assumed to have a good starting point to include rehabilitation exercises without patients having visual and cognitive problems playing the game. How specific exercises and problems would be addressed, could afterwards be taken into account. We believe one of the most noteworthy advantages of such an experimental approach is that not only the content of the game can be adapted to the serious context, but also the form of the game itself. For instance, without this phase, we would perhaps have developed a more traditional game with an extensive interface. This interface would then have needed to be adapted to the visual and cognitive abilities of future players. However, in our eventual game prototype, we almost completely removed the interface as our experimental game did not need it, thus avoiding this issue altogether.

While we could only shortly address the design approach of the second phase due to limits of space, this phase was perhaps the most creatively complex one. Because there were only two preliminary elements, there were a lot open design possibilities on how to actually design the game. The idea of abstraction and minimization was certainly not immediately clear, nor was it clear that this was a valuable path to take. In spite of this, this phase largely defined the unique look and feel of the final prototypes and in hindsight served as a great way to combine the rehabilitation perspective with the game design perspective. In relation to Schön's (1983; 1992) theory of the reflective practitioner, this phase does not tell how to *move*, but rather encourages design researchers to experiment with this move, as long as they base it on *seeing* the preliminary game elements.

In the third phase, we maintained a more traditional approach to game design. It is interesting to note here again that the project could be considered completed after the third phase. A functional game prototype was developed and showed promise in terms of playability, user experience as well as relevance to the rehabilitation therapy. Nevertheless, a final rehabilitation game—*Shapes*—was developed in which a variety of the previously defined virtual features were merged with a new feature: the physical space. This phase taught us that a design project is never really finished. The design possibilities are theoretically endless and design researchers may always continue to not only refine, but also to expand their products. This provided us with a renewed version of our game prototype that could be used for different purposes within rehabilitation therapy.

Furthermore, the project underscores that different stages of the design process might require different mindsets for evaluating the serious aspect. For example, in the first two phases, our objective was not to find if our particular design would be effective. Instead, these phases served to scope out the design possibilities of how to integrate rehabilitation and game characteristics. Therapists therefore served as experts who commented on the *potential* of the game concept and in contrast to its current usefulness. If we would not have maintained this experimental attitude and directly evaluated with our target audience, these prototypes would perhaps have been discounted on the basis of their lack of playability as well as irrelevance to rehabilitation therapy. Therefore, it is critical to reflect on the underlying potential of the experimental game to advance the further design process, and not only on how it measures to the concept of a fully functioning and effective rehabilitation game. Of course, eventually serious games need to be functional and effective, and these more experimental phases should be followed by a phase with a focus on playability and usefulness.

CONCLUSION

The role of experimentation has been significantly emphasized in the field of design. Yet, this role has not always gone unchallenged in practice. Time and financial constraints can easily sway designers away from experimentation in favor of more immediate results. The importance of frameworks emphasizing experimentation in game design—such as the one presented in this chapter—must therefore not be underestimated. These frameworks encourage designers to embrace untraversed paths that can lead to unexpected yet invaluable results. In our own project, for example, we could not have expected beforehand that the limited visual abilities of our target audience would eventually inspire the abstract minimalist game style which eventually typified the main contributions of our end-result.

The presented experimental serious game design framework tries to reach a fine balance between obtaining concrete results and exploring new design opportunities. Clear learning or training characteristics lay at the root of the framework. However, rather than formulating these characteristics as elements that are simply required to be in the end-product, they are held as starting points of inspiration for the design process. In this manner, the framework transforms these characteristics into design possibilities rather than design difficulties. Designers are thus encouraged to choose where they go, but the predefined learning or training characteristics somewhat limit where they come from. Finally, evaluations with the target audience and educational or training professional make sure designers do not drift too far away from the intended goal. Of course, the role of evaluation is different in each phase. The early phases put more emphasis on evaluating if the experiment was successful, while the third and fourth phases focus more on how the overall goal is addressed.

It is difficult to predict how well our design approach translates to other serious game design projects, especially in an educational rather than a training setting. Nevertheless, it would be interesting to include similar steps of experimentation within existing frameworks to understand how this would affect the overall framework. We hope our example encourages other researchers to add more experimentation in their work and thereby not design unique serious games in spite of educational or training objectives, but rather because of them.

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