Experimenting with Endogenous Design for Digital Therapy Games

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ABSTRACT
Digital Therapeutic (DTx) Games promise to engage users in physical and mental health therapy and thereby provide effective treatment over a period. Games for different kinds of therapies are emerging in recent milieu. However, the promise of engagement and effectiveness of these games can be realized only when there is a balance between the joy and purpose of participating in therapies. Designers today lack specific guidance on designing purposeful games that achieve seamless integration between these two. We propose the use of an endogenous design approach to address this problem. In this paper we describe the approach and demonstrate its application through three case studies.

Keywords
Digital Therapeutic Games, Stress Management, Endogenous design

INTRODUCTION
Digital Therapeutics (DTx) are software program-based interventions that prevent, manage, or treat a medical disorder (Kvedar et al. 2016). The increased availability of digital devices and interfaces have enabled users to learn, schedule and practice therapeutic interventions regularly. Integrated solutions in the form of dedicated mobile apps have also made this practice easier. While these apps are very useful, daily interactions with such apps might become boring and tedious. Therefore, use of playful elements and games can be a promising option for continued engagement with therapeutic interventions.

Purposeful games that include aid for mental as well as physical improvement can be termed ‘therapeutic games.’ The motivational appeal of games has already been recognized for health-related behavior change (Baranowski et al. 2008). Therapeutic games played using digital mediums provide interactions which offer higher user engagement and hence greater user retention. The positive influence of game interactions on improving patient engagement with digital health apps is established as Digital Therapeutic Games (DTx Games) (Chandrashekhar, 2018).

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In the past couple of decades purposeful games in the space of healthcare have been designed to create awareness and support rehabilitation (Rego et al. 2010). Games help cater to the psychological needs of competency, autonomy, and relatedness (Ryan et al. 2000). An ailment or an injury needs a goal-oriented recovery path. Games in themselves have a goal and a path to achieve a goal and these can be integrated with patient recovery goals. An interesting game-based challenge not only retains the patient's attention but motivates them to engage and progress towards recovery with greater enthusiasm.

However, the design of purposeful games has not been addressed adequately in literature (Athavale et al. 2019). Therefore, it is not surprising that designers use varied design approaches based on heuristics. Purposeful game design requires seamless integration of purpose and gameplay and lack of guidance leads to poor integration. Unrelated gameplay is typically superimposed on the content making the game neither fun nor effective in meeting the purpose. The term 'chocolate-coated-broccoli' aptly summarizes the general state of purposeful game designs (Deen, 2005). DTx games exhibit similar issues of superficial integration of purpose and gameplay. In this paper we study the approaches for design of purposeful games and then select an approach termed as 'endogenous design'. We present implementation of three DTx games using the endogenous design approach and share observations in the context of mental health.

EXISTING DESIGN APPROACHES

Existing design approaches in the field of DTx apps and games can be studied using three aspects, namely, – a) the choice of game versus gamification, b) design principles and approaches and c) specific strategies and steps to create a new game. We briefly reviewed these aspects and their implications in DTx games.

Gamification is applying game-like elements to non-game contexts (Deterding et al. 2011) and is generally applied in the real world. Gamification has early advantages but also has limitations in the long run. The main criticism is the diminishing power of the leaderboards and badges over time (Hanus et al. 2015). Games on the other hand are designed ground-up, as complete independent artificial worlds and are more immersive. However, games too have disadvantages, for example a serious healthcare user may not be interested in downloading a game but would rather focus on some utility to resolve the issue (Iacovides et al. 2015). A fruitful combination would be the design of a utility app which embeds specific game elements.

In terms of approaches and principles in the space of game applications for health, Almarshedi et al (2015) propose the 'Wheel of Sukr' with a set of broad gamification principles. Similarly, Floryan et al (2019), who conducted an empirical study of several web and mobile apps for health and found five principles of design that were commonly found in these apps. The transformational framework by Culyba, S (2018) explains the use of eight exploratory questions along with tips, best practices and insights to help teams navigate through transformational games. These approaches provide broad guidance but do not have specificity for implementation in practice.

The search for specific strategies for design of DTx games does not yield many results other than a few such as Deterding's method for gameful design (2015), which suggests a series of specific steps. While it is a useful process, there is only a line on synthesis. Elaboration of the synthesis processes is generally elusive. This is where designers need support –how does one translate the content/context into a meaningful game?

Delving specifically into mental health space, a recent paper (Cheng et al. 2019) noted that application of gamification for improving mental health, was broadly divided into 2 themes: (1) promoting engagement and (2) enhancing an intervention's intended

effects. These themes can apply to other health conditions as well. Within the mental health space, the extent of using games or game elements varies significantly across DTx apps. Games like Lumosity or Cognifit are cognitive games, that are aimed at enhancing capabilities like memory, attention, flexibility, concentration, reasoning, perception etc. Other DTx apps like Equoo and SuperBetter (Jane 2012) recommend users to perform activities in a gamified narrative. MindMaze, BehaVR and Akili engage users through games in a Virtual Reality setup to address conditions like Autism, ADHD and stroke. A large number of DTx apps merely use game-like elements for completing tasks and providing rewards. Some examples are Ovia (women's health), Dario Health (diabetes), Mango Health (medication adherence), Propeller Health (Asthma, CoPD) and Happify (improve overall happiness). Game-like elements such as points and rewards address only extrinsic motivation.

Across literature, we seek an approach which is supported by specific strategies that designers can use in synthesis of purposeful games (in this case therapy games). A recent work on strategies for endogenous design of educational games (Athavale et al. 2019), comes close to our expectations. The authors have further proposed an 'Endogen' framework (Athavale et al, 2020), and includes an overall approach and embedded strategies for endogenous design. Endogenous design is one in which the game design is created by using the elements within the content. Such a design would be the antithesis to Chocolate coated broccoli. The framework acts as a guide to the designers on creating a game from the educational content. However, this framework has not been proposed or tried in the context of other purposes including therapy. In this paper we explore the use of this 'Endogen' framework for endogenous design in the context of DTx games.

CHOICE OF ENDOGENOUS DESIGN

The concept of endogenous design in educational games can be extrapolated to games for health purposes. This is because games for purposes other than education also have similarities with games for education such as creating awareness (knowledge acquisition), application and practice (knowledge application) and evaluation of how well the user performs in the game to complete a feedback loop (knowledge assessment). Floryan (2019) has also suggested that endogenous application of gamification which involves developing mechanics intrinsic to the given experience is an effective approach which we haven't easily found in other frameworks.

The extension of Endogenous design in educational games to games for therapeutics has not been actively explored and it is the focus of our paper. DTx finds application mainly in the following three forms: treatment, management, and improvement of a health function (Dang et al. 2020). Thus, the goal of a DTx game is to make the users aware of treatment interventions, help in treatment adherence, help perform the required exercises and report the required parameters. In such context, the "content" is a set of procedures with additional support in terms of reminders. The procedures can be mental or physical. With such a reduction, the DTx games tend to be similar to educational games and hence it is possible to apply design strategies used for educational games in procedural learning.

If the DTx games were to be exogenous, the therapy activities would remain unchanged but get 'coated' with a game layer. This means a game-like perception would be created but the game engagement and fun would be absent. The players are unable to enjoy the game knowing the obvious intentions. A stroke rehabilitation game, for example, requires a patient to perform certain hand movements. In this, when a player lifts their arm, they are rewarded with some points for each lift. Although the act of lifting the arm is clinically beneficial for the patient-player there is not enough intrinsic

motivation to continue with such an act (Przybylski et al. 2010), thus exhibiting treatment adherence issues due to lack of motivation.

It is essential to have adequate engagement with any purposeful game. However, this engagement must be inherent rather than superimposed. While it is hard to find engaging activities in patient care, it is possible to translate mundane or even sometimes painful activities into parallel accomplishments in the game world. The sense of accomplishment is a key aspect of motivation to continue the activity. Normally a routine activity such as performing hand exercise for stroke rehabilitation may not satisfy the reward center of the brain on a day-to-day basis. However, when translated to the game world and especially digital world, it can lead to achievement and satisfaction as a patient-player can fly an airplane through different hand movements, fight different challenges and even explore various terrains while earning rewards and if connected to a sensor driven feedback, a real time report of the physical improvements can be obtained.

While we argued the case for endogenous design in therapeutic games, it is essential to identify specific strategies that DTx game design can deploy. We base our proposal of using the strategies in the Endogen framework for endogenous design (Athavale et al.,2020).

ENDOGENOUS DESIGN FRAMEWORK AND STRATEGIES

We reproduce the highlights of the 'Endogen' framework for endogenous design (Athavale et al., 2020) here for clarity and reuse and explain it using figure 1.

Figure 1: Endogen - Endogenous design framework

The framework essentially is a design process which helps designers in understanding the problem space (content/context) and in translating it to a game. The framework has 6 stages for design. The stages are content exploration, core design (divergence and convergence), translation (of content elements to game elements), elaboration and verification. Each stage has varying number of steps and supporting strategies.

The exploration stage begins with content scanning and core concepts identification. Step 4 in this stage, – explore systematic strategies to identify elements of interest in the content. This includes identifying actors, actions, objects, interactions, events etc. which could be potentially translated to player roles/game characters, mechanics and resources in the game. Step 5 suggests the use of different lenses to extract elements of interest if they were not obvious in step 4. This includes object centric lens which is to look at objects (real or abstract) and identify their arrangements, affordances, properties etc., a human centric lens which would suggest finding out what humans could do in that context – what would be their goals, motivations, movements etc. These lenses help bring out elements such as goals, resources, and transactions that designers can toy with to make a game. In step 6, the strategy is to observe unique elements e.g., phenomena, things that change, movements, contrasts, constraints, patterns in the content. This will help designers to work on opposition mechanics, as well as design rules that create interesting dynamics.

The next stage is core design (divergence) in which the designer generates multiple game structures – a structure would include decisions about type of game, medium, number of players, game world, goal etc. At step 9, the strategies for game world creation are presented. These include creating either a simulation world, fantasy world, representational world (game objects, shapes, abstract concepts etc.) or a mix of these. The second part of core design is a convergence stage but it is sequenced after a translation stage in between.

In translation stage, designer translates the extracted elements of content into game elements and tries to combine it with the game world ideas created. In step 13, the designer can translate objects into resources of various kinds – those which can be possessed, traded, hidden etc. In step 14 the strategies for design mechanics are presented. There are two ways in which this is done – either apply several verbs to the resources identified and select interesting combinations or translate the actions from the exploration stage and apply them to resources.

In the convergence stage, the suitable combinations of game world, mechanics, resources, and other game elements are retained to make a final game concept. In the elaboration stage the concept is elaborated with rules, and if the game is not covering content adequately more game elements are added to complete the required coverage of learning content. In the final verification stage, various aspects of the concept are checked (e.g., completeness) and if there are gaps the steps are iterated.

Use of Endogenous Framework and Strategies in DTx Game Design

The framework has two broad sections: analysis of the problem space for extraction of relevant elements, and translation to game elements. The extraction part in the case of DTx games could lead to identification of specific sequence of steps, activities to be done periodically, activities that need to be done together, activities that cannot be (or should not be) done together etc. These observations can be translated to useful game elements such as mechanics and rules in the game.

Designing purposeful games can lead to the creation of different types of game world, predominant amongst them are simulation world, representational world, and fantasy world (Ke 2016). A stroke rehabilitation game for example, can be rendered as a simulation world wherein the actions are replicated in game but translated to game mechanic such as flying an airplane. A fantasy world can also be created where the player, the patient, is required to lift their arm to control the airplane, its direction, speed, and stability as described earlier.

To demonstrate the application of the framework in the context of DTx games, we adopt the endogenous design framework to design specifically three games for mental health and specifically, Stress management. Stress management is an ever-important issue and the COVID19 pandemic has made it worse (Pfefferbaum et al. 2020). Stress management solutions can range from self-help to counselling to use of medicines. However, the core of stress management approaches lies in self-regulation and practice. Digital therapies are hence well suited for such remedies (Marks et al. 2007). We envisage that the stress management games will need to engage with players over a duration of weeks to months using a digital avatar of a counsellor. In this context we describe three cases of games that we designed for implementation in a digital companion app using the endogenous design process.

CASE STUDIES

The games that we are presenting in this section were designed for stress management and will be integrated into a mental wellbeing application with a host of other features which are not in the purview of this paper.

The first game discussed is a Stress buster game designed to provide immediate distraction and venting out in stressful situations. The game is based on the stress relieving aspects of art therapy. The second game discussed is designed on the principles of mindful breathing and is designed for regular practice whereas the third game is based on the stress relieving aspects of music as a therapy along with doodling. We will now explain the application of endogenous design process to all three games in detail.

A Stress Buster Game using Art Therapy

Explanation

This game is based on digital application of art therapy. The game goal is to color a picture composition using a unique mechanism that allows players to swipe colored balloons in the direction of the picture. A bucket with colored balloons is displayed on the screen as shown in figure 2, tapping on the lower portion of the bucket enables players to change the color of the balloon. The balloon then needs to be swiped in the direction of the painting. If the balloon hits an element in the painting the element gets colored, for balloons that miss the painting a chance is deducted from a total of 5 chances to complete the painting.

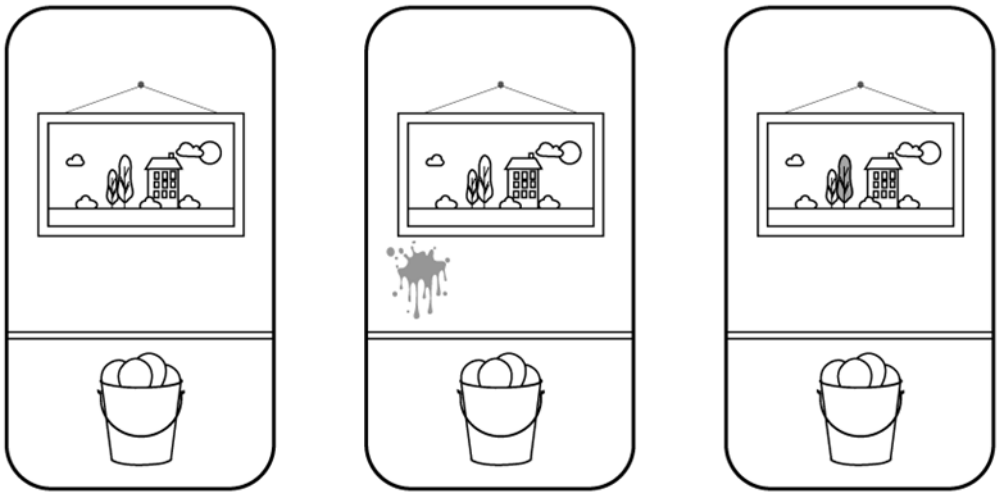

Figure 2: Stress Buster game on Art Therapy game implementation steps

How Endogenous framework was used

Exploration Stage: A content scan in the existing domain of therapeutic interventions for stress management was made. Art therapy was identified as an intervention to manage stress from a list of alternate therapies like yoga, meditation etc. We explored the factors in art therapy that promote relaxation (Azeemi et al. 2005) such as venting out. A systematic exploration of the stress relieving factors in art therapy was made and its effectiveness to improve other mental health conditions like PTSD (Spiegel et al. 2006), Alzheimers and Dementia (Chancellor et al. 2014) etc. was referenced.

As part of the core design, we identified the reasons for the increase in unwanted stress as well as game mechanisms that would enable the release of such stress. We also referenced the existing digital implementations of art therapy in the form of mandala art, coloring apps etc. Suppression of complex emotions has been shown to be the biggest cause of stress (Quartana et al. 2007). Therefore, we looked at some of the existing game mechanisms that enable venting out.

Translation Stage: We studied game mechanisms which could channelize this restless energy and enable venting out (Granic et al. 2014). We looked at interactions on the mobile which would offer the feeling of venting out to the user. Among the available interactions, the flick (quick unidirectional motion of finger on screen) was a suitable candidate, as it is neither a controlled interaction (like the swipe) nor discreet interaction (like tapping). Crumpling of paper, throwing of paint filled balloons and popping of bubble wrap were some of the metaphors identified to visually convey the act of venting out.

Core design Stage: The best-known examples of games which enable venting out are in the genre of shooting game. However, we wanted to refrain from any game induced stress especially because our intent is to reduce stress. We further studied games like *Paper Toss* (Backflip Studios 2009) and *Angry Birds* (Rovio Entertainment 2009) which implement mechanisms like toss and catapult which are less restrictive and allow a degree of venting out.

The toss or throw mechanism in a digital interface appealed to us as a liberating act. We also borrowed from the physical act of throwing colored balloons on a canvass and the fun and liberation the experience enables. This approach satisfied most of our design constraints of liberation without violence, interactive and non-restrictive

experience etc. Thus, the idea of swiping/tossing colors towards a painting on the wall was thus generated.

What were the challenges that the framework helped address?

Our approach for applying the endogenous framework was simple we listed the possible features under each stage as defined by the framework. We then used our existing knowledge as designers to establish interconnections between the listed elements as described in the previous section. The convergence approach in the endogenous framework enabled us in defining player interaction, fortifying gameness, and finalizing the concept. We derived inputs from our existing game implementations for detailing the gameplay (Agrawal et al. 2020). The end goal of the game was designed such that players felt motivated with the result and each time the result gave them a varied visual experience.

The systematic approach of the framework acted as an enabler to understand the problem space and then complete the design by reflecting on the content as well as the game mechanics in a balanced manner. It is also important to mention that our existing knowledge of designing purposeful games helped in finding the appropriate game mechanics to be integrated with the subject of stress management. The systematic approach of the framework is a great enabler to iterate and refine the implementation.

How was this game received?

The game was tested progressively at each step of ideation and implementation. Players responded positively to the concept of venting out stress through a game. During playtesting, the players' expressions were observed. The players seemed quite engaged during the game sessions. Few players suggested that the difficulty level of the game be reduced. This feedback was taken into consideration and we decided to include two variations of the game, one with a fixed number of chances and the other with an infinite number of chances to finish painting the picture.

Mindful breathing game

Explanation

Mindful breathing is the practice of focusing attention to changes in the breath and moment-by-moment bodily sensations, thoughts, and emotions, as these phenomena arise (Desikachar, 1995). Current wellbeing apps like *Headspace* (Headspace Inc. 2010), *Calm* (Calm.com Inc. 2012) and *The Mindfulness App.* (MindApps 2021) have implemented mindful breathing as part of their solution.

We designed an activity that consists of a character which visually guides the user through the 4-7-8 breathing technique as indicated in figure 3. The character of a whale was found to be a great analogy of holding breath underwater as applicable in real time. We use the movement of the whale as a visual affordance to guide the users.

While there are already various mindful breathing apps available in the market, we have tried to take a playful and endogenous design approach to the same. To understand the process of guided mindful breathing, we looked at the literature in psychology to understand the different breathing practices which would be apt for stress management. In stressful situations it is important to regain stability, while deep breathing exercises are effective, a guided practice to hold breaths at different stages sets a rhythm faster. The 4-7-8 breathing technique was found to be an effective practice (Weil. 2017). Further, we also surveyed the “non-game” designs of guided mindful breathing in other popular wellbeing apps like *Headspace* (Headspace Inc. 2010), *Calm* (Calm.com Inc. 2012) and *The Mindfulness App.* (MindApps 2021)

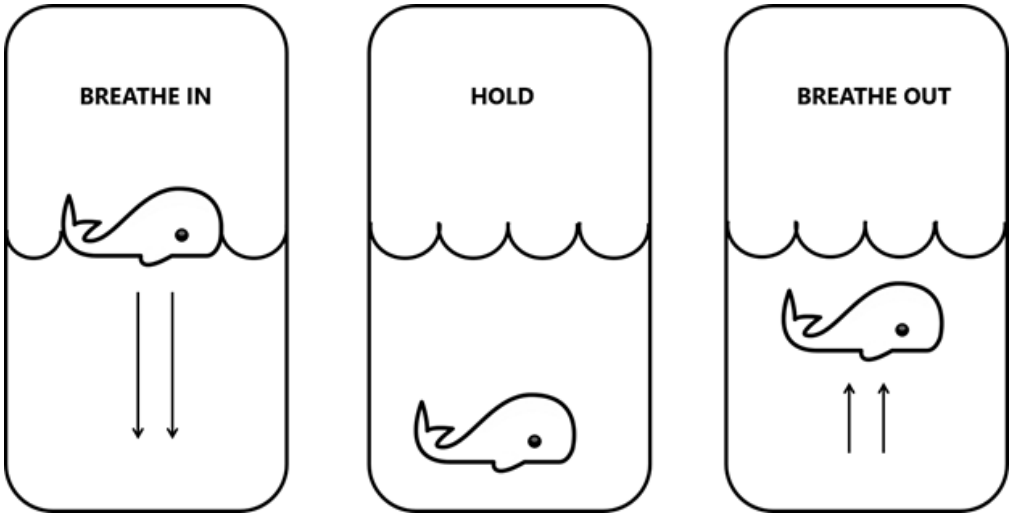

Figure 3: Mindful Breathing game implementation steps

How Endogenous framework was used

Exploration Stage: The analysis of content (breathing exercises) gave us elements such as the high and low (or in and out) movement of breath, being focused on the act and holding the breath, we also explore the guided visual vs guided voice breathing and found the visual implementation more appealing.

Translation Stage: From the content we actively looked at elements that can be translated to potentially make it a playful experience. A companion character seemed like a positive idea to us. We hence choose the character of whale. The choosing of whale as a character enabled us to set an analogy of holding the breath underwater as applicable in real time. Also, the breathing pattern of a whale could both metaphorically and visually be used to explain well as part of the guided breathing technique.

Core Design Stage: Once we decided on the character, we needed to detail the game mechanic. We synced the guided breathing visually with the movement of the whale character. So, the whale breathes in on the surface of the ocean, holds its breath while it goes down and breathes out as it comes back to the surface. To give a sense of control, we added three different modes each with a different duration (3, 5 and 10 min), so the player can choose a mode as per convenience.

What were the challenges that the framework helped address?

The framework provided clear starting points like system exploration and identifying interesting elements. This eliminated the decision paralysis that beginner/novice designers undergo during the initial stages of the design process.

The Endogenous framework was structured keeping in mind the design of purposeful games; however, in this case, we have used it in the context of designing playful activities instead of games. While games and playful activities are comparable, they are different. For example, the translation phase, the framework is structured in terms of resources, game mechanics, opposing mechanics and gameplay. While mechanics and game play are co-relatable, opposing mechanics is not easily mapped to playful activities.

How was this game received?

During the testing of prototype, the activity received positive responses from the users. Also, the activity received positive feedback from subject matter experts from both psychology and the product domain during pilot testing. Further, we have planned to test the activity with a larger number of users.

A Musical Relaxation Game

Explanation

The third case is that of a musical relaxation DTx game with free doodling. This game is based on music as well as doodling as a therapy to induce relaxation. Music therapy is a known method for relaxation and an advisable approach to manage stress (Lin et al. 2011). The game offers a free doodling interface where a player can control the music by doodling on the mobile interface. Unrestrictive doodling enables players to relax while giving them control over the music they are listening. There are a few existing game implementations which incorporate music (Benveniste et al. 2010), but there are very few DTx game implementations that use music as well as doodling (Jo 2008).

How Endogenous framework was used

Exploration Stage: The content scan gave us various leads in the use of music for stress management, such as doodling in silence, doodling with natural sounds, listening to music when anxious etc. In situations of high stress and anxiety like waiting in hospital for an ailing friend or relative, trying to calm oneself down after a fight or after any other high stress situation, music helps calm the mind. However, listening to music alone is not sufficient. In such situations a mechanism of physical engagement is helpful (Woodward 2021) along with the incoming music to calm down or feel relaxed. The content elements we extracted are a) the act of doodling without any constraints, b) controlling the music with doodling, as well as c) giving color to the stroke while doodling.

Translation Stage: The initial idea of combining music with doodling had to be converted into a playable game and this is what led us to further refine the idea We created a doodling interface where user has to move a figure on a guided path on the screen to generate music.

Core Design Stage: The idea generated for the game world is a space for self-expression without any constraints. This led to the introduction of the concept of two modes - guided doodling (challenge) as well as unconstrained doodling (freedom) to control music (Moore, undated).

To implement this, we designed a free interface where the music could be controlled by doodling. Thus, if a player doodled on the digital interface, they would hear the music. As soon as they removed their finger from the screen, the music would pause.

What were the challenges that the framework helped address?

Framework helped in exploration of content space and identification of gameable elements such as act of performing a music-controlled activity that would relieve stress. The iterative approach of the framework and the core design based on convergence and divergence enabled us to identify an appropriate combination of game mechanics.

How was this game received?

The game was tested in multiple stages. Before designing, the therapeutic effects of music as well as interaction with mobile was analyzed for stress relieving effects. Users were consulted for the activities they engage in for instantaneous stress and anxiety relief.

Post implementation, sample users were given the game as we observed their reactions. Players enjoyed the game. The guided mode provided the adequate challenge to complete a certain number of patterns in a given time and the free mode allowed players to play the game like meditation. The few internal users of the game found the game helpful in distraction from existing mental state of stress and anxiety.

For all the three games described above we conducted semi structured interviews with three questions a) whether the players enjoyed the game, b) if they found the game effective in reducing stress c) would they prefer this game over any other existing techniques to manage their stress. We analyzed the qualitative responses thus received using thematic analysis and identified that the games created are preferred over the existing non-game interventions to manage stress and the games need to incorporate tools and techniques to collect discrete data of their effectiveness.

DISCUSSION

Through the case studies we hoped to explore the possibility of endogenous design for designing DTx games, and the Endogenous design framework was a perfect tool in this regard. Though our approach of using case studies to further our research has limitations of adequacy, the case studies do help us meet initial exploratory research objectives of applying Endogenous design approach to therapy.

The endogenous design framework was formulated from studying learning games. A fundamental difference between Learning and DTx games is that learning is concerned with knowing/understanding concepts longer and then applying them quickly whereas therapeutics is about quickly knowing the essentials and then applying them in an activity/exercise over a longer period. Despite that, we did not find any aspect of the framework restrictive to the educational context. In other words, the stages and individual steps in the Endogenous framework are generic enough to apply in a variety of contexts including therapy. In any case, there are not many aids to help game designers design DTx games, and we recommend this framework as a good starting point. The framework allows freedom for selection and interpretation of steps, not all steps are mandatory, and even the sequence of steps can be altered by the designers. For instance, the stress buster on art therapy does not have an opposing mechanic hence, the step can be skipped.

We also noted a few limitations of the framework. While we found that the framework can be useful across contexts, it may need some more work to fit across purposes. For example, while designing an activity for mindfulness, the problem is related to change in behavior and not about learning new concepts and applying/practicing them. It would be beneficial if the exploration strategies for at least a few recurring purposes are embedded with framework.

As part of our future work, we would like to test the efficacy of the DTx games presented in this paper. This will help us verify if the game designed using endogenous design framework is meeting the goal of effectiveness in meeting the purpose. It will also enable us to run iterations of this framework and propose a specific version of an endogenous design framework for Digital Therapeutics games.

CONCLUSION

Digital therapeutics has become prevalent in the last few years and the process has been accelerated by the current pandemic. However, the success of Digital Therapeutic solutions, like any other consumer facing digital solutions, will depend on user engagement. That's where games and gamification play a role. While games for therapy are already being designed, there is a lack of systematic approach or shared knowledge about design practices.

Through this paper, we try to explore the endogenous design approach applied in educational games and attempt to reapply it in therapy games. We have presented three case studies and how we used the endogenous framework to design applied games/playful activities for stress management. We have briefly summarized what worked and a few gaps that exist. This paper initiates discussion on formal approaches

for synthesis of digital therapeutic games. It also tries to derive a parallel with design of educational games and hence opens the possibility of bringing the principles of design from an established domain to an upcoming one.

As part of future work, we will continue to design new games using the endogenous design approach. We also intend to keep improvising the method and the design while encouraging the community to contribute to this journey.

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