Augmented Reality Enriched Business Modeling:

A qualitative study into the implementation of a VR serious game in the rehabilitation care

Arian Merzaie

University of Twente

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Abstract

Introduction: Currently, the step from a traditional rehabilitation program to the real world, for children with developmental coordination disorder learning to ride a bicycle, seems too large. Therefore, a healthcare organization in the Netherlands (RRD), in conjunction with their commercial partner (TR), have been developing an innovative medical product, the Vreye!, which proposes to close the gap between the clinic and the real world, by allowing children to learn how to ride a bicycle in a virtual environment while being monitored.

Objective: The objective of our study was to determine whether the Vreye!, as a finished medical product, is marketable and whether it adds value to the healthcare sector, and thus, if it can be brought to the market as a commercially viable medical product. We determined this by (1) formulating a value proposition for the product; (2) testing for technical feasibility, (3) looking at competitors on the market and the attitude of healthcare providers towards VR, and (4) mapping potential revenue models.

Methods: In order to map the marketability of the Vreye!, we used the STOF framework. To gather data, we used a systematic literature review and we investigated existing literature, in order to give us a better understanding of the developmental coordination disorder in children and VR and its benefits. Our own data consisted of testing the Vreye! and conducting interviews with a wide variety of people such as: therapists, researchers, investors, innovation managers, marketing managers, managing directors, and developers.

Results: Our initial findings with regards to the STOF model were: that the eye tracking function of the Vreye! would contribute to increased motor skills (physical fidelity) and cognitive fidelity of children suffering from developmental coordination disorder (DCD); the technology is still in development; the main competitors of the Vreye! use subscription-based models; and the best way to finance the Vreye! is through funding. Furthermore, we conducted interviews with 14 experts and we found that (1) the Vreye! has the potential to have significant therapeutic value for children with DCD, as well as for any person that is learning or relearning to ride a bicycle; (2) The development of the Vreye! will take a long time; (3) there is production driven culture in healthcare organizations according to our participants, which affects the willingness of therapists to accept new technologies; (4) and we found that being dependent on funding was not a good long-term solution, rather involving health insurers could be the most viable solution.

Conclusion: Based on our early-stage business model, we can determine that the most viable option for the Vreye! is to first apply for a research funding in the development stage. After the Vreye! is fully developed, we propose a model that is centered around health insurance companies. In this business model, the Vreye! will be offered as a service to healthcare organizations in collaboration with health insurance companies. The healthcare insurance companies will be responsible for financing the treatment with the insurance money they receive from the patients of the healthcare organizations.

Keywords: Serious Games, VR, Rehabilitation, Business Model, Adoption

Introduction

One of the major goals of rehabilitation is to make quantitative and qualitative improvements in daily activities in order to improve the quality of independent living (Sveistrup, 2004). In pursuing this endeavor, the healthcare sector has been increasingly using advanced equipment to accelerate the medical progress (Heng, 2015). One of the most important unique aspects of e-health is that the health service is being offered in a different and more scalable way, which allows for better monitoring and a wider scale availability of services. For this research we will be specifically focusing on one domain of e-health, namely, the integration of VR to provide advanced healthcare services. VR refers to a computer-generated simulation in which a person can interact with artificial three-dimensional environment using devices, such as goggles (Laurel, 2016). VR is being applied to a wide range of medical areas, including medical education/training, surgery and diagnostic assistance for heath staff, rehabilitation, treatments, and more. Especially as a treatment VR has been proven to be useful, not only for therapists but also for the patients in general, as it allows for better monitoring, feedback, and analysis (Pillai & Mathew, 2019). VR is a cutting-edge technology and it has a lot of potential in the healthcare. However, since it is very new, it is still underutilized in many sectors and the healthcare industry is no exception.

For this research we will be studying one specific VR application, the Vreye!. The Vreye! is a VR application that is being developed in the Netherlands by the RRD in conjunction with their commercial partner, TR. The Vreye! is a VR serious game (VR-SG) that helps to train children with DCD to ride a bicycle. Currently, children that suffer from DCD get traditional rehabilitation training, during which they perform abstract movements that will train them to ride a bicycle, in a clinic and then go into the real world to practice riding a bicycle. The Vreye!, in its final form, proposes that the gap between the clinic and the real world is too big, and aims to a step between the two, in order to shorten the gap between the clinic and the real world.

Since the demand for VR applications in healthcare is large and there are not many applications being used a treatment in healthcare, we will be looking at how the Vreye! can approach the market and become a viable treatment option in healthcare (Fertleman et al., 2018). In order to do this, we formulated the following research question: *"How can the Vreye!, a VR application focused on teaching children with dcd to ride a bicycle, best be introduced to the Dutch market as a commercially viable medical product?"*. This goal can be achieved by creating a business model, which provides a value proposition and gives insight in to the feasibility, financials and organizational actors of the project.

In the first section, we will discuss our methodology we used in order to gather data. The second part gives a background to our research by gather related works. Thirdly, our literature study will be illustrated. The following section contains our proposition. Next, we will discuss the results of the interviews and analyze the data. Furthermore, we will describe all facets of our business model. In the discussion section we will address our findings and provide avenues for future research. Finally, we will conclude by answering the research question and discussing the limitations to our study. Figure 1 depicts a rundown of the coming sections.

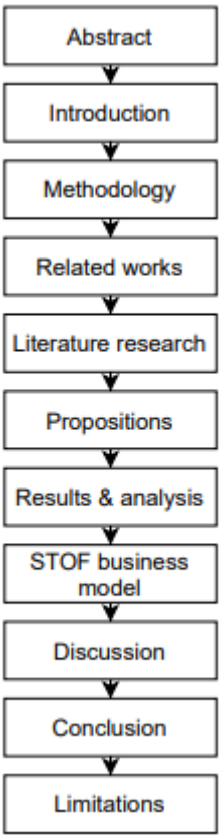

Figure 1 - Overview

Methodology

Data collection

The data for this research will be collected by 2 methods: interviews and observations. The interviews will be conducted to get a clear understanding of the Vreye! and its added value. The interviews will help formulate a value proposition and give further insight into the feasibility, financials, and organizational aspect. Moreover, the interviews will be held with therapists and experts on serious gaming and rehabilitation. Also, the interviews will partly be conducted with people from RRD, but also with people

unrelated to the rehabilitation center. For the interview questions, see appendix D. Lastly, in order to acquire a better understanding of how it can be implemented as an e-health application, we will be involved in the testing process of the prototype. The results of the observations/testing can be found in appendix E. We have opted for 2 different types of data collection to ensure the reliability and validity of the research. This method is called triangulation and it is most commonly used for qualitative research (Polit & Beck, 2012). Next to using different data collection methods, we will also interview people with different backgrounds, functions and expertise, in order to give us more insight. This is a different form of triangulation, which is called investigator triangulation (Barbour, 1998).

Interviews

The main goal of our interviews is to gather information in order to create our business model. Currently we have created a business model based on our expectations, which were derived from related works and testing. However, our current model might not coincide with the reality, therefore, it is necessary to interview people that are involved with the creation, adaptation, and implementation of the Vreye!. Although the Vreye! is still in development, the majority of the questions will be regarding the eventual finished medical product, as this will give us a better perspective of the products intended capabilities in the long run. Accordingly, we have divided the questions into four domains, service, technology, organization, and finance. For each of the domains we have selected the most appropriate people. Also, to ensure that all elements of the STOF framework are discussed, we have created a stakeholder matrix. The stakeholder matrix visualizes per question which stakeholder we intend to consult on which element (See appendix F).

Method

Predominantly, the interviews will be conducted digitally. Before start, the participants will be asked to sign the informed consent agreement. If permitted, the interviews will be recorded and transcribed afterwards. Moreover, there are three fundamental types of interviews: structured, semi-structured, and unstructured. For this research we will use semi-structured interviews, which consists of a few key questions that guide the interviewee to the correct area of exploration, while leaving room for him or her elaborate on their views and answers. Also, this interview format is used most frequently in healthcare, which makes it fitting for our purpose (Gill, Stewart, Treasure, & Chadwick, 2008). Each interview will approximately take about 30 to 45 minutes.

Participants

We will interview a wide variety of people for this research, including people such as: innovation managers, policymakers, managing directors, researchers, therapists, investors, and developers. Some of these people will already know a great deal about the Vreye! in its current stage and healthcare in general, some however, will have little to no knowledge about the topic. Therefore, we will start the interviews by first explaining what the Vreye! is now and what it will become eventually, what it does, and what its intended purposes are. For the stakeholder matrix, see appendix F.

Sampling

For this research we have chosen the purposeful sampling approach. Purposeful sampling is a non-random method which ensures that particular categories of cases are represented in the final sample. Not only is this method time-effective, it is also effective because there are only a limited number of people that can contribute to the study. Accordingly, RRD will provide us with the experts, specialists, and managers to conduct interviews with. Subsequently, this method will ensure that from a theoretical understanding, these specific individuals may have a unique, different or important perspective on the matter at hand (Mason, 2017; Trost, 1986). We will adhere to the IPA (interpretative phenological analysis) guidelines by Smith et al. (2012). According to the guidelines, a study should contain between 3-16 participants for a single study, the lower limit is meant for undergraduate students and the upper limit is suitable for large scale funded projects. Therefore, we will use 8-10 participants for satisfactory results regarding the generality of the study results.

Validity

The validity will be based on the following five criteria, namely; sensitivity to context, rigour, transparency, coherence, and impact/importance (Yardley, 2000). First of all, to ensure the sensitivity we have clearly defined the group of people we want to interview in conjunction with RRD. Second of all, the rigour is ensured by adhering to the IPA guidelines and picking an adequate sample size. Thirdly, transparency is enhanced by being descriptive of the research-and interview methods. Moreover, the coherence is strengthened by systematically fitting the sampling process with the research aim, research questions, and literature analysis. Finally, the impact is the extent to which the information contributes to the theory or practice. Since, we are creating a business model based on the interviews, the impact shall be great.

To accommodate the abovementioned, the validity of the interviews also largely depends on the willingness of respondents to be "good" informants. Some key informants might refuse to be interviewed, others might not want to be audiotaped, and some might give socially desirable answers. While they all may have good reasons to do so, it will certainly compromise the validity of the information (Barriball & While, 1994).

Data analysis and coding

In accordance with our literature review theory, we will abide by the rules of the grounded theory and use inductive coding to analyze the interviews. In this fashion we will stay loyal to the data in front of us, as we will develop codes by using phrases and terms used by the participants themselves (Linneberg & Korsgaard, 2019). The coding process starts with cleaning and preparing the data. Following, the data will be thoroughly read, to gain an understanding of the general themes of the interviews. Since this is a smaller project with a limited amount of data, we will use simple color coding with digital markers. These highlighted codes will then be developed into categories. Accordingly, each category will have its own label, description, data associated to the category, and eventually the categories may be linked to each other. Next, we will look for subtopics, contradictory points and new insight within each category. An appropriate number of quotes will be selected that convey the core essence of a category. In this fashion, the categories will be combined; thus, downsizing the number of categories (Thomas, 2003).

Related works

Background

The Vreye! in its eventual form is an innovative medical product without any predecessors, which makes it hard to find relevant literature that adds value to its credibility. Therefore, in this section, we will describe related research areas in order to create a better understanding of the topic and to place our own contributions in context. As stated before, the Vreye! is a VR serious game that trains children with DCD to ride a bicycle. In order to clearly understand the dimensions that are needed to make a business model, we must first get a better grasp of DCD and how it affects the children's motor functions. Thereafter, we will have to look at the learning outcomes of serious gaming as a treatment. VR is the next evolution of gaming in general, so, we will look at VR and its benefits. Finally, we will take a look at the integration of VR into the children's treatment of DCD. We will research rehabilitation as well, because the Vreye! as a treatment aims to strengthen the traditional rehabilitation programs that are being used to train children with DCD. In short, we will be briefly discussing the following topics in order to get a better understanding the disease and the role of VR in its treatment: DCD development, the learning outcomes of serious games, the key elements of VR, the integration and benefits of VR into children's treatment of DCD.

DCD and CP

Development of motor skills and disorders: CP and DCD

An infant enters the world with adaptive movement reflexes and a visual that is already attuned to movement. These movements are then finetuned and soothed over the first 6 months by performing repetitive object-oriented interactions, allowing the infant to develop motoric skills (Hyde & Wilson, 2011).

The capacity of the motor system to learn the systematic relationship between motor output commands and their effects on the biochemical system is critical to motor development (Diedrichsen, White, Newman, & Lally, 2010). Over time, a child learns to calibrate and adjust output signals to better approximate a desired movement. This process is called perceptual motor mapping and it enables 'feedforward control' (Shadmehr, Smith, & Krakauer, 2010). Feedforward (or predictive) control has the ability to effect rapid changes in movement trajectory in response to sudden events in the environment by predicting the future location of the moving limb (Sukerkar, 2010). The frontal cortex also develops rapidly in childhood and plays an important role in enabling flexible behavior when performing challenging tasks in dynamic environments (Brocki & Bohlin, 2004). In general, the amount of feedback control will substantially increase over childhood, enabling complex movements with more speed and flexibility (Hyde et al., 2011) However, in children with DCD, the brain parts related to motor skills are slightly alternated. This miswiring in the brain of children with DCD also leads to a delay between executive functions and motor control, meaning that these children have more trouble performing a motor task under cognitive load. The disadvantages in a child's brain with DCD, coupled with a delay between executive functions and motor control, lead to the conclusion that these children have poor feedback control (Wilson, Ruddock, Smits-Engelsman, Polatajko, & Blank, 2013).

Learning outcomes of serious games in healthcare

To many researchers the positive effects are clear, however, the existing body of work is often times incoherent and fragmented (Ke, 2009). Accordingly, to bring more structure and clearness to the literature, Connolly et al. (2012) performed a series of experimental studies in order to capture, analyze, classify the different outcomes and impact of serious games. Finally, he argues that the impact of serious games can be categorized under four concepts, namely, memory and understanding, perceptual and cognitive skills, motor skills, and soft skills. For this section however, we will only focus motor skills, as this subject is relevant to our research and because the cognitive aspects will be discussed in our own literature research.

Motor skills

Motor skills are movements and actions of muscles in the human body. Most commonly motor skills and serious games are linked to each other on the consensus of rehabilitation. The premise is that serious games improve the performance of rehabilitation patients in general both in terms of acquiring new skills and/or refining previously learned skills (Rostami & Ashayeri, 2009). In 2012, a group of researchers conducted a longitudinal, controlled study on the relation between VR serious games and Parkinson's disease (dos Santos Mendes, 2012). The study investigated the ability of the patients to learn, retain and transfer learning on 10 serious games requiring cognitive and motor skills. The study proved that the games allowed for Parkinson's patients to learn just as fast and efficient as the healthy candidates. More importantly, the studies also showed that not only do serious games improve the performance of Parkinson's patient's motor skills through a virtual environment, they also help retain the skills and translate them into daily life skills (Behrman, Cauraugh, & Light, 2000; Pendt, Reuter, & Müller, 2011).

Adaptationally, in a research by Chen and colleagues (2012), the effectiveness of VR rehabilitation for children with cerebral palsy was reviewed. The rehabilitation method of choice was a therapy provided through a virtual environment in which children interact with objects that mimic real life. The technology allows for great immersion and creates real life scenarios through sound, smell, sight, and touch. The study uncovered evidence that VR rehabilitation is effective for balance and overall motor development. Moreover, this type of rehabilitation also enhances neural links in the brain, that appeared to optimize rehabilitation in children with cerebral palsy (Weiss, Tirosh, & Fehlings, 2014). More information on serious gaming in terms of important aspects, learning outcomes, and application to healthcare can be found in appendix A.

Literature research

Literature review strategy

In order to systematically review the literature, this paper makes use of the grounded theory. The approach, popularized by Wolfswinkel (2011), splits up literature review in to five steps: define, search, select, analyze, and present. The elaborate version of the literature review strategy can be found in appendix B; here however, we will only show the final results of the 'present' phase, in the table below. The literature was used for the related works section, which gives us a background on the subject, as well as a context to place our own contributions in. We found that the most important concepts were augmented feedback, eye tracking, motor skills (physical fidelity), and cognitive fidelity. These concepts were all related to VR rehabilitation and children suffering from DCD. Also, these concepts had interface with the value proposition of the Vreye! as a final product.

Table 1 - Literature matrix

Author(s)	Year	Title	Concepts			
			Augmented feedback	Eye tracking	Motor skills	Cognitive fidelity
Wilson et al.	2013	Understanding performance deficits in developmental coordination disorder: a meta-analysis of recent research.	x		x	x
Bermudez et al.	2012	Using a hybrid brain computer interface and VR system to monitor and promote cortical reorganization through motor activity and motor imagery training. *IEEE*		x	x	x
Wulf & Prinz	2001	Directing attention to movement effects enhances learning: A review.		x	x	
Peruzzi et al.	2013	Feasibility and acceptance of a VR system for gait training of individuals with multiple sclerosis.			x	x
Hyde & Wilson	2011	Online motor control in children with developmental coordination disorder: chronometric analysis of double-step reaching performance.	x		x	x
Wälchli et al.	2016	Maximizing performance: augmented feedback, focus of attention, and/or reward?	x		x	
Todorov et al.	1997	Augmented feedback presented in a virtual environment accelerates learning of a difficult motor task.	x	x	x	x
Subramanian et al.	2013	Arm motor recovery using a VR intervention in chronic stroke: randomized control trial.	x		x	x
Heiden & Lajoie	2010	Games-based biofeedback training and the attentional demands of balance in older adults.	x		x	x
Dyer et ala.	2017	Transposing musical skill: sonification of movement as concurrent augmented feedback enhances learning in a bimanual task.	x		x	x
Wulf et al.	2010	Motor skill learning and performance: a review of influential factors.		x	x	x
Ronsse et al.	2011	Motor learning with augmented feedback: modality-dependent behavioral and neural consequences.	x		x	
Howard	2017	A meta-analysis and systematic literature review of VR rehabilitation programs			x	x
Sukerkar	2010	Source localization of visual and proprioceptive error processing during visually-guided target Tracking with the wrist.		x	x	
Piron et al.	2007	Reinforced feedback in virtual environment facilitates the arm motor recovery in patients after a recent stroke.		x	x	x

VR

Beneficiaries of VR

Children might be the biggest beneficiaries of the VR revolution. The origin for this argument is two-fold and resides on the merits of 3 studies (Korakakis, Pavlatou, Palyyos, & Spyrellis, 2009; Mikropoulos & Natsis, 2011). The studies concluded the following guiding principles: 1) the fascination of young people

with new technologies, suggests greater interest in learning in such environments; and 2) VR facilitates a visual understanding of complex concepts and it reduces misconceptions, especially for young people

Key elements of VR

VR serious games create an environment of immersion and presence. Immersion and presence have been identified as key factors for enhancing the rates of learning (Mikropoulos et al., 2011). To elaborate, presence can be defined as the immediate perception of "being there" and a feeling of existing inside the VR environment (Steuer, 1992). Bowman (2007) defines immersion as the technological fidelity of VR that the program can evoke. Consequently, because of the objectivity of "immersion", it is usually regarded to as a better measure of VR experience (Checa et al., 2020). Game developers have been focusing on immersion and presence since 2015, because of the lifted limitations on the hardware and software of their products. Therefore, recent innovations in technology have allowed developers to create more immersive environments.

Immersion and presence are crucial of course; however, it is not the only factor that determines the success of a VR serious game. A third element is called user interactivity with the VR environment. In a successful VR game, the player should feel in control of an interactive learning process, which facilitates active and critical learning (Stapleton, 2004). Serious games are known to be effective when it comes to enhancing the learning experience, however, adding VR to the mix raises new questions. Despite this, a meta-analysis by Checa and Bustillo (2020) shows that the combination of VR and serious games have the highest learning satisfaction than all other learning methodologies. Along with the satisfaction, VR-SGs boost the highest learning rates and improvement of skills.

The integration of VR into children's treatment of DCD and CP

VR rehabilitation

To focus more on the central question of this thesis, we will look at the implications of VR-SGs in the healthcare sector. Healthcare is no stranger to the use of SGs, but since 2015 innovations gave way to a new implication, called VR rehabilitation (VRR) (Howard, 2017). The main purpose of VR-SGs in the healthcare is to accommodate the rehabilitation process. While there is not much literature on VR-SGs and its effects, existing literature does proof that VR-SG programs outperform traditional rehabilitation programs (Chen, Hong, Cheng, Liaw, Yung, Chung, & Chen, 2012; Subramanian et al., 2013).

The benefits and unique aspects of VR treatment for children with DCD

Based on our literature research, there are two main avenues for intervention in CP/DCD treatment: augmented feedback (AF) and attentional training. In combination with technology, both these treatments have proven beneficial to children with DCD and CP (Van Dijk, Jannink, Hermens, 2005; Wilson, Green, Caeyenberghs, Steenbergen, Duckworth, 2016). We will discuss both treatments with the implications for the use of VR-systems, as well as the benefits of VR on the cognitive fidelity and motor skills (physical fidelity) of children with DCD and CP.

Augmented feedback

AF can be seen as feedback from an external source about the performance of a certain action. There are 3 main forms of AF; namely, knowledge of results (KR), knowledge of performance (KP) and concurrent AF (Wilson et al., 2016; Ronsse et al., 2011). KR provides information (e.g., goals achieved for a set challenge), whereas, KP provides feedback on the quality and execution of the movements. Finally, concurrent AF provides perceptual feedback about a movement in real time. AF is most effective during the long term (6-12 weeks) and when the information is not redundant (Wälchli, Ruffieux, Bourquin, Keller, & Taube, 2016; Dyer, Stapleton, & Rodger, 2017).

Attentional training/tracking

A study by Todorov and colleagues (1997) suggests that it is beneficial to focus on the attention of children in general while performing tasks. In order to test the attention, during a task, external cues are provided for the children to focus on while performing the task, prohibiting them from solely focusing on the physical task. This trains the children to enhance the cognitive load they are able to process while performing tasks. A related theory is called the "ideomotor theory", and it states that "every mental representation of a movement awakens to some degree the actual movement which is its object" (James, 1890). In essence, it suggests that actions are controlled by their intended effects. Thus, the more a child practices a certain movement, the more his brain learns to predict the effects of the intended action (Wulf & Prinz, 2001). However, it is not yet proven that this is also the case for children with DCD. Attentional training coupled with concurrent AF allows for a template in which the therapist can monitor the movement and attention of the performer and give real-time feedback. This may help the child's prediction skills and it allows him to adjusts his movement in real time, thus, making this a powerful tool for motor skill development and rehabilitation (Wulf, Shea, Lewthwaite, 2010; Piron et al., 2007).

Increased motor skills (physical fidelity)

Typically, the problem with rehabilitation programs is that they let patient performs movements and actions that are not similar to the actual movements required in daily life (Holden & Dyar, 2002). For instance, to develop motor skills, traditionally patients will be asked to perform abstract behaviors, such as finger tapping exercises or moving their hands in a circle. As opposed to more typical motor skill activities such as writing (Broeren, Rydmark, & Sunnerhagen, 2004). Proponents of VR-SGs argue for the importance of learning by imitation. Accordingly, they believe that it would be more beneficial when patients perform tasks that imitate the real life equivelant (Holden et al., 2005; Mirelman, Maidan, Herman, Deutsch, Giladi, & Hausdorff, 2011).

Moreover, only performing abstract movements may lead to not properly developing all the necessary muscles and skills to link to sequentially link together the different aspects of a certain ability, like riding a bicycle (Howard, 2017). More importantly, rehabilitation tasks that are similar to the desired activities may activate pertinent neurological pathways (Bermudez i Badia, Morgade, Samaha, & Verschure, 2012). When it comes to physical impairments, cognitive and motor functions go hand in hand. Usually, physical abilities cannot be gained/regained without proper cognitive functioning. Subsequently, through the stimulation of the neurological pathways, the cognitive functions can be strengthened. Consequently, this makes a strong case for the importance of neurological pathways, in connection to rehabilitation programs (Howard, 2017; Lucca, 2009; Jang et al., 2005).

Increased cognitive fidelity

Cognitive fidelity is vastly important in the realm of rehabilitation, because cognitive demands are often present in the real world. During traditional rehabilitation programs, patients undergo training in a stimulus-free environment. That may help the patients complete the tasks in the rehabilitation program, however, this does not translate well in to similar behaviors outside of the rehabilitation clinic (Peruzzi, Ceratti, Mirelman, Della Croce, 2013). For example, when walking, we are not solely focused on walking but oftentimes we are having conversations as well. When following a traditional rehabilitation program in a clinic, patients are often times ill prepared for the cognitive demands that the real world requires from them (Heiden & Lajoie, 2010).

VR can create an array of scenarios that demand cognitive attention, and prevent patients in general from solely focusing on the physical activities (Heiden et al., 2010). For example, there are many VR-SGs designed for the purpose of improving balance in rehabilitation patients. While authors did not find huge differences in the improvement of balance between the VR-SGs and traditional rehabilitation programs, they did find that the patients that used the VR-SGs were more readily able to adapt and respond to unexpected auditory and visual stimulus (Yen, Lin, Hu, Wu, Lu, & Lin, 2011).

Propositions

Based on our literature research we identified 4 key concepts in relation to VR rehabilitation products, namely, augmented feedback, eye tracking, increased motor skills, and increased cognitive fidelity. These concepts mainly relate to the technological aspects of VR products and to the benefits of such a medical product. In order to link the literature to our business model, we have formulated propositions for each facet of the business model:

Service

1. The eye tracking function of the Vreye! in its eventual form will be perceived to add significant value for the therapist.
2. The Vreye! as a finished product will have value for other patients besides children with DCD.

Technology

3. The development of the Vreye! will take a minimum of two years.
4. The Vreye! technology will be outdated by the time it is released on the market.

Organization

5. Younger therapists will be more inclined to work with new technologies, whereas the older ones will be more hesitant.
6. It will be difficult to convince the board of healthcare organizations to eventually buy the Vreye!.
7. The implementation phase will be crucial for the success of the Vreye!.
8. Healthcare providers are afraid of being replaced by new technologies.

Finance

9. The developers will aim to implement servitization as their revenue model.
10. Using funds will be a good long-term business model for the final version of the Vreye!.

Table 2 - Correlation between the propositions and key concepts found in the literature

		Key concepts literature			
Domains	Propositions	**Augmented feedback**	**Eye tracking**	**Motor skills**	**Cognitive fidelity**
Service	1.		x	x	x
	2.		x	x	x
Technology	3.		x		
	4.		x		
Organization	5.				
	6.				
	7.				
	8.				
Finance	9.				
	10.				

As can be seen in table 2, the majority of our propositions have no correlation with the literature. On the service domain, the final version of the Vreye! has correlation to key concepts such as eye tracking, motor skills, and cognitive fidelity. In the technology domain, the eye tracking plays a major role in the development of the Vreye!. There has been no mention of any augmented feedback mechanisms throughout the process of our research. As for the organizational and financial aspects of the business model, there seemed to be no correlation at all between the key concepts from our literature study and the Vreye!. The disconnect between the literature and the propositions based on the STOF model will be elaborated on in the discussion section.

Results & analysis

In order to see whether our initial propositions match the actual situation, we conducted 14 interviews with the following stakeholders: researchers, external experts, investors, top management, healthcare specialists, a developer, and an innovation manager. We coded them in the following manner to ensure the data is anonymized: RES_1, RES_2, EXP_1, EXP_2, EXP_3, INV_1, INV_2, TM_1, TM_2, HS_1, HS_2, HS_3, DEV_1, and IM_2. We will now look at each proposition individually, and check whether we can confirm or deny our propositions based on the interview results.

Coding

To collect the data, we typed along with the interviews and later on we made a concise summary of the answers. In order to code our gathered data, we used the strategy by Miles and colleagues (2014). Our coding process is made out of 3 cycles. For the first cycle of coding, we used the 'In Vivo Coding' approach. We analyzed each interview and looked for frequent quotes that we heard. Following, we highlighted the most important and frequent quotes and we assigned categories to them. The first cycle is basically summarizing segments of data. Moving on to the second cycle of our coding, we divided the initial summaries into smaller number of categories. Finally, we combined the second order codes with our own reflections and hunches regarding the data. This process is called analytic memoing. Our coding scheme is displayed in table 2.

Table 3- Coding scheme

Dimension	Codes	Definition	Example quote
Service	Widely applicable	The participants thoughts on the applicability of the Vreye! to people with other diseases than DCD.	*"Riding a bicycle is a tremendously complex procedure that asks a great deal of a person's motoric capabilities. That is why I think the Vreye! is useful for anyone that has to learn to ride a bicycle again."* (TM_1)
	Added value	How participants believe the Vreye! adds value to the therapeutic treatment.	*"I think the Vreye! is the missing link between the clinic and the real world and that is exactly the reason I think it will have significant added value for therapists"* (HS_1)
Technology	Development time	Estimation of how long participants think the development of the Vreye! will take.	*"Currently the project is at a complete standstill because of Corona. And we also don't have any financial incentive to continue the development. So, I can't tell exactly how long it will take, but it will take a long time."* (INV_1)
Organization	Technology replacing therapists	The participants view on the fear of therapists to be replaced by technologies	*"I believe that therapists are maybe subconsciously afraid of being afraid by robots. But I do not think this will be case because a human touch is always very essential in healthcare"* (RES_2)
	Healthcare organization culture	This alludes to the proposed production driven culture within healthcare organizations.	*"Most healthcare organizations really do have a production driven culture and that makes it hard to learn new technologies"* (HS_2)
	Difference between older and newer generation of therapists	The influence of age on therapist's willingness to accept new technologies.	*"You will always have some early adopters that fight for the new changes to be accepted. Oftentimes these are young people within organizations that really take away the fears of their colleagues"* (EXP_1)
Finance	Servitization model	The views of participants regarding the servitization model.	*"Nowadays, I would definitely go with the servitization model. It makes no sense to do anything else"* (EXP_3)
	funding	The participants view regarding the use of funding.	*"Basically, what it comes down to is, we are not willing to invest in something we are not that familiar with. And I have feeling RRD isn't either, funds are a good way to"* (INV_2)

Service

1. The Vreye! as a final product will have value for other patients besides children with DCD.

8 out of 14 participants believe that the Vreye! definitely has the potential to be of value to people with other diseases. The commonly held believe between the participants was that the Vreye! can have value for any person that has to learn or relearn how to ride a bicycle.

2. The eye tracking function of the Vreye! will be perceived to add significant value for the therapist.

We can confirm that the eye tracking function of the Vreye! is perceived as the true added value of the product. 11 out of the 14 interviewees shared this believe. Multiple participants went as far as saying that the eye tracking function is crucial for the success of the Vreye! as a medical product. The following quote illustrates the importance of the eye tracking:

"The eye tracking function is the single most important aspect of the Vreye!. It allows therapists to pinpoint where exactly the child gets distracted while performing certain movements. I conducted my own literature study a year ago and I found that over 50% of the children suffering from DCD also suffer from ADHD. So eye tracking is key in analyzing problems." (DEV_1)

Technology

3. The development of the Vreye! will take a minimum of two years.

A variety of answers have pointed to the fact that it will take anywhere between 1 to 5 years until the final version of the Vreye! can be released to the market. 10 out of the 14 participants think the development of the Vreye! will at least take 1 year. With the majority of the 10 people believing it will take closer to 3 years. The following reasons gives us an inclination to believe that at least 2 years will pass before the Vreye! is ready for the market. First of all, the Vreye! has to be continuously tested and improved based on feedback. However, the testing has been at a standstill for a while because of the current corona situation and the future of testing is insecure in the short term. Secondly, according to the head developer it takes roughly 6 months to develop a level and the goal is to have at least 5 levels varying in difficulty. Thirdly, both parties involved in the development have no financial incentive to work on the product. RRD does not want to invest in a medical product that has yet to be proven in terms of effectiveness and TR does not want to invest their money in a product without a clearly defined target audience. Finally, the certification process for medical device regulation also takes a few months. The exact time will depend on the class of safety the medical product falls under. Also, the certification only applies to the disease for which you applied, so if the developers would like to target a market outside of children with DCD, then they would have to go through the entire process again. All in all, we cannot say how long the development will take exactly, but we can state that it will take a long time.

4. The Vreye! technology will be outdated by the time it is released on the market.

6 of the 14 participants believe that the Vreye! will be outdated by the time it gets released to the market. However, 3 of those 6 believe it will not matter because the Vreye! can still be successful because of its therapeutic value. They believe that the technology will undoubtedly be outdated, but not many competitors will focus their VR cycling application to children with dcd. One quote in particular illustrates the doubt of the group:

"In this moment, VR products are a huge gimmick. As soon as you drop the words VR, everybody will want to be associated with you. But I don't think that the hype will last that long. For now, almost any VR product can be successful. However, the longer you wait, the stiffer the competition gets and the better their technologies will be. And healthcare is an especially competitive branch." (EXP2)

Organization

5. It will be difficult to convince the board of healthcare organizations to eventually buy the Vreye!.

In this case our proposition was false. 9 of the 14 people believe that it will be relatively easy to sell the board of healthcare organizations on new technologies. The commonly held believe is that the board of healthcare organizations and rehabilitations are very keen to embrace new technologies, as it brings them good publicity. Especially VR applications are popular and the participants believe that healthcare organizations will be applauded if they associated are associated with this new innovative technology.

6. Healthcare providers are afraid of being replaced by new technologies.

9 out of the 14 acknowledge that they believe that the majority of healthcare providers are afraid of being replaced by new technologies. Yet, there is a split between the people these 9 participants. 5 out of the 9 acknowledge that healthcare providers are afraid of being replaced, but they believe that they have nothing to worry about because technology will never be able to replace them. They believe that technologies will always be used in accordance with the healthcare providers to further support them in their functions. The other 4 out of 9 on the other hand, believe that not only can technologies replace healthcare providers completely, they should replace humans. They believe that there is a shortage of healthcare providers in the world and that this gap will only widen, therefore it is necessary for technologies to completely take over the role of humans, in order to combat the current and future shortage of healthcare provides. The following quote illustrates the latter believe:

"To be honest I believe new technologies and innovation like VR are fantastic! There is truly so much we can do with the new technologies, it's unbelievable. Actually, I think we should move towards the replacement of healthcare professionals, rather than support them. Of course, I understand that therapists and doctors are scared and do not like this idea of being replaced, but we really need it. And especially now with the current corona pandemic, it is blatantly obvious that we have a huge shortage of medical professionals. I get that to some extent there has to remain a human relationship between the healthcare professional and the patient, but technologies are crucial for the future." (IM_1)

7. Younger therapists will be more inclined to work with new technologies, whereas the older ones will be more hesitant.

7 out of the 14 participants believe that there is indeed a gap between older and younger people with regards to their willingness to work with new technologies. 6 out of the 7 believe that younger people are more inclined to work with newer technologies, whereas, older people will be hesitant. According to the participants, this has multiple reasons. First of all, a lack of experience. The older generation never learned in school about implementing technologies in their treatments. Secondly, some participants believe that the older generation just has less affinity with technology because they did not grow up with it. A third reason was that the younger generation of people are more inclined to experiment with new treatment methods, whereas the older generation wants to see that the technology is thoroughly proven before they use it.

8. The implementation phase will be crucial for the adoption of the Vreye! as a final product.

11 out of 14 participants agree with the sentiment that the implementation phase is of significant importance, if not crucial, for the success of any technology adoption process. The participants all had similar ideas about how they could assist the therapists at other organization to learn how to use the Vreye!. One suggestion was to make younger people the ambassadors for the implementation of new technologies within an organization. Other suggestions were to involve therapists in the development of the new technologies; to give workshops and presentations to other organizations; to make the technologies so accessible that there is almost no learning curve; and to send specialists from their own organization to learn the other therapists how to properly use the Vreye!.

We found among 10 of the 11 participants that the commonly held believe was that it would be very difficult to implement new technologies in the treatment of patients. We uncovered the supposed reason for this, was that there is a proposed culture inside healthcare organizations is predominantly focused on production. Therapists get paid for treatments, not for learning to work with new technologies. Therefore, therapists in general are very quick to stop using a new technology after 1 or 2 times if they don't see sufficient results, because they feel an immense pressure from the management to treat as many people as possible within their working hours. 6 out of the 11 participants mentioned numerous times that this is a problem within the culture of healthcare organizations. The following quote encompasses this believe:

"The implementation of new technologies within healthcare organizations remains a money issue. We get paid to treat people and not to engage in lengthy learning processes in order to use new technologies. The management only looks to the number of performed treatments. If we spend less time treating people because we are learning to use a new product, then it will be a bad look for the management." (HS_3)

Finance

9. The developers will aim to implement servitization as their revenue model since it is a big trend currently.

As it stands, it is not possible to apply a servitization model to the Vreye!. Nonetheless the management at TR said that they are planning to develop the Vreye! in such a manner that they will eventually be able to offer the medical product as a monthly subscription rather than a one-time payment. However, they have no idea how to do that as of yet. Next to that, 5 out of the 14 participants mentioned that it is a no-brainer to go for the servitization model because they believe it is the future of revenue models.

10. Using research funding will be a viable long-term business model for the final version of the Vreye!.

7 out of 14 participants did mention funding is the best way to go 6 out of 14 thinks that the best approach is to go through the health insurers. 7 out of 14 participants advised to write a good proposal and apply for regional, national, and European funding. The other 6 out of 14 believe that the best option is to offer the medical product to healthcare providers and to invoice the health insurers. The health insurers can then pay the invoice with the monthly premium they receive from the patients linked to a specific healthcare organization. As a sidenote, during the interviews it was revealed to us that you can't just simply invoice a health insurer, in order to do that you need certain types of certification, which TR does not have. So, if TR apply this approach, they would have to sell the medical products to RRD first and they will in turn sell it to healthcare organizations because they do possess over the certifications to invoice health insurers. The following example quote stresses the importance of the health insurers:

"I would involve the health insurers as quickly as possible in this process. I believe In Twente roughly 60% of the people have the same health insurers, Menzis. Knowing that, I would try to schedule a meeting with them as soon as possible to see whether they believe in this product or not." (TM_2)

Some other suggestions also came up during the interviews as alternatives to funding, because they thought funding would have no continuity. The suggestions came from 3 out of 14 people. One suggestion was to sell the Vreye! to the end-users directly, in this case the therapists, and hope that they will pay for it by using their yearly doctor's budget. Another approach was to find financial partners that already know the healthcare market and that are willing to invest in the Vreye!. Finally, a suggestion was made to approach large international VR companies that are willing to invest in the product or even buy the idea.

Business model

We have chosen the STOF-business model over others models such as the Jaap Gordijn's 3-value model, because the STOF model is specifically developed for the implementation of e-health applications (Haaker et al., 2013; Spil & Kijl, 2009; Gordijn & Van Der Raadt, 2006). In order to create clarity and structure, the STOF model will be used as the framework for the entire thesis. We will create two separate business models. The first model will be based on our literature review and results of testing at the research and development department of RRD. The first model can be viewed as a conceptual model that maps our expectations about the Vreye! as a commercially viable medical product. The second model will be more exhaustive and precise, as we will first interview experts on the four separate dimensions of the STOF model. Further information about the STOF model can be found in appendix C. The components of the STOF model will be worked out in the following fashion:

1. Service (description of intended value, delivered value, expected value, perceived value);
2. Technology (description of technical architecture, service platforms, devices, applications);
3. Organization (description of actors, roles, interactions, strategies and goals, value activities);
4. Finance (description of investment sources, cost sources, revenue sources, risk sources, pricing).

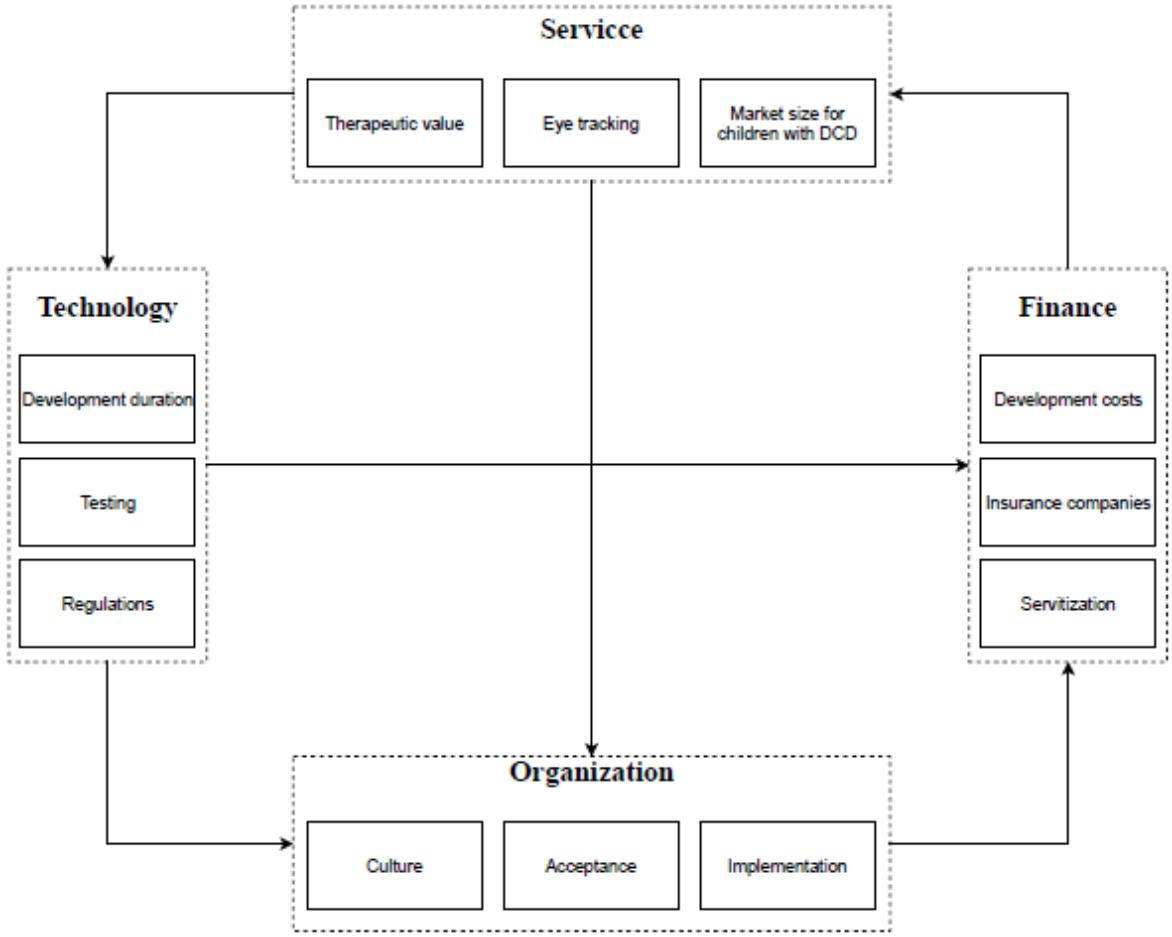

Figure 2 - STOF model

In this section, we created a business model based on the interviews with experts. We will describe how the Vreye!, according to experts, proposes to create value, as well as the technological, organizational and financial aspect that come in to play when entering the market as a commercially viable medical product. This is our second business model, as our first one can be displayed in appendix G. Our initial model was based on literature and some testing. Figure 2 depicts a visual representation of the STOF model for the Vreye!.

Service

Value proposition

Currently, the step from learning to ride a bicycle in the clinic to going out into the traffic is too big for children. Not only does this result in injuries to children from falling off their bicycle, it also keeps the therapists occupied because they are running after the children in order to catch them when they are falling. This leaves little room for analyzing mistakes and traces the causes. The Vreye! allows children to practice in a safe environment and the added benefit for the therapist is that he can now focus on analyzing the mistakes. Combined with the eye-tracking function, the therapist can now carefully analyze situations and see what exactly distracts the child. Another benefit is that the virtual realm makes it possible to expose the child to every type of circumstance that is possible in the real world. Whereas, if you would train a child in traffic, he might not be exposed to all possible factors within a ten-week training program. Thus, there are 2 potential benefits. First, the Vreye! could save time and money by teaching children how to ride a bicycle faster than a traditional rehabilitation program. Secondly, it has the potential to improve the quality of care by better preparing children for the real world. Although there is potential, there is no proof of existing patients hat have benefited.

Technology

Development of the Vreye!

Presently the Vreye! is in a very early prototype stage and the general thought is that more prototype version will follow before the actual medical product is fully developed and can be tested. As of right now, TR develops software and RRD tests it and gives feedback. This loop continues until most, if not all, bugs are removed. This feedback loop will continue until all levels are completed and it takes about 6 months per level to be completed. As for the hardware of the product, TR buys it from a supplier and does not produce it themselves, so this is not an issue for development. Eventually, TR would like to apply the Vreye! to a broader audience outside of children with DCD. Ideally, they would want to use the product for anyone that has to learn how to ride a bicycle again, but for now the focus will be solely on children with DCD.

The Vreye! also has to be certified before it can be sold as a medical product. For the certification the Vreye! will have to apply for the medical devices regulations (MDR). The benefit of this regulation is that once a product has this certificate, it adheres to very strict safety rules and people should not be so much worried about the negative effects of the product. The downside however, is that the process can take anywhere between 4 to 6 months, and sometimes ever longer. Once the MDR certification is obtained, it will be only obtained for children with DCD, as this the intended target audience for the Vreye!. If the developers wish to focus on other audiences, such as people with Cerebral Palsy or Parkinson's, then they will have to go through the entire MDR certification process again.

According to the developers, the goal is to eventually offer the medical product as a service. However, as of yet they have no idea on how realize that. The Vreye! still has a very long way to go until it is a fully developed product. The game is currently at a standstill. Both parties, have no financial incentive to develop the game further. TR does not want to invest money in a game that has no clear target audience to pay for the medical product, and similarly, RRD does not want to invest in a medical product that has yet to be proven in terms of effectiveness and added value. All in all, if both parties wish to continue with the development of the Vreye!, it will take a long time until it can be introduced to the market. Because of the long development time the Vreye! runs the risk of being outdated compared to its competitors by the time it reaches the market. But, that does not matter if the value proposition is good.

Organization

The organizational element of the STOF framework has been used to describe the actors and the key organizational aspects.

Actors

The first actor that has to be convinced of the Vreye! will be the board and policy makers inside healthcare organizations. The next actor is perhaps the most important; namely, the therapists. The therapists will not be easily convinced to expose their patients to new technologies of which they do not yet know the effectivity. The third actors are the children, convincing them will largely be dependent on how "fun" the game is perceived as. TR is the fourth actor, playing the role of the software developer and commercial partner to RRD. Finally, health insurers are our last actor in this business model. Table 4 describes these actors.

Table 4 – Actors and their activities

Role	Actor	Activity
Patient	Children with DCD	Is treated by the Vreye!
Therapist	Therapist working in healthcare organization	Offers care accompanied by the Vreye!
Software developer (TR)	Company developing software	Develops and offers Vreye! software
Hardware supplier	Company developing hardware	Offers hardware
Health insurance company	Insurance company	Offers health insurance to patients
Service Provider (RRD)	Company providing Vreye! services	Offers the Vreye! as a service, including support

Organizational aspects

The general view is that the board of healthcare organizations will not be difficult to convince when it comes to buying new technologies. Embracing new technologies is good publicity for the organizations and the board usually welcomes it, especially since VR is big trend currently. It will be harder to convince the therapist for a number of reasons. Therapists in general are wary of new technologies, because they usually have little affinity with technology and they can't confidently treat their patients if they are not confident about the technology themselves. According to the interviews, another main reason is that therapist, whether consciously or subconsciously, are afraid of being replaced with new technologies. Although these reasons apply to therapists in general, there is still a distinction to be made. Younger therapists will be more likely to embrace new technologies and implement them in their treatments. Once the Vreye! has been bought, the implementation process starts. We found that this part will be crucial for the adoption of any new technology within a healthcare organization. It's a common practice for organizations to buy a new technological product and only use it once or twice. The main reason for this is a production centered culture within healthcare organizations according to our participants. This means that healthcare providers are pushed to treat as many patients as possible within the available time slots. If the numbers drop because healthcare providers are busy learning to work with a new technology, then it will look bad for the management which is held accountable for the numbers. It is difficult to change the perceived culture, however, there are ways to guide the implementation in hopes of a shorter learning curve. For example, RRD could send their therapist to these healthcare organizations to give workshops, presentations, and guide other therapists in one-on-one sessions.

Finance

Due to the lack of funding, neither RRD or TR feel incentivized to move further with the development of the Vreye!. Luckily, there are numerous funds that can be called upon. For example, funding can come from the Dutch government, the European Union, or an independent development fund. A major downside of these funds is that when the funds have run out, other financial resources are hard to find. Therefore, our initial proposition, that funding would be a business model with continuity, was wrong. Funds are good to get a projected started, but there is no continuity possible with funds only. We believe that in the first case, funding is very beneficial, because it provides both parties incentives to continue the development process. However, once the Vreye! is finished, funds have no real place anymore and a business model with more continuity is required. We asked the external experts on business modelling, which revenue model would be best suited for the Vreye!. Based on this, we will describe an early-stage business model of how the Vreye! offers services and creates money.

The main actors in our business model are: TR (software developer), RRD (service provider), the healthcare provider/organization, the patient, and the insurance company. TR develops the software and buys the hardware from their supplier, which they sell to RRD as a complete medical product. RRD then offers the Vreye! as a service to healthcare providers who treat their patients. However, RRD does not invoice the healthcare providers, but instead they invoice the insurance company that is linked to the healthcare organization. The health insurer then pays RRD for their services with money they receive from the insurance money that the patients of the healthcare organizations pay to the insurance company. In order for this to work, the Vreye! must be offered as a service. In the current state this is not possible, but the developers aim to adopt the servitization model and change the product accordingly. Also, TR has to sell to RRD because they do not hold the necessary certifications to be able to invoice health insurers. Our business model is an early stage model that described the revenue model and the value streams on a surface level. As it stands, the Vreye! is still early stages, so we will not delve deeper into the exact funding of the product by the health insurance companies. The figure below depicts a visual representation of the model.

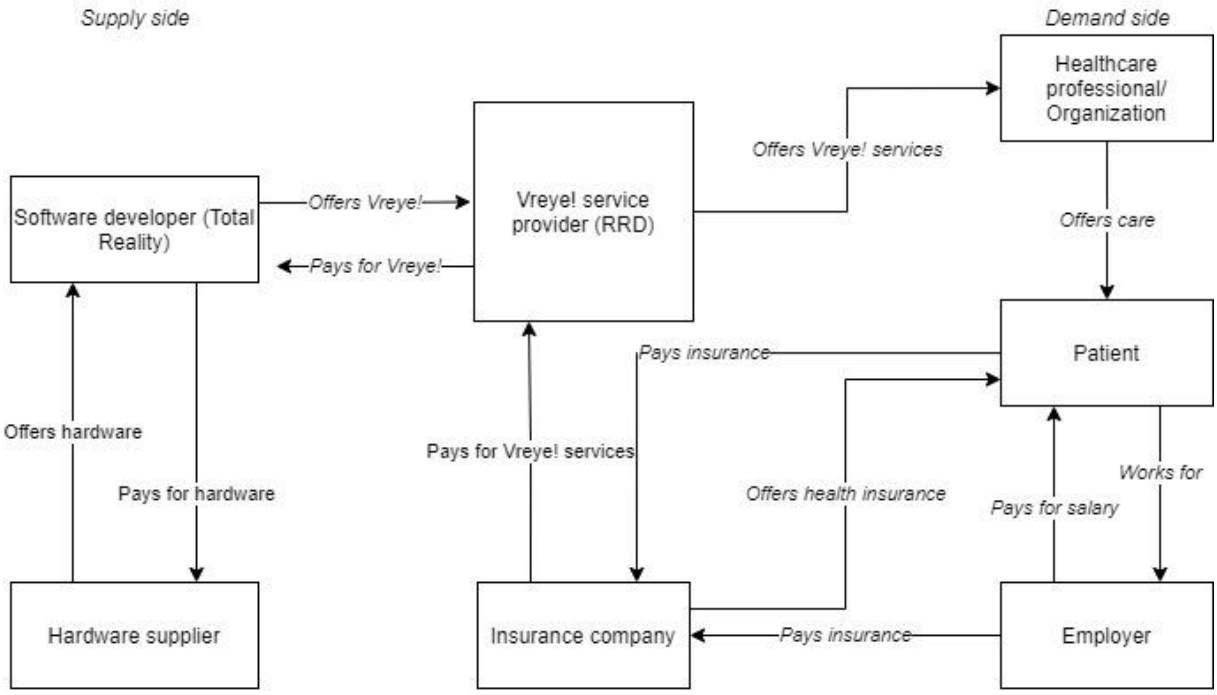

Figure 3- Revenue model Vreye!

Discussion

This section contains the interpretation and explanation of the data in the context of our research.

Literature research

Firstly, the topic of VR, in some regards, is still in its infancy. After conducting our literature research, we noticed that the topic of VR was indeed relatively immature, as the studies mainly focused on the added value and technological aspects of VR products. This explains the disconnect between our literature research and the propositions we have formulated. The STOF model is a business model specifically designed for e-health implementations, however, the literature paid very little to no attention toward the organizational and financial aspects of VR products. Therefore, our literature research added very little value because it lacked focus on organizational and financial aspects. We do expect that the literature regarding VR will mature in the coming years.

Service

As suggested by the experts, the Vreye has the potential to add significant therapeutic value. The eye tracking function of the Vreye! is something that is unique to the medical product and it could prove very beneficial especially for children with DCD. Moreover, the majority of the participants believed that the Vreye! could be applicable to a broader spectrum of patients, for example: any person that has to learn or relearn how to ride a bicycle. In our literature review we stressed the importance of the cognitive abilities of patients and how it would be improved by applying VR rehabilitation products. However, we could not gather enough information about this topic in relation to the Vreye! because it has yet to be tested thoroughly, therefore, we cannot conclude anything meaningful on that subject. Based on the interviews, we expect the Vreye! to add therapeutic value to current rehabilitation programs.

Technology

In its current shape, the Vreye! is still an early model prototype and according to our interviews it could still take a long time before it is finished. Next to that, the product is tied the medical regulation such as the MDR. When it comes to the MDR, there are 3 levels of classification. With 3 being the highest and 1 being the lowest. While there is no solid proof, some participants indicated that the Vreye! would probably fall under the class 1 devices, which means that it is very low risk. Unfortunately, this is not our area of expertise,

so we cannot give an indication of how long it will take to get such a certification. The participants do believe that the development of the Vreye! as a whole will take a long time and the downside of the long development time can have significant risks, because it may cause the Vreye! to be outdated by the time it enters the market. Based on our own testing and interviews, we do expect that the development will take a significantly long time, however, that will not matter if the value proposition is good.

Organization

Our interviews revealed that the main bottlenecks may reside within the organizational realm of our business model. The interviews suggest that the boards of healthcare organizations are willing to accept new technologies, because they believe it leads to good publicity. However, there seems to be a disconnect between the board and the management according to the participants. The management predominately focuses on optimizing the number of people that can be treated within a given timeslot. This leads to the proposed production driven culture that was described in the interviews, which discourage learning to work with new technologies. We expect that because of the presumed production driven culture within healthcare organizations, therapists and other healthcare providers will not be very eager to learn how to work with new technologies. Thus, it will be difficult for the Vreye! to replace traditional rehabilitation programs.

Finance

According to the experts, it is best to offer the Vreye! as a service. This is in line with the developers, whom have stated their ambitions to further develop the Vreye! until is suitable to offer as a service only. However, that could prove to be difficult because of the hardware that the Vreye! incorporates. In order to continue the development process, it is advisable for TR and RRD to apply for research funding. Since the Vreye! is a completely new medical product that proposes to improve healthcare, they could have a solid case to apply for the PIHC funding. The PIHC is an innovation fund that stimulates technological innovations in the healthcare sector, therefore, the concept of the Vreye! would fit perfectly with the fund's goal.

Based on the interviews with experts, our proposed revenue model is centered around health insurance companies. The Vreye! will be offered as a service to healthcare organizations and the treatment will then be financed by the insurance companies. The service provider should be in possession of certain certifications which allows them to send invoices to health insurance companies. At this point it is unclear which party will act as the service provider. The required certification was mentioned by the experts; however, no specifics were mentioned as it was not their expertise. Moreover, in our initial business model, we had determined that the Dutch market of children with DCD existed out of approximately 200.000 patient's. After conducting the interviews, we realized that this number would be much smaller because children with visual impairments cannot use the VR headset. This is also a notion that the developers have think about before moving any further.

Business model

In the beginning we had our doubts whether we had chosen the right business model to analyze the Vreye! in the development stage, as well as the final product, but in hindsight this turned out to be an appropriate choice, because the STOF model has a heavy focus on the technological aspects of a product, as compared to traditional canvas business models (Haaker et al., 2013). This helped to map the biggest potential risk of the Vreye!, namely, the long development time leading the product being outdated.

Recommendations for future research

In our related works section, we found that cognitive fidelity and motor skills (physical fidelity) are important aspects of any rehabilitation program. In the earlier stages of our research, we propositioned that the Vreye! would eventually have significant benefits towards the physical and cognitive abilities of children with DCD, because of the eye tracking function. Unfortunately, we were not able to research this because the Vreye! has a long way to go before the effectiveness can be tested. Therefore, we recommend future research to explore the effectiveness of medical VR tools that aim to enhance cognitive and physical abilities of children by using eye tracking technologies.

Moreover, we found that the organizational aspects were more important than we had initially figured. Our current research predominately focused on the financial aspects of the business model. Although we described the organizational aspects, we found that the topic was too big to properly cover within a business model. The implementation of the Vreye! needs a separate research that thoroughly incorporates change management and technology adoption models. Our interviews results suggest that younger people are more accepting when presented with new technologies. This could play a big role in the implementation process of any new technology. This notion is strenghted by a 2018 study by Hauk and Colleagues, which shows that there is a negative correlation between chronological age and technology acceptance, therefore we believe this subject is worth researching.

A final recommendation for future research is to look at a somewhat similar product, the Reducept. While the Reducept is not specifically related to bicycling, it is still a virtual reality game that is being used as a treatment to sufferers from chronic pain. The Product is popular in the rehabilitation care and it has been covered on big media platform in the Netherlands. This product could be studied to gain insight as to why it gained such popularity and why it became a commercial success.

Conclusion

The use of VR and related technologies in rehabilitation is an emerging field within the healthcare sector. Currently, the step from a traditional rehabilitation program to the real world seems to be too large. Therefore, RRD and TR are working together on the Vreye!, an innovative VR product that proposes to minimize the gap between the clinic and the real world. Our objective was to determine whether the Vreye! will eventually be a marketable medical product and whether it adds therapeutic value. By combining literature with testing and interviews, we were able to create a business model that answers the following question: *"How can the Vreye!, a VR application focused on teaching children with dcd to ride a bicycle, best be introduced to the Dutch market as a commercially viable medical product?"*. Based on our early-stage business model, we can determine that the most viable option for the Vreye! is to first apply for a research funding in the development stage. After the Vreye! is fully developed, we propose a model that is centered around health insurance companies. In this business model, the Vreye! will be offered as a service to healthcare organizations in collaboration with health insurance companies. The healthcare insurance companies will be responsible for financing the treatment with the insurance money they receive from the patients of the healthcare organizations.

Although there are some risks that could obstruct the Vreye! from reaching the market, the results of the research seem promising. The therapeutic value of Vreye! is perceived as significant for therapists and the impression we got from the interviews, was that they are open willing to accept the Vreye!. Of course, they would like to have some indication of effectiveness first, but they are welcoming of the idea to not run after the children in the parking lot anymore to prevent them from falling. And with these results, this research has added to the existing body of literature. We cannot directly compare this research to any other articles because the Vreye! is a completely new medical product. While other products do incorporate eye tracking, feedback mechanisms, VR, and bicycling, they are not sold or used as medical devices. Thus, our data contributes to a clearer understanding of VR applications as medical tools in terms of therapeutic value, the development process, organizational aspects, and revenue models.

Limitations

Several weaknesses should be considered when comparing this research to other articles. Firstly, the reliability of the results is impacted by the lack of participants from other healthcare organizations, as all of our interviewed therapists worked at RRD. Secondly, a lack of input from external experts may have lowered the quality of our research. We only interviewed 3 external experts and it led to some interesting insights, this leads us to believe that interviewing more external experts could have led to better results. Another limitation was the time restriction. To arrive at a more substantial business model we would need to have a better understanding of what the Vreye! can do and how effective the product is. However, this could take years and our research had to be finished within roughly 6 months.

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Appendix A | Background information on Serious gaming

Important aspects of serious games

In order to classify serious games and give an overview, we first define the characteristics that are most important and will make a significant difference in the success of a serious game. According to Laamarti et al. (2014), the most important criteria to look at are: activity, modality, interaction style, environment, and the application area.

Activity type

The activity type entails the type of activity that is required by the game. Activity types can be categorized as physical exertion or as psychological. The latter is mainly focused on rehabilitation or for the detection of health conditions.

Modality

The channel by which information is communicated from the computer to the player ("modality") is an important factor. The most common modalities include visual, auditory, smell, and haptic (Chen, 2006). Accordingly, studies have shown that visual indicators keep players motivated and engaged. The studies showed that players with visible displays of their performance were able to keep their activity levels up; whereas, their counterparts without visible aids sustained a decrease in their performance (Consolvo et al., 2008).

Interaction style

During the development of a serious game, some earnest thoughts have to be given to the interaction style of the game. Traditional interfaces contain a keyboard, mouse, or a joystick. Additionally, we also have intelligent interfaces that tracks eye gazes, movement, brain frequencies, and other tangible actions. The interface is designed to make to players move their bodies according to the required interaction levels of the game. However, some game consoles fail to properly align the interface with the goals, such as the Nintendo Wii. The Nintendo Wii allowed players to comfortably sit on the coach while simply moving the remotes, which indicates to the game that they are moving around (Whitehead, Johnston, Nixon, & Welch, 2010). Fortunately, The Nintendo Wii was made for entertainment purposes, so it did not matter that much that the interface had its shortcomings. However, this could prove troublesome for a game that was developed to monitor the progress of a person that is rehabilitating from a stroke. Thus, it is crucial to carefully choose an interface that suits the specific needs of the target users (Alamri, Cha, & El Saddik, 2010).

Environment

The environment of a serious game can come in 5 forms. The first form is 2D/3D, which is most commonly used for side scrolling, roleplaying, or fighting games. Examples of these are Mortal Kombat, Grand Theft Auto, and Super Mario Bros. Studies have shown that what makes games motivational is a proper fantasy context. Moreover, game designers have found that games with a strong fantasy and interesting story are key to the player's immediate decision whether to play or not (De Waal, 1995). The next dimension is VR and it can either represent reality or a purely imaginative realm (Yim, & Graham, 2007). Next, social presence described the social aspect of the game. Social presence determines whether a game is single-player or multiplayer. According to Yim (2008), social presence matters a great deal, because multiplayer games have proven to be much more motivating and engaging than single-player games. Finally, the mobility of the environment, determines whether the game is mobile or not. Moreover, games can be in an online environment, over a computer network. Accordingly, the online element adds a form of competitiveness to the mix.

Application area

It is key to know in what domain your application area resides. Up until the early 2000's, serious games for educational purposes were dominating the market. With a market share of 66%, chances were high that

developers had to assign certain attributes to games to make them educational in nature (Djaouti et al., 2011). However, in the late 2000's the market share of educational games had already decreased to about 26%. Consequently, areas such as healthcare, well-being, cultural heritage, and interpersonal communication have been dominating the market ever since (Djaouti et al., 2011). In short, adhering to the 5 criteria that Laamarti et al. (2014) developed, it is crucial to know your area of application, and your target audience. By doing so, a developer can align the requirements, goals, and measurements of the games to the needs of his target audience; thus, maximizing the potential for success of a serious game.

Learning outcomes of serious games

To many researchers the positive effects are clear, however, the existing body of work is often times incoherent and fragmented (Ke, 2009). Accordingly, to bring more structure and clearness to the literature, Connolly et al. (2012) performed a series of experimental studies in order to capture, analyze, classify the different outcomes and impact of serious games. Finally, he argues that the impact of serious games can be categorized under four concepts, namely, memory and understanding, perceptual and cognitive skills, motor skills, and soft skills.

Memory and content understanding

Numerous serious games have been developed for the purpose of aiding memory and the understanding of concepts. For this variable, some researches showed with their research that the effects of serious gaming are not always positive, but in some cases may negatively impact children. However, an overwhelmingly larger body of research almost exclusively shows improvement of performance on memory tests and concept understanding (Papastergiou, 2009). In fact, another study showed even stronger positive results for the memory of recovering cancer patients (Beale, Kato, Marin-Bowling, Guthrie, & Cole, 2007).

However, the results remain questionable about whether or not the actual game elements help to bring along the positive effects. For example, a study by Cameron and Dwyer (2005) found that adapting to a game-based approach for the acquisition of knowledge about physiology and functions of the human heart did not necessarily improve the performance of the players. In fact, it was more so the inclusion of feedback about the accuracy of the response in an engaging manner. Although it is not clear whether or not the game-based elements are the sole cause of the improvements, it is clear that rehabilitation patients are the biggest beneficiary of serious games. The most pronounced positive effects are present among recovering cancer patients and patients with chronic illnesses.

Soft skills and social skills

The use of soft skills is fundamental to success in many careers and work-related environments. This is especially true for rehabilitation patients trying to get back to the workforce after a stroke or similar incidents. Unfortunately, there are close to no studies available on the effects of serious gaming of the soft skills of people. However, since soft skills somewhat overlap with social skills, we decided to focus on the latter since there are more studies on the subject. The studies provide evidence to support the theory that some serious games can indeed aid the development of social skills that can be used in the real world. The main skills that were studies were leadership, trustworthiness, and use of communication media (Assmann & Gallenkamp, 2009; Dondlinger, 2007; Dede, 2000). The main characteristic of these games was that they involved activities which would not have been possible inside of a traditional classroom, which makes them suitable for emulating real-life scenarios in which social skills are needed (Connolly, 2012). Although these studies provided some evidence that there is a correlation between social skills and serious games, these studies were very limited. The number of participants was small, as well as the number of studies; therefore, we cannot say anything about social skills in relation to serious games.

Application of serious games in healthcare

One of the earliest records of a serious game that was designed for healthcare purposes dates back to 1992. *Captain Novolin* was a game created to teach children about managing diabetes (Djaouti et al., 2011). From here on out, a great number of serious games were developed to aid professionals in the healthcare sector.

For example, we now have games that promote physical exercise ("exergaming"), educate children on making health-conscious decisions, distract children from their chronic pain, recovery and rehabilitation, train professionals for surgical procedures, diagnoses, and games for cognitive brain functions (Susi, Johannesson, & Backlund, 2007). Although there is great diversity among the different types of games, realistically they can all be categorized under four banners; namely, health monitoring, detection and treatment, therapeutic education and prevention, and rehabilitation (Laamarti et al, 2014).

Health monitoring

To begin with, the literature illustrates the effectiveness of several serious games for health monitoring (Finkelstein, Wood, Cha, Orlov, & Dennison, 2010). An example of these types of games is the "My Fitness Coach" game for the Nintendo Wii. This game helps patients in general with congestive heart failures to monitor their weight and quality of their life (Fergus, Kifayat, Cooper, Merabti, & El Rhalibi, 2009).

Disease detection and treatment

Furthermore, there is a smaller field of healthcare that is seeing benefits of the implementation of serious games; namely, therapeutic education and prevention. This area of healthcare helps patients in general to educate themselves and the people around them about a specific illness they have. For example, if a person is suffering from depression, these types of games will inform people around the patient about the illness and keep them involved in the process (Laamarti, 2014).

Therapeutic education and prevention

In the third place, the number of serious games for the purpose of disease detection and treatment have grown substantially. Games like "21 Tally" helps to detect concentration problems in young children (McKanna, Jimison, Pavel, 2009). Whereas, games like Match-3 is a game developed to combat childhood obesity (Scarle et al., 2011). On the other hand, there are also a wide array of games that support medical professionals in their job. Certain games give doctors a virtual environment in which they can more readily detect Parkinson's disease and managing the effects thereof (Atkinson & Narasimhan, 2010). Also, there are games that analyze behavior and can promote certain social skills of people with neurological development issues (Bartolomé, Zorilla, & Zapirain, 2010).

Rehabilitation

Lastly, rehabilitation games are the one specific area that enjoys a noteworthy positive effect of implementing serious games. Studies have shown the pronounced effects of serious games on patients that lack proper control over their motor skills (Laamarti et al., 2014). The main issue for rehabilitating patients is their motivation to follow through with the rehabilitation exercises. Subsequently, the lack of motivation is combination of being overly protected by family members, comparing themselves to other patients, lack of information and support, and a strong desire to want to leave the healthcare organizations (Maclean, Pound, Wolfe, & Rudd, 2000). Accordingly, the reason why serious games have such a positive effect on rehabilitation patients, is their ability to provide information and feedback in a playful manner that motivates and engages the player (Rego, Moreira, & Reis, 2010).

Appendix B | Literature review strategy (grounded theory)

Define

Define the criteria for inclusion/exclusion

In the define stage we will carefully process what exactly will be included in to the literature review. The research involves the use of serious gaming in a VR environment to enhance the rehabilitation process of children with developmental coordination disorder (DCD). Naturally, articles that touched on areas of serious gaming, healthcare, chronic pain relief, healthcare, etc. were included. In the exclusion phase, all articles that did not have interface with eye-tracking, augmented feedback, cognitive fidelity or motor skills (physical fidelity), were excluded in the sampling process. Furthermore, articles that were written in languages other than Dutch and English were excluded. Also, the inclusion of articles that were more than 10 years old were minimized because they might not be as relevant in today's day and age.

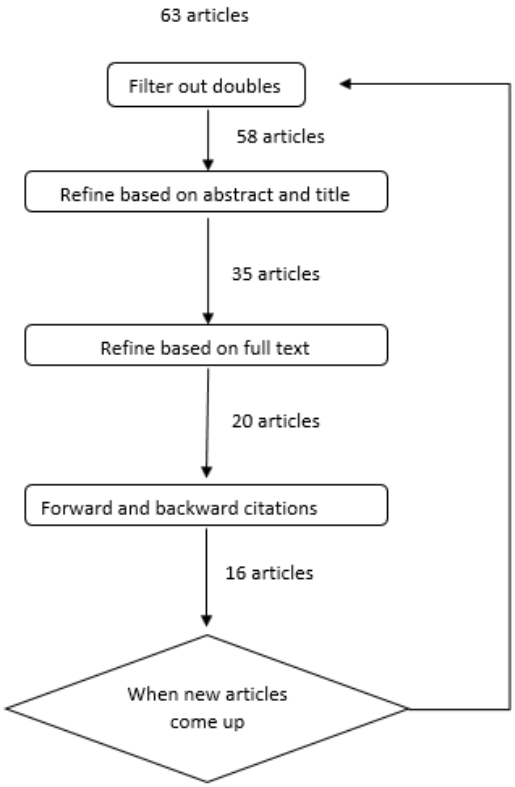

Figure 4- Select stage in reviewing the literature

Identify the fields of research

Based on the nature of the research question, the frame of reference requires a multidisciplinary approach. And so, the following fields of research have been identified: information technology, games for learning, games for health, social and personality psychology, cognition and cognitive neuroscience, developmental psychology, pedagogy, rehabilitation, and e-health.

Determine the appropriate sources

In order to optimize the finding of desired texts that fit the research, it is necessary to not only define criteria and identify research fields, but to also select the right sources. Schwartz and Russo (2004) have published an article that helps researches to quickly find articles by first establishing which search engine or index is best suited for finding specific articles. Abiding by their logic, the online databases that were used to procure articles were: Google Scholar, Scopus, and Picarta.

Search

Search

The search terms that we used included terms that were in conjunction with terms for possible outcomes, impacts of effects of playing serious games. After carefully assessing the research question and the purpose of the research, specific terms were formulated to capture and address the variety of outcomes correlated to serious games and rehabilitation:

("VR" OR "Serious Games") AND ("Motor Skills" OR "Rehabilitation") AND ("Business Model")

Select

A total of 60 articles were screened by reading the title and the abstracts. First, articles that did not meet the criteria were filtered out as well as doubles. Finally, 20 articles were selected based on their focus on the specific scope of the research. And so, these articles moved on to the "analyze" stage. These articles laid the

base for the thesis. The process can be seen in figure 2. The list of articles that were eventually used can be found in table 1.

Analyze

In order to properly conduct a literature review, the articles were coding in the following three ways: open, selective, and axial. The open coding process consists of reading the articles and highlighting relevant parts in order to identify concepts and insights based on the paper. Next, selective coding is used to integrate and refine the categories and concepts that were identified. This step mainly forces the researcher to thoroughly think through the concepts before starting the literature review. Finally, axial coding was used to find relations between the articles and categories until all papers were read and linked to each other.

Appendix C | STOF model

Business model

Business modelling is relatively new and is still often confused with business cases and business process models. Fundamentally, a business model is an illustration of how organizations offer innovative services in an economically viable manner. The business model acts on a strategic level and can be the basis for more detailed business process models and business cases. According to Limburg and colleagues (2011), a business model can be created early in the development process and it can be refined or altered depending on unforeseen changes or new insights. The former description fits perfectly with the Vreye!, which is still in development and has to deal with unforeseen circumstances regarding the testing protocol due to COVID-19. There are many business models available to us from the management field, however, we have opted to use the STOF framework. The STOF framework is a business model specifically developed for e-health innovations. The framework exists of four distinct factors, service, technology, organization and finance (Haaker et al., 2013; Spil & Kijl, 2009). Firstly, the service domain gives a description of the service offering and value proposition. Secondly, the Technological aspect depicts the technical architecture of the functionality which is required to realize the service offering. Furthermore, the organizational actors, roles, strategies and value activities are all described in the organizational domain. Lastly, the finance domain described the way in which an organization intends to generate revenue from a particular product. Also, it gives an account of how the investments sources, risk factors, and revenue sources are divided among the actors (Spil et al., 2009; Menko, Visser, Janssen, Hettinga, & Haaker, 2013).

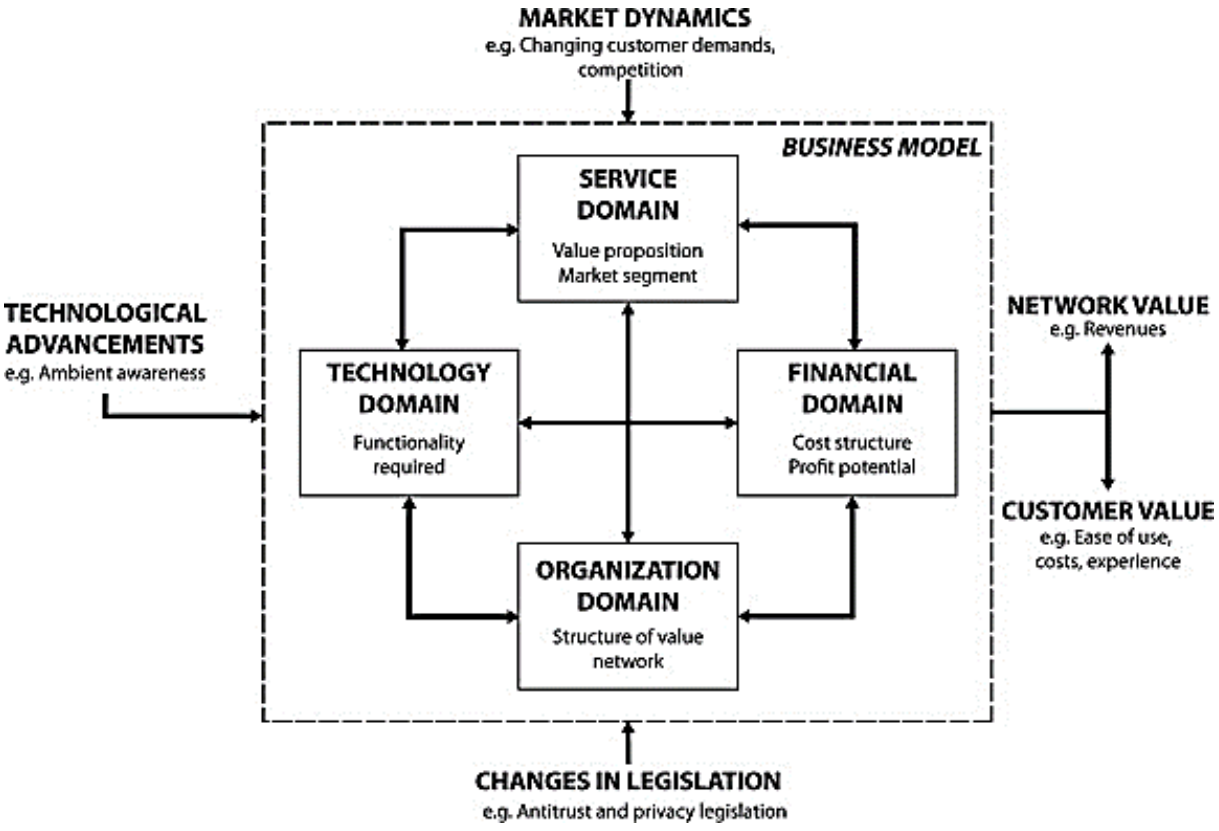

Figure 5- STOF model

Appendix D | Interview questions

Introductie

Allereerst zal ik beginnen met uitleg geven over de Vreye! als product en het doel beschrijven. Vervolgens begin ik met introductievragen zoals: wat is uw naam?, wat is uw functie?, hoelang bekleed u deze functie?, etc. Na de introductie zal ik gerichte vragen stellen omtrent de domeinen van het STOF framework. De domeinen en de vraag staan hieronder geformuleerd, alsmede een matrix waarin per vraag de desbetreffende stakeholder type is vermeld.

Service

1. Voor welke doelgroep wordt de Vreye! (commerciële eindproduct) ontwikkeld?
2. Wie moet ervoor gaan betalen volgens u?
3. Wat is volgens u de toegevoegde waarde van de Vreye!?
4. Hoe geschikt denkt u dat de uiteindelijke versie van de Vreye! zal zijn voor kinderen met DCD?
5. Wat zijn de 'unique selling points' van de Vreye! (commerciële eindproduct)?
6. Wat is het beoogde ideale resultaat van de Vreye! als eindproduct?
    - Doorvraag in termen van: verbetering van communicatie met patiënten, verbetering van patiënt zijn vaardigheden, verbetering in waargenomen toegankelijkheid van therapeuten naar de patiënten toe, etc.
7. Welk resultaat is daadwerkelijk mogelijk volgens u met de huidige versie van de Vreye!?
    - Doorvraag in termen van: verbetering van communicatie met patiënten, verbetering van patiënt zijn vaardigheden, verbetering in waargenomen toegankelijkheid van therapeuten naar de patiënten toe, etc.
8. Denkt u dat de uiteindelijke versie van de Vreye! ook breder inzetbaar is?
    - Doorvraag in termen van: is het product te gebruiken voor mensen met andere ziektes?, is het product alleen effectief voor kinderen?, wat zijn ziektes waarvan u denkt dat de Vreye! zou kunnen helpen?

Technology

1. Hoe lang duurt het om een commerciële versie van de Vreye! te ontwikkelen?
2. Welke disciplines waren betrokken bij het ontwikkelen van de Vreye!?
    a. Welke disciplines waren betrokken bij de huidige versie van de Vreye!
    b. Welke disciplines zullen betrokken moeten worden voor een commerciële versie?
    c. Hoe zijn de rollen verdeeld? (voor beide situaties)
3. Heeft u eerder een soortgelijk product ontwikkeld?
    a. Tot in welke mate waren ze vergelijkbaar?
4. Hebben andere klinieken in Nederland soortgelijke applicaties in huis?
5. Wat is volgens u de slagingskans van de Vreye!, wat betreft commercieel succes?
    a. Aan welke factoren is dat te koppelen?
6. Is de Vreye! als commercieel eindproduct schaalbaar?
    a. Wat gebeurt er als de vraag enorm toeneemt? Hoe kan hier op in worden gespeeld?
    b. Kan het product makkelijk re-designed worden indien nodig voor een andere doelgroep?
    c. Hoe zal het productieproces eruit zien?
    d. Hoe zal het distributieproces eruit zien?

Organization

1. Is het beleid/bestuur van zorginstellingen er klaar voor om VR te omarmen als een daadwerkelijke behandeling?
    a. Doorvraag: waarom wel/niet?

2. Hoe denkt u over het gebruik van games als een daadwerkelijke behandeling?
    a. Hoe denkt u dat uw collega's en andere zorginstellingen erover zullen denken?
    b. Denkt u dat er genoeg draagvlak is binnen de zorg voor de Vreye! als commercieel eindproduct?
        - Doorvraag in termen van: zorg in het algemeen, binnen uw organisatie, onder uw afdeling, onder uw vakgenoten?
3. Hoe denkt u persoonlijk over werken met VR?
    a. Staat u er open voor? tot in welke mate?
    b. Tot in hoeverre denkt u dat uw collega's en andere zorginstellingen er open voor staan?
        - Doorvraag op: waarom wel/niet?
4. Wat is ervoor nodig om de overstap te maken naar deze nieuwe vorm van zorg?
5. Welke personen binnen een organisatie zijn belangrijk voor het implementatie en adoptatie proces van de Vreye! als commercieel product in een later stadium?
6. Welke eigenschappen/capaciteiten hebben therapeuten nodig om het maximale uit de Vreye! (eindproduct) te halen? (in termen van affiniteit en eerdere werkeveringen met e-health applicaties en technologiën)
7. Hoe kan RRD de implementatievan de uiteindelijke versie van de Vreye! facciliteren?
8. Wat is ervoor nodig om de Vreye! als commercieel eindproduct eventueel op landelijke schaal uit te rollen?
    a. In hoeverre moet de effectiviteit/toegevoegde waarde van de Vreye! bewezen zijn?

Finance

1. Hoe ziet de kostenstructuur van de Vreye! eruit?
    a. Wat zijn de initiële investeringskosten?
    b. Wat zijn de vaste kosten?
    c. Wat zijn de variable kosten?
2. Wat is volgens u een verstandig renevue model voor de Vreye!?
    a. Wat zijn de voor- en nadelen van subsidie aanvragen?
    b. Is het mogelijk om de Vreye! als abonnement aan te bieden (subscription-based)?
        - Doorvraag op: waarom wel/niet?, is het nog mogelijk om de Vreye! zo te ontwikkelen dat het wel als abonnement aangeboden kan worden?
    c. Is het verstandig om de Vreye! via brokers op de markt te brengen?
        - Doorvraag op: wat zijn de risico's?, wat zijn de mogelijkheden? wat zijn de kosten?
3. Wat zal een Vreye! kosten initieel en wie zou dat realitisch gezien willen betalen?
4. Wat is volgens u de beste manier om de Vreye! op de markt te introduceren

Appendix E | Vreye! test results

Uitgevoerde tests:

- Door eendjes fietsen
- Door rood fietsen
- Kruising stoplicht rechtsafslaan (moet rechtdoor)
- Sloot (verkeerde kant langs rotonde)

Technische observaties:

- Beginnen met trappen, fiets begint te hard: langzamere opbouw snelheid;
- Korte uitrol als stoppen met trappen: remfunctie zou wenselijk zijn;
- Start checkpoint 2: proefpersoon keek achteruit, bord licht op als 'gezien', niet zinvol, want bord wordt van achteren bekeken;
- Na einde spel: scrollen door samenvatting van punten aantal erg traag;
- Na einde spel: geen samenvatting van gegeven waarschuwingen (leeg vak);
- Optie mist om vanuit spel terug naar hoofdmenu te gaan;
- Als checkpoint wordt overgedaan, lichten eendjes die voor terugkeer checkpoint gezien waren niet opnieuw op;
- Geen waarschuwing als door rood of door de eendjes wordt gereden op UI, misschien wel in de data (moet ik nog verwerken, gaat deze/volgende week niet lukken);
- Zandweg kan je sloot niet in rijden, fiets gaat 'gewoon' verder, geen melding oid
- Geen meldingen bij te wilde stuurbewegingen;
- Tacx gaat soms te snel op stand-by, dan programma opnieuw opstarten om hem weer werkend in game te krijgen.

Ervaring proefpersoon:

- Misselijkheid en duizeligheid door de virtuele omgeving;
- Realistische fietservaring;
- Op den duur was het mogelijk om voor langere periodes de VR-headset op te laten.

Appendix F | Stakeholder matrix

Tabel 5 - Stakeholder matrix

Vraag	Behandelaar	Ontwikkelaar	Innovatiemanager	Investeerder	Onderzoeker	Beleidsmaker/directeur
Service						
1		x			x	x
2	x	x		x	x	x
3	x	x	x	x	x	x
4	x	x			x	x
5		x			x	x
6		x			x	x
7		x			x	x
8	x	x			x	x
Technology						
1		x				
2		x				x
3		x				
4		x			x	x
5		x	x		x	x
6		x				
Organization						
1	x	x	x		x	x
2	x		x	x	x	x
3	x					
4			x		x	x
5	x		x			
6	x		x		x	
7	x		x		x	x
8		x	x	x		x
Finance						
1		x			x	
2		X		x	x	x
3		x		x	x	x
4		x			x	x

Appendix G | STOF framework (expectations)

Service

value proposition

This part of the STOF framework describes the value proposition of the Vreye! in the final version. The Vreye! will offered as an advanced treatment that trains children with DCD to ride a bicycle. The Vreye! offers a unique experience as opposed to other VR cycling applications, because it makes use of an actual bicycle. Children put on a VR headset while sitting on a stationary bicycle; in this fashion, they use all the actual muscles and muscle functions that would normally be activated while cycling. Also, the headset tracks the eye movement of the children and notifies the therapist when a child misses certain key traffic signs in the virtual realm. The eye tracking functions allows the therapists to see what kind of influence the environment has on the steering movement of the child. Next to that, two monitors are placed in the practice room to track the head and steering motions of the child.

The main premise of the Vreye! is to be the link between motor skills training in a clinic and the real world. Most VR games have the patient sitting stationary with a virtual headset on and allow them to control their action by pressing buttons on a controller. Afterwards, the children have to go out a practice riding a bicycle in real life, and in most cases, the step from the rehabilitation center to real life is too big. The Vreye! on the other hand, makes children put on the headset while sitting on an actual bicycle, performing the actual movements, without the risk of injuring themselves by falling off the bike. By mimicking the movements of the real life equivalent, the Vreye! allows for the necessary muscles and skills to sequentially link together. Thus, by creating a more real experience, the hope is that the children will adapt quicker to the real world; thereby, shortening the learning curve.

The program starts with a consultation during which the child receives instructions about the Vreye!. A dedicated health professional, such as a therapist, will monitor the children that use the application. The therapist will monitor the child in realm time by looking for notifications to pop up on the screen. The bicycle will be linked to a computer and measure the following: how fast the child cycles, the steering movement, and how hard the child peddles. With the eye tracking function, the therapist will be able to monitor whether the child notices crossing animals, traffic signs, traffic lights, and whether he takes the right turns. The application gathers the data and allows the therapist to analyze it. Thereafter, the therapist assesses the mistakes and decides what feedback is best to give without overloading the child's cognitive capacities. Thus, the Vreye! has benefits for both the users and the therapists. Making this form of advanced treatment appealing to end-users as well as healthcare providers. The main benefits of the Vreye! are:

- Better monitoring of children's steering and viewing behaviors;
- Better feedback for the therapists about children's mistakes
- Better feedback for children on what they should do or improve on;
- Better analysis of children's mistakes.

Technology

Technological feasibility

This domain contains a description of the technical functionality that is required to realize the service offering. In the case of the Vreye!, it is difficult to assess how well the technological variables are fulfilled, because the product is still in the early stages of development. However, a prototype was available and gave us an indication of the products capabilities. For this research we were involved in the testing phase of the prototype. The testing of the prototype is done to ensure that you can accurately measure what you want to without technical difficulties. Accordingly, the tests involved the following 3 domains:

1. *Usability*: By letting a test subject perform the set-up of the Vreye!, we are able to gage the usability of the product. This ensures that therapists and other experts can easily set the Vreye! up.
2. *User experience*: By observing and interviewing the test subject, we could get a better grasp of what the user is experiencing while riding the bicycle and wearing the VR headset.

3. *Feasibility*: The feasibility of the prototype is related to the perception of the therapists and the degree to which they think the Vreye! has added value and how effective the product could be. This is the most important step, as it dictates whether the prototype testing can be performed with children as test subjects.

Following the testing process, the rehabilitation center will send the results to the software development team for further improvements of the Vreye!. If the final results are approved, then the testing can go forward with children as the test subjects. and the current prototype can measure the 3 domains accurately, then testing can go forward. As of right now, it is unclear whether the testing procedures may go forward with children; however, RRD was optimistic about the post-test results.

Organization

The organizational element of the STOF framework has been used to describe the market, the actors and the key players.

Actors

RRD is the rehabilitation center in the Netherlands and has a lot of experience with threating children with motor skills problems. Moreover, they work together with therapists, doctors, pediatricians, general practitioner's, and other medical experts Within the organization, there is a specialized DCD-team which focuses on the children's motor problems and other related subjects, such as: motor problems, social and emotional problems, learning problems, and language problems. The second actor is TR, a small company that offers VR solutions. TR is developing and funding the Vreye!, and they would like to turn the application into a commercial success.

Market

Growing healthcare demand and rising costs have forced countries to look towards more efficient and cost-effective solutions to health problems. In response, The European Union is increasing the public support for serious games in healthcare to tackle challenges. Although the e-health game markets are just emerging, the European union has a competitive advantage over the US market, because of the less strict and innovation-friendly regulations. Recently, the European Union has taken initiative by developing a new plan called "Horizon2020". "Horizon2020" is a planned program by the European union in which roughly 9 billion euros are allocated for health, demographic change and wellbeing. Moreover, the plan entails the use of specific instruments that support small and medium-sized enterprises (SME's) in general in terms of loans and grants (Kaleva, Hiltunen, & Latva, 2013).

As for the Vreye! in specific on the Dutch market, we first have to look at the target audience. The target audience of the Vreye! are children with DCD. According to studies, the most reported number is in the 5 to 6% range (Kotorp, Lindenschot, & Steultjens, 2012; van den Berg & van Gaalen, 2018). This is equal to roughly 1 in 20 children with DCD. Moreover, there are approximately 3.4 million children in the Netherlands between the ages of 0 and 18 (Lanting, Deurloo, Wiefferink, & Uilenburg, 2017). Therefore, the potential market for the Vreye! ranges between 170.000 and 204.000 patients.

Competitor analysis

As the Vreye! is still in development, it is important to look at similar games to get an idea of the game's effectiveness. Therefore, we will be looking at the potential competitors of the Vreye!: 'VRkeer' and 'WegwijsVR'. We will be solely focusing on these two because they are the most similar to the Vreye! and have both enjoyed widescale success of a national level.

Competitors: 'VRkeer' and 'WegwijsVR' are both examples of similar games that had successful implementations. Firstly, 'VRkeer' is a VR serious game that aims at making cycling safer for children in primary school by providing virtual scenarios which help children react appropriately to difficult traffic situations. The children make choices and see the consequences of their actions. Moreover, the teacher has access to the game's analytics, allowing for analyses and feedback. Similarly, 'WegwijsVR' is an app that simulates an environment in which children from the primary school walk or cycle through traffic. The app

immediately gives feedback to the children, in order for them to alter their behaviors. The children's performances can be tracked digitally in an online dashboard. The information for both competitors was found at their own respective websites, https://wegwijsvr.nl/ and https://vrkeer.app/.

Competitors strategy: Both competitors use the servitization model. This means that they are mainly offering services in return for a monthly/yearly payment (Palo, Åkesson, & Löfberg, 2019). Their products allow them to offer their game as software, although, they do expect their customers to have a VR headset. Other than that, no other hardware is required and the game can be played at home. Their distribution channel is B2C, as they mainly target parents of younger children and preliminary schools. We have looked at this popular subscription model that the competitors are using to generate revenue; however, it is not feasible for the Vreye!, because the Vreye! is not simply a software application that can be installed, but it involves a lot of hardware and requires the help of lab management to set up the application for the therapists.

Finance

Revenue model

The financial domain describes the way the service intends to generate revenue and how investments are divided among the various actors in the network. There are a number of ways in which the product can generate revenue. First, the company has to choose a distribution channel to bring their product to the market. Research was conducted on the different types of distribution and we arrived at two possible ways of bringing the Vreye! to the market. First, the Vreye! could be brought to the market by 3rd party brokers, wholesalers, and distributors.

Distribution channels

According to Osterwalder and colleagues (2005), a successful business model involves the various distribution channels that a company has at its disposal to reach the buyers. For this purpose, the company can use their own website, the websites of their distributors, or even social platforms, such as Instagram or Facebook. Game developers can specialize in a particular kind of distribution, which will then shape their opportunities to distribute the game to the users. Specialization is a key-term when it comes to serious games and games in general that are developed by or for healthcare providers, as the distribution of such games is commonly very targeted and not as widespread. According to Mayo (2009), marketing will play a crucial role for the distribution of games in this day and age. For the time being, the serious game market can be divided into three segments:

- B2B: this segment is made up of serious games developed by public or private bodies on behalf of other companies.
- B2C: this segment features serious games developed by public or private bodies that are marketed to the general public.
- B2B2C: this segment takes in serious games developed by private or public bodies on behalf of other organizations, who then distribute them to the general public. (Michaud & Alvarez, 2008)

B2B2C is a distribution model in which the company does not enter the market itself, rather it does it through other businesses. However, the final consumer will still be able to recognize the original brand. This distribution model, originates from the evolution and improvement of the B2B and B2C models and forms somewhat of a hybrid agreement between the traditional distribution models. The key benefit of the new distribution model is that it enables an organization to reach a larger customer base through the other businesses (Cai, He, Dai, & Zhu, 2018).

When we look at the different types of markets, we observe that the B2C market has higher entry level barrier and higher competition. On the B2C market, games have to compete with core consoles and games that have been a staple in many households in the last years. Also, the games on the B2C market have more experience and are more capable of creating excellent games (Kaleva, Hiltunen, & Latva, 2013). Although the game market is traditionally a B2C market, including the serious games market, the medical

games and e-health solutions market remains an area where B2B strategies are more prevalent (Kummervold et al., 2008). However, the B2B market also distinct challenges. Firstly, it is difficult for medical games to obtain public funding because usually these types of games concern a very specific type of problem that only applies to a small group of people. Secondly, the scalability of the business model is a challenge as long as the game is sold as a hardware instead of software/licensing rights. Thirdly, medical games usually have long development times because of rigorous clinical trials (Kaleva et al., 2013). In short, although there is plenty of public funding for e-health games and research on these games, there are still high entry barriers to the market as funding is difficult to obtain.

Despite the success of the new distribution model, it comes with some modern challenges. The main challenge will be having an effective marketing strategy. Especially for VR-SG's, as it does not usually widespread sections of the market. Marketing can come in many forms, such as: reviews from certified sources (e.g., healthcare providers, news outlets, governmental branches), showing a variety of content, frequently updated screenshots on the website, and press releases (Georgieva, Arnab, Romero, & Freitas, 2015). When it comes to the rehabilitation center's third-party options, there are three main choices: brokers, wholesalers, and distributors. Brokers are individual companies that take possession of the product in the distribution process and sell to the final users. They represent the producers and take commissions in exchange for their services. Wholesalers also sell the product for the producers; however, they most likely will not sell to the final users. Wholesalers will resell the products to other distributors for higher prices. Distributors are very similar to wholesalers, with the one difference being their loyalty. Distributors will not ship similar or competing products (Brass, 2009).

Another option for the Vreye! to come to the market is through public funding. The Vreye! can be offered as a fee-based service to public health insurance organizations for the treatment of their patients. The health insurance organizations would then be the primary revenue source, allowing healthcare providers to reimburse the treatment for their patients (Haaker et al., 2013; Kijl et al., 2010). The demand would have to come from healthcare professionals and therapist organizations that see the added benefits and unique points of the Vreye!. Some alternatives are to apply for funding such as "Horizon 2020" and "PIHC". PIHC (pioneers in healthcare) is an innovation fund formed by the university of Twente, Saxion university, 'Medisch Spectrum Twente', 'ziekenhuisgroep Twente, and 'Deventer ziekenhuis'. These hospitals are promoting a bottom-up approach collaboration between innovative technologies and medical practices. Their main goal is to facilitate the introduction of innovative technology in clinics and they provide €600.000 annually for innovations (Pioneers in Health Care: Technical Medical Centre: University of Twente, 2020)

Table 6 - STOF framework (based on literature)

Situation #1	**STOF framework based on our expectations**
Brief description	Developing a VR application that trains children with DCD to ride a bicycle.
Why STOF model	The STOF model has been used to gain insight in how the Vreye! creates value, how it is being developed, what organizational hurdles will be encountered, and what the strategy is to introduce the new application to the market. Also, because the STOF model was developed specifically for the implementation of e-health applications.
Service	The Vreye! is proposed to make the step between cycling in a clinic versus the real world smaller. The Vreye! is proposed to enhance monitoring of steering and viewing behavior, offer better feedback to the therapists and allow for better analysis. This should lead to a better and more effective rehabilitation program for children with DCD with regards to riding a bicycle.
Technology	The Vreye! is still in development; however, the prototype is available. Testing was done conducting on three fronts: usability, user experience, and feasibility. The testing serves as a verification process in order to start testing with children as the subjects. As of now, the results have not been approved yet, but RRD is positive about the outcome.
Organization	The Vreye! is an innovative product with no predecessors, so, it was difficult to gather from literature alone how well organizations would adopt the application. Therefore, we have looked at similar games (competitors) that are successful nationwide, to see what their strategy was. Both competitors implore a subscription-based model and require little to no set up, as opposed to the Vreye!
Finance	Multiple revenue models have been identified. The most feasible model would be to apply for government funding.
Conclusion	The Vreye! still has a long way to go in order to be fully developed as a commercial product. However, if the value proposition proves to be correct, the Vreye! could become interesting for healthcare organizations in the future.