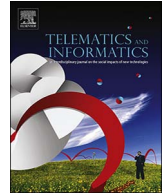




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Gamification and serious games in depression care: A systematic mapping study

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ABSTRACT

Depression is a common mental disorder that causes sadness and loss of interest. It affects 350 million people in the world and its most severe state can lead to suicide. Many technologies are being used to aid the depression treatment and gamification has been used as an approach to improve adherence and engagement in the treatment. This systematic study aimed at identifying how gamification and serious games have been applied to support the treatment of depression, what technologies are being used currently and what gaps are still left unexplored. Eight scientific repositories were used to search for papers in the area of depression and a filter process was used to remove bias. As a result of this search and filter process, 28 works were completely reviewed, analyzed and categorized in this paper. In the reviewed papers the technologies found for treatment of depression were mobile, computer, wearables and web applications. These technologies are applied in gamification, serious games, virtual reality and speech analysis. Some papers used Cognitive Behavioral Therapy as an intervention and other papers used gamification as a way to promote engagement and adherence to treatment.

1. Introduction

World Health Organization (WHO, 2017a) defines depression as a common mental disorder, characterized by sadness, loss of interest or pleasure, feelings of guilt or low self-worth, disturbed sleep or appetite, feelings of tiredness, and poor concentration. Globally, depression has reached 350 million people of all ages and it was the leading cause of disability worldwide, affecting more women than men. At its worst, depression could lead to suicide (Simon and VonKorff, 1998). In addition, depression can be long-lasting or recurrent, thus impairing individual's ability to function at work or school or to cope with the daily life. The diagnostic and the treatment can be done reliably by non-specialists as a part of primary health care and when diagnosed as mild, people can be treated without medicines but when depression is moderate or severe, the people diagnosed may require medical monitoring and the use of medicines (WHO, 2017a).

There are many treatments for depression. Antidepressants, for example, can be an effective form of treatment for moderate-severe depression, however, they are not the first line of treatment when the cases are of mild depression. Antidepressants should not be used as the first-line treatment for children and teenagers (in this case, antidepressants should be used with caution (WHO, 2017b)). Besides the use of medicines, experts recommend that friends and family should participate in the treatment of patient who suffers from depression.

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Non-drug treatments such as exercises, psychotherapy or counseling (Association, 2010) and mindfulness-based interventions (Strauss et al., 2014) are being used to treat depression. Furthermore, technology, such as serious games, mobile systems and gamification, has been used to support mental health, which is why gamification can also be used to support an increase in social engagement. According to Barrios (Barrio et al., 2015) the term “gamification” is relatively recent, it was used for the first time in a paper in 2010 (Inc, 2010), and it is known for the use of game dynamics and mechanics in computer applications to change user’s behavior.

Although the terms game dynamics and mechanics are closely related, they are also used interchangeably. Game mechanics relate to gameplay, such as score, levels, dialogs, tips, progress, challenges and classification, whereas game dynamics focus on results that the game mechanics lead to, such as the sense of reward, achievement, competition and altruism. Gamification has become a strategy to motivate and engage users of educational applications, business and health (Brown et al., 2016).

Serious games are an example of non-entertainment games, they are designed to improve some specific aspect of learning or training, to be used in education area or in health care. Their genres, complexity, and platforms are as varied as in entertainment games.

This paper uses the systematic mapping study methodology in order to show the usage of gamification and serious games on depression treatment. Other systematic studies were already conducted to gauge how mobile applications have been used for supporting Cognitive Behavioral Therapy (CBT) and Behavioral Activation (BA) (Huguet et al., 2016) and to check the acceptability of interventions delivered online and by mobile phones (Berry et al., 2016).

Given that the subject in question is relatively new, the motivation of this study is to find out what are the databases most relevant to the research area of gamified depression treatment. This work also focuses on discovering who are the main authors of the area, which are the most relevant papers, the shortcomings and challenges in the area. This study presents the current theoretical state of the art, serving to support future researches.

The paper is organized as follows: in Section 2 is presented how the mapping study was assembled and executed. The text selection process is presented in more detail in Section 2.3. In Section 3, the most relevant papers found are organized in the respective search questions and Section 4 exposes the threats to the validity of the work. Finally the last two sections, namely Section 5 and Section 6, conclude this paper by introducing a discussion regarding the works found, followed by a brief presentation of future work.

2. Methodology

This paper uses systematic mapping study as methodology, which eliminates or greatly reducing bias when compared to single reference reviews, thus getting more reliable results (Cooper, 2016). This type of methodology does not discuss just the final finding but all activities related to the finding. Thus systematic mapping study collects data about locations where activity occurs and media where it was published, mapping that linkage. Mapping often focuses on published papers but can be used with other medias like books, newspapers and grant proposals. The methodology consists in the execution of the following steps:

- Elaboration of the research questions.
- Design the search process.
- Defining the criteria for filtering results.

2.1. Research question

The research questions led this study to find out works that could be linked with gamification and serious games on depression treatment. For this work, three General Questions (GQ), two Focused Questions (FQ) and two Statistical Questions (SQ) were defined. The purpose behind the GQs is to understand how technologies are aiding in mental health. The purpose behind the FQs is to identify how specific technologies are used to treat depression. Lastly, the purpose behind the SQs is to find statistical data about the area being studied. These questions are presented in Table 1.

Table 1
Research Questions.

References	Questions
<i>General Questions</i>	
GQ1	What technologies are being used to support mental health disorder?
GQ2	How technologies are being applied to mental health treatment?
GQ3	How gamification is being used to support mental health?
<i>Focused Questions</i>	
FQ1	How smartphone is being used to aid depression treatment?
FQ2	How gamification can support motivation of people with depression?
<i>Statistical Questions</i>	
SQ1	Where have the researches been published?
SQ2	What is the number of publications by year?

Table 2
Search string terms.

Major Terms	Synonyms
Gamification	Gamification OR gamified OR serious games OR game mechanics OR game dynamics OR game design OR game-based OR game based OR gaming
Depression	Depressive OR despondency OR dejection OR melancholy OR sadness

2.2. Research process

Through a well-defined research process by Petersen et al. (2008), three steps were defined: specify the search string, choose the databases to apply the search string and obtaining the results. The first step begins by identifying the major terms and their more relevant synonyms. In this study were chosen Depression and Gamification as major terms, the synonyms for gamification were based on terms finding in Derryberry (2007) paper and for depression, the synonyms were based on a search of synonyms in the online dictionary Collins¹ (see Table 2).

These terms generated the search string to be used in research databases. The resulting search string is presented bellow:

((gamification OR gamified OR serious games OR game mechanics OR game dynamics OR game design OR game-based OR game based OR gaming) AND (depression OR depressive OR despondency OR dejection OR melancholy OR sadness))

Once the search string was set, the research parameters to be used in the databases were defined. Thus, the second step was to select relevant databases for the area of study to apply the search string. Therefore, eight research databases have been used, which include Journal of Medical Internet Research (JMIR), PubMed Central, ACM Digital Library, Google Scholar, IEEE Xplore Digital Library, Science Direct, Springer Library and Wiley. The first two are references for research in the health area and the remaining are renowned research databases in the computer science.

The search in ACM Digital Library required the use of advanced search features of this database, wherein the above search string was inserted into the Edit Query field. The search process in Google Scholar was done using the query string in advanced search considering just the title, this filter was made to achieve the most relevant results. To search in IEEE Xplore the Search command from the Other Search Options menu was used. In the JMIR database, the search string was inserted in the criteria field. In PubMed Central, the advanced search was used, and the search string was inserted in both abstract and title fields.

The search process in Science Direct repository involved applying the query string to title, abstract and keywords. In the Springer Library, in addition to using the search string as the search query, it was required to remove papers categorized as “Preview Only” and select the search filter titled “Psychology” to get more relevant results. Finally, in the Wiley database, the advanced search was used and the search string was inserted in the abstract field.

2.3. Study filtering

The studies were filtered to select the most relevant papers. To do this, some Inclusion Criteria (IC) were defined, as shown below:

- IC1: The study should be published in a conference, workshop or journal.
- IC2: The study should be related to the context of usage of gamification and serious games to the treatment of depression.
- IC3: The study should be a full paper.

In turn, Exclusion Criteria (EC) were also defined, as shown below:

- EC1: The studies that are published earlier than 2006.
- EC2: The study that is not written in English.
- EC3: The studies that are published in magazine or thesis.
- EC4: The studies that present an entertainment game.
- EC5: The studies that are not related to the research questions.

The inclusions and exclusions criteria help the filter process to getting the most relevant studies and eliminating any noise generated in the search. The studies obtained from the search process were filtered, removing impurities that were not in accordance with the inclusions criteria IC1, IC2 and IC3.

The remaining papers were stored in a tool called Mendeley,² where the texts were organized in specific folders for each research database. The next step was to analyze the papers by title and abstract. Papers were combined in the same folder and the duplicate

¹ The search can be viewed in <http://www.collinsdictionary.com/dictionary/english-thesaurus/depression>.

² Mendeley can be accessed in the address: <https://www.mendeley.com>.

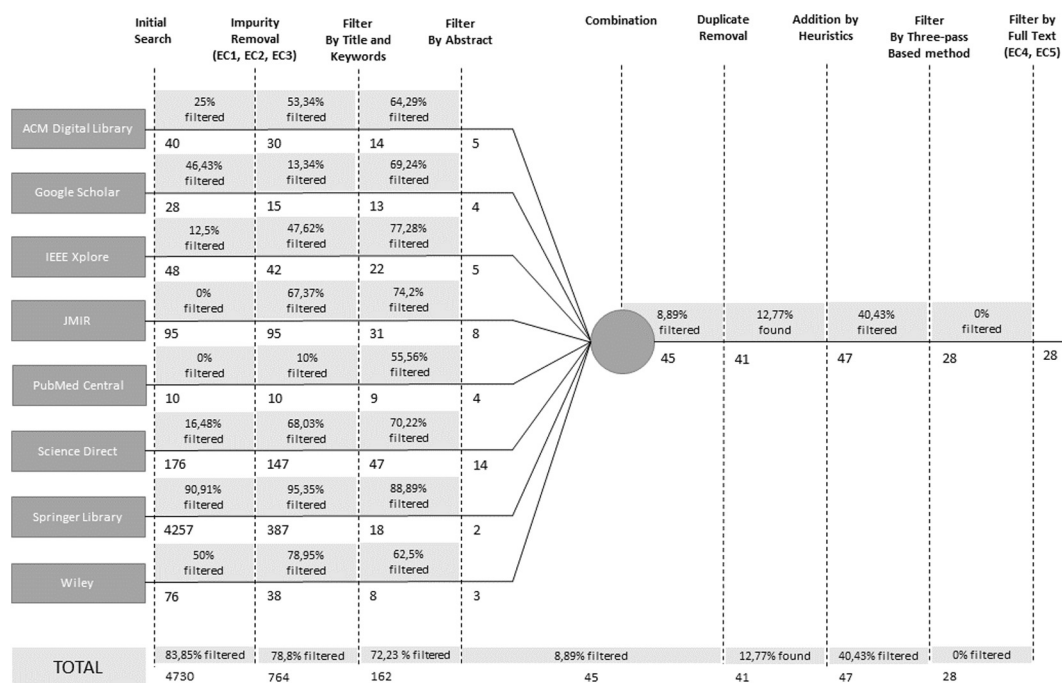


Fig. 1. Steps of filter process.

papers were removed. The papers (Jones et al., 2014; Kuhn et al., 2014; Meinschmidt et al., 2016; Paim and Barbosa, 2016; Pramana et al., 2014; Watanabe et al., 2015) were added by heuristic, once they are relevant to this study, even if not found in the search process.

The next filter was based on the first two passes of three-pass approach introduced by Keshav (2007). The first pass is a quick scan and consists of: 1) reading the title, abstract, and introduction; 2) reading just the section and subsection headings, but ignoring everything else; 3) glancing at the mathematical content (if any) to determine the underlying theoretical foundations; and 4) reading the conclusions.

The second pass consisted of looking carefully at the figures, diagrams and other illustrations in the paper, paying special attention to graphs. Finally, the remaining papers were filtered analyzing the full text and observing the exclusion criteria EC4 and EC5. Fig. 1 presents the filter process, with IC and EC applied in each step.

Fig. 1 shows that the PubMed Central database brought fewer but more assertive papers related to search string, with 60% of the filtered results. Whereas the Springer Library database had 99.96% of the results filtered, showing that, although this database brought more results when compared to the other databases using this search string, Springer Library database brought many unrelated papers. Another case was that after filtering results the best papers of Google Scholar were contained in the other databases used.

The filtering process has shown many papers that analyzed the development of depression and anxiety when adolescents and young people spent several hours playing a video game, these texts were removed from the study.

3. Results

Based on the filtered results, the papers were organized by title, year of publication, authors, databases, technologies (if it is a Gamified System, Serious Game or something else), if the paper evaluates a mobile application, the age of participants (when applicable), focused mental illness and work aims. The results are classified into categories and presented in Appendix A. The finds by each research question are presented in the subsequent subsections.

3.1. GQ1 – what technologies are being used to support mental health disorder?

The way used to detect mental health disorders were extracted from the papers by analyzing the type of technology used in each work. Table 3 shows the technologies used in the works.

Table 3

Technologies found in the papers to support mental health disorder.

Technologies	Papers
Mobile Application	Jones et al. (2014), Kuhn et al. (2014), Meinlschmidt et al. (2016), Paim and Barbosa (2016), Pramana et al. (2014), Watanabe et al. (2015), Ahtinen et al. (2013), Wahle et al. (2016)
Wearables	Wahle et al. (2016)
Magnetic Resonance	Meinlschmidt et al. (2016)
Computer Application	Mok et al. (2014), Cheek et al. (2015), Li et al. (2014), Shepherd et al. (2015), Shook et al. (2007), Destoop et al. (2012), Shao et al. (2015), Clark et al. (2013), Shin et al. (2015), Poppelaars et al. (2016), jun Zhang et al. (2012)
Web Application	Hookham et al. (2016), Rusch (2012), Salter (2016), Oliveira et al. (2014), Bolier et al. (2013), Brown et al. (2016), Knox et al. (2011), Cuijpers et al. (2015), Landback et al. (2009)

The results showed that in some papers more than one technology was used, as shown by Wahle et al. (2016) who used a wearable together with a mobile application to get patients' biofeedback. Another paper used a mobile application and a magnetic resonance exam to get brain waves information from patient (Meinlschmidt et al., 2016).

3.2. GQ2 – how technologies are being applied to mental health treatment?

The technologies that support depression treatment were analyzed and categorized by technology usage such as Gamification, Serious games, Virtual Reality and Analyze Speech. Table 4 maps the studied papers with their categorization.

Analyzing the GQ2 results was identified that the most common way to apply technology is using Serious Games, two papers (Cheek et al., 2015; Poppelaars et al., 2016) used the same system SPARX to aid depression treatment. Gamification was applied in different ways and in different parts of each application to improve adherence to the treatment program.

3.3. GQ3 – how gamification is being used to support mental health?

Analyzing the works that support mental health using gamification was possible to understand how gamification is being used. Table 5 shows the six papers identified from Table 4.

Table 5 shows that different features were used but all the works used gamification aiming on improving the adherence and engagement on the treatment.

3.4. FQ1 – how smartphone is being used to aid depression treatment?

Based on the categorization done in General Questions, the focused questions can be answered. The FQ1 presents how the smartphones resources can be used to identify depression and the corresponding results are presented below.

In Meinlschmidt et al. (2016), smartphones were used for patients do health interventions like, for example, watching a video teaching a technique and then apply that technique via the mobile application. In Paim and Barbosa (2016), the smartphone was used to alert about resources for the treatment that are in the current context of the patient, using gamification to encourage the patient to make use of these resources. Watanabe et al. (2015) and Ahtinen et al. (2013) used the smartphone to aid the patient through a cognitive-behavioral therapy (CBT) mobile application based on a manualized treatment, allowing the usage of this technique on patient's disorder treatment. Finally, Wahle et al. (2016) used the accelerometer and GPS of the smartphone to monitor patients' behaviors, and execute a CBT mobile application.

Table 4

How technologies are being applied to mental health treatment.

How technology are being applied	Papers
Gamification	Paim and Barbosa (2016), Watanabe et al. (2015), Ahtinen et al. (2013), Wahle et al. (2016), Bolier et al. (2013), Brown et al. (2016)
Serious Games	Hookham et al. (2016), Rusch (2012), Salter (2016), Oliveira et al. (2014), Cheek et al. (2015), Knox et al. (2011), Li et al. (2014), Shepherd et al. (2015), Shook et al. (2007), Destoop et al. (2012), Shao et al. (2015), Clark et al. (2013), Poppelaars et al. (2016), jun Zhang et al. (2012)
Virtual Reality	(Shin et al. (2015))
Analyze Speech	(Mok et al. (2014))

Table 5
Gamification usage in the papers.

Papers	Gamification usage
Paim and Barbosa (2016)	The paper uses gamification to encourage the user to consume a health resource. Rate and rewarding the user
Watanabe et al. (2015)	In this paper gamification was used to explain the principles and skills of CBT using a interface based on dialogs
Ahtinen et al. (2013)	The paper uses gamification to promote motivation and adherence, a mood graph and progress details were used
Wahle et al. (2016)	In this paper gamification was used to increase adherence and engagement, use levels in the treatment and score were used
Bolier et al. (2013)	The paper uses gamification to raise client satisfaction and encourage participants to stick to the intervention
Brown et al. (2016)	In this paper the concepts of rewards, badges, challenges, visualization of progress and automated goal setting activities were used

Table 6
Using gamification to motivate people with depression

Papers	Gamification usage
Paim and Barbosa (2016)	In this paper features of score and ranking were used, adding points to user according to the use of a health resource
Watanabe et al. (2015)	The paper uses feature of narratives between characters to explain the principles and skills of CBT
Ahtinen et al. (2013)	In this paper features of score and progress were used, adding points to user according to tasks are being completed
Wahle et al. (2016)	The paper uses features of progress and rating, e.g. when an activity is finished by user, he sees the percentage of his progress
Bolier et al. (2013)	In this paper features of tips and messages such as “an apple a day keeps the doctor away” are presented to the user, encouraging him to complete his daily mental fitness training
Brown et al. (2016)	The paper uses features such as story, progress, feedback, goal setting, rewards, challenge, trophies, and points, were used in the treatment activities aiming to improve patients’ adherence to treatment

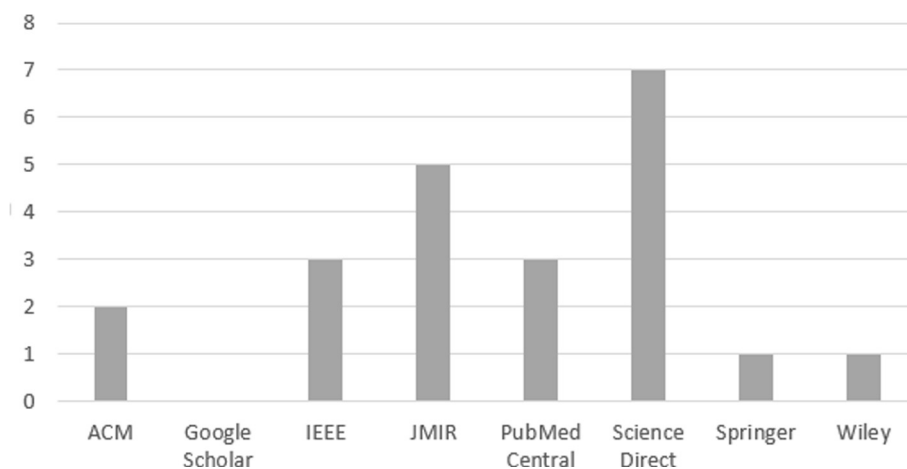


Fig. 2. Databases where researches have been published.

3.5. FQ2 – how gamification can support motivation of people with depression?

The researches that explore treatment for depressive patients using any feature of gamification were detailed in Table 6. In all papers, the primary aim of researchers in using gamification was to improve engagement in the depression treatment.

3.6. SQ1 – where have the researches been published?

The papers were categorized in the eight databases used in this systematic mapping study. Fig. 2 presents the count of categorized results and shows that the most accurate database performing the query string was PubMed Central and the less accurate database was Springer Library. The analysis of databases accuracy was based on the percentage of eliminated papers from initial results found by the search string and by the final results after applying the IC and EC.

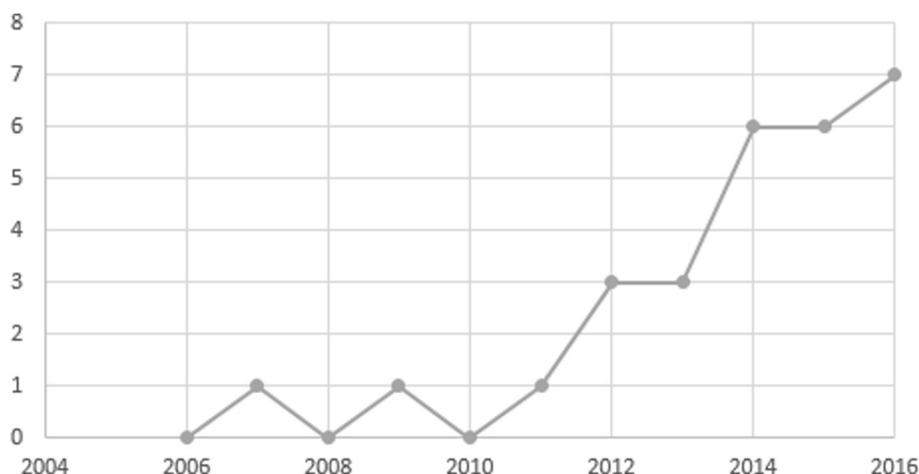


Fig. 3. Frequency of publications.

3.7. SQ2 – what is the number of publications by year?

The distribution of publications was grouped according to the years of paper publication. Fig. 3 presents the distribution of papers. Since the past decade, the number of publication about depression and gamification are increasing. This growth showing the interest of researchers in improving the treatment of patients suffering from depression by applying gamification and serious games.

4. Threats to validity

Like any other systematic mapping study, this work has some risks that could be affected the results found. Risks can occur as a result of decisions made during the systematic mapping.

In order to guarantee better research results, eight databases were selected, which are known in the academic world because of their relevance in the areas of computer science and mental health, thus mitigating the risk of the databases affects on the obtained results.

Two major terms and their synonyms were chosen to build the search string. For the term “Gamification”, synonyms used in the papers of the area were selected to have a better assertiveness in the search. For the term “Depression”, synonyms were selected from the Collins online dictionary in order to increase the assertiveness of the search. Thus, the search string was constructed considering the main terms and their synonyms, with the greatest possible coverage of keywords in the research. Therefore, the search string build process avoids that the terms used generating an ineffective search.

The filtering process may have restricted the papers in such a way that relevant works may have been removed. To mitigate this risk the filtering process was based on Petersen technique (Petersen et al., 2008).

Throughout the filtering process, the papers were analyzed and selected without a reviewer, and this may have affected the results. To mitigate this risk, we used revision processes already used by other authors (Gonçales et al., 2015), as well as software that would support this selection process, such as the Mendeley tool.

The systematic mapping study did not consider security aspects in gamification and serious games. This topic is strategic, especially when considering the sensitivity of information that is transmitted and stored in systems that focus on the health conditions of users. Recent research has addressed security issues in Cloud Computing and Big Data Analytics (Bhadoria, 2015; Swarnkar and Bhadoria, 2017). The inclusion of security aspects in the research questions would increase the validity of this study.

5. Discussion

This paper focused on the usage of gamification to treat depression and can guide future works about the usage of technology to treat mental disorders.

Analyzing the 28 works was possible to see that technologies as computer, video-games and smartphones are being used to aid treatment of mental disorders. Some works used smartphones because of the power and variety of sensors and in one work wearables were used to record bio-data from the user.

This mapping study presented many ways that technology was used to support treatment of mental disorders like, for example, CBT applications (Watanabe et al., 2015), serious games (Hookham et al., 2016) and gamified applications (Paim and Barbosa, 2016). Papers in which the subject was depression used gamification to improve adherence and engagement of people (Ahtinen et al., 2013; Wahle et al., 2016; Bolier et al., 2013; Brown et al., 2016). Many gamification features were used to give patients a better experience in their treatment (Bolier et al., 2013), for example, scores, goals and progress level (Brown et al., 2016). Many works showed that users tend to like gamification features and serious games, but the works did not prove the gamification effectiveness.

Although the studies did not present definitive results on how efficient the gamification and the serious games are in the treatment of depression, some findings were discussed. Wahle et al. (2016) affirmed that their gamified application has kept a user retention level greater than other Android applications. In addition, they asserted that the usage of the application increased over time. Besides that, Poppelaars et al. (2016) and Landback et al. (2009) showed a reduction of medium effect size in depression levels in patients diagnosed with mid-level depression.

The efficiency of gamification and serious games can be influenced by specific circumstances. Li et al. (2014) showed that gamification and serious games have a greater effect in young and adult people than in the elderly. Another identified circumstance was that self-help interventions performed better than interventions involving therapists. Finally, they showed that serious games involving virtual reality had a greater effect than serious games without this feature. The decrease in depression levels when using virtual reality was also observed by Shin et al. (2015).

Considering a general perspective, strategies and techniques used in gamification and serious games applied to the depression care do not differ from those applied in other health care (Brown et al., 2016) or even in other non-health related applications. The specificities in depression care are related to the definition of what aid activities should be gamified or should be considered in the serious game. However, the same consideration should be made, for example, when performing gamification to aid in the treatment of chronic diseases (Paim and Barbosa, 2016). On the other hand, although no specific study on this topic has been found, some lessons learned in depression care appear to be generic enough to be considered in other health treatments, or even in any kind of gamification or serious game. For example, Shepherd et al. (2015) concluded that the development of a game should consider the ethnicity of users and the customs of the population that will use the game in order to create an inclusive application. Landback et al. (2009) concluded that the improvement of the design and accessibility of their prototype resulted in increased user engagement and in a higher rate of completion of activities, going from a rate of 30% to 90%.

Analyzing the filter process presented in Fig. 1 and the SQ1 presented in Fig. 2, the most accurate database performing the query string was PubMed Central and the less accurate database was Springer Library. Another statistical data was that, since the past decade, the subjects of depression and gamification are increasing in publication number, showing the interest of researchers in improving the treatment of patients suffering from depression by applying gamification and serious games.

6. Conclusion

This systematic mapping study presented the state of art in the usage of gamification on depression treatment. The paper also presented the different ways that technology is used to aid the treatment of mental disorders and the importance of engagement in the treatment.

The primary aim of researchers in using gamification was to improve engagement. However, none of the reviewed papers clearly documented that gamification could effectively improve such aim.

Another interesting fact was the use of smartphones in treatment is due to their variety of sensors, and their discreet use (Ahtinen et al., 2013; Wahle et al., 2016).

The review of the published works in the last decade may provide initial insights to interventions based on gamification and serious games in the depression treatment and either identified the lacks in this area of study.

Two main gaps were found during the works evaluation on this research, one about evaluation of effectiveness and other about hazard analyses, as none of the works tried to analyze side effects of using gamification and serious games in depression treatment.

Acknowledgments

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Appendix A

Table A.7.

Table A.7
Categorized Results

Title	Year	Authors	In	Technology	Mobile	Age	Focus	Aims
Using Startle Probe to Compare Affect and Engagement between a Serious Game and an Online Intervention Program (Hookham et al., 2016)	2016	Hookham et al.	Australasian Computer Science Week	Serious Game	No	18–30	Depression	Understand relationship between affective processing and engagement and explore the use of the Startle Probe for assessing engagement in Serious Games
Elude Designing Depression (Rusch, 2012)	2012	Doris C. Rusch	Proceedings of the International Conference on the Foundations of Digital Games	Serious Game	No	n/a	Depression	Help caregivers to understand how depression works
Technology-Enhanced Program for Child Disruptive Behavior Disorders: Development and Pilot Randomized Control Trial (Jones et al., 2014)	2014	Jones, Deborah J. et al.	J Clin Child Adolesc Psychol	Helping the Noncompliant Child (HNC) Mobile Program	Yes	3–8	Disruptive behaviors	Increase engagement of low-income families and, in turn, child behavior outcomes, with potential cost-savings associated with greater treatment efficiency
Preliminary Evaluation of PTSD Coach, a Smartphone App for Post-Traumatic Stress Symptoms (Kuhn et al., 2014)	2014	Kuhn, Eric et al.	Military Medicine	Mobile Application	Yes	Mean 45.25 (SD 14.03)	Post-Traumatic Stress Symptoms	Help individuals who have post-traumatic stress disorder (PTSD) symptoms better understand and self-manage their symptoms
Smartphone-Based Psychotherapeutic Micro-Interventions to Improve Mood in a Real-World Setting (Meinlschmidt et al., 2016)	2016	Meinlschmidt, Gunther et al.	Frontiers in Psychology	Mobile Application	Yes	1865	Mood disorders	Estimate changes in mood and hypothesized that mood would improve from pre- to post-micro-intervention
Octopus: A Gamification Model to Aid in Ubiquitous Care of Chronic Diseases (Pain and Barbosa, 2016)	2016	C. A. Pain and J. L. V. Barbosa	IEEE LATIN AMERICA TRANSACTIONS	Serious Game	Yes	n/a	Chronic Disease	A model was constructed exploring gamification to stimulate the use of context sensitive resources to assist in the ubiquitous care of chronic diseases
The SmartCAT: An m-Health Platform for Ecological Momentary Intervention in Child Anxiety Treatment (Pramana et al., 2014)	2014	Pramana et al.	TELEMEDICINE and e-HEALTH	Mobile Application	Yes	914	Anxiety	Design and develop an mhealth platform and to evaluate its feasibility and utility with youth receiving CBT for their anxiety disorder
Adding smartphone-based cognitive-behavior therapy to pharmacotherapy for major depression (FLATT project): study protocol for a randomized controlled trial (Watanabe et al., 2015)	2015	Watanabe et al.	BioMed Central	Mobile Application	Yes	2559	Depression	Examine the effectiveness of switching antidepressants and starting a smartphone-based CBT program at the same time, in comparison to switching antidepressants only
Proposal of a depression detector (Mok et al., 2014)	2014	Mok et al.	APSIPA	Mobile Application	Yes	1319	Depression	Investigate the relationship between depression and voice characteristics namely pitch, loudness and number of pauses, so as to determine markers for depression
Playing at empathy: Representing and experiencing emotional growth through Twine games (Salter, 2016)	2016	Anastasia Salter	SeGAH	Platform for Serious Games	No	n/a	Emotional Health	Analysis of a textual games platform for build mental health care games
Rumination Room: A serious game to deal with disturbing thoughts (Oliveira et al., 2014)	2014	Eva Oliveira et al.	SeGAH	Serious Games	No	47	Ruminative Thoughts	Develop a serious game, based on attention training, which has been one of the strategies used to deal with rumination thoughts
Mobile Mental Wellness Training for Stress Management: Feasibility and Design	2013	Ahtinen et al.	JMIR MHEALTH AND UHEALTH	Training Application	Yes	n/a	Stress	A mobile app based on acceptance and commitment therapy (ACT), was designed to support active learning of

(continued on next page)

Table A.7 (continued)

Title	Year	Authors	In	Technology	Mobile	Age	Focus	Aims
Implications Based on a One-Month Field Study (Ahtinen et al., 2013)	2016	Wahle et al.	JMIR MHEALTH AND UHEALTH	Mobile Application	Yes	20–57	Depression	skills related to mental wellness through brief ACT-based exercises in the daily life
Mobile Sensing and Support for People With Depression: A Pilot Trial in the Wild (Wahle et al., 2016)								Uses the smartphone app Mobile Sensing and Support (MOSS) to collecting context-sensitive sensor information and providing just-in-time interventions derived from cognitive behavior therapy
An Internet-Based Intervention to Promote Mental Fitness for Mildly Depressed Adults: Randomized Controlled Trial (Bolier et al., 2013)	2013	Bolier et al.	JOURNAL OF MEDICAL INTERNET RESEARCH	Online self-help intervention	No	21 +	Depression and Anxiety	Examine the effectiveness of Psyfit, an online positive psychological intervention without support from a therapist, to reduce depressive and anxiety symptoms in comparison with a waiting-list control group
Integrating Health Behavior Theory and Design Elements in Serious Games (Cheek et al., 2015)	2015	Cheek et al.	JMIR MENTAL HEALTH	Serious Game	No	13–27	Depression	Analyze studies using SPARX to propose a framework to design Serious Games
Gamefication and Adherence to Web-Based Mental Health Interventions: A Systematic Review (Brown et al., 2016)	2016	Brown et al.	JMIR MENTAL HEALTH	Literature Review	No	n/a	Depression	Review the literature to examine whether gaming features predict or influence reported rates of program adherence in Web-based interventions designed to manage common mental disorders and well-being
Game-based biofeedback for paediatric anxiety and depression (Knox et al., 2011)	2011	Knox et al.	Mental Health in Family Medicine	Serious Game	No	9–17	Depression	Test the effects of bio-feedback-assisted relaxation training with a video game format for anxious children and youths
Game-Based Digital Interventions for Depression Therapy: A Systematic Review and Meta-Analysis (Li et al., 2014)	2014	Li et al.	Cyberpsychology, Behavior, and Social Networking	Literature Review	No	n/a	Depression	Conducted a systematic review of trial studies that emphasized game-based digital interventions and depression improvements in a categorized fashion, thus identifying the current research trends and contributing to knowledge in the field of game-based intervention
The Design and Relevance of a Computerized Gamified Depression Therapy Program for Indigenous Mori Adolescents (Shepherd et al., 2015)	2015	Shepherd et al.	JMIR SERIOUS GAMES	Serious Game	No	16–18	Depression	Find out Mori opinions of a prototype computerized cognitive behavioral therapy (cCBT) program called SPARX, a free online computer game intended to help young persons with mild to moderate depression
Negativity bias in attitude learning: A possible indicator of vulnerability to emotional disorders? (Shook et al., 2007)	2007	Shook et al.	Journal of Behavior Therapy and Experimental Psychiatry	Serious Game	No	n/a	Depression	The current study examined the possibility that the extent to which individuals display a learning bias in attitude formation is related to negative cognitive style and emotional disorder symptoms, through playing a computer game that required learning whether novel stimuli produced positive or negative outcomes
Internet-based treatment of depression (Gijpers et al., 2015)	2015	Gijpers et al.	Current Opinion in Psychology	Literature Review	No	n/a	Depression	

(continued on next page)

Table A.7 (continued)

Title	Year	Authors	In	Technology	Mobile	Age	Focus	Aims
Better to give than to take? Interactive social decision-making in severe major depressive disorder (Destoop et al., 2012)	2012	Destoop et al.	Journal of Affective Disorders	Serious Game	No	Mean 39	Depression	The study examined how the Internet-based treatment are applied and their outcomes, to help in further studies
The neural basis of social risky decision making in females with major depressive disorder (Shao et al., 2015)	2015	Shao et al.	Neuropsychologia	Serious Game	No	25–55	Depression	The study use Ultimatum game to investigate social decision-making in patients with Major depressive disorder The study aimed to investigate the neural basis of Major depressive disorder patients' reduced tendency of making low-risk cheating choices in the modified multi-round trust game
Cooperation and depressive symptoms (Clark et al., 2013)	2013	Clark et al.	Journal of Affective Disorders	Serious Game	No	Mean 32	Anxiety and depression	The current study looks to extend the paradigm of economic games (prisoner's dilemma, the public goods game, the ultimatum game, and the trust game) to the study of depressive symptoms
Effects of game-based virtual reality on health-related quality of life in chronic stroke patients: A randomized, controlled study (Shin et al., 2015)	2015	Shin et al.	Computers in Biology and Medicine	Virtual Reality	No	18+	Depression	The study was to determine whether health-related quality of life (HRQOL), depression, and upper extremity function could be improved using game-based VR rehabilitation plus conventional occupational therapy (OT), compared to the same amount of conventional OT alone
A randomized controlled trial comparing two cognitive-behavioral programs for adolescent girls with subclinical depression: A school-based program (Op Volle Kracht) and a computerized program (SPARX) (Poppelaars et al., 2016)	2016	Poppelaars et al.	Behaviour Research and Therapy	Serious Game	No	11–16	Depression	The study investigated the prevention effects of two CBT programs, Op Volle Kracht (OVK) a school-based program designed to prevent depression, and and SPARX a computerized program shown to be effective in treating mild to moderate depression
From Prototype to Product: Development of a Primary Care/Internet Based Depression Prevention Intervention for Adolescents (CATCH-IT) (Landback et al., 2009)	2009	Landback et al.	Community Ment Health J	Training Application	No	1421	Depression	Developed and evaluated a prototype internet intervention to adolescents with depression
Impaired social decision making in patients with major depressive disorder (Jun Zhang et al., 2012)	2012	Zhang et al.	Brain and Behavior	Serious Game	No	21–60	Depression	Examine the relationship between depression and social decision making, testing the behavior of depressed participants by a trust-reciprocity game

(e.g., noncompliance, defiance, aggression)

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