A Game Design Framework for Alleviating Negative Emotions of Cancer Patients

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***Abstract*—Cancer has been, and still is, one of the most widespread diseases of the last decades, the predominant cause of death in people under the age of 65 in the European Union, and the reason for people to feel fear, shame, loneliness, to name only but a few emotions. The application of games in healthcare offers i) high levels of immersion, ii) increased motivation, especially from younger people, and iii) the ability to build environments providing an experience that is impossible to have in real-life. The aim of this paper is to propose a comprehensive game design framework based on two pillars: 1. a methodology for designing games specifically targeted at alleviating negative emotions in cancer patients, and 2. a methodology for choosing the technology with which the game will be implemented.**

***Index Terms*—Virtual reality, Emotion recognition, Client-server systems**

I. Introduction

Cancer has been, and still is, one of the most widespread diseases of the last decades and the predominant cause of death in people under the age of 65 [1] in the European Union. Moreover, cancer is not just the most fatal disease but also the reason for people to feel fear [2], shame [3], guilt [4], [5], stress [6], loneliness [7], to name only but a few emotions, and in general to be stigmatised [8] and feel depressed, even to the degree of not proactively screening themselves for cancer [9]. In turn, these emotions have a negative effect both on patient's well-being, as well as that of their families and close relatives [10]. Moreover, negative emotions have been identified as risk factors for cancer progression [11]–[16], especially when they are chronically experienced and are not just the outcome of certain events [17]–[20].

A variety of studies has been focused on alleviating negative emotions of cancer patients with or without the use of games, many of which are analysed in more detail in Section II. Several of these studies have shown positive results, strengthening the hypothesis that indeed tailored interventions, and particularly games, for cancer patients have increased likelihood of succeeding in their purpose. Nevertheless, the literature is as of to date relatively limited and even the few studies that have reported positive results suffer from a variety of limitations, like small sample size, lack of control group, to name just two. The greatest limitation of the reported studies though is the lack of a coherent and robust game design methodology. While the absence of a methodology does not equate with lack of knowledge on how to build games, it is an impediment on efficiently and effectively designing them. In other words, along with the ever increasing amount of knowledge and information, it is becoming equally more difficult and cumbersome to pinpoint those pieces of knowledge that would have a significant contribution in any given project. As a result, researchers either spend an unnecessary amount of time searching for relevant information or are forced to reinvent the wheel. Consequently, a need has emerged for a grounded methodology [21], based on interdisciplinary research, that would explore how the different mechanics and principles of games influence the emotional state of cancer patients, and further dive into the role of technology in that endeavour.

The main objective of this paper is therefore to propose a game design framework for games specifically targeted to alleviate cancer-related emotions. The framework consists of two main pillars: 1. a methodology for designing games specifically targeted at alleviating negative emotions in cancer patients, and 2. a methodology for choosing the technology with which the game will be implemented. In the first pillar, the emotional state of patients is assessed through the improvement of the Quality of Life (QoL). While no explicit definition has received universal acceptance among researchers [22] with regards to what is QoL, there have being some attempts of defining it [23]–[25]. This paper adopts the definition by Gotay et al. [26], who define QoL as the composite of two components: i. the ability to perform everyday activities which reflect physical, psychological, and social well-being and ii. patient satisfaction with levels of functioning and the control of disease and/or treatment-related symptoms. In the second pillar, the methodology is proposed based on the different requirements a project might have, like accessibility, security, information sensitivity, budget restrictions etc.

It is important before developing a specific methodology and consequently games specifically targeted to alleviate cancer-related emotions, it should be evident that indeed such games have something more to offer than other interventions, like non-gamified experiences and entertaining games. On the one hand, regarding non-gamified experiences, the advantages of games stated above are a strong indication that games could offer an added value, particularly with respect to immersion. On the other hand, entertaining games have been used in cancer patients with success [27], [28] but they have been solely used for distraction rather than truly dealing with emotions. More-

over, studies have shown that compared to entertaining games, games targeting particularly cancer patients have exhibited better results [29]. Still, studies differ on whether cancer as a disease should be explicitly or implicitly addressed within the game [30], [31], which opens new possibilities on game design for that purpose, in the sense that a game could alleviate cancer-related emotions without necessarily referring to the disease itself. Finally it should be noted that in many cases, although not necessarily, cancer patients differ from normal players with regards to their reflexes and concentration. Thus, there are strong indications that cancer-specific games are more likely to succeed in alleviating cancer-related emotions than entertaining games.

In Section II, the state of the art in this interdisciplinary field is presented. In Section III, the methodology for designing games targeted to alleviate cancer-related emotions is proposed. In Section IV, the methodology for decisions with regards to technology is presented. Finally, in Section V, final remarks are made.

II. Background Work

An abundance of research exists on using psychological [32] and psychosocial [33]–[35] interventions, which though usually lack audio and visual aids. Even those interventions that are based on audiovisual elements are predominantly focused on alleviating the physical pain that patients experience either by using animated interventions [36] or games [37] as a distraction or by using active video games that promote physical activity [38]. Nevertheless, research that is within the scope of audiovisual interventions specifically targeting cancer-related emotions, while limited, has shown positive results. Music has been found to significantly reduce cancer-related emotions [39] and reestablishing a sense of confidence to patients [40]. Positive results have been reported from using games for reducing stress [27], reducing the stigmatisation [41], and facilitating the socialisation, especially for younger cancer patients [30].

In the more technologically intense area of game design for cancer patients, several studies have reported positive effects on patients. Oyama et al. [42] used a virtual reality (VR) environment and found statistically significant results in reducing cancer-related fatigue. Li et al. [43] explored the effects of VR games in promoting the psychological well-being of children hospitalised with cancer and in contrast to the control group, children receiving the VR intervention reported statistically significant fewer depressive symptoms than children in the control group within 7 days. Espinoza et al. [44] built a psychological VR intervention aiming at inducing positive emotions on 21 adult oncology inpatients. Results showed significant improvements in the emotional as well as the physical comfort of patients with almost all metrics demonstrating positive change.

Regardless from the technology used to develop games, very few studies have reported, even briefly, the game design approach they followed and the rationale behind their game design decisions. Perhaps the most famous example of such a game is Re-Mission [29], [45]. The authors give a brief description of the core principles in their design process and they identified, based on targeted research, the psychological and behavioural targets the game should have. Their approach appears to be methodologically sound but it lacks any detail that would enable to validate the game as well as to further be enhanced by other researchers and developers. Similarly, Caldwell et al. [46] give a relatively more detailed description on their roadmap towards developing a video game for improving the quality of life of paediatric cancer patients, though with two limitations: i. the game is only playable within the premises of a hospital, and ii. the technology used is very specific and thus not platform agnostic, which in turn raises a number of issues, like accessibility, cost etc. In [47], Gansohr et al. break down the design decision according to the age of the intended audience. It is perhaps the only work that gives details on how to approach the design of games for cancer patients in a methodological grounded way, by taking into account an important variable, i.e. age, as well as providing a step-by-step guide.

III. Design Methodology

In this section, the methodology for developing games targeted to alleviate cancer-related emotions is proposed.

The proposed methodology, shown in Figure 1, consists of six components described below.

A. C1: Defining Factors that Influence Quality of Life

In this part of the methodology, the variables (dependent) that define the quality of life (QoL) and well-being of cancer patients are identified, which in turn would determine the independent variables that need to be measured and controlled. Given the adopted definition of QoL, there are four dependent variables: a. physical well-being, b. psychological well-being, c. social well-being, and d. patient satisfaction with regards to controlling the disease and its symptoms.

Having defined the QoL and as a result the dependent variables, a tool for measuring the independent variables needs to be developed or adopted. In this particular case, the tool developed by Cella et al. [48] is adopted because it can capture all the aspects of the abovementioned definition of QoL and it is thoroughly tested against the reliability and validity of its results.

B. C2: Methods & Techniques for Dealing with Cancer-related Emotions

The second component is about identifying, through literature and through collaboration with psychology experts, how the most common causes of deteriorating cancer-related emotions (independent variables in C1) are dealt with. The goal in this phase is to understand how these emotions can be tackled and thus identify the most appropriate game design principles and practices that could enable us to develop effective games.

From the literature point of view, designing an intervention in order to educate patients about their disease has not always been found beneficial, though there are no reports that it has

any negative effects [49], [50]. What was, in many cases, found to induce significantly positive results on alleviating cancer-related emotions are facilitated discussions, either in the form of group therapy or, even preferred, individual sessions or sessions including spouses and close relatives [50], [51].

Despite the positive effects of interventions, reports from studies have been, in many cases, frugal with regards to details on the design of these interventions [52]–[55]; thus, in order to have a more detailed image of how experts deal with cancer-related emotions, the development of a questionnaire targeted on psychologists and social workers specialised in cancer is considered paramount.

C. C3: Game Design Principles and Best Practices (Toolbox)

The third component concerns the creation of a dictionary of game design principles and best practices for game design. The goal in this phase is not just to propose a specific design for one game but a comprehensive methodology for designing effective games in general.

There are game elements that govern the design of almost every game, like rules, challenges, rewards etc [56], [57]. A combination of these elements should be, and usually is, implemented in a game. This phase of the study intends to build on these *traditional* game elements and enrich it with those design principles that would enable a more effective design of games for cancer patients. The effectiveness of these games depends on their design being tailored to tackle three main areas:

1) Alleviate cancer-related emotions, like fear, shame, guilt etc., through explicit game design decisions that translate the findings of C2 into a playable experience.
2) Enable the socialisation of player through the game, thus mitigating the effects of loneliness and isolation that cancer dictates, especially in this era which mandates self-distancing even in 100% healthy individuals.
3) Incorporate *ilities* that would maximise the effects of the two abovementioned points. The list of *ilities* can be quite extensive, but in this project, the focus is on three, namely, i. Usability, ii. Accessibility, and iii. Interruptibility. Usability refers to several aspects in a game that should be taken into account, like simple and intuitive controls and a playing experience with an adequate learning curve, i.e. the game should have flow [58]. Accessibility refers to having an easy and affordable access to the game. Interruptibility refers to having a flexible gameplay [59], i.e. being able to play for short periods and stop whenever one needs to without consequences.

Several game design principles have been identified to be effective in alleviating emotions related with chronic diseases in general and cancer in particular. Namely, these principles are:

- Compelling storyline/narrative, which increases intrinsic motivation for players [60] and compels them to return and play again [59], [61].
- Clear, consistent, and intuitive rules, challenges, and objectives [62], as well as gradually increasing difficulty [63] that allow players to progress through the game without creating frustration (too difficult early on or incomprehensible mechanics) or boredom (too easy even towards the end) that could potentially have counter-productive results.
- Combination of mental and physical exercises [61] particularly for short-term improvement of mood [64], [65], physical functioning and pain [66], which in turn decreases the fatigue and increases the QoL [67], [68]. While developing and maintaining an autonomous long-term motivation was shown to be successful in only half of the patients [69], this number could still be considered quite high given that the patients were not pressured or forced to keep the activity.
- Content that is fun but also brings awareness [61]. Intertwining entertaining with disease-related content and particularly the integration of information about the latter should be tread carefully, as studies have been contradictory with regards to its positive effects [30], [31]. Nevertheless, in this context, i.e. alleviating cancer-related emotions, designers could consider not incorporating cancer-related information and solely focus on those design elements that can improve the emotional state of cancer patients.
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D. C4: Narrow Down the Toolbox

The fourth component is about narrowing down the list of game design principles, assembled in Step 3, based on the expert opinion of psychologists, in order to include those principles that are more likely to be effective on patients diagnosed with cancer. The goal in this step is to link the previously identified variables (Steps 1 & 2) and the principles (Step 3), in order to be able to choose the appropriate principles and best practices from the toolbox, depending on the particular emotion(s) a game aims to alleviate.

While the first 3 components are general practices that could be performed once and revised less frequently, the fourth and subsequent components concern each individual game that is designed. In other words, the first 3 components provide the general guidelines on how to effectively build games for alleviating cancer-related emotions, whereas the last 3 components use these guidelines in a targeted way, in order to design a specific game.

E. C5: Prototype Games

The fifth component materialises the findings from C4. This is the phase in which a prototypical game is built according to the game mechanics and best practices identified in C4. Initially, the goal in this phase is to build one or more games that would help fine-tune the proposed methodology and also put into test the technological approach adopted in this project, which is illustrated in Section IV.

Upon finalising the methodology and deciding the different technologies that will be used for the development of the games, this phase's focus will shift towards its actual purpose; designing games with the aim to use them in real patients.

F. C6: Feasibility Test

In the sixth, and final, component, for each functional prototype, a feasibility test is performed following a 5-step experimentation process:

1) Non-patients (Alpha & Beta testing), e.g. students, volunteers etc., in order to pinpoint and improve design flaws in a risk-free and ethical way.
2) Recovered patients, who compared to non-patients can provide additional insights on how cancer patients feel and what could alleviate their negative emotions.
3) Patients with mild/benign types of cancer, who compared to recovered patients experience those feelings now.
4) Adult patients with more severe types of cancer, who compared to patients with mild/benign types of cancer experience emotions related to more life-threatening situations.
5) Kids and adolescents with cancer, who compared to adults belong to a more vulnerable group but also are more keen to technology.

A feasibility test includes 8 areas of focus in three different phases [70]. The feasibility test described in this proposal incorporates all 8 areas of focus but, for the time being, is conducted only during the first development phase, i.e. it answers the question: *Can it work?*, and is shown in more detail in Table I.

TABLE I
PHASES OF A FEASIBILITY STUDY [70]

Area of Focus	**Intervention Development Phase**
	Can it work?
Acceptability	Will the game fit the daily-life activities of the participants? (Focus groups)
Demand	Will the game be used by the target population? (Survey)
Implementation	Can the game be deployed in a clinical context? (Survey)
Practicality	What is the cost, benefit, and duration of the game in a small-scale demonstration? (Interviews & Cost-effectiveness analysis)
Adaptation	To what extent can the game be adapted to be used, for example, in a different population? (Survey)
Integration	What are the costs and benefits in implementing the game, given the current knowledge and infrastructure of the target organisation? (Observations)
Expansion	Would an expanded version of the game work? (Interviews)
Limited efficacy	Would the game be effective in a non-ideal situation, e.g. limited resources? (Observations)

The goal in this phase is to test the feasibility [71] and validity [72], [73] of the game as well as to further fine-tune the methodology. The 5-step experimentation process allows to gradually build confidence on the methodology and subsequently on the games.

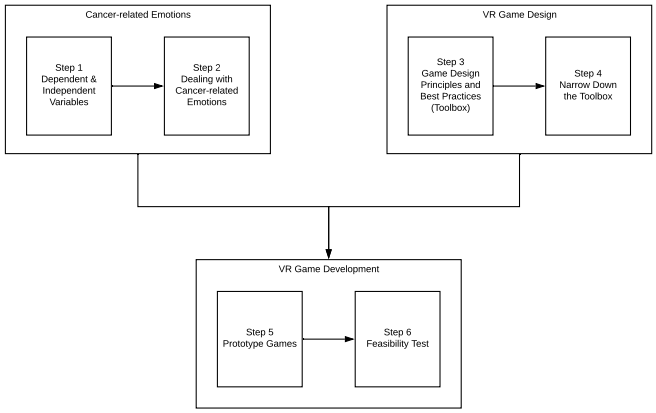

Fig. 1. A graphical illustration of the proposed methodology.

IV. TECHNOLOGY

From a technology point of view, the implementation of a digital game is concerned with two aspects, the client side and the server side. One of the objectives of this paper is to propose a methodology for building games that would tend the needs of patients with different types and in different stages of cancer, as well as take into account the capabilities and limitations of the development team. It is therefore crucial that any technology used to build these kind of games would be inline with these objectives. In Section IV-A and Section IV-B, different client and server side platforms are presented along with their advantages and disadvantages with regards to different factors. The terms client and server side are commonly used interchangeably with the terms front-end and back-end respectively. This study has chosen the former terms because front-end is heavily associated explicitly with browsers and back-end does not distinguish on where the processes take place, i.e. processes could run on user's device. In Table II, a summary of these platforms is shown.

The analysis of the different platforms is performed by taking into account the following factors and associated -ilities:

- Game Design, which is concerned with the i. usability and ii. level of immersion of the game developed.
- Accessibility, which is concerned with i. the extent to which the game is platform agnostic (i.e. the amount of work needed to be ported in different devices), ii. the open-source capabilities that would allow collaboration between developers and between developers and players, iii. the level of confidence that the game could be accessible 24/7 which is expressed with the term Decentralisation, in the sense that an application that is decentralised is accessible even if the original creator abandons it, and iv. the level of interoperability the game has, particularly with players' profiles.
- Security, which is concerned with how difficult is to block malicious attacks and prevent sensitive data from being exposed to a third party.
- Affordability, which is concerned with i. the development cost of a game and ii. the cost for acquiring and playing

this game by players.

A. Client Side

The client side of a game corresponds to the device the game is delivered on and which is used by the end-user. This analysis differentiates between four types of clients. Namely, these clients are a. Web browsers, b. Native applications, c. Game consoles, and d. VR platforms, all of which are analysed below.

1) Web browsers: A web browser is a pre-installed application in almost every available device, like PCs, mobile phones, even smart TVs, which translates into virtually zero acquisition cost on behalf of end-users as well as ease of use and the ability to access the game from everywhere. In addition, web-based games are considered to be relatively inexpensive with regards to development, which is the result of the standardisation of the programming languages used in web development. Moreover, due to the common standards on which browsers are built, games do not usually require any modifications in order to be played in different devices, making this games almost by default platform agnostic. Lastly, the openness and popularity of browsers offer increased capabilities with regards to open-source development.

On the down side, due to being open, browsers are susceptible to malicious attacks and are relatively easy to hack. Moreover, the current technology regarding web-based games is still behind in terms of immersiveness and overall quality.

2) Native Applications: Native applications, either on a PC or a mobile phone, are a very popular avenue for game developers and end-users. The popularity of these devices means that there is almost zero acquisition cost for end-users and due to the numerous developers, the cost of implementing native games is relatively low, though significantly higher than that of browsers. Similarly with browsers, it has become very easy to have access to such a device and while there are no common standards on the different operating systems of these devices, there are several tools that enable porting with minimal effort and thus cost. Lastly, native applications tend to take full advantages of a device's resources and are generally designed with high standards regarding usability.

Native application do come with a few disadvantages. There are significantly less options, compared with browsers, with regards to open-source projects, particularly in closed environments. They tend to be more protected than browsers but still relatively easy to hack. Native games are undoubtedly better than games on a browsers though compared to other platforms analysed below not as immersive and of much less quality, especially in low-end devices.

3) Game consoles: Game consoles are yet another widespread medium for video games. This popularity comes with similar advantages as with browsers and native applications, like the affordability, accessibility, and usability for end users. In addition, game consoles tend to be more secure and less prone to malicious attacks compared to browsers.

Nevertheless, game consoles are characterised by significant disadvantages, the most important of which is the barriers to entry for developers. Developing games for consoles like Playstation or XBox is associated with increased scrutiny from the consoles companies, specialised equipment for development, and eventually notably higher development costs compared to any other gaming platform. Moreover, with very few exceptions, game consoles are not portable devices and usually require significantly more work, in order to port them in other platforms. Lastly, there are very few, if any, possibilities for open-source projects.

4) VR platforms: VR due to late technological advancements has ceased to be a niche technology and has rather become a disruptive one [74]. In turn, various industries, including healthcare, have taken advantage of the benefits VR has to offer compared to traditional interventions, the most important of which are the i) high levels of immersion [75], ii) increased motivation [76], especially from younger people, and iii) ability to build virtual environments providing an experience that is impossible to have in real-life [77]. Particularly for people with cancer, VR offers a platform where people can "disconnect" from their everyday environment, which in many cases is the hospital, thus providing a more pleasant experience; moreover, in a VR game, tasks that would otherwise be impossible to perform, like physically demanding movements, become feasible. Moreover, the democratisation of VR has enabled the development of platforms that are in certain cases more affordable than mobile phones and almost equally portable. Finally, VR platforms tend to be less prone to cyberattacks and with several possibilities for open-source projects.

VR being young as a technology, compared to the other game platforms analysed above, usually results in an increased development cost and with additional work and cost required to port a specific game in multiple VR platforms. One of the greatest challenges in VR game development is overcoming issues particularly found in VR, like motion sickness, which are even more present in games targeting people with a compromised immune system and more prone to symptoms like dizziness.

B. Server Side

The server side of the game corresponds to the processes and services running on the background of the game. The associated files are not located on the user's device but on a remote location, which can be a traditional implementation with a database in a server or a decentralised implementation using blockchain.

1) Traditional server implementation: A traditional server implementation with a database (relational or not) has been the sole solution for decades. Is is very affordable to build and maintain and it offers many possibilities for open-source projects. All files and data are located in a centralised server, which makes access and manipulations easy and any kind of authentication instant.

On the down side, a traditional server implementation relies exclusively on the developers; a game grows as long as the developers put their time on it and subsides if the developers

TABLE II
TECHNOLOGICAL ATTRIBUTES (LIKERT SCALE 1-5)

Attributes	Client Side				Server Side	
	Web Browser	*Native Apps*	*Game Platforms*	*VR*	*Traditional*	*Blockchain*
Usability	4	5	5	3	NA	NA
Immersion	1	2	3	5	NA	NA
Platform agnostic	5	2	1	2	5	5
Open-source	5	2	1	3	5	5
Decentralisation	NA	NA	NA	NA	1	5
Interoperability	NA	NA	NA	NA	3	5
Security	1	3	4	4	3	5
Affordability (Developers)	5	3	1	2	5	2
Affordability (Users)	5	4	3	3	NA	NA

abandon it. In addition, traditional servers are very susceptible to DDoS attacks, which can render the game unplayable, as well as prone to hacking, especially when sensitive data, like medical data, are involved.

2) Blockchain: Blockchain has been a disruptive technology in the past decade with various applications across several domains. Gaming is one of those domains that can benefit from the use of blockchain [78]. A game on blockchain means that the game is decentralised, thus it has the potential to exist and grow beyond the intentions of its developers. In other words, if developers abandon a game, the game does not cease to exist and its users or any other interested party can continue its development or maintenance, making blockchain almost by default open-source-friendly. In addition, blockchain could offer interoperable players' profiles as well as increased security [79]. Particularly with regards to security, blockchain is virtually immune to DDoS attacks, extremely difficult to hack and obtain access to the game data, and could provide real-time cheat prevention mechanisms [80].

By all means, blockchain is a very young and immature technology and a game in blockchain would today translate to significantly increased development costs as compared to a traditional server implementation. Another significant disadvantage is the authentication mechanisms of blockchain, which despite being very secure and robust, are very slow with the current technology and thus in many cases unsuitable for a game implementation.

V. DISCUSSION & CONCLUSION

In this paper, a framework for designing games aimed at alleviating negative emotions of cancer patients is presented, based on two pillars. The first pillar refers to the game design methodology, whereas the second pillar refers to the methodology for choosing the most appropriate technologies to implement the designed game. The game design methodology consists of six steps guiding designers from conception to feasibility tests. The central idea is about linking practices from psychology on tackling negative emotions associated with cancer patients with game design choices that would enable the "gamification" of those practices. On the other hand, the technology methodology consists of an analysis of the current technological options in front- and back-end game development.

The main limitation of the proposed methodology, which is less of a limitation and more of a design decision, is the absence of any form of debriefing. While debriefing is paramount in games, in this study it has not been considered because despite its benefits, it strongly inhibits the accessibility to a game. In other words, if an expert is required during and/or after every session, either physically present or remotely, in order to facilitate the game and maximise its outcome, the number of times that a player could play the game would be severely limited and subject to the expert's availability. Moreover, the associated cost would significantly increase, raising even more the barriers of playing a game.

The work presented in this paper is the first step towards addressing the primary problem with games targeted for cancer patients, the lack of a coherent and robust game design methodology. The next step would be the validation and fine-tuning of the methodology through testing it with pre-existing successful games and through applying it to the design and development of new games. Nevertheless, to the best of our knowledge, this is the first attempt in addressing the above-mentioned limitation, which in turn opens the way for a more evidence-based game design.

REFERENCES

[1] P. Brennan, M. Perola, G. J. van Ommen, E. Riboli, and E. C. Consortium, "Chronic disease research in Europe and the need for integrated population cohorts," *European Journal of Epidemiology*, vol. 32, no. 9, pp. 741–749, 2017.

[2] N. Straker, "Introduction: Facing cancer and the fear of death: A challenge for the twenty-first century," in *Facing cancer and the fear of death: A psychoanalytic perspective on treatment*. Jason Aronson, 2013, pp. ix–xiii.

[3] J. Newirth, "Overcoming the shame of cancer," *Psychoanalytic Dialogues*, vol. 27, no. 2, pp. 213–217, 2017.

[4] R. D. Abrams and J. E. Finesinger, "Guilt reactions in patients with cancer," *Cancer*, vol. 6, no. 3, pp. 474–482, 1953.

[5] N. K. LoConte, N. M. Else-Quest, J. Eickhoff, J. Hyde, and J. H. Schiller, "Assessment of guilt and shame in patients with non–small-cell lung cancer compared with patients with breast and prostate cancer," *Clinical Lung Cancer*, vol. 9, no. 3, pp. 171–178, 2008.

[6] E. M. V. Reiche, S. O. V. Nunes, and H. K. Morimoto, "Stress, depression, the immune system, and cancer," *The Lancet Oncology*, vol. 5, no. 10, pp. 617–625, 2004.

[7] M. Wells and D. Kelly, "The loneliness of cancer," *European Journal of Oncology Nursing*, vol. 12, no. 5, pp. 410–411, 2008.

[8] S. Knapp, A. Marziliano, and A. Moyer, "Identity threat and stigma in cancer patients," *Health Psychology Open*, 2014.

[9] C. Vrinten, A. Gallagher, J. Waller, and L. A. V. Marlow, "Cancer stigma and cancer screening attendance: A population based survey in England," *BMC Cancer*, vol. 19, no. 1, 2019.

[10] L. Baider, "My illness, myself: On the secrecy of shame," *Asian Pacific Journal of Cancer Prevention*, vol. 11, no. Suppl 1, pp. 59–62, 2010.

[11] J. Bukberg, D. Penman, and J. C. Holland, "Depression in hospitalized cancer patients," *Psychosomatic Medicine*, vol. 46, no. 3, pp. 199–212, 1984.

[12] D. Spiegel, "Health caring. Psychosocial support for patients with cancer," *Cancer*, vol. 74, no. S4, pp. 1453–1457, 1994.

[13] D. Spiegel and J. Giese-Davis, "Depression and cancer: Mechanisms and disease progression," *Biological Psychiatry*, vol. 54, no. 3, pp. 269–282, 2003.

[14] J. L. Steel, B. Carr, D. A. Geller, T. C. Gamblin, M. C. Olek, and B. I. Carr, "Immunity, and survival in patients with hepatobiliary carcinoma," *Journal of Clinical Oncology*, vol. 25, no. 17, pp. 2397–2405, 2007.

[15] Y. Chida, M. Hamer, J. Wardle, and A. Steptoe, "Do stress-related psychosocial factors contribute to cancer incidence and survival?" *Nature Clinical Practice Oncology*, vol. 5, no. 8, pp. 466–475, 2008.

[16] J. R. Satin, W. Linden, and M. J. Phillips, "Depression as a predictor of disease progression and mortality in cancer patients: A meta-analysis," *Cancer*, vol. 115, no. 22, pp. 5349–5361, 2009. [Online]. Available: https://acsjournals.onlinelibrary.wiley.com/doi/10.1002/cncr.24561

[17] S. A. Everson, D. E. Goldberg, G. A. Kaplan, R. D. Cohen, E. Pukkala, J. Tuomilehto, and J. T. Salonen, "Hopelessness and risk of mortality and incidence of myocardial infarction and cancer," *Psychosomatic Medicine*, vol. 58, no. 2, pp. 113–121, 1996.

[18] G. Buccheri, "Depressive reactions to lung cancer are common and often followed by a poor outcome," *European Respiratory Journal*, vol. 11, pp. 173–178, 1998.

[19] M. Watson, J. S. Haviland, S. Greer, J. Davidson, and J. M. Bliss, "Influence of psychological response on survival in breast cancer: A population-based cohort study," *Lancet*, vol. 354, no. 9187, pp. 1331–1336, 1999.

[20] M. Stommel, B. A. Given, and C. W. Given, "Depression and functional status as predictors of death among cancer patients," *Cancer*, vol. 94, no. 10, pp. 2719–2727, 2002.

[21] A. Chirico, F. Lucidi, M. De Laurentiis, C. Milanese, A. Napoli, and A. Giordano, "Virtual reality in health system: Beyond entertainment. A mini-review on the efficacy of VR during cancer treatment," *Journal of Cellular Physiology*, vol. 231, no. 2, pp. 275–287, 2016.

[22] K. C. Calman, "Definitions and dimensions of quality of life," in *The Quality of Life of Cancer Patients*, N. K. Aaronson, J. H. Beckmann, and J. L. et al. Bernheim, Eds. New York: Raven Press, 1987, pp. 1–10.

[23] D. F. Cella and E. A. Cherin, "Quality of life during and after cancer treatment," *Comprehensive Therapy*, vol. 14, no. 5, pp. 69–75, 1988.

[24] S. A. Shumaker, R. T. Anderson, and S. M. Czajkowski, "Psychological tests and scales," in *Quality of Life Assessments in Clinical Trials*, B. Spilker, Ed. New York: Raven Press, 1990, pp. 95–113.

[25] H. Schipper, "Guidelines and caveats for quality of life measurement in clinical practice and research." *Oncology (Williston Park, N.Y.)*, vol. 4, no. 5, pp. 51–7; discussion 70, 1990.

[26] C. C. Gotay, E. L. Korn, M. S. McCabe, T. D. Moore, and B. D. Cheson, "Quality-of-Life assessment in cancer treatment protocols: Research issues in protocol development," *JNCI Journal of the National Cancer Institute*, vol. 84, no. 8, pp. 575–579, 1992.

[27] D. J. Kolko and J. L. Rickard-Figueroa, "Effects of video games on the adverse corollaries of chemotherapy in pediatric oncology patients: A single-case analysis," *Journal of Consulting and Clinical Psychology*, vol. 53, no. 2, pp. 223–228, 1985.

[28] J. Vasterling, R. A. Jenkins, D. M. Tope, and T. G. Burish, "Cognitive distraction and relaxation training for the control of side effects due to cancer chemotherapy," *Journal of Behavioral Medicine*, vol. 16, no. 1, pp. 65–80, 1993.

[29] P. M. Kato, S. W. Cole, A. S. Bradlyn, and B. H. Pollock, "A video game improves behavioral outcomes in adolescents and young adults with cancer: A randomized trial," *Pediatrics*, vol. 122, no. 2, 2008.

[30] A. Fuchslocher, K. Gerling, M. Masuch, and N. Krämer, "Evaluating social games for kids and teenagers diagnosed with cancer," in *IEEE 1st International Conference on Serious Games and Applications for Health, SeGAH 2011*, 2011, pp. 1–4.

[31] A. Fuchslocher, J. Niesenhaus, and N. Krämer, "Serious games for health: An empirical study of the game "Balance" for teenagers with diabetes mellitus," *Entertainment Computing*, vol. 2, no. 2, pp. 97–101, 2011.

[32] B. L. Andersen, W. B. Farrar, D. Golden-Kreutz, C. F. Emery, R. Glaser, T. Crespin, and W. E. Carson, "Distress reduction from a psychological intervention contributes to improved health for cancer patients," *Brain, Behavior, and Immunity*, 2007.

[33] A. L. Stanton, P. A. Ganz, J. H. Rowland, B. E. Meyerowitz, J. L. Krupnick, and S. R. Sears, "Promoting adjustment after treatment for cancer," *Cancer*, vol. 104, no. S11, pp. 2608–2613, 2005.

[34] I. Fawzy, "Critical review of psychosocial interventions in cancer care," *Archives of General Psychiatry*, 2011.

[35] A. L. Stanton, "What happens now? Psychosocial care for cancer survivors after medical treatment completion," *Journal of Clinical Oncology*, vol. 30, no. 11, pp. 1215–1220, 2012.

[36] S. Maharjan, B. U. Maheswari, and M. Maharjan, "Effectiveness of animated cartoon as a distraction strategy on level of pain among children undergoing venipuncture at selected hospital research officer (CREHPA)," *International Journal of Health Sciences and Research*, vol. 7, no. 8, pp. 248–252, 2017.

[37] E. Jameson, J. Trevena, and N. Swain, "Electronic gaming as pain distraction," *Pain Research and Management*, vol. 16, no. 1, pp. 27–32, 2011.

[38] L. Kauhanen, L. Järvelä, P. M. Lähteenmäki, M. Arola, O. J. Heinonen, A. Axelin, J. Lilius, T. Vahlberg, and S. Salanterä, "Active video games to promote physical activity in children with cancer: A randomized clinical trial with follow-up," *BMC Pediatrics*, vol. 14, no. 1, p. 94, 2014.

[39] M. Pothoulaki, R. MacDonald, and P. Flowers, "Methodological issues in music interventions in oncology settings: A systematic literature review," *Arts in Psychotherapy*, vol. 33, no. 5, pp. 446–455, 2006.

[40] M. H. Rykov, "Experiencing music therapy cancer support," *Journal of Health Psychology*, vol. 13, no. 2, pp. 190–200, 2008.

[41] C. G. Brown-Johnson, B. Berrean, and J. K. Cataldo, "Development and usability evaluation of the mHealth Tool for lung cancer (mHealth TLC): A virtual world health game for lung cancer patients." *Patient Education and Counseling*, vol. 98, no. 4, pp. 506–11, 2015.

[42] H. Oyama, M. Kaneda, N. Katsumata, T. Akechi, and M. Ohsuga, "Using the bedside wellness system during chemotherapy decreases fatigue and emesis in cancer patients," *Journal of Medical Systems*, vol. 24, no. 3, pp. 173–182, 2000.

[43] W. H. Li, J. O. Chung, and E. K. Ho, "The effectiveness of therapeutic play, using virtual reality computer games, in promoting the psychological well-being of children hospitalised with cancer," *Article in Journal of Clinical Nursing*, vol. 20, no. 15-16, pp. 2135–2143, 2011.

[44] M. Espinoza, R. M. Baños, A. Garcia-Palacios, and J. M. Cervera, "Promotion of emotional wellbeing in oncology inpatients using VR," *Annual Review of Cybertherapy and Telemedicine*, pp. 53–57, 2012.

[45] R. Tate, J. Haritatos, and S. Cole, "HopeLab's approach to Re-Mission," *International Journal of Learning and Media*, vol. 1, no. 1, pp. 29–35, 2009.

[46] C. Caldwell, C. Bruggers, R. Altizer, G. Bulaj, T. D'Ambrosio, R. Kessler, and B. Christiansen, "The intersection of video games and patient empowerment: Case study of a real world application," in *IE '13: Proceedings of The 9th Australasian Conference on Interactive Entertainment: Matters of Life and Death*. New York, New York, USA: ACM Press, 2013, pp. 1–7.

[47] C. Gansohr, K. Emmerich, M. Masuch, O. Basu, and L. Grigull, "Creating age-specific interactive environments about medical treatments for children and adolescent patients diagnosed with cancer," in *Games for Training, Education, Health and Sports. GameDays 2014. Lecture Notes in Computer Science*, vol. 8395 LNCS. Springer Verlag, 2014, pp. 141–152.

[48] D. F. Cella, D. S. Tulsky, G. Gray, B. Sarafian, E. Linn, A. Bonomi, M. Silberman, S. B. Yellen, P. Winicour, J. Brannon, K. Eckberg, S. Lloyd, S. Purl, C. Blendowski, M. Goodman, M. Barnicle, I. Stewart, M. McHale, P. Bonomi, E. Kaplan, S. T. IV, C. R. J. Thomas, and J. Harris, "The functional assessment of cancer therapy scale: Development and validation of the general measure," *Journal of Clinical Oncology*, vol. 11, no. 3, pp. 570–579, 1993.

[49] S. J. Lepore, V. S. Helgeson, D. T. Eton, and R. Schulz, "Improving quality of life in men with prostate cancer: A randomized controlled trial of group education interventions." *Health Psychology*, vol. 22, no. 5, pp. 443–452, 2003.

[50] R. L. Osborn, A. C. Demoncada, and M. Feuerstein, "Psychosocial interventions for depression, anxiety, and quality of life in cancer survivors: Meta-analyses," *The International Journal of Psychiatry in Medicine*, vol. 36, no. 1, pp. 13–34, 2006.

[51] S. Greer, "Improving quality of life: Adjuvant psychological therapy for patients with cancer," *Supportive Care in Cancer*, vol. 3, no. 4, pp. 248–251, 1995.

[52] F. I. Fawzy, N. Cousins, N. W. Fawzy, M. E. Kemeny, R. Elashoff, and D. Morton, "A structured psychiatric intervention for cancer patients: I. Changes over time in methods of coping and affective disturbance," *Archives of General Psychiatry*, vol. 47, no. 8, pp. 720–725, 1990.

[53] T. Hosaka, Y. Sugiyama, Y. Tokuda, and T. Okuyama, "Persistent effects of a structured psychiatric intervention on breast cancer patients' emotions," *Psychiatry and Clinical Neurosciences*, vol. 54, no. 5, pp. 559–563, 2000.

[54] N. C. Allard, "Day surgery for breast cancer: Effects of a psychoeducational telephone intervention on functional status and emotional distress." in *Oncology Nursing Forum*, vol. 34, no. 1, 2007.

[55] L. D. Cameron, R. J. Booth, M. Schlatter, D. Ziginskas, and J. E. Harman, "Changes in emotion regulation and psychological adjustment following use of a group psychosocial support program for women recently diagnosed with breast cancer," *Psycho-Oncology: Journal of the Psychological, Social and Behavioral Dimensions of Cancer*, vol. 16, no. 3, pp. 171–180, 2007.

[56] B. Roungas and F. Dalpiaz, "A model-driven framework for educational game design," in *4th International Conference, GALA 2015, Revised Selected Papers*, A. De Gloria and R. Veltkamp, Eds., vol. 9599. Rome, Italy: Springer International Publishing, 2016, pp. 1–11.

[57] B. Roungas, F. A. Bekius, and S. Meijer, "The game between game theory and gaming simulations: Design choices," *Simulation & Gaming*, vol. 50, no. 2, 2019.

[58] M. Csikszentmihalyi, *Flow: The psychology of optimal experience*. Harper & Row New York, 1990.

[59] K. Gerling, A. Fuchslocher, R. Schmidt, N. Krämer, and M. Masuch, "Designing and evaluating casual health games for children and teenagers with cancer," in *International Conference on Entertainment Computing*. Springer, Berlin, Heidelberg, 2011, pp. 198–209.

[60] E. J. Lyons, T. Baranowski, K. M. Basen-Engquist, Z. H. Lewis, M. C. Swartz, K. Jennings, and E. Volpi, "Testing the effects of narrative and play on physical activity among breast cancer survivors using mobile apps: Study protocol for a randomized controlled trial," *BMC Cancer*, vol. 16, no. 1, p. 202, 2016.

[61] C. S. Bruggers, S. Baranowski, M. Beseris, R. Leonard, D. Long, E. Schulte, A. Shorter, R. Stigner, C. C. Mason, A. Bedrov, I. Pascual, and G. Bulaj, "A prototype exercise-empowerment mobile video game for children with cancer, and its usability assessment: Developing digital empowerment interventions for pediatric diseases," *Frontiers in Pediatrics*, vol. 6, p. 1, 2018.

[62] T. Fullerton, *Game design workshop: A playcentric approach to creating innovative games*. CRC press, 2014.

[63] A. Gotlieb, M. Louarn, M. Nygård, T. Ruiz-Lopez, S. Sen, and R. Gori, "Constraint-based verification of a mobile app game designed for Nudging People to attend cancer screening," in *AAAI*, 2017, pp. 4678–4685.

[64] L. Poole, M. Hamer, A. J. Wawrzyniak, and A. Steptoe, "The effects of exercise withdrawal on mood and inflammatory cytokine responses in humans," *Stress*, vol. 14, no. 4, pp. 439–447, 2011.

[65] P. Ekkekakis, G. Parfitt, and S. J. Petruzzello, "The pleasure and displeasure people feel when they exercise at different intensities," *Sports Medicine*, vol. 41, no. 8, pp. 641–671, 2011.

[66] K. Basen-Engquist, D. Hughes, H. Perkins, E. Shinn, and C. C. Taylor, "Dimensions of physical activity and their relationship to physical and emotional symptoms in breast cancer survivors," *Journal of Cancer Survivorship*, vol. 2, no. 4, pp. 253–261, 2008.

[67] S. F. A. Duijts, M. M. Faber, H. S. A. Oldenburg, M. van Beurden, and N. K. Aaronson, "Effectiveness of behavioral techniques and physical exercise on psychosocial functioning and health-related quality of life in breast cancer patients and survivors - A meta-analysis," *Psycho-Oncology*, vol. 20, no. 2, pp. 115–126, 2011.

[68] P. D. Loprinzi and B. J. Cardinal, "Effects of physical activity on common side effects of breast cancer treatment," *Breast Cancer*, vol. 19, no. 1, pp. 4–10, 2012.

[69] B. M. Pinto, C. Rabin, and S. Dunsiger, "Home-based exercise among cancer survivors: adherence and its predictors," *Psycho-Oncology: Journal of the Psychological, Social and Behavioral Dimensions of Cancer*, vol. 18, no. 4, pp. 369–376, 2009.

[70] D. J. Bowen, M. Kreuter, B. Spring, L. Cofta-Woerpel, L. Linnan, D. Weiner, S. Bakken, C. P. Kaplan, L. Squiers, C. Fabrizio, and M. Fernandez, "How we design feasibility studies," *American Journal of Preventive Medicine*, vol. 36, no. 5, pp. 452–457, 2009.

[71] R. M. Baños, M. Espinoza, A. García-Palacios, J. M. Cervera, G. Esquerdo, E. Barrajón, and C. Botella, "A positive psychological intervention using virtual reality for patients with advanced cancer in a hospital setting: A pilot study to assess feasibility," *Supportive Care in Cancer*, vol. 21, no. 1, pp. 263–270, 2013.

[72] B. Roungas, S. A. Meijer, and A. Verbraeck, "A framework for optimizing simulation model validation & verification," *International Journal on Advances in Systems and Measurements*, vol. 11, no. 1 & 2, 2018.

[73] B. Roungas, S. Meijer, and A. Verbraeck, "A framework for simulation validation & verification method selection," in *SIMUL 2017: The Ninth International Conference on Advances in System Simulation*, Athens, Greece, 2017, pp. 35–40.

[74] J. Psotka, "Educational games and virtual reality as disruptive technologies," *Educational Technology & Society*, vol. 16, no. 2, pp. 69–80, 2013.

[75] W. Winn, "A conceptual basis for educational applications of virtual reality," University of Washington, USA, Tech. Rep., 1993.

[76] V. Pantelidis, "Reasons to use virtual reality in education," *VR in the Schools*, vol. 1, no. 1, p. 9, 1995.

[77] F. Mantovani, G. Castelnuovo, A. Gaggioli, and G. Riva, "Virtual reality training for health-care professionals," *CyberPsychology & Behavior*, vol. 6, no. 4, pp. 389–395, 2003.

[78] T. Min, H. Wang, Y. Guo, and W. Cai, "Blockchain games: A survey," in *2019 IEEE Conference on Games (CoG)*. IEEE, 2019, pp. 1–8.

[79] L. Besançon, C. F. Da Silva, and P. Ghodous, "Towards blockchain interoperability: Improving video games data exchange," in *2019 IEEE International Conference on Blockchain and Cryptocurrency (ICBC)*. IEEE, 2019, pp. 81–85.

[80] S. Kalra, R. Sanghi, and M. Dhawan, "Blockchain-based real-time cheat prevention and robustness for multi-player online games," in *Proceedings of the 14th International Conference on Emerging Networking Experiments and Technologies*, 2018, pp. 178–190.