Design and rationale of an interactive serious game to teach Basic Life Support among schoolchildren in Brazil.

Uri Adrian Prync Flato, Emilio José Beffa dos Santos, Isabella Bispo Diaz Toledo Martini, Vinicius Rossignoli, Thais Dias Midega, Lucas Kallas-Silva, Ricardo Ferreira Mendes de Oliveira, Adriana do Socorro Lima Figueiredo, Mario Vicente Guimarães, Hélio Penna Guimarães

Submitted to: JMIR Serious Games
on: December 09, 2023

Table of Contents

Design and rationale of an interactive serious game to teach Basic Life Support among schoolchildren in Brazil.

Uri Adrian Prync Flato[1]; Emilio José Beffa dos Santos[2]; Isabella Bispo Diaz Toledo Martini[2]; Vinicius Rossignoli[2]; Thais Dias Midega[1]; Lucas Kallas-Silva[3]; Ricardo Ferreira Mendes de Oliveira[3]; Adriana do Socorro Lima Figueiredo[4]; Mario Vicente Guimarães[1]; Hélio Penna Guimarães[1]

[1]Hospital Israelita Albert Einstein São Paulo BR
[2]Universidade de Marília Marília BR
[3]Faculdade Israelita de Ciências em Saúde Albert Einstein São Paulo BR
[4]Instituto Sanare São Paulo BR

Corresponding Author:
Uri Adrian Prync Flato
Hospital Israelita Albert Einstein
Av. Albert Einstein, 627/701
Morumbi
São Paulo
BR

Abstract

Background: Cardiovascular diseases are among the leading causes of death and morbidity in the world including in Brazil. Cardiopulmonary resuscitation (CPR) and early defibrillation increase the chances of survival. Serious Games (SG) are defined as learning and training tools that can be used to enhance the learning processes. It can be presented in several ways, using the game's characteristics as an entertainment factor to achieve educational objectives and specific skills. Current strategies focus on teaching people in the community and schoolchildren how to conduct CPR. The SG Children Save Hearts was developed to teach the five steps of resuscitation according to the guidelines of the International Liaison Committee on Resuscitation on Basic Life Support. Before being applied to schoolchildren for efficacy evaluation, it should go through a formative (Qualitative Usability Testing) assessment by game developers and health professionals. This parameter refers to the ease with which users can consume, learn, and interact with the system. Therefore, usability validation is a critical step in ensuring the effectiveness of the educational resources before introducing them to a specific population.

Objective: This study aims to discover and fix usability issues using a System Usability Scale (SUS).

Methods: The Serious game Children Save Hearts was developed on the Smile Game Builder platform (open source) and implemented on Windows 7 to 11 operating systems, targeting schoolchildren from 7 to 17 years old. The script and storytelling are based on the ILCOR 2020 guidelines. The game includes using a joystick and simple commands to simplify the user experience, allowing greater focus on the content. After finishing the SG, participants were invited to answer a survey of 10 questions regarding its usability on a Likert-type scale. A grade higher than 70 is considered acceptable to proceed to a minimum viable product. A sample size of 17 users was needed based on an estimated probability of encountering an error in the interface expressed as 10% to find 85% of the problems.

Results: The SG Children Save Hearts was applied to 17 volunteers, with a mean age of 22 years, and 47% were male. Regarding professional training, 8 (47%) were bachelor's in information technology, and 9 (53%) were nurses and doctors (health professionals). All participants played the game and answered the questionnaire at the end. The mean SUS score was 75 (Table 1). The mean score was 3.0. Questions 2 and 4 had the lowest score (2.0), and questions 7 and 9 had the highest. The game performed better on efficiency and error minimization criteria with healthcare professionals ($p<0,05$), with worse performance on memorization criteria. The average time spent in the game was 3.2 minutes, which was approximately 2 minutes to complete the questionnaire.

Conclusions: The SUS is a validated tool for usability tests and was selected for its practicality, ease of realization, and having been cross-culturally validated into Portuguese, that is, with discriminatory power of acceptability of implementation in Brazil. Active teaching methods were required to improve the chance of survival and translate accessible knowledge into practice.

Several cardiac awareness programs, such as Kids Save Lives and World Restart a Heart Day (WRAH), are currently underway to teach schoolchildren that CPR is vital to our future. Although the game has points to improve in its usability, it is considered adequate to be used in the teaching process of schoolchildren in cardiopulmonary resuscitation in Brazil.

(JMIR Preprints 09/12/2023:55333)
DOI: https://doi.org/10.2196/preprints.55333

Preprint Settings

1) Would you like to publish your submitted manuscript as preprint?

✓ **Please make my preprint PDF available to anyone at any time (recommended).**
Please make my preprint PDF available only to logged-in users; I understand that my title and abstract will remain visible to all users.
Only make the preprint title and abstract visible.
No, I do not wish to publish my submitted manuscript as a preprint.

2) If accepted for publication in a JMIR journal, would you like the PDF to be visible to the public?

✓ **Yes, please make my accepted manuscript PDF available to anyone at any time (Recommended).**
Yes, but please make my accepted manuscript PDF available only to logged-in users; I understand that the title and abstract will remain v
Yes, but only make the title and abstract visible (see Important note, above). I understand that if I later pay to participate in <a href="http

Original Manuscript

Design and rationale of an interactive serious game to teach Basic Life Support among schoolchildren in Brazil.

Uri Adrian Prync Flato[1,2], Emilio José Beffa dos Santos [3], Isabella Bispo Diaz Toledo Martins[3] Vinicius Rossignoli[3], Thais Dias Midega[1] , Lucas Kallas-Silva[2] , Ricardo Ferreira Mendes de Oliveira [2], Adriana do Socorro Lima Figueiredo[4], Mario Vicente Guimarães[1] , Helio Penna Guimarães[1]

1. Hospital Israelita Albert Einstein, São Paulo, SP, Brazil.
2. Faculdade Israelita de Ciências em Saúde Albert Einstein, São Paulo, SP, Brazil.
3. Universidade de Marília, Marília, SP, Brasil.
4. Instituto Sanare,São Paulo, SP, Brazil.

Corresponding Author: Uri Adrian Prync Flato

Hospital Israelita Albert Einstein, São Paulo, SP, Brazil.

Av. Albert Einstein, 627/701 - Morumbi, São Paulo zipcode 05652-900

Phone: 55 11 97585-8889

Email:uriflato@gmail.com

orcid.org/0000-0002-8381-8830

Introduction

Cardiovascular diseases are among the leading causes of death and morbidity worldwide [1, 2]. Cardiopulmonary resuscitation (CPR) and early defibrillation increase survival chances [3]. Serious Games (SG) are tools used to enhance the learning process through entertainment. Current strategies focus on teaching CPR to the community and schoolchildren [4].

While other games exist for teaching Basic Life Support (BLS), no studies have validated these for children in low-to-middle-income settings. The SG Children Save Hearts teaches the five resuscitation steps per International Liaison Committee on Resuscitation (ILCOR) guidelines. Before use in schools, it requires a formal usability assessment by game developers and healthcare professionals to ensure ease of use, learning, and interaction.

The primary objective was to evaluate the usability of SG Children Save Hearts among healthcare and Information Technology (IT) professionals using the *System Usability Scale* (SUS) [5], a validated usability assessment tool.

Methods

Ethical Considerations

The study protocol was approved by the ethics committee of the University of Marilia (Brazil) number CAAE: 57160121400005496. All participants signed an informed consent form.

Study design

We used a non-probabilistic casual sample to include participants in the area of IT and healthcare professionals. The usability test was conducted in August 2022 in the university's IT department after a 10-minute lecture on the SG's purpose. The SG Children Save Hearts was developed on the *Smile Game Builder* platform and implemented on Windows 7 to 11, targeting schoolchildren aged 7 to 17. The script and storytelling are based on the ILCOR 2020 guidelines. The game uses a joystick and

simple commands to simplify the user experience **(Multimedia Appendix 1)**. The design and testing process is illustrated in **Figure 1.**

Multimedia appendix 1: Serious Game screenshots and setup.

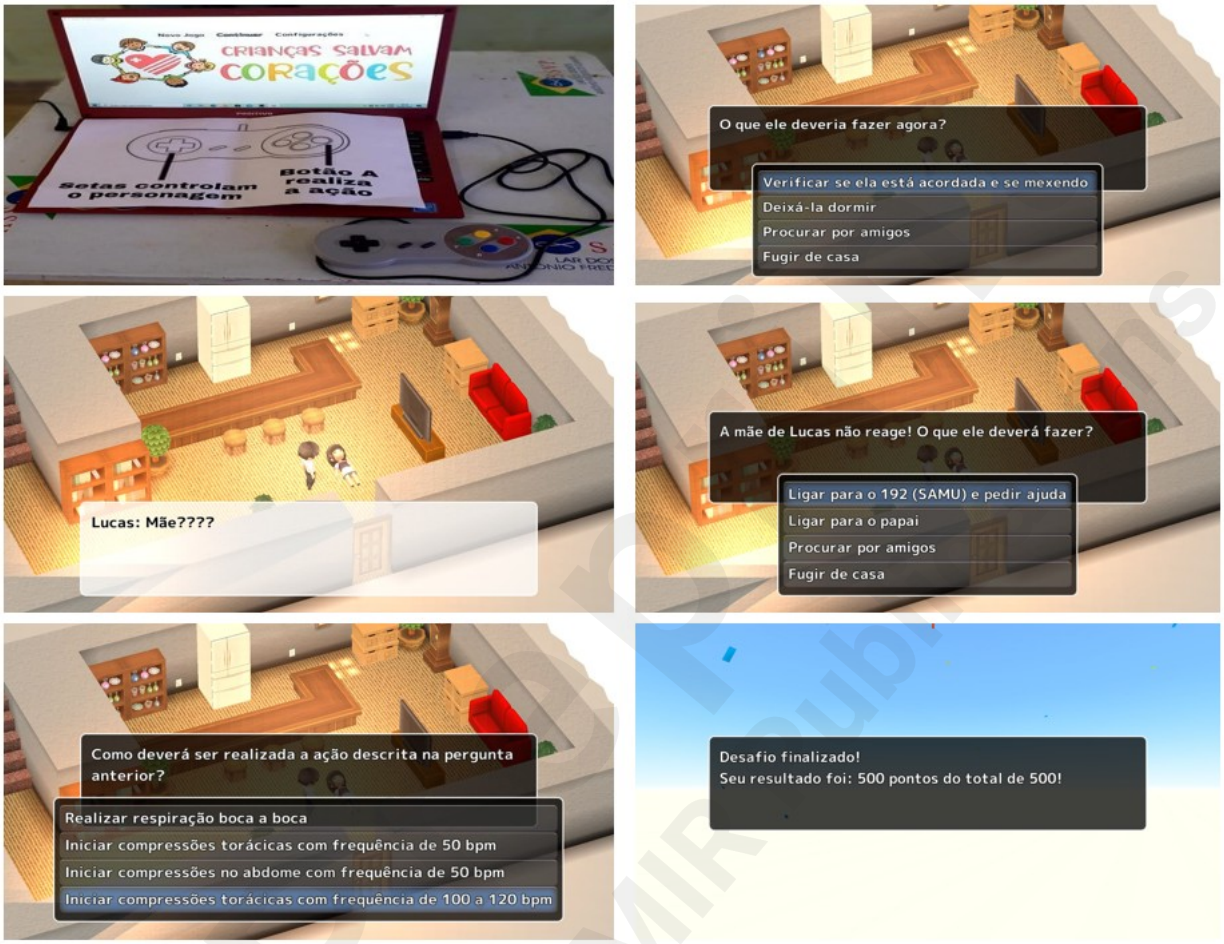


Figure 1-Design of Serious Game for teaching cardiopulmonary resuscitation among schoolchildren.

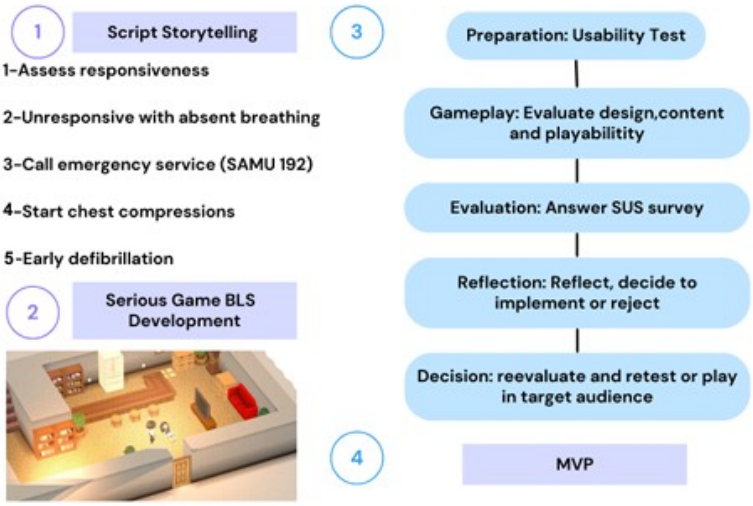


Figure 1-Design of Serious Game for teaching cardiopulmonary ressuscitation among schoolchildren. SUS: System Usability Scale; MVP: minimum viable product.

SUS: *System Usability Scale; MVP: minimum viable product.*

After completing the SG, participants answered a 10-question survey on its usability using a Likert-type scale. The final grade is converted to a 0 to 100 scale **(Multimedia Appendix 2)**. A grade above 70 is considered acceptable to proceed to a minimum viable product. A sample size of 17 users was required, based on a 10% estimated probability of encountering an interface error, to identify 85% of the problems.

Multimedia Appendix 2: SUS Questionnaire questions and domains

Item (a)	Questions
Q1	I think I'd like to use this system often
Q2	I find the system unnecessarily complex
Q3	I found the system easy to use
Q4	I think I would need help from a person with technical knowledge to use the system
Q5	I think the various functions of the system are very well integrated
Q6	I think the system has a lot of inconsistency
Q7	I imagine people will learn how to use this system quickly
Q8	I found the system cluttered to use
Q9	I felt confident when using the system
Q10	I had to learn several new things before I could use the system

Item	Domains (b)
Q3, Q4, Q7, Q10	Ease of learning
Q5, Q6, Q8	Efficiency
Q2	Ease of memorization
Q6	Minimization of errors
Q1, Q4, Q9	Satisfaction

(a) Questions applied in the System Usability Scale (SUS). In each question, the user rates their experience by means of a *Likert* scale, assigning grades from 1 to 5, with grade 1 corresponding to "strongly disagree" and grade 5 corresponding to "strongly agree". After a conversion based on SUS, each question assumes a score from 0 to 4, with the number 4 corresponding to the best performance. The scores of each question are added up and, at the end, multiplied by 2.5, resulting in a scale ranging from 0 to 100. (b) A group of questions form a domain in the SUS. SUS consists of 5 domains.

Statistical analysis

Categorical variables are presented as absolute and relative frequencies. Continuous variables are presented as median with interquartile range (IQR). Normality was assessed by the Shapiro-Wilk test. Comparisons were made between IT and healthcare professionals. Continuous variables were compared using independent *t* test (normal distribution) or Mann-Whitney U test (non-normal distribution). All analyses were performed using the R (version 4.1.0, 2021) software.

Results

The SG Children Save Hearts was applied to 17 volunteers, with a mean age of 22 years (IQR 20 - 26), and 8 (47%) were male. Regarding professional training, 8 (47%) were bachelor's in IT, and 9 (53%) were healthcare professionals. All participants played the game and answered the questionnaire. The mean SUS score was 75 (IQR 72.5 - 87.5) **(Table 1)**. Questions 2 and 4 had the lowest median score, and questions 7 and 9 had the highest. Healthcare professionals attributed higher grades to all 5 domains, when compared to IT professionals. The average time spent in the game was 3.2 minutes.

Table 1- Participants characteristics and System Usability Scale grading by profession

	All (n=17)	IT (n=8)	HP (n=9)	p*
Domains				
Age (median [IQR])	22.00 [20.00, 26.00]	21.00 [18.75, 22.75]	24.00 [22.00, 27.00]	0.074[a]
Male, n (%)	8 (47.1)	4 (50.0)	4 (44.4)	1.000[b]
Questions				
Q1 (median [IQR])	3.00 [3.00, 4.00]	3.00 [2.00, 3.25]	4.00 [3.00, 4.00]	0.077[a]
Q2 (median [IQR])	2.00 [2.00, 3.00]	2.00 [1.75, 3.00]	3.00 [2.00, 3.00]	0.466[a]
Q3 (median [IQR])	3.00 [3.00, 4.00]	3.00 [3.00, 4.00]	4.00 [3.00, 4.00]	0.359[a]
Q4 (median [IQR])	2.00 [2.00, 3.00]	2.00 [1.75, 2.25]	2.00 [2.00, 3.00]	0.609[a]
Q5 (median [IQR])	3.00 [3.00, 4.00]	3.00 [3.00, 3.00]	4.00 [3.00, 4.00]	0.072[a]
Q6 (median [IQR])	4.00 [3.00, 4.00]	3.00 [2.00, 3.25]	4.00 [4.00, 4.00]	0.002[a]
Q7 (median [IQR])	3.00 [3.00, 4.00]	3.00 [3.00, 3.00]	4.00 [4.00, 4.00]	0.009[a]
Q8 (median [IQR])	4.00 [3.00, 4.00]	3.00 [2.75, 3.25]	4.00 [4.00, 4.00]	0.025[a]
Q9 (median [IQR])	4.00 [3.00, 4.00]	3.00 [3.00, 3.25]	4.00 [4.00, 4.00]	0.030[a]
Q10 (median [IQR])	3.00 [3.00, 4.00]	3.50 [3.00, 4.00]	3.00 [3.00, 4.00]	0.677[a]
Analysis				
TOTAL (median [IQR])	30.00 [29.00, 35.00]	27.50 [25.50, 30.50]	34.00 [30.00, 35.00]	0.050[c]
SUS (median [IQR])	75.00 [72.50, 87.50]	68.75 [63.75, 76.25]	85.00 [75.00, 87.50]	0.050[c]
Ease of learning (Q3, Q4, Q7, Q10) (Median [IQR])	3.25 [2.75, 3.25]	3.00 [2.50, 3.25]	3.25 [2.75, 3.50]	0.540[c]
Efficiency (Q5, Q6, Q8) (Median [IQR])	3.67 [3.00, 4.00]	3.00 [2.50, 3.17]	4.00 [3.67, 4.00]	0.019[a]
Ease of memorization (Q2) (median [IQR])	2.00 [2.00, 3.00]	2.00 [1.75, 3.00]	3.00 [2.00, 3.00]	0.466[a]
Minimization of errors (Q6) (Median [IQR])	4.00 [3.00, 4.00]	3.00 [2.00, 3.25]	4.00 [4.00, 4.00]	0.002[a]
Satisfaction (Q1, Q4, Q9) (Median [IQR])	2.67 [2.67, 3.33]	2.67 [2.33, 2.83]	3.33 [2.67, 3.67]	0.078[a]

*P values were calculated using [a] Mann-Whitney U test, [b] Fisher test and c Two-sample Student's t-test. Values represent median interquartile range (IQR) or n/n total (%).IT: Information Technology Professionals; HP: Healthcare Professionals. US: System Usability Score.

Discussion

The SG Children Save Hearts was developed to teach BLS to schoolchildren. When tested on 17 IT

and healthcare professionals, it achieved an overall SUS score of 75, suitable for implementation.

Novel technologies like Virtual Reality (VR) have been successfully used in Europe to teach CPR to schoolchildren [6]. However, transferring this technology to developing countries faces challenges, such as language barriers, VR device acquisition, cultural context, and technical support . Previous SGs for CPR teaching were developed and tested in first-world settings [7]. Educational strategies for teaching CPR in developing countries have focused on healthcare professionals and students [8], not schoolchildren, highlighting a significant gap in the literature. This is the first SG developed in Brazil in Portuguese for schoolchildren.

Our study has some limitations. First, we had a small sample size due to insufficient data to calculate sample size in usability tests and financial constraints in contracting a Software House. Continuous usability monitoring with larger sample sizes is needed to maintain external validation. Further studies should target schoolchildren to assess the effectiveness of teaching BLS in schools and explore user experiences to gain insights into how users feel about the SG.

Active teaching methods are crucial to improving survival rates and translating accessible knowledge into practice. Programs like Kids Save Lives [9] and World Restart a Heart Day [10] are teaching schoolchildren that CPR is vital. Despite some usability issues, the game is adequate for testing in schoolchildren.

Acknowledgments

We would like to thank the University of Marília for the use of their facilities and resources. We also thank the participants for their time and dedication to our study.

Funding Statement

Not applicable.

Data Availability

Due to the nature and design of this study, the raw data supporting our findings cannot be made publicly available. The data set contains detailed information that could compromise the privacy and confidentiality of the participants involved. Protecting participant confidentiality is a priority for us, and thus, in adherence to ethical considerations and participant consent agreements, we are unable to deposit our data in publicly accessible repositories or present it within the manuscript or supplementary files.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Author Contributions

This study was conducted with the collaboration of the following authors, who contributed significantly to various aspects of the work:

Uri Adrian Prync Flato: Conceptualization, Methodology, Software, Validation, Formal analysis,

Investigation, Resources, Data Curation, Writing - Original Draft, Visualization, Supervision, Project administration, Funding acquisition.

Emilio José Beffa dos Santos: Conceptualization, Validation, Investigation, Resources, Writing - Review & Editing, Visualization, Supervision.

Isabella Bispo Diaz Toledo Martins: Software, Validation, Formal analysis, Data Curation, Writing - Review & Editing.

Vinicius Rossignoli: Software, Validation, Investigation, Data Curation, Writing - Review & Editing.

Thais Dias Midega: Methodology, Validation, Investigation, Resources, Data Curation, Writing - Review & Editing, Visualization.

Lucas Kallas-Silva: Writing – Original Draft, Review & Editing, Supervision.

Ricardo Ferreira Mendes de Oliveira: Writing – Original Draft, Review & Editing, Supervision.

Adriana do Socorro Lima Figueiredo: Validation, Formal analysis, Investigation, Resources, Data Curation, Writing - Original Draft.

Mario Vicente Guimarães: Methodology, Software, Validation, Investigation, Writing - Review & Editing.

Helio Penna Guimarães: Conceptualization, Methodology, Writing - Original Draft, Project administration.

Abbreviations

CPR: Cardiopulmonary Resuscitation

SG: Serious Games

BLS: Basic Life Support.

ILCOR: International Liaison Committee on Resuscitation

IT: Information Technology

HP: Healthcare Professionals.

SUS: System Usability Scale.

MVP: Minimum Viable Product

Multimedia Appendix 1: SUS Questionnaire questions and domains

Declaration of Generative AI and AI assisted technologies in the writing process.

The authors did not use AI to create this manuscript.

MULTIMEDIA APPENDICES

Multimedia appendix 1: Serious Game screenshots and setup.

Multimedia Appendix 2: SUS Questionnaire questions and domains

REFERENCES

1. Tsao CW, Aday AW, Almarzooq ZI, et al. Heart Disease and Stroke Statistics-2023 Update: A Report From the American Heart Association. Circulation 2023;147(8):e93-e621. (In eng). DOI: 10.1161/CIR.0000000000001123.
2. Oliveira GMM, Brant LCC, Polanczyk CA, et al. Cardiovascular Statistics - Brazil 2020. Arq Bras

Cardiol 2020;115(3):308-439. (In eng|por). DOI: 10.36660/abc.20200812.

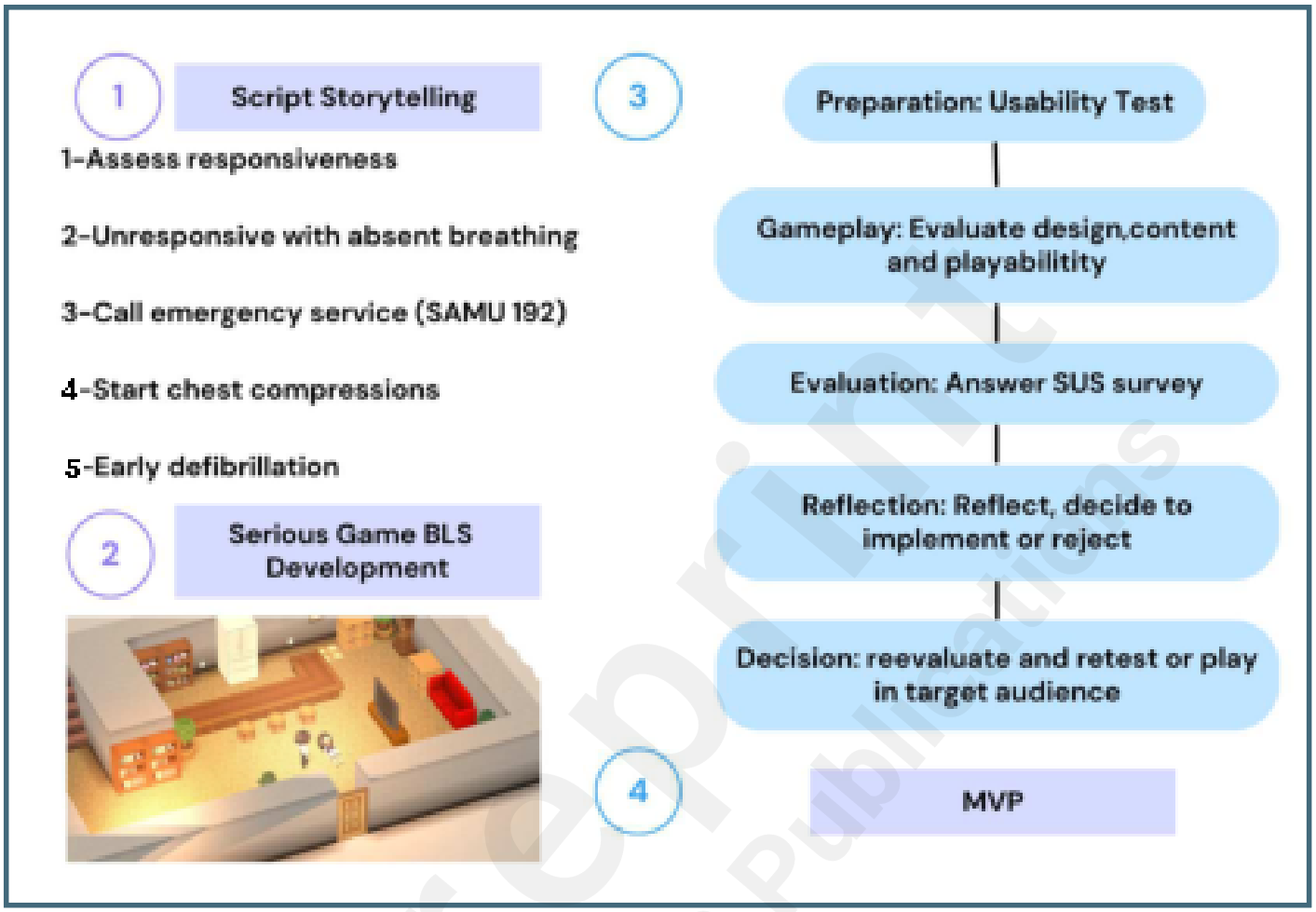
3. Wyckoff MH, Greif R, Morley PT, et al. 2022 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science With Treatment Recommendations: Summary From the Basic Life Support; Advanced Life Support; Pediatric Life Support; Neonatal Life Support; Education, Implementation, and Teams; and First Aid Task Forces. Circulation 2022;146(25):e483-e557. (In eng). DOI: 10.1161/CIR.0000000000001095.
4. Berglund A, Jaarsma T, Berglund E, Strömberg A, Klompstra L. Understanding and assessing gamification in digital healthcare interventions for patients with cardiovascular disease. Eur J Cardiovasc Nurs 2022;21(6):630-638. (In eng). DOI: 10.1093/eurjcn/zvac048.
5. Bangor A, Kortum, P. T., Miller. Determining what individual SUS scores mean: Adding an adjective rating scale. Journal of Usability Studies 2009;4(3):114-123.
6. Yeung J, Kovic I, Vidacic M, et al. The school Lifesavers study-A randomised controlled trial comparing the impact of Lifesaver only, face-to-face training only, and Lifesaver with face-to-face training on CPR knowledge, skills and attitudes in UK school children. Resuscitation 2017;120:138-145. (In eng). DOI: 10.1016/j.resuscitation.2017.08.010.
7. Cheng, P. *et al.* (2024) 'The effects of serious games on cardiopulmonary resuscitation training and education: Systematic review with meta-analysis of randomized controlled trials', *JMIR Serious Games*, 12. doi:10.2196/52990.
8. Siqueira, T.V. *et al.* (2020) 'The use of serious games as an innovative educational strategy for learning cardiopulmonary resuscitation: An Integrative Review', *Revista Gaúcha de Enfermagem*, 41. doi:10.1590/1983-1447.2020.20190293.
9. Nakagawa NK, Salles IC, Semeraro F, Bottiger BW. KIDS SAVE LIVES: a narrative review of associated scientific production. Curr Opin Crit Care 2021;27(6):623-636. DOI: 10.1097/MCC.0000000000000872.
10. Horriar L, Rott N, Semeraro F, Böttiger BW. A narrative review of European public awareness

initiatives for cardiac arrest. Resusc Plus 2023;14:100390. (In eng). DOI: 10.1016/j.resplu.2023.100390.

Supplementary Files

Figures

Design of Serious Game for teaching cardiopulmonary resuscitation among schoolchildren. SUS: System Usability Scale; MVP: minimum viable product.



Multimedia Appendixes

Serious game screenshots and setup.
URL: http://asset.jmir.pub/assets/a74cfac12d7792d4147b693e74c4357a.pptx

SUS Questionnaire questions and domains (a) Questions applied in the System Usability Scale (SUS). In each question, the user rates their experience by means of a Likert scale, assigning grades from 1 to 5, with grade 1 corresponding to "strongly disagree" and grade 5 corresponding to "strongly agree". After a conversion based on SUS, each question assumes a score from 0 to 4, with the number 4 corresponding to the best performance. The scores of each question are added up and, at the end, multiplied by 2.5, resulting in a scale ranging from 0 to 100. (b) A group of questions form a domain in the SUS. SUS consists of 5 domains.
URL: http://asset.jmir.pub/assets/6c7434731b8cb3ced5dcaa7ce31ba643.docx