SurviveCovid-19 - An Educational Game to Facilitate Habitation of Social Distancing and Other Health Measures for Covid-19 Pandemic

Akhila Sri Manasa Venigalla, Dheeraj Vagavolu, and Sridhar Chimalakonda

Research in Intelligent Software & Human Analytics (RISHA) Lab, Department of Computer Science & Engineering, Indian Institute of Technology, Tirupati, India

ABSTRACT

Covid-19 has been causing severe loss to the human race. Considering the mode of spread and severity, it is essential to make it a habit to follow various safety precautions such as using sanitizers and masks and maintaining social distancing to prevent the spread of Covid-19. Individuals are widely educated about the safety measures against the disease through various modes such as announcements through online or physical awareness campaigns, advertisements in the media, and so on. The younger generations today spend considerably more time on mobile phones and games. However, there are very few applications or games aimed to help in practicing safety measures against a pandemic, which is much lesser in the case of Covid-19. Hence, we propose a 2D survival-based game, SurviveCovid-19, aimed to educate people about safety precautions to be taken for Covid-19 outside their homes by incorporating social distancing and usage of masks and sanitizers in the game. SurviveCovid-19 has been designed as an Android-based mobile game, along with a desktop (browser) version and has been evaluated through a remote quantitative user survey, with 30 volunteers using the questionnaire based on the MEEGA+ model. The survey results are promising, with all the survey questions having a mean value greater than 3.5. The game’s quality factor was 69.3, indicating that the game could be classified as excellent quality, according to the MEEGA+ model.

1. Introduction

Several pandemics have proved to be a risk to people across the globe during many instances. The important lessons learned from pandemics witnessed by the world, such as Cholera (Colwell, 1996; Mutreja et al., 2011), H1N1 (Xu et al., 2010), Smallpox (Cunha, 2004; Li et al., 2007), Ebola (Richardson et al., 2016), and so on (Hays, 2005) are the role of awareness campaigns and practice of safety measures. It has been observed that public awareness campaigns reduce the severity of the outcomes of disease, including hospitalization and death (Mytton et al., 2012). Several governments across the world and researchers have highlighted the need to improve public health education campaigns aimed toward improving health literacy among the people (Eastwood et al., 2010). Health professionals across various nations have been advised to practice several control activities, including basic sanitation facilities, identify and isolate suspected cases, and educate the general public through awareness campaigns (Sepulveda et al., 2006). Along with the medical care required, all individuals worldwide must be aware of and follow safety precautions to control the pandemic (Lacitignola & Saccomandi, 2021).

A severe outbreak of pneumonia caused by SARS-Cov-2, Covid-19 (Ciotti et al., 2019) has spread rapidly, affecting more than 2.76 million people, spread across several countries of the world, as reported by WHO as of March 28 2021. It spreads on a large scale, in a short span of time, ranging from 110.7 million cases as of 23 February 2021 to 126.3 million cases as of March 28 2021, affecting more than 15.6 million people in a span of one month (from February 23 2021 to March 28 2021). Symptoms of Covid-19 include fever, cough, dyspnea, lymphocytopenia, fatigue (Yuki et al., 2020; Zhou et al., 2020), which weakens the immune system and increases complications in a few cases, leading to heart failures, kidney failures, respiratory failures, nervous system, and mental health (Bouaziz et al., 2020; Hao et al., 2020; Wang et al., 2020; Zheng et al., 2020; Zhou et al., 2020). The number of deaths caused due to Covid-19 have increased from 2.45M to 2.76M during February 23 2021 to March 28 2021. Several measures to control the Covid-19 pandemic are being taken by WHO and various nations across the world (Güner et al., 2020; Nussbaumer-Streit et al., 2020; Rozhnova et al., 2021; Sohradi et al., 2020). These measures include expediting the diagnosis and contact tracing process, increasing health care facilities and scaling up health care equipment, encouraging the process of discovering drugs to treat Covid-19, and bringing awareness among the public. Vaccines are being developed to prevent the contraction of Covid-19 and ways to administer and educate about these vaccines to a wider
population are being explored (Burgess et al., 2021; Forni & Mantovani, 2021).

Public awareness programs about Covid-19 are being carried out in various ways across the globe. The public is being educated and repeatedly reminded of safety measures to be followed through telephonic and television advertisements, physical and online campaigns, flyer displays at public places, and many online websites, schools and so on (Rozhnova et al., 2021). Several websites dedicated to Covid-19 are being developed, to provide information about precautions to be taken and the status of Covid-19 (Venigalla et al., 2020). In many countries across the world, lockdown instructions are eased, and their citizens are allowed to come outdoors. It is essential to follow safety precautions when people are in public places. Today, the younger generation spends a lot of time with their mobile phones and desktops on various apps and games (Chan et al., 2017). Thus, mobile applications and games are being proposed in various domains to teach and monitor multiple aspects that include road safety (Trager et al., 2021), monitoring use of cannabis (Santesteban Echarri et al., 2020), affective states in blended environments (Tikadar & Bhattacharya, 2020), and so on. Also, it has been observed that games can affect players’ behavior, cognitive skills, and attitude and contribute to better learning (Chen et al., 2020; Orji et al., 2013; Wang, 2020; Zhang et al., 2021).

Despite the large-scale public health awareness programs being carried out, we are not aware of any mobile games aimed to educate people about the safety measures to be taken against Covid-19 and help people to make a habit of following them. While the games Infection Defender (Nikolov & Madsen, 2021) and Can you save the world (Jacob & Wiseman, 2020) consider various issues faced during Covid-19 such as need for social distancing, lack of hospital infrastructure, effects of closing infrastructure on mental health, and so on, they do not specifically focus on self-health precautions such as using masks and sanitizers. The current awareness practices are communicated to a wide range of population and games generally target the younger population in the society. However, games have the advantage of impacting the behavior of the population, rather than only dissipating information (Orji et al., 2013; Wang, 2020). Thus, we propose SurviveCovid-19, a survival theme-based 2D mobile and desktop (browser) game, to educate users about various safety measures to be followed against Covid-19 when in outdoors and consequently help them in practicing these safety measures. A snapshot of the game is presented as Figure 1.

2. Related work

Bringing out awareness among public with respect to various diseases plays a primary role in keeping people healthy. With the increase in use of mobile and web applications, several health care mobile apps and websites are being developed.

2.1. Mobile apps for health literacy

Mobile apps to support prevention of various diseases such as obesity, cardiovascular diseases, chronic diseases such as skin cancer, and so on have been developed (Brinker et al., 2018; Kong & Tan, 2012; Matsumura & Yamakoshi, 2013; Sindi et al., 2015). Brinker et al. have presented a facial-aging mobile app, SunFace, aimed to prevent skin cancer (Brinker et al., 2018). SunFace encourages users to click a selfie and view changes induced due to 5 and 25 years of skin aging with and without sun protection. It also provides information about most commonly caused skin cancers due to UV rays and displays odds ratio of skin cancer based on various behaviors (Brinker et al., 2018). A study conducted to evaluate SunFace app with around 350 Brazilian secondary school students has shown increased considerations for UV protective behaviors (Brinker et al., 2018, 2017). CAIDE Dementia Risk Score App has been developed by Sindi et al. to predict risk of dementia based on the profile of individuals (Sindi et al., 2015). It also provides guidance to individuals to reduce the risk of dementia. The “medical history, health status and current health behaviour” of individuals is taken as input, through a questionnaire and risk score is calculated based on this information. It also provides a platform for medical practitioners to monitor risk of dementia of an individual and provide necessary guidance (Sindi et al., 2015).

Kong et al. have developed DietCam, a mobile phone based application that aims to reduce obesity (Kong & Tan, 2012). It assesses the food intake of users based on three images, clicked from three different perspectives, or a short video of the food being consumed. The type of food in the image or video is classified by comparing result of feature matching with different types of food stored in food and nutrition database. The volume of the food is identified through geometry calibration and 3D

Figure 1. Snapshot of SurviveCovid-19.
reconstruction. An estimation of number of calories being consumed based on the type of food and volume generated is presented to the users, which helps them in assessing the calorie intake, and consequently manage their diet (Kong & Tan, 2012). Studies also reveal that more than 70% of users, using weight loss reduction mobile applications show successful weight reduction (Chin et al., 2016). These studies thus imply the positive outcomes of using mobile applications in health care. iPhysioMeter has been proposed as a smartphone program (on iPhone 4, 4S and 5) to measure heart rate (HR) and normalized pulse volume (NPV) (Matsumura & Yamakoshi, 2013). The HR and NPV values are calculated by the program when users tap on the iPhone home screen and cover the flash LED and CMOS camera with their left index finger. The results of measurements are sent to the users’ e-mail (Matsumura & Yamakoshi, 2013).

2.2. Games for healthcare

Several mobile games have also been developed to promote self-health monitoring for various diseases (Baghaei et al., 2016; Bin Hussein et al., 2019; Birn et al., 2014; Park et al., 2015). MobileQuiz has been developed as a mobile game, to promote both physical and cognitive skill among older adults, and is to be played outdoors (Birn et al., 2014). It assigns tasks to users in view of the physical distance and direction to be covered by the user, which when accomplished, users are rewarded with points and are provided with a questionnaire related to the location or surrounding regions (Birn et al., 2014). Park et al. have proposed SnackBeaker, a mobile game, aimed to promote healthy food choices among the players (Park et al., 2015). It presents a quiz that can be answered based on elimination of one among two choices, in terms of nutritional values provided by the two alternatives, thus educating users about the nutritional value of different snacks and consequently helping them choose snacks with high nutritional values (Park et al., 2015). A mario style based mobile game, Diabetic Mario, was introduced to help in understanding ways to manage diabetes (Baghaei et al., 2016). The player is assigned with the task of managing blood sugar level of Diabetic Mario by selectively choosing the food items provided in the game console and eventually save the princess (Baghaei et al., 2016).

Considering the importance of Automated External Defibrillators (AED) in cases of out-of-hospital cardiac arrests, a crowdsourced mobile game has been designed to make users vary of AED locations and also to motivate them to report condition of AEDs (Bin Hussein et al., 2019). Infection Defender has been proposed to raise awareness among children toward various problems being faced due to the spread of Covid-19, such as negative impact on mental health due to closing of infrastructures such as schools, less capacity in hospitals due to increased need for hospitalization and testing, need for maintaining social distance and so on (Nikolov & Madsen, 2021). Can you save the world game (Jacob & Wiseman, 2020) has been proposed to educate people about the importance of social distancing to control Covid-19. People of the Pandemic (Observable, 2020) has also been proposed to help individuals make informed decisions about their activity during the pandemic, along with a team of other individuals, which would impact the state of availability of facilities in the hospitals, raise in the number of people affected by the pandemic and so on. However, this game largely depends on the decision making of the players and does not focus much on the game-play and in-game interactions, which would be of interest to the younger population.

2.3. Web-based applications for awareness during pandemic

Considering the importance of public awareness toward a pandemic and the importance of research in view of planning and response to curb the pandemic, few online websites and telephonic lines have also been developed. Isis has been developed as a web framework to help in planning and response against pandemics by analyzing multiple simulations of possible interventions, including “administering a vaccine to a part of population, using antivirals as treatment, closing schools and work places and instituting social distancing” (Beckman et al., 2014). WHO also lists out various safety measures on the WHO website to enable public awareness during pandemics. Few web-based applications and websites are also being developed to help in tracking Covid-19 reported cases and in bringing public awareness toward Covid-19. Dong et al. have developed web-based dashboard that displays visualizations of Covid-19 reported cases from time to time (Dong et al., 2020). It “reports cases of the Covid-19 pandemic at level of cities in USA, Australia and Canada, province level in China and country level in other cases” (Dong et al., 2020). Few governments across the world have also promoted use of various mobile based applications which are aimed to bring awareness among people about risks, best practices, and relevant advisories regarding Covid-19.

Considering the positive impact of mobile and desktop games and apps (Orji et al., 2013) in the area of health care and the proven usefulness in bringing awareness about various diseases and inculcating healthy habits through mobile games and apps, designing games to help in public awareness in the context of Covid-19 pandemic could be useful. However, in spite of the availability of mobile and web applications toward containment of Covid-19, we are not aware of any mobile or desktop games that promote inculcating the habit of following safety measures with respect to Covid-19. While there exists some games (Jacob & Wiseman, 2020; Nikolov & Madsen, 2021; Observable, 2020) in the Covid-19 context, to teach the skill of managing issues faced during Covid-19, they do not focus largely on the safety measures to be followed other than social distancing, such as wearing masks and using sanitizers, which are also the important aspects to be considered in bringing awareness about Covid-19. Hence, we present SurviveCovid-19, a survival based 2D game, aimed to educate users and help in practicing various safety measures to be followed against Covid-19 pandemic.

3. Design

Multiple studies in the literature propose various ways to improve effectiveness and simplify development of serious games for educational purposes, which included sets of guidelines based on the target audience for the games (Manuel
et al., 2019; Valenza et al., 2019; Westera, 2019). The guidelines presented in Westera (2019) were observed to be more closely related to the goals of SurviveCovid-19, such as motivation and reduced cognitive load.

SurviveCovid-19 has thus been designed keeping in mind the desirable factors for effectiveness of serious games for better learning outcomes, such as better motivation and reduced cognitive load, as suggested in Westera (2019). This is an educational game that helps people in understanding the importance of masks and sanitizers and following the safety measures to keep themselves and people in their surroundings safe from Covid-19. This game is inspired by a simple pixel-based top-down style design where people navigate the city with safety and health measures. People above 18 years of age are generally not accompanied by their parents, and thus there is a need to strongly educate such a population about the need and importance of following safety measures toward controlling Covid-19. A study on compliance toward Covid-19 precautions among people of various age groups and professions revealed that population in the age group of 18–24 years had lesser fear of Covid-19 and lesser compliance (Kabasakal et al., 2021). Further, it was also observed that population in the age group of 18–34 years do not tend to adapt to the Covid-19 precautions, unlike the older adults (Kim & Crimmins, 2020). Another study with 2013 participants also indicated similar adherence patterns among different age groups toward Covid-19 precautions, with individuals in the age group of 18–24 years less likely to be following social distancing (Coroiu et al., 2020). Considering these factors and the interest among this younger population of the society toward games, we design SurviveCovid-19 to be relevant to the people in the age group of 17–27 years, thus selecting individuals in the age group of 17–27 years as our focus group.

The game begins by showing a landing screen. As the game starts, the player sees a short video depicting a simple storyline of a person who needs to get essential items from the city during lock down for his family while following proper health measures and avoid spreading the virus. The scenes displayed in the game are designed to be appealing to the users, and also resemble real-life scenarios, thus meeting the styling criteria and reducing cognitive load, as mentioned in (Westera, 2019). The video is then followed by a screen showing the specific instructions to complete the game. The goal of the player is to collect the allotted number of groceries and medicines while navigating the city. While doing so, the player also has to make use of face masks and sanitizers to avoid getting infected or infecting other people. To make the game challenging and fun for the players, both of these utilities have been given a timer. The player has to make use of them strategically to win. The game finishes when the player collects all the required items and reaches home, as shown on the map.

The game also keeps in check the number of people getting affected because of the user’s action in terms of people being infected directly and indirectly. This prompts the player to tread the path with caution and by taking proper health measures throughout the game. The game rewards the player with safety shield when masks or sanitizers are used within the game, thus motivating the players to make use of these elements.

Studies on educational games aimed toward similar age groups (under-graduate students) revealed that integrating the goal-setting theory and associating interesting rewards on accomplishing these goals challenges the target audience and consequently motivates them to finish the goals and learn the concept being taught (Landers & Callan, 2011). The aspects of setting targets or goals to the players and adding points as rewards on accomplishment of the goals could be challenging enough to the younger population (focus group) and thus could motivate them to play the game. Also, the obstacles (virus) that infect the player in the game and the in-game advantages the player gets by following safety precautions could influence the younger generations in understanding the importance of following health measures against Covid-19. This also preserves the aspects challenge, players’ control which are some essential components of simulation games aimed toward similar age groups (Braghiroli et al., 2016). The game involves player moving around the city that requires only four controls, corresponding to four directions, which are up, down, left, and right. These minimal controls and interactions are thus less complex and could support younger players and non-game savvy individuals in playing the game. This being mentioned, the goals assigned to the player, the game objects involved, and the challenges presented to the players could motivate both game savvy and non-game savvy individuals to play the game.

4. Development

We have developed SurviveCovid, as an motivational and educational game to learn the importance of, and to follow proper health measures against Covid-19 using the Unity 3D game engine. We followed a step by step approach to develop the game, as shown in Figure 2. We then used the Android SDK module provided by Unity to export the game for android-based mobile devices.

We have used 2D tiles from the standard assets pack provided by Unity to define most of the game objects. The rest has been created using Photoshop software. The tiles are first imported into Unity and then using the tile-map feature of Unity, we design the game. In this way, the map of the city in which the player has to navigate is created. A mask and a sanitizer object are created and have been placed at strategic positions on the map. These utilities are meant to help the player to complete the level.

All the events in the game are controlled using scripts written in C# programming language. A mechanism to simulate the spread of disease through touch has been implemented using C# scripts. This spread can be prevented by taking appropriate measures like using the mask and the sanitizer.

Many obstacles, such as infected people and monsters which spread the virus on touch, are placed on the map. The people are positioned such that they mimic real crowds and queues of people.

A single script keeps track of the groceries and medicine that have been collected by the player. A Quota is assigned to the player automatically to collect groceries and medicine. Only on completing the assigned quota, the player may cross the finish line.

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All the media, such as videos and photos in the game, are made using Windows Video Maker and Photoshop softwares.

5. User scenario

Consider Moksha, an individual staying indoors due to lockdown instructions in her locality, interested to play games and to gain awareness against Covid-19. She considers playing SurviveCovid-19, to pass her time and also to be habituated to follow safety measures when in outdoors. She downloads SurviveCovid-19 on her Android mobile and starts the game. She is displayed with a start screen, with options—Start, About, and Exit, as shown in Figure 3. She selects to start the game by clicking on [A] of Figure 3. She is then displayed with a short video that describes the lockdown situation of a person, who is required to go outdoors to get daily essentials and medicine. Moksha can also choose to skip the video and directly navigate to the game by clicking on Press here to Continue ([B] of Figure 4). A snapshot of the video is shown in [A] of Figure 4. Information about various game elements is also displayed as a part of the video, as shown in [C] of Figure 4. Moksha is then presented with Instructions screen containing instructions to be followed as shown in [A] of Figure 5, a map depicting layout of the city, shown in [B] Figure 5, options to continue and exit, as shown in [C] and [D] of Figure 5, respectively. She clicks on Continue ([C] of Figure 5) and starts the game.

Figure 2. Development of SurviveCovid-19.

Figure 3. Start screen of SurviveCovid-19 depicting [a] Start option, [b] About option and [c] Exit option.

Figure 4. Snapshots of short video describing different game elements including [a], conversation in video, [b] option to skip video, [c] Grocery, medicine pack and sanitizer, [d] virus in the game and [e] doctor.
Moksha is then displayed with the number of Groceries and Medicines to be collected, as shown in [G] of Figure 6. The number of groceries and medicines collected versus the goal to be collected are displayed in [G] of Figure 6. [A] of Figure 6 depicts lifeline of the player, while the score is displayed to the top right, as shown in [H] of Figure 6. The player can move around in the city using the controls depicted in [E] and [F] of Figure 6. In cases where the player is infected with virus and gets in contact with other individuals in the game, the player infects those individuals as shown in [C] of Figure 6. When these infected individuals move around the city, they also infect other healthy individuals. The total number of individuals infected by the player directly and indirectly is represented in [D] of Figure 6. She starts moving around the city to collect required essentials. Considering the safety precautions, not to be affected by the virus, she collects the mask and sanitizer wherever available. The lifeline of existence of sanitizer is displayed below the player’s lifeline, as depicted in [A] of Figure 7. [B] of Figure 7 indicates virus not being able to harm player in the presence of sanitizer. The lifeline of mask is depicted in [A] of Figure 8 and [D] of Figure 8 indicates the mask protecting player from the virus. Score of the player increases on collecting elements displayed in [C] of Figure 8. Player contracts the virus in the absence of mask or sanitizer, thus resulting in declining
motivation, user experience, usefulness, and so on, based on different evaluation models such as TAM (Technology Acceptance Model) (Venkatesh et al., 2003), MEEGA+ (Petri et al., 2016), and so on. These evaluation models present certain questionnaires that are aimed to evaluate user perception in terms of ease of use, usefulness, intention to use, and so on, toward the technology being introduced. TAM supports evaluation by largely considering the perceived ease of use, perceived usefulness, and intention to use factors, while MEEGA+ considers player experience and usability factors.

Among the existing evaluation models, we see that MEEGA+ has been commonly used to evaluate educational games (Santos et al., 2019; Tsopra et al., 2020), as it considers desired factors such as fun, challenge, learnability, operability, and so on, thus including both player experience and usability. As these factors are also relevant for the evaluation of SurviveCovid-19, we adapt MEEGA+ for evaluating the game. However, as SurviveCovid-19 aims to influence players to follow safety precautions against Covid-19, we also evaluate its influence on players toward making a habit to follow the safety measures. Also, we design SurviveCovid-19 based on the suggestions in (Westera, 2019), to make it more effective for learning. Thus, we evaluate SurviveCovid-19 based on the factors—intrinsic motivation and reduced cognitive load. Hence, we design the questionnaire based on an amalgamation of the factors discussed above. The factors considered for evaluation are as follows:

- Influence/impact (I)
- In-game safety precautions (SP)
- Motivation
  - Competence (C)
  - Autonomy (A)
  - Style elements (SE)
  - Rewards (RW)
- Reduced cognitive load (RCL)
- Player experience
  - Focused attention (FA)
  - Satisfaction (S)
  - Relevance (R)
  - Fun (F)
  - Challenge (Ch)
- Usability
  - Learnability (L)
  - Operability (O)
  - Esthetics (As)
  - Accessibility (Acc)

The current version of SurviveCovid-19 is a single-player game, targeted at a wider audience, outside the classroom. While introducing the game in classrooms could help students learn the importance of health measures against Covid-19, the target audience of this game includes population with different professional backgrounds such as architects, doctors, and so on, along with students pursuing medicine and engineering. Thus, the scope of the game was not restricted only inside the classroom. Hence, some factors of MEEGA+ such as Social Interaction, Perceived Learning, and User Error Protection have been omitted for evaluation of the game. We design a questionnaire, as presented in Table 1, based on the factors mentioned above.

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**Figure 8.** Snapshot of SurviveCovid-19 depicting [a] Lifeline of mask, [b] Player not being affected by virus in presence of mask & [c] Game elements.

**Figure 9.** Snapshot of SurviveCovid-19 depicting infected player visiting a doctor.

**Figure 10.** Snapshot of SurviveCovid-19 depicting player reaching home on accomplishing assigned tasks.

**6. Evaluation**

SurviveCovid-19 has been developed to educate about and motivate public to follow safety measures to be taken to control Covid-19 pandemic, as an Android and Web-based mobile game. Though we could not find games developed to support public health awareness toward pandemics, several health care-related and learning-oriented games have been evaluated based on similar factors such as learning outcomes, usability, lifeline of the player. Moksha then visits a doctor as shown in [A] of Figure 9, to get cured and revive player’s lifeline. Once all the groceries and medicine are collected, player reaches home, as shown in [B] of Figure 10.
Table 1. Quantitative user survey.

| Factors | Questions | Mean   | SD    |
|---------|-----------|--------|-------|
| I       | The theme of the game influenced my actions in real-time | 3.67   | 1.09  |
| I       | After playing the game for more than 3 times, I intended to use sanitizers more frequently in my day-to-day life. | 3.5    | 1.25  |
| I       | After playing the game for more than 3 times, I intended to follow more often social distancing in my day-to-day life | 3.67   | 1.12  |
| I       | After playing the game for more than 3 times, I intended to more frequently use masks in my day-to-day life | 3.64   | 1.16  |
| RW/SP   | There were in-game rewards that motivated me to follow wearing masks in the game | 3.87   | 1.1   |
| RW/SP   | There were in-game rewards that motivated me to follow social distancing in the game | 3.67   | 1.09  |
| RW/SP   | There were in-game rewards that motivated me to follow using sanitizers in the game | 3.76   | 1.22  |
| C       | When I first looked at the game, I had the impression that it would be easy for me. | 3.9    | 1.02  |
| A       | It is due to my personal effort that I managed to advance in the game. | 3.73   | 0.94  |
| A       | I could reach the target in the game on my own | 3.76   | 1.03  |
| SE/Acc  | The fonts (size and style) used in the game are easy to read. | 4      | 0.83  |
| SE/As   | The game design is attractive (interface, graphics, etc.). | 4.06   | 0.98  |
| RCL     | Game presents visuals of real-time scenarios, which helped me to relate well to my surroundings | 3.76   | 1.04  |
| FA      | There was something interesting at the beginning of the game that captured my attention. | 3.8    | 1.03  |
| S       | I would recommend this game to my colleagues. | 4.1    | 0.84  |
| S       | I feel satisfied with the things that I learned from the game. | 3.8    | 1.03  |
| S       | Completing the game tasks gave me a satisfying feeling of accomplishment. | 3.9    | 0.88  |
| R       | The game contents are relevant to my interests. | 3.67   | 1.09  |
| F       | Something happened during the game (game elements, competition, etc.) which made me smile. | 3.93   | 0.98  |
| F       | I had fun with the game. | 4.03   | 0.8   |
| Ch      | The game does not become monotonous as it progresses (repetitive or boring tasks). | 3.67   | 1.02  |
| Ch      | The game provides new challenges (offers new obstacles, situations or variations) at an appropriate pace. | 3.64   | 1.15  |
| Ch      | This game is appropriately challenging for me. | 3.84   | 0.94  |
| L       | I think that most people would learn to play this game very quickly. | 3.87   | 0.97  |
| L       | Learning to play this game was easy for me. | 3.87   | 0.97  |
| O       | The game rules are clear and easy to understand. | 4      | 0.94  |
| O       | I think that the game is easy to play. | 3.93   | 0.82  |

E-Mails were sent out to 70 individuals with varied professional background, which included doctors, architects, engineers, chartered accountants, and students pursuing medicine, engineering, and architecture. The e-mail consisted of information about the game, link to browser and android versions of the game, and link to the user survey. These individuals were requested to either download the *SurviveCovid-19* application and install the same on their Android mobile phones or navigate to the browser version of the game. A 5-point Likert Scale based questionnaire as shown in Table 1, has been sent to all the participants as a user survey in the e-mail. Apart from the questions based on the factors considered, as presented in Table 1, other questions that could support the analysis such as demographic questions were also included in the user survey (as presented in Table 2). The participants were asked to play the game and provide their feedback by answering the questionnaire presented in the user survey. Of these 70 individuals, 30 individuals responded to the user survey after playing the game.

Table 2. Demographics.

| Gender |          |          |
|--------|----------|----------|
|        | Female   | 13       |
|        | Male     | 17       |
| Age (in years) | |          |
|        | 17–20    | 6        |
|        | 21–24    | 17       |
|        | 25–27    | 7        |
| Profession |        |          |
|          | Architect| 3        |
|          | Architecture Student | 2       |
|          | Doctor   | 2        |
|          | Public Health/Medical Student | 2       |
|          | Software engineer | 4        |
|          | Engineering student | 16       |
|          | CA       | 1        |
| Frequency of playing games | |          |
|          | Very often | 8        |
|          | Often     | 6        |
|          | Neutral   | 1        |
|          | Sometimes | 10       |
|          | Never     | 5        |
| Version played | |          |
|          | Mobile    | 20       |
|          | Desktop/browser | 3        |
|          | Both      | 7        |
7. Results

We observed that there were 13 female and 17 male participants among the 30 volunteers who responded to the user survey (these details are presented in Table 2). These participants had varied professional backgrounds, which also included 2 doctors, 2 public health and medical students, 2 architects, 2 architecture students, and 16 engineering students, apart from software engineers and chartered accountants. Majority of the volunteers belonged to the age group of 21–24 years and 25 participants have agreed to have played games at least sometimes. All the participants have played the SurviveCovid-19 game on an average of 5 times, before answering the user survey questionnaire.

Table 1 indicates the results of user survey in terms of mean and standard deviation of each question in the questionnaire. It can be observed that the mean for all the questions is greater than or equal to 3.5, indicating the positive experience of users. Figure 11 depicts the mean and standard deviation values for each of the three quality factors. The mean values for each of the quality factors were considered to calculate the quality score based on MEEGA+ model. Applying the Cronbach Alpha value for means of player experience (FA, F, Ch, S, and R) and usability (L, O, As, andAcc) factors and then normalizing the resultant value by multiplying it by 10 resulted in quality score of 69.3. The MEEGA+ evaluation theory states that games with quality score greater than 65 are of excellent quality, while that between 42.5 and 65 are considered to be of better quality. The quality score of SurviveCovid-19 is 69.3, indicating that the game could be included in excellent quality category. This result indicates that such games are challenging for learners, without monotonous activities and clear rules to play the game. The mean of motivation factors (C, A, SE, RW), and other factors (I, SP, and RCL) is 3.76, indicating that majority of the participants find SurviveCovid-19 to be motivating and helps the players in inculcating safety precautions against Covid-19 as a habit.

Among the participants of different age groups, we observed that participants in the age group of 17–20 years had more positive experience with SurviveCovid-19, with mean values for all the factors greater than 4.4 for 10 of the 13 factors. Participants in the age group of 17–20 years played the game on an average of 6.5 times, which was 4.05 and 5.3 times for participants in the age groups 21–24 years and 25–27 years, respectively. The trends of results of the user survey

Figure 11. Result of questionnaire in terms of mean and standard deviation of quality factors.

Figure 12. Mean and Standard Deviation of Quality Factors across three age groups, 17–20, 21–24 and 25–27 years.
revealed that people in lesser age groups were interested to play the game than those in the higher age groups. The distribution of mean values in Figure 12 indicates the same, with values decreasing across 11 of the 13 factors in the ascending order of the age groups. We further observed that participants who used the Mobile platform played the game more times (5.1) on an average than those who used the desktop/browser platform (4.3). This could indicate that the game on mobile motivates the participants to play it more times. However, no specific trends could be observed from the mean values of the quality factors. We observed that participants in the medical field had more positive experience, with highest mean values for all the quality factors (greater than 4.5), followed by software engineers and engineering students. This could further indicate that participants in the medical domain find SurviveCovid-19 to be interesting and useful toward inculcating safety measures as habits among the public, thus strengthening the purpose of SurviveCovid-19.

Participants also suggested that:
- Control sensitivity for navigation buttons could be improved.
- Way to home and to hospitals could be indicated in the game.
- The game button reaction is quite fast, rest all is fine.

8. Discussion and limitations

SurviveCovid-19 is based on survival theme, where the storyline deals with a person who needs to go outdoors to purchase daily essentials and medicine during Covid-19 situation. The game has been designed in a way which enforces the players to follow safety measures to stay safe from Covid-19 when outdoors. Thus, the developed prototype version of SurviveCovid-19 aims to educate players about precautions to be taken and also inculcate the habit of following these precautions against Covid-19. Though this game has been developed to address the younger generations of society, it can be played by a wide range audience, irrespective of any social or educational backgrounds. The only requirement of the game is that the players are expected to be equipped with using a mobile phone or a desktop/laptop.

The current version of SurviveCovid-19 has only one level. However, further levels can easily be added to the game and difficulty level could also be increased with every level being added. The game could also include roles for the player, such as scientist, doctor and health-care workers, and also include the aspect of vaccines. Also, the existing SurviveCovid-19 application can be played only on Android based mobile devices and on browser (from desktop). The future versions of the game could be made compatible to mobile devices operating on other operating systems such as Apple and Windows.

While we develop the game to facilitate habitation of health measures, the current evaluation could be further strengthened by long-term testing of participants’ habits to strongly understand the habits inculcated by the game. The results of the evaluation that presented the change in participants’ attitude toward health measures. Hence, we see that SurviveCovid-19 is capable of facilitating habitation of safety and health measures against Covid-19, among the players. However, a long-term user study before and after playing the game to understand change in player behavior could be added in future versions of the game, to obtain better insights on usefulness of the game.

The game elements included in SurviveCovid-19 are based on game principles described in educational games and gamification of different aspects to promote better learning among undergraduate students, mostly in the age group of 17–23 years (Bodnar et al., 2016; Braghiroli et al., 2016; Landers & Callan, 2011). However, taking progressive feedback from the target audience during multiple phases of development could help in making better informed design choices and could have further positive impact on the players.

9. Conclusion and future work

In this article, we presented the prototype version of SurviveCovid-19, a survival based 2D mobile and desktop (browser) game, aimed to bring awareness about safety measures to be followed against Covid-19. Public awareness campaigns are considered as one of the most important measures to be taken across the world in cases of a pandemic or a disease outbreak (Eastwood et al., 2010; Myttton et al., 2012). The current outbreak of Covid-19 pandemic requires all individuals across the world to follow precautions to prevent the spread of Covid-19. Large scale public health awareness campaigns are being carried out by almost all the governments and various organizations across the world, including WHO to control Covid-19. Considering the large amount of time spent by younger generations on mobile and desktop apps and games in the present day, and the effect of games on players’ attitude (Chan et al., 2017; Orji et al., 2013), it could be useful to introduce games that contribute toward public health awareness and help the public in inculcating safety precautions as a habit. SurviveCovid-19 aims to educate people about the safety measures to be followed during Covid-19 and motivates them to follow the precautions in real time. We have evaluated SurviveCovid-19 through a questionnaire adapted from factors in MEEGA+ model and other factors such as motivation and impact of the game. The evaluation was done through a remote quantitative user survey with 30 volunteers, and obtained positive feedback with game quality score equal to 69.3, indicating excellent quality category of the game. Majority of the volunteers found the game to be motivating and interesting (more than 70% responded with agree or strongly agree for the respective questions).

The current version of the game supports trivial learning outcomes of using masks and sanitizers and following social distancing. We plan to introduce other non-trivial learning outcomes such as keeping track of the infrastructure availability, patient count, and so on, which would require reinforcement learning for the players, thus, needing long-term use of the game. Hence, we plan to improve the game design to support personalized incremental learning that could contribute to support long-term use of the game. Our target audience when we initially designed the SurviveCovid-19 game is the younger population among the general public.
Designing the game specifically for classroom usage could be useful, and hence a newer version of the game with different design practices that suit classroom use could be explored in the future. The game currently supports Android mobile devices. It can further be extended to support mobile devices running on other operating systems. We plan to improve the game by increasing number of levels in the game and difficulty of the levels. Also, future versions of the game can include online and multiplayer features unlike the current offline and single player version of the game. We also plan to modify the game controls by improving the sensitivity of the control keys, as suggested by the participants in the survey. As a part of the future work, we plan to develop a personalized version of the game that keeps track of the learnings of each user. This version could be adapted for different target groups (players of different age groups) to enhance the player experience. We plan to reach out to non-profit, independent, non-governmental organizations (NGOs) that aim to educate the underprivileged population about safety measures and help them in bringing awareness through the game. The game could also be communicated to the World Health Organization (WHO), which could be included as a part of the awareness program. We also plan to develop a multiplayer version of the game to depict the need for collaboration in controlling Covid-19. The multiplayer version of the game could include information about roles and responsibilities of people with various professions toward controlling the pandemic, along with safety measures to be followed. Each player in the team playing the game could be associated with different professions and play the game accordingly.

We further plan to take progressive feedback from the users during multiple development stages, to ensure that the game design fits the nature and desires of the focus group.

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No potential conflict of interest was reported by the author(s).

**ORCID**
Akhila Sri Manasa Venigalla https://orcid.org/0000-0001-5706-4038
Sridhar Chimalakonda https://orcid.org/0000-0003-0818-8178

**References**
Baghaei, N., Nandigam, D., Casey, J., Direito, A., & Maddison, R. (2016). Diabetic marios: Designing and evaluating mobile games for diabetes education. *Games for Health Journal, 5*(4), 270–278. https://doi.org/10.1089/ghj.2015.0038
Beckman, R., Bisset, K. R., Chen, J., Lewis, B., Marathe, M., & Stretz, P. (2014). Isis: A networked-epidemiology based pervasive web app for infectious disease pandemic planning and response. In *Proceedings of the 20th ACM Sigkdd International Conference on Knowledge Discovery and Data Mining* (pp. 1847–1856). ACM.
Bin Hussein, M. I. H., Fong, J. H., Lim, C. X., Lee, J. S., Tan, C. T., & Ng, Y. Y. (2019). Mobile application for crowdsourced gamification of automated external defibrillator (AED) locations. In *Proceedings of the 4th International Workshop on Multimedia for Personal Health & Care* (pp. 24–31). ACM.
Birn, T., Holzmann, C., & Stech, W. (2014). Mobile quiz: A serious game for enhancing the physical and cognitive abilities of older adults. In *International Conference on Universal Access in Human-Computer Interaction* (pp. 3–14). Springer.
Bodnar, C. A., Anastasio, D., Enzer, J. A., & Burkey, D. D. (2016). Engineers at play: Games as teaching tools for undergraduate engineering students. *Journal of Engineering Education, 105*(1), 147–200. https://doi.org/10.1002/jee.20106
Bouaziz, J., Duong, T., Jachib, M., Velter, C., Lestang, P., Cassius, C., Arsouze, A., Domergue Than, Trong, E., Bagot, M., Begon, E., Sulimovic, L., & Rybojad, M. (2020). Vascular skin symptoms in covid-19: A French observational study. *Journal of the European Academy of Dermatology and Venereology, 34*(9), e451–e452. https://doi.org/10.1111/jdv.16544
Braghiroli, L. F., Ribeiro, J. L. D., Weise, A. D., & Pizzolato, M. (2016). Benefits of educational games as an introductory activity in industrial engineering education. *Computers in Human Behavior, 58*, 315–324. https://doi.org/10.1016/j.chb.2015.12.063
Brinker, T. J., Heckl, M., Gatza, M., Hepp, M. V., Rodrigues, H. R., Schneider, S., Sondermann, W., de Almeida, E. Silva, C., Kirchberger, M. C., Klode, J., Ehn, A. H., Knispel, S., Von Kalle, C., Stoffels, I., Schadendorf, D., Nakamura, Y., Esser, S., Assis, A., & Bernardes-Souza, B. (2018). A skin cancer prevention facial-aging mobile app for secondary schools in Brazil: Appearance-focused interventional study. *JMIR mHealth and uHealth, 6*(3), e60. https://doi.org/10.2196/mhealth.9794
Brinker, T. J., Schadendorf, D., Klode, J., Cosgarea, I., Rösch, A., Jansen, P., Stoffels, I., & Izar, B. (2017). Photoaging mobile apps as a novel opportunity for melanoma prevention: Pilot study. *JMIR mHealth and uHealth, 5*(7), e101. https://doi.org/10.2196/mhealth.8231
Burgess, R. A., Osborne, R. H., Yongabi, K. A., Greenhalgh, T., Gurdasani, D., Kang, G., Falade, A. G., Odono, A., Busse, R., Martin-Moreno, J. M., Reicher, S., & McKee, M. (2021). The 2019 covid-19 vaccines rush: Participatory community engagement matters more than ever. The Lancet, 397(10268), 8–10. https://doi.org/10.1016/S0140-6736(20)32642-8
Chan, A., Kow, R., & Cheng, J. K. (2017). Adolescents’ perceptions on smart-phone applications (apps) for health management. *Journal of Mobile Technology in Medicine, 6*(2), 47–55. https://doi.org/10.7309/jmmtm.6.2.6
Chen, S., Zhang, S., Qi, G. Y., & Yang, J. (2020). Games literacy for teacher education. *Educational Technology & Society, 23*(2), 77–92. https://www.jstor.org/stable/26921135

**Notes**
1. https://www.who.int/publications/m/item/weekly-epidemiological-update-on-covid-19—31-march-2021
2. https://www.who.int/publications/m/item/weekly-epidemiological-update—23-february-2021
3. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports
4. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public
5. The game is also available at https://survivecovid-19.itch.io/game2020
6. https://www.mygov.in/aarogya-setu-app/
7. https://play.google.com/store/apps/details?id=pl.gov.mc.protegosafe
8. https://www.coronawarn.app/en/
9. https://covid-19.ontario.ca/covidalert
10. https://unity.com/

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emergency: A review of the 2019 novel coronavirus (COVID-19). International Journal of Surgery, 76. https://doi.org/10.1016/j.ijsu.2020.02.034

Tikadar, S., & Bhattacharyya, S. (2020). Detection of affective states of the students in a blended learning environment comprising of smartphones. International Journal of Human–Computer Interaction, 37, 1–18. https://doi.org/10.1080/10447318.2020.1861762

Trager, J., Kalová, L., Pagany, R., & Dorner, W. (2021). Warning apps for road safety: A technological and economical perspective for autonomous driving—the warning task in the transition from human driver to automated driving. International Journal of Human–Computer Interaction, 37(4), 363–377. https://doi.org/10.1080/10447318.2020.1860545

Tsopra, R., Courtine, M., Sadki, K., Eap, D., Cabal, M., Cohen, S., Bouchaud, O., Mechai, F., & Lamy, J.-B. (2020). Antibiogame: A serious game for teaching medical students about antibiotic use. International Journal of Medical Informatics, 136(136), 104074. https://doi.org/10.1016/j.ijmedinf.2020.104074

Valenza, M. V., Da Silva Housell, M., & Gasparini, I. (2019). Serious game design for children: Validating a set of guidelines (Vol. 22) (No. 3). JSTOR.

Venigalla, A. S. M., Chimalakonda, S., & Vagavolu, D. (2020). Mood of India during covid-19—an interactive web portal based on emotion analysis of twitter data. In Conference Companion Publication of the 2020 on Computer Supported Cooperative Work and Social Computing (pp. 65–68). Association for Computing Machinery.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. MIS Quarterly, 27(3), 425–478. https://doi.org/10.2307/30036540

Wang, H.-Y., Li, X.-L., Yan, Z.-R., Sun, X.-P., Han, J., & Zhang, B.-W. (2020). Potential neurological symptoms of covid-19. Therapeutic Advances in Neurological Disorders, 13(3), 1756286420917830. https://doi.org/10.1177/1756286420917830

Wang, Y.-H. (2020). Integrating games, e-books and ar techniques to support project-based science learning. Educational Technology & Society, 23(3), 53–67. https://www.jstor.org/stable/26926426

Westera, W. (2019). Why and how serious games can become far more effective: Accommodating productive learning experiences, learner motivation and the monitoring of learning gains. Journal of Educational Technology & Society, 22(1), 59–69. https://www.jstor.org/stable/26558828

Xu, R., Ekiert, D. C., Krause, J. C., Hai, R., Crowe, J. E., & Wilson, I. A. (2010). Structural basis of preexisting immunity to the 2009 h1n1 pandemic influenza virus. Science, 328(5976), 357–360. https://doi.org/10.1126/science.1186430

Yuki, K., Fujigoi, M., & Koutsgiannaki, S. (2020). Covid-19 pathophysiology: A review. Clinical Immunology, 215(108427), 108427. https://doi.org/10.1016/j.clim.2020.108427

Zhang, H., Shen, Z., Liu, S., Yuan, D., & Miao, C. (2021). Ping pong: An exergame for cognitive inhibition training. International Journal of Human–Computer Interaction, 37, 1–12. https://doi.org/10.1080/10447318.2020.1870826

Zheng, Y.-Y., Ma, Y.-T., Zhang, J.-Y., & Xie, X. (2020). Covid-19 and the cardiovascular system. Nature Reviews. Cardiology, 17, 1–2. https://doi.org/10.1038/s41569-019-0294-y

Zhou, F., Yu, T., Du, R., Fan, G., Liu, Y., Liu, Z., Xiang, J., Wang, Y., Song, B., Gu, X., Guan, L., Wei, Y., Li, H., Wu, X., Xu, J., Tu, S., Zhang, Y., Chen, H., & Cao, B. (2020). Clinical course and risk factors for mortality of adult inpatients with covid-19 in Wuhan, China: A retrospective cohort study. The Lancet, 395(10229), 1054–1062. https://doi.org/10.1016/S0140-6736(20)30566-3

About the Authors

Akhila Sri Manasa Venigalla is a PhD Scholar in the Department of Computer Science & Engineering, pursuing her thesis in the areas of Software Engineering and Software Documentation, at IIT Tirupati, India. She is interested in the areas of End User Software Engineering, software systems for society and educational technologies.

Dheeraj Vagavolu was an undergraduate student in the Department of Computer Science & Engineering at IIT Tirupati, India, during the development and study of the game. He is interested in the research and development of approaches and systems in the areas of computers for society and software engineering.

Sriddhar Chimalakonda is an Assistant Professor in the Department of Computer Science & Engineering at IIT Tirupati, India and leads the Research in Intelligent Software & Human Analytics (RISHA) Lab, which works on pushing the boundaries of software engineering research and leverages the potential of computing for social good.