

Development and usability of a gamified app to help children manage stress: an evaluation study

Sviluppo e usabilità di una app gamificata per aiutare i bambini a gestire lo stress: uno studio di valutazione

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ABSTRACT Children generally have difficulty managing stress. As a result, stress may escalate to anxiety. Stress prevention interventions that are easily accessible on mobile devices could be one way for children to learn how to manage stress before it reaches the levels of anxiety. There are less than a handful of stress management apps targeting children presently available and these do not combine gamification techniques with behavior change theory. This study describes the design and development of a gamified interactive storytelling mobile app to teach young children how to manage stress through relaxation exercises. It evaluates the app's usability using learning analytics data and the SUS usability scale. The gamified app called Kids' Stress Relief received a satisfactory usability score (73.55) and was well accepted by a sample of 71 children (5-12 years old). It may have the potential to support children in learning how to perform stress relief techniques as a stand-alone application. Instructional and design implications, of interest to developers of psychology-based apps, are drawn.

KEYWORDS Stress Management; Prevention Intervention; Children; Interactive Storytelling; Gamified Mobile Application (App).

SOMMARIO I bambini hanno generalmente difficoltà a gestire lo stress. Di conseguenza, lo stress può aggravarsi fino a determinare una risposta di ansia. Interventi di prevenzione dello stress facilmente accessibili sui dispositivi mobili, potrebbero essere un buon modo per i bambini di imparare a gestire lo stress, prima che raggiunga i livelli di ansia. Attualmente è disponibile un numero esiguo di applicazioni

per la gestione dello stress rivolte ai bambini e nessuna di queste combina tecniche di gamification con la teoria del cambiamento dei comportamenti. Questo studio descrive la progettazione e lo sviluppo di un'app gamificata per dispositivi mobili, basata su storytelling interattivo, atta ad insegnare ai bambini piccoli come gestire lo stress attraverso esercizi di rilassamento. L'usabilità dell'app è stata valutata utilizzando learning analytics e la scala di usabilità SUS. La app gamificata denominata "Kids' Stress Relief" ha ottenuto un punteggio di usabilità soddisfacente (73.55) ed è stata ben accolta da un campione di 71 bambini (5-12 anni). Si ritiene che avrebbe il potenziale di supportare i bambini nell'imparare a eseguire tecniche di riduzione dello stress come applicazione stand-alone. In questo contributo vengono descritte inoltre le possibili implicazioni didattiche e di progettazione, di interesse per gli sviluppatori di app basate su costrutti psicologici.

PAROLE CHIAVE Gestione dello Stress; Interventi di Prevenzione; Bambini; Storytelling Interattivo; Applicazione Mobile Gamificata (App).

1. INTRODUCTION

Internalizing disorders, such as depression and anxiety, are common in pediatric populations (Stiles-Shields, Ho, & Mohr, 2016). During the past decade, the results of international epidemiologic surveys have revealed that anxiety disorders are one of the most prevalent classes of mental disorders in the general population of children and adolescents (Merikangas, Nakamura, & Kessler, 2009). Childhood and adolescence are the core risk groups for the development of anxiety symptoms and syndromes, ranging from transient mild symptoms to full-blown anxiety disorders, and the median onset age for anxiety disorders is six years old (Beesdo, Knappe, & Pine, 2009). Schoneveld et al. (2016) characterized childhood anxiety as a global mental health concern. Given anxiety's early onset and association with significant impairment, and given the association between a high degree of perceived stress and anxiety (Racic et al., 2017), there is a clear rationale to intervene early with children (Morgan, Rapee, & Bayer, 2016; Morgan et al., 2017), and particularly with those at risk, to teach them how to manage stress before it reaches the levels of anxiety.

Behavioral intervention technologies, also referred to as digital health interventions, include a subset of mHealth and eHealth interventions. They employ a broad range of technologies, such as mobile phones, the Web, and sensors to support users in changing behaviors and cognitions related to health, mental health, and wellness (Mohr, Schueller, Montague, Burns, & Rashidi, 2014). Historically, the empirical literature pertaining to the use of computer-supported cognitive-behavioral treatment of anxiety disorders dates back to the early 2000s. Prevailing technologies at that time included palmtop computers, virtual reality exposure therapy, and personal computer software programs (Anderson, Jacobs, & Rothbaum, 2004). Behavioral intervention technologies are currently considered to have enormous potential to improve the uptake and accessibility, efficiency, clinical effectiveness and personalization of mental health interventions (Hollis et al., 2017). As a delivery mechanism, they have the capability of overcoming access and health disparity barriers and of overcoming emotional, practical, or symptom-based barriers to treatment (Mohr et al., 2014). Interest in the use of mobile technology to deliver mental health services has grown considerably in light of the economic and practical barriers to treatment. Yet research on alternative delivery strategies that are more affordable, accessible, and engaging is still in its infancy (Dennis & O'Tool, 2014).

Mobile and smartphone health apps are common examples of behavioral intervention technologies (Stiles-Shields, Ho, & Mohr, 2016). Recent research has documented the effectiveness of smartphone apps for treating anxiety and stress through randomized trials, in which the use of apps resulted in a significant decrease in anxiety and stress both in adults (Proudfoot et al., 2013; Pramana, Parmanto, Kendall, & Silk,

2014; Ly, Asplund, & Anderson, 2014) and in children (Pramana et al., 2014). It is also generally assumed that behavioral intervention technologies will be preferred by children and young people given their ubiquitous digital activity (Hollis et al., 2017), thus increasing the possibility of uptake and acceptance of such interventions by young children.

Hundreds of apps have been developed in recent years addressing stress management, but the vast majority of these target adults (Hoffmann, Christmann, & Bleser, 2017) rather than children. Moreover, the quality of these apps is often questionable. For example, a recent study that assessed the quality of 52 smartphone apps developed for a specific anxiety disorder found that the content proposed was rarely evidence-based and apps received low user ratings in the form of self-help scores, defined as the potential of smartphone apps to help users in their daily life (Van Singer, Chatton, & Khazaal, 2015).

Gamification, the “use of game design elements in non-game contexts” (Deterding, Dixon, Khaled, & Nacke, 2011, p.9) has been suggested as one way to support learning, with learning in this case referring specifically to health behavior change. Gamification in stress management apps, in particular, appears to be a novel concept, as designers of stress management apps fail to use gamification techniques to influence the user’s behaviors and reactions (Hoffmann et al., 2017). “Interactive storytelling” assumes by definition the existence of interaction mechanisms that support user intervention in reaction to observed narrative progression, with the ultimate objective of altering the user’s own course of action (Cavazza & Charles, 2017), therefore it is considered as another way to support behavior change. In this study, these two concepts, gamification and interactive storytelling, have been combined with the goal to develop an interactive storytelling gamified app for stress management targeting young children.

The aim of this study was to design, develop and test the app that teaches young children how to identify body signs of stress and perform stress relief exercises. In particular, the objectives were to: (1) evaluate the usability of the app (RQ1); (2) examine the extent to which children perceived that a stress relief technique taught within the app produced intended results (RQ2); and (3) examine the extent to which children perceived that they can perform a stress relief technique with no other prior (teacher or parental) intervention, through the sole use of the app (RQ3).

2. STATE OF THE ART

Overall, recent research findings suggest that gamified interventions can be effective for reducing disorder-related symptoms and for reducing anxiety. For example, preliminary evidence shows that gamification on mobile applications can improve anxiety management and reduce subjective anxiety and observed stress reactivity, at least in highly trait-anxious participants (Pham, Khatib, Stansfeld, Fox, & Green, 2016; Dennis & Toole, 2014; Dillon, Kelly, Robertson, & Robertson, 2016).

In recent reviews of the literature on mobile apps targeting stress and anxiety (Tozzi, Nicolaidou, Galani, & Antoniadou, 2018; Stiles-Shields, Ho & Mohr, 2016), specific gaps are identified. The great majority of existing mobile applications on anxiety a) are developed for treatment purposes, rather than prevention (defined as an intervention targeting symptoms *prior* to the occurrence of a disorder), b) focus mostly on adults or adolescents rather than on young children, and c) do not integrate gamification elements. In a recent review that evaluated the use of therapy-informed cognitive behavioral intervention technologies for the prevention and/or treatment of depression and anxiety among youth, Stiles-Shields et al. (2016) found that prevention interventions receive less attention compared to treatment interventions. Additionally, according to the same review, the child population of 5-12 year-olds receives less attention; the studies considered included children and adolescents ranging in ages from 8 to 21 years, with the majority focusing on the age range of 12-17 years (Stiles-Shields et al., 2016). Thus a gap emerged in studies addressing the needs of children younger than

8 years old for prevention purposes, i.e. before instances of stress or subclinical anxiety escalate to clinical anxiety, with the latter needing the support of a professional psychologist or psychiatrist.

Focusing on gamification in particular, in a recent review, Hoffmann et al. (2017) investigated the use of gamification techniques in apps aimed specifically at stress management and found that there are less than a handful of stress management apps targeting children (Hoffmann et al., 2017). In her review of a total of 62 stress management apps from the Google Play Store targeting adults, she concluded that designers of stress management apps rarely use gamification techniques to influence user behaviors and reactions. Moreover, app designers aiming to develop users' stress management skills do not exploit the potential of combining gamification techniques with behavior change theory (Hoffmann et al., 2017).

To address these gaps, the authors have designed and implemented a gamified, interactive-storytelling mobile app targeting children as young as five years old. The aim was to produce a prevention intervention for stress management that supports 5-12 year old children in identifying body signs of stress and subsequently in managing stress through relaxation techniques. The app is based on the integration of several widely used evidence-based approaches, such as mindfulness (Marusak et al., 2018; Malboeuf-Hurtubise, Lacourse, Herba, Taylor, & Amor, 2017), behavioral change techniques (Hoffmann et al., 2017) and positive psychology principles (Manicavasagar et al., 2014).

Having children as the end-users of apps that attempt to teach them relaxation techniques through mindfulness and positive psychology poses some significant challenges. One is the extent to which children can understand the techniques that are presented via the app, and another is the extent to which they can apply those techniques not only while interacting with the app but, most importantly, through practice in real life. As Schoneveld et al. (2016) pointed out, there is a need for anxiety prevention interventions for children that are effective, relatively inexpensive, accessible, and that engage children sufficiently to build emotional resilience skills through practice.

A small scale preliminary evaluation study of the app's use by 11 children between the ages 5 and 11 years old yielded promising results in terms of usability and acceptability for practicing relaxation techniques, especially for children over seven (Nicolaidou, Tozzi, Kindynis, Panagiotou, & Antoniadou, 2017). Specifically, it seemed easier for children over seven to engage in, correctly practice and verbally describe a breathing exercise. Results showed that children under seven watched the breathing exercise passively but did not follow the instructions. Nevertheless, they received rewards for 'following', without this meaning that they had in fact engaged in the stress releasing strategies that the app designers had intent them to perform. Therefore, there is a need to examine the extent to which 5-12 year-old children can perform a stress relief technique with no other prior (teacher or parental) intervention, through the sole use of an app. For this purpose, learning analytics were integrated in the app design. Learning analytics is an emerging field that focuses on analyzing learners' interactions with educational content; it is considered particularly challenging to incorporate effectively in serious games and gamified environments, which generate a diverse range of data (Serrano-Laguna et al., 2017). Despite these challenges, it is commonly agreed that the highly interactive nature of games makes them an ideal application of learning analytics; capturing learners' interaction data can lead to better understanding of and improvements in the learning process (Alonso-Fernandez, Calvo, Freire, Martinez-Ortiz, & Fernandez-Manjon, 2017).

3. DESIGN AND DEVELOPMENT OF A GAMIFIED MOBILE APP TO HELP CHILDREN MANAGE STRESS

The design goal of the gamified mobile app, called *Kids Stress Relief*, is to offer a prevention-based approach

through interactive storytelling, which introduces key concepts to children that can help them self-manage stress intuitively from a very early age. *Kids Stress Relief* is a developmentally appropriate app for ages six to nine, but can also be used by children as young as five years old and as old as twelve. The app uses mindfulness techniques, behavioral change techniques and positive psychology principles. Its prototype currently includes five short stories (Figure 1) that help children identify emotions of happiness, sadness and anger, manage their anger, show empathy, identify body signs of stress (Figure 2) and overcome stress related to their every-day life, such as stress related to taking school tests, hearing thunderstorms and meeting new friends. A stressometer (Figure 2) indicates levels of stress and supports children in understanding when stress is increased or decreased depending on stressors encountered.



Figure 1. Screenshot of the prototype Kids Stress Relief app, showing five stories and two relaxation tutorials for breathing and visualization exercises.

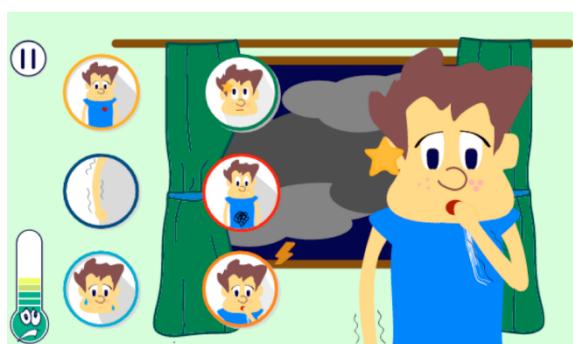


Figure 2. Screenshot of the prototype Kids' Stress Relief app, showing body signs of stress on the character Alex and related stressometer reading.

Kids Stress Relief was designed by a multidisciplinary team following a structured user-centered approach. An iterative design approach was implemented, with testing being performed at every step. Feedback from both parents and children was solicited so as to refine app design and features in an effort to ensure that the app is acceptable to children, is user-friendly, motivational, and produces the intended results. The preventative psychoeducation of the app covers topics related to: symptom recognition, emotion rec-

ognition, stress reduction and relaxation techniques, interpersonal relationship management skills and improving social interactions. The design of the app includes reward systems, modeling as a change strategy, and reinforcement through gamification. These have been identified as desirable design characteristics of cognitive behavioral therapy-informed intervention technologies for youth with depression and anxiety (Stiles-Shields et al., 2016).

Specifically, *Kids' Stress Relief* makes use of five gamification techniques, as defined and identified by Hoffmann et al. (2017) in her review of apps for stress management. The app implements: a) digital rewards, in the form of a super-power, which increases as the player progresses; b) an agent, in the form of a virtual character (in our case, a boy named Alex) who provides instructions and support; c) visual and auditory feedback regarding evaluation of the user's performance in relation to either a set standard (correct and incorrect answers) or in relation to completing a relaxation exercise tutorial; d) levels, in the sense that the player progressively unlocks content of gradually increasing difficulty or engagement (e.g. unlocks a relaxation exercise only after playing the related tutorial); and e) secondary game objectives, in the form of optional secondary goals of play. This last category includes rewards for activity completion (e.g. the player can choose an object from a proposed set of virtual items to add to her imaginary place in the visualization exercise) or may simply appear for engagement purposes.

An example story called "*School Test*" describes how a young boy, Alex, who was worried about facing a school test, learned how to identify body signs of stress and how to overcome his worry by performing a breathing exercise. In this case, individual users are presented with interactive breathing and visualization tutorial/exercise pairings to help them acquire easy-to-perform mindfulness and positive psychology techniques for managing stress. They can then practice performing these exercises through the app, with the guidance of Alex. These mindfulness techniques show the young users how to focus their attention on experiences occurring in the present moment, e.g. how to focus on their breathing and observe the movement of air in their belly and lungs while inhaling and exhaling. They are also encouraged to use these techniques in daily life the next time they may feel worried or stressed, thus encouraging behavioural change.

The app has a simple interface featuring audio recordings (to address the needs of pre-schoolers who cannot read) and immediate feedback. Reinforcement is provided through a superpower users receive, which increases according to the number of times they perform relaxation exercises (Figure 3). These relaxation exercises unlock only after the child has displayed the related tutorial at least once.

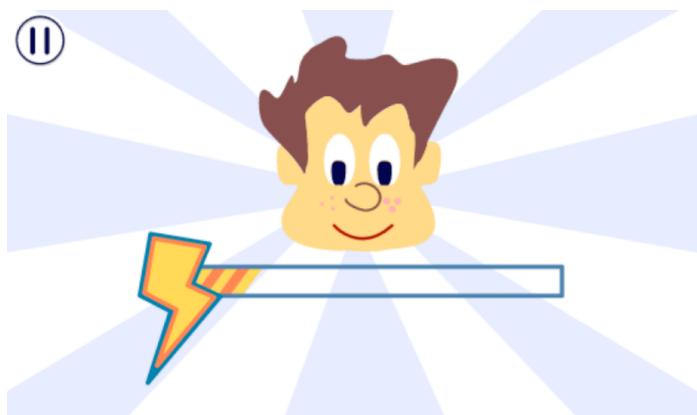


Figure 3. The app's motivational reward, the superpower, whose level increases each time a user performs a relaxation exercise.

Data-driven approaches represent a possible way to respond to the general lack of understanding of how

learners interact with serious games (Freire et al., 2016; McCoy, Lewis, & Dalton, 2016). The potential of such approaches is an important component integrated into the design of *Kids' Stress Relief* and has been implemented through the automatic collection of data concerning users' decision-based navigation within the app. This occurs in all instances during interaction in which the user is asked to make a choice. For example, when users are presented with any story that describes how Alex overcame a stressful situation (taking a school test, meeting new people, hearing thunderstorms, etc.), they are asked whether they themselves feel stress when they are faced with the same situation in their lives. Their "yes" or "no" answer is automatically recorded by the app. At the end of each story, Alex asks users whether or not they want to learn how to perform a relaxation exercise. If they choose "yes", then the related relaxation exercise tutorial is activated. At the end of the tutorial, users can choose whether to practice performing the relaxation exercise together with Alex. Capturing and analyzing these decision-based data provides an indication as to whether children are willing to learn how to perform relaxation techniques through an interactive storytelling app. Analyzing the amount of time children spend on a tutorial or a relaxation technique exercise (time-on-task) provides an indication as to whether the latter was engaging.

4. METHODOLOGY

4.1. Research questions

- RQ1. How do 5-12 year-old children evaluate the usability of a stress relief gamified mobile app?
- RQ2. To what extent does a stress relief technique taught within the app produce intended results for 5-12 year-old children?
- RQ3. To what extent do 5-12 year-old children report that they can perform a stress relief technique with no other prior (teacher or parental) intervention, through the sole use of the app?

4.2. Research design and Participants

The study was quantitative in nature. Participants in the study were 85 children who interacted with the *Kids Stress Relief* gamified app during a science festival, which took place in 2017, in Cyprus. Out of these 85 children, some either did not complete the usability evaluation questionnaire or interacted with the game for less than two minutes and were therefore removed from the sample. This resulted in a sample of 74 children (41 boys and 33 girls) with a mean age of 8.44 years (SD=1.77, min=5, max=12 years old).

4.3. Materials

4.3.1. Usability of the gamified app

The usability of the gamified app was measured using a modified version of the System Usability Scale (SUS) (Brooke, 1996). SUS was chosen to be used as the base for our instrument because (a) it has been found to be a highly robust and versatile tool for usability professionals (Bangor, Kortum, & Miller, 2008), and (b) it allows comparison of similar systems. The modified scale included the following ten items, with responses graded by a 5-point Likert scale ranging from completely disagree to completely agree.

- 1) I think that I would like to use this app frequently.
- 2) I found the app unnecessarily complex.
- 3) I thought the app was easy to use.
- 4) I think that I would need help from my parents or siblings to be able to use this app.

- 5) I found the various functions in the app were well integrated.
- 6) I thought there was too much inconsistency in the app.
- 7) I would imagine that most children my age would learn to use this app very quickly.
- 8) I found the app very cumbersome to use.
- 9) I felt very confident using the app.
- 10) I needed to learn a lot of things before I could get going with this app.

The usability questionnaire was translated into Greek and was then pilot-tested with five children between five and ten years old. Necessary modifications were made in order to ensure that the younger children (five to seven year-olds) understood the questions when read to them by a researcher, and that older children (who were eight to ten years old) could complete the questionnaire on their own. More specifically, the changes that were made to the SUS instrument referred to deleting the word “unnecessarily” (statement 2) and replacing the word “cumbersome” with the word “complicated” (statement 8).

Additional system-specific statements using the same 5-point Likert scale were added to the SUS scale to paint a more complete picture of the children’s evaluation of the game’s usability.

These statements were the following:

- 1) I like the app.
- 2) I understood the stories in the app.
- 3) I would like to play this app at home.
- 4) I would recommend this app to my friends.
- 5) I learned how to perform a breathing exercise on my own.
- 6) The breathing exercise was difficult.

Demographic data, specifically gender and age of the child, were also collected at the end of the questionnaire. In addition to the above, the following data were collected through learning analytics techniques.

- Children’s use of the breathing relaxation exercise.
The number of times each child played a breathing relaxation exercise was automatically captured by the app.
- Children’s evaluation of their feelings after completing a breathing relaxation exercise.
The feelings children reported after playing a breathing relaxation exercise (choosing from the range happy, relaxed, frustrated, or angry) were recorded. The intended results from completion of the relaxation exercise were feelings of happiness and relaxation.
- Children’s evaluation of the difficulty level of the breathing exercise.
The children’s reported evaluation of the difficulty level of the breathing exercise (easy, moderate, or difficult) was collected.
- Total time spent interacting with the app.
The total time each child spent interacting with the app, including the performance of relaxation exercises, was automatically captured.

4.4. Procedure

The app was offered for free to all children aged 5-12 who attended the Mediterranean Science Festival, a one-day event held in a European Union country (Cyprus), in 2017. A researcher first informed their parents/carers about the goal of the app and gave them a leaflet with a description and access information. They were also informed about the objective of the research study, and their permission was sought so that after the child had had the opportunity to interact with the app, a researcher could ask her/him some questions on the app’s usability. If the permission was granted, the child was then asked by the same researcher if she/he wanted to try the app and if she/he could reply to some evaluation questions afterwards. If the child

responded positively, both the parent and the child signed a consent form.

Children's interaction with the app took place individually on one of eight available tablets on which the app had been previously installed, using headphones. An app reset button provided a unique six-digit code number, which was used as the sole means for identifying individual sessions (all app use was anonymous). For the purposes of this study, a session is defined as a child's individual interaction with the app. The same identification number was associated to the related usability evaluation questionnaire responses, which were also provided in a totally anonymous manner. In this way, each child's app interaction session, and the learning analytics data that were captured from it, could be anonymously coupled with the related usability evaluation data.

During the Science Festival event, the children were allowed to interact with the app for as long as they wanted. Their average use was 7.5 minutes (SD=3min, n=71). Immediately afterwards, each child undertook the questionnaire, either in a verbal question-answer sequence (in the case of five to seven-year olds) or on paper (eight to twelve year-olds). Six researchers were on hand to act as facilitators who individually oversaw each of the interaction instances run at the festival, responding to any questions that parents or children raised during interaction with the app. These researchers had undergone previous training on how to interact suitably with parents and children, on how to solve any technical problems that might occur with the tablets, and on how to pose the usability evaluation questions verbally to young children without influencing their responses. Researchers did not interfere with the children's interaction with the app nor did they help children in any way with respect to performing relaxation exercises.

4.5. Data analysis

Data from 71 fully completed usability evaluation questionnaires, together with the learning analytics data from 84 interaction sessions with the app, were processed and analysed using a statistical package (SPSS).

4.5.1. Usability of the app

For RQ1 analysis (the SUS usability questionnaire results), the procedure for calculating usability evaluation scores proposed by the author of the instrument was followed (Brooke, 1996). Specifically, for odd-numbered items, one was subtracted from the user response. For even-numbered items, the user responses were subtracted from 5. This scaled all values from 0 to 4 (with four being the most positive response). The converted responses for each user were added up and the total was multiplied by 2.5. This converted the range of possible values from 0 to 100 instead of from 0 to 40. An average SUS score was calculated for all participants. The SUS score was then converted into a percentile rank and a letter grade from A to F, according to the norms proposed by Sauro (2011).

For analysis of the individual questions that had been added to the SUS instrument (such as: "I liked the app", "I understood the stories in the app", etc.) using the same 5-point Likert scale (Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly agree), descriptive statistics, specifically frequencies were used.

4.5.2. Breathing exercise evaluation

For RQ2, descriptive statistics were used to calculate the percentage and frequency of children who: a) used the breathing exercise, and b) reported that they felt happy or relaxed (the intended results) after the breathing exercise.

For RQ3, descriptive statistics were used to calculate the percentage and frequency of children who: a) reported that the exercise was easy and b) reported that they could perform the exercise on their own.

Furthermore, to examine whether the time that each child spent on the breathing exercise relates to the re-

ported level of difficulty, a Spearman’s rho correlation analysis was conducted between the two variables: time and reported level of difficulty.

Lastly, to examine whether the breathing exercise is more engaging for younger or older children, a Pearson’s correlation analysis was conducted between the two scale variables: age and time spent on the breathing exercise.

5. RESULTS

5.1. Research Question 1: How do 5-12 year-old children evaluate the usability of the proposed stress relief gamified mobile app?

To provide an answer to RQ1, the average scores of the SUS scale provided by 71 children were calculated. The app received a satisfactory usability score based on an average usage of 7.5 minutes (SD=3min, n=71) during the Science Festival event. The raw average SUS score was 73.55, which is in the 70% percentile rank, and would result in a grade of B.

Figure 4 shows how the percentile ranks (y axis) associate with SUS scores (x axis) and letter grades (Sauro, 2011). This process is similar to “grading on a curve” based on the distribution of all scores. For example, a raw SUS score of 74 converts to a percentile rank of 70%. A SUS score of 74 has higher perceived usability than 70% of all products tested (Sauro, 2011). It should be noted that as the questionnaire that was used was slightly different from the original one, therefore the possibility of using the normative distribution of the original questionnaire for universal comparisons is limited.

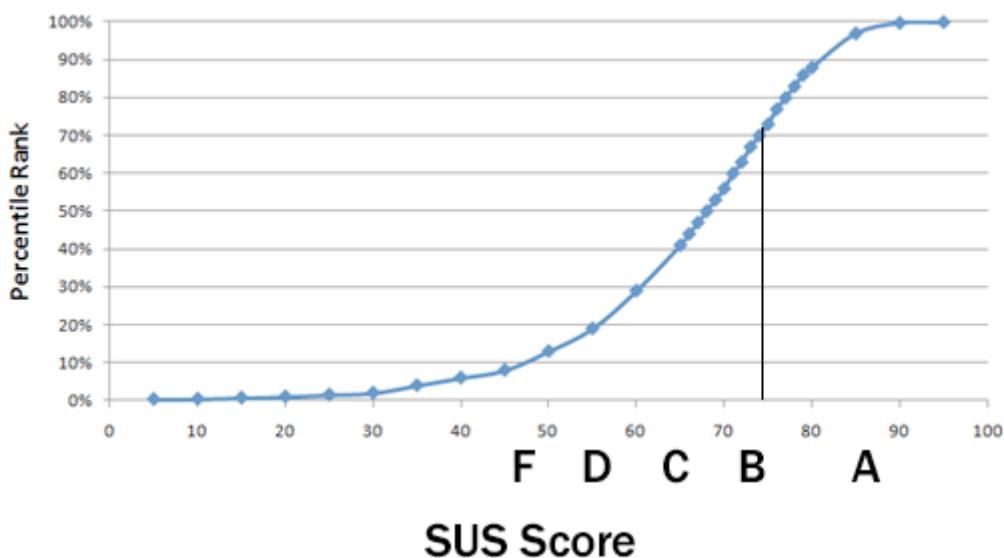


Figure 4. The raw average SUS score of the Kids Stress Relief app, based on a sample of 71 participants.

Moreover, to go into more detail on the children’s evaluation of the usability of the app, the analysis of individual questionnaire statements showed that the majority of the children liked the app (82.8%, 58/70) and

the vast majority of children (92.9%, 66/71) understood the stories in the app. A relatively high percentage of children (70.4%, 50/71) would recommend the app to their friends.

Lastly, with respect to the usability of the breathing exercise in particular, learning analytics data showed that out of the 54 children who tried the breathing exercise and evaluated its level of difficulty, 83.3% (45/54) thought that it was “easy”. Small percentages of children reported that the exercise was “average in difficulty” (3.7%, 2/54) and “difficult” (5.5%, 3/54). This indicates that the breathing exercise was user-friendly and not challenging for children to perform.

5.2. Research Question 2: To what extent does the stress relief technique taught within the app produce intended results for 5-12 year-old children?

The expected results for RQ2 were reported feelings of happiness or relaxation after the completion of the breathing exercise. Analysis was based on data from the subset of participating children who chose to interact with the breathing exercise tutorial during their app trial and who also completed the usability evaluation questionnaire (n=54).

Learning analytics data revealed that 64% (54/85) of the children who tried the app played the breathing exercise after watching the breathing tutorial. Of these, 57% (31/54) tried the exercise at least once. Out of the 54 children who responded in the questionnaire about how they felt after performing the breathing exercise in the app, 61.1% (33/54) reported that they felt “happy” after performing the exercise, while 33.3% (18/54) reported that they felt “relaxed”. The other options (feeling “angry” or “frustrated”) were chosen by a very small percentage of children (4/54, 5.6%). This shows that a very high percentage of the children (94.4%, 51/54) reported that the breathing exercise was successful in inducing positive feelings (happy or relaxed), which provides an indication that the breathing exercise produced the intended results, at least based on children’s self-reports. However, it should be pointed out that base-level data for the children were not available, therefore there is no way of knowing whether they already felt happy and relaxed before playing the breathing exercise. Another limitation is that the average time of use of the app (M=7.5 min, SD=3min) was low, therefore limiting the ability to draw conclusions about the app’s efficacy.

5.3. Research Question 3: To what extent do 5-12 year-old children report that they can perform a stress relief technique with no other prior (teacher or parental) intervention, through the sole use of the gamified mobile app?

With regard to RQ3, the vast majority of the children who attempted to practice the breathing exercise (93.8%, 45/48) agreed or strongly agreed with the statement that they learned how to do so on their own. This indicates that the children felt capable of performing a breathing exercise without parental, teacher or any other guidance except for the scaffolding provided within the app.

Furthermore, to examine RQ3 in greater detail, we wanted to examine the extent to which children’s self-reported data presented above agree with data on their use of the app as recorded by learning analytics. Therefore, we attempted to examine whether there is a relation between children’s use of the app and the level of difficulty they reported for the breathing exercise. To this end, a non-parametric Spearman’s rho bivariate correlation analysis was conducted with the following two variables: a) the time that each child spent interacting with the app, which includes the time spent performing the breathing exercise, as reflected in the learning analytics data; and b) the children’s reported level of difficulty performing the breathing exercise, as collected from the usability questionnaire. A moderate, inverse, statistically significant correlation was found ($r=-0.28$, $n=57$, $p=0.038$), indicating that the longer the children used the app, the less difficult (therefore “the easier”) they found the breathing exercise. This provides evidence that practicing the breathing exercise makes its performance easier for children over time.

Lastly, we wanted to examine whether the breathing exercise is more engaging for younger or older children. We therefore examined the relation between children's age and the time spent on the breathing exercise. To this end, a Pearson's bivariate correlation analysis was conducted with the following two variables: a) children's age; and b) the time spent on the breathing exercise, as reflected in the learning analytics data. A statistically significant, moderate, negative correlation was found ($r=-0.46$, $p=0.006$, $n=34$), meaning that the younger the children were, the more time they spent on practicing breathing exercises. This may indicate that the breathing exercise is potentially more engaging for younger children and that younger children are more willing to repeat the exercise to fully understand the steps it entails.

6. DISCUSSION

The *Kids Stress Relief* gamified mobile app described in this study is a behavioral intervention technology (Mohr et al., 2014) designed to support young children's learning in the sense of changing behaviors related to their mental health and wellness. Specifically, the app is designed to support young children in identifying body signs of stress and in managing stress in their daily life. The app addresses a gap identified in the literature on mobile apps targeting anxiety and stress (Stiles-Shields et al., 2016; Tozzi et al., 2018), as it specifically targets children as young as five, and is designed as a prevention intervention that many children can use to prevent stress from escalating to anxiety.

This study has sought to describe the design and development of the app and study its usability. Moreover, it examined the extent to which children report that a stress relief technique they engaged in through the app produced the intended results (e.g. led to positive feelings), as well as the extent to which children report that they can perform a stress relief technique using the app, without any external support.

The app was found to be user-friendly with a SUS usability score of 73.55, which is in the 70 percentile rank, and would result in a grade B (Sauro, 2011). It was well accepted by over 80% of children who tried it in the study. This finding is in agreement with Hollis et al. (2017), who found that behavioral intervention technologies have a high possibility of uptake and acceptance, especially by children and adolescents.

Another conclusion from the study, which should, however, be interpreted with caution, was that there is some evidence that the stress relief technique taught in the app produces the intended results, as the majority of children reported that the stress relief technique they learned to perform was successful in making them experience positive feelings and it was not challenging to perform. However, it should be pointed out that base-level data for the children in the study were not available, therefore there is no way of knowing whether they already felt happy and relaxed before executing the breathing exercise.

Limitations of the study include the small sample size of participating children and the fact that the sampling procedure used to solicit participating children was not random, as participants included children whose parents chose to attend a specific science festival. The science fair as a setting for conducting the study was also a limitation, as it almost certainly impacted negatively on the short time-on-task by children, who tended to rush in order to have time to try out other interesting activities taking place at the same time at the fair. Another limitation refers to the use of solely quantitative data. Due to time limitations it was not possible to conduct interviews with children to examine the topic in more depth.

Additional limitations include the context of the study, which was in essence a single trial, the nature of the collected data, which were learning analytics data and self-reported data by the children only, the limited duration of the children's app use, the lack of base-line data for children's prior emotional state and the possibility of the risk of Hawthorn effect, namely the alteration of behaviour (and self-reporting) by participants in a study due to their awareness of being observed.

Lastly, it should be pointed out that the robustness of the modified usability evaluation instrument adopted

has been affected by the need to simplify statements to make them appropriate for very young children and the need to translate the instrument from English to Greek.

Despite these reported limitations, the study's findings indicate that the app has the potential to teach children how to perform a stress relief technique without external (teacher or parental) intervention. This indicates that the app can potentially be used as a standalone application. The findings of this study add to the body of literature on alternative delivery strategies that are more affordable, accessible, and engaging (Dennis & Toole, 2014).

7. CONCLUSIONS AND DIRECTIONS FOR FUTURE RESEARCH

The aims of this study were (1) to describe the development of a stress relief gamified app as a behavioral intervention technology for young children to learn how to identify body signs of stress and how to perform stress relief exercises, (2) to evaluate the usability of the app, (3) to examine the extent to which children report that a stress relief technique they learned to perform in the app produces intended results and (4) to examine the extent to which children can perform a stress relief technique with no other external (teacher or parental) intervention, through the sole use of an app. The study's findings showed that the *Kids Stress Relief* gamified mobile app is user-friendly for and well accepted by children aged 5-12 as a way of learning about stress management, and it has the potential to teach stress relief techniques via a stand-alone application.

Some instructional and design implications can be drawn that may be of particular interest to developers of psychology-based apps. Designers seeking to develop apps specifically intended to help children address psychology-related matters (such as for emotional education, stress management, life skill development, etc.) are advised to combine the motivational affordances offered by gamification techniques with behavior change theory. This combined strategy, also supported by the study of Hoffmann et al. (2017), should increase the likelihood that the resulting app will be both engaging and effective for children.

Another implication refers to the need to provide for the gathering, analysis and operationalisation of learning analytics data generated via children's interaction with the app as part of an overall iterative, user-oriented design method for psychology-based apps. These data may be comprehensive, relating to all user actions, such as icon selection, navigation pattern, time spent on each educational component (such as a story, a tutorial, or an exercise), as well as user decision making when faced with any questions asked within the app. Alternatively, they can relate specifically to research questions posed in studies involving app evaluation. Capturing and analyzing these data provides an indication as to whether children are willing to interact with, or would rather avoid, specific educational components of an app. In accordance with the General Data Protection Regulation (GDPR) and provided that both children's guardians and children give their consent, such anonymized data can, under specific circumstances, be shared with parents or teachers, app designers and researchers. Moreover, analysing the amount of time children spend on each educational component may provide a very rough, rule-of-thumb indication as to whether this was engaging, the hypothesis being that the higher the amount of time children spend on an educational component, the more engaging this educational component is.

This first release of the app was intended for use by children aged 5 to 12. However, one of the five stories it proposes regards school tests, a topic which is not applicable to preschool children. To avoid such incongruences, apps of this kind should allow the user to indicate her age and, as a result, the app should automatically configure so that only age-appropriate and developmentally appropriate content is available. Moreover, as children showed a preference for shorter rather than longer stories, content blocks should be designed to have a short duration not exceeding 1.5 minutes so as to better respond to children's short

attention span. It is also equally important to keep children engaged by providing interactivity features within stories and tutorials. Designers should also keep in mind that younger children in particular may require additional scaffolding, either to be built into the app e.g. in the form of prompts or hints, or through parental guidance, with advice that can be given to parents on how to help their child interact with the app. To assess the app's efficacy more thoroughly, an evaluation is required with a larger sample of children who are selected based on a random sampling procedure. Ideally, this evaluation should be conducted in a more controlled setting, should be longitudinal, and should also involve parents as participants in the study. It would also be beneficial to collect and analyse qualitative data in the form of interviews, especially with younger children, for triangulation purposes and for tapping into children's understanding of the stories and of relaxation techniques that are presented in the app.

8. REFERENCES

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