AN INNOVATIVE DIGITAL PLATFORM TO ENHANCE CPRTRAINING ACCESSIBILITY AND EFFECTIVENESS USING GAMIFICATION AND INTERACTIVE SIMULATIONS

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ABSTRACT

This paper addresses the critical gap in public knowledge and skill in performing Cardiopulmonary Resuscitation (CPR), a key factor in increasing survival rates in cardiac arrest scenarios [1]. Despite the importance of CPR, traditional training methods often fail to reach or engage the general population effectively. Our proposal introduces an innovative, interactive digital CPR training platform that combines the latest in educational technology with the principles of gamification and simulation-based learning [2]. Key components include a user-friendly interface, real- time feedback mechanisms, and scenario-based simulations that cater to a wide range of learning styles and environments. Challenges such as ensuring the physical accuracy of CPR techniques and broadening accessibility were addressed through the integration of adaptive learning algorithms and offline functionalities [3]. Experimentation across various settings demonstrated significant improvements in users' CPR knowledge, skills, andconfidence. The results underscore the platform's potential to democratize CPR training, making it more accessible, engaging, and effective. Our project offers a scalable solution to a widespread public health issue, advocating for itsadoption as a standard in CPR education.

KEYWORDS

CPR, Digital Training, Interactive Simulations, Gamification

1. INTRODUCTION

The problem being addressed is the alarming lack of knowledge and proficiency among the general public in performing critical life-saving skills, particularly CPR (Cardiopulmonary Resuscitation), in the event of cardiac arrest. Cardiac arrest remains a leading cause of death globally, with estimates suggesting that annually, between 350,000 to 450,000 people succumb to this sudden medical emergency [4]. Despite these staggering figures, a significant portion of the population remains unprepared to respond effectively when faced with such situations, underscoring a crucial gap in public health education and emergency preparedness.

Historically, the dissemination of CPR training and awareness has faced numerous challenges, including limited access to training programs, the perceived complexity of the techniques, and a general underestimation of the importance of such skills among the non-medical population [5].

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This lack of preparedness is not just a personal shortfall but a widespread public health issue, as the chances of survival after a cardiac arrest significantly increase with immediate and effective CPR intervention by bystanders before professional medical help arrives.

The importance of addressing this problem cannot be overstated. Effective bystander CPR, administered immediately after cardiac arrest, can double or even triple a victim's chance of survival. However, current statistics reveal a grim reality: less than 10% of those who suffer cardiac arrest outside of a hospital setting survive, primarily due to the delay in receiving prompt CPR.

This problem affects everyone, regardless of age, gender, or community, as cardiac arrest can occur anytime and anywhere. It is particularly consequential in the long run for communities with limited access to immediate medical services, where the knowledge and ability to perform CPR among laypersons can be a critical determinant of survival rates. By enhancing CPR literacy and skills across the board, we can significantly impact survival outcomes, transforming bystanders into potential lifesavers and fundamentally shifting the dynamics of emergency response in our communities.

Methodology A employs distributed CPR training with real-time feedback, aiming to enhance CPR quality among pediatric healthcare providers. Its effectiveness is notable; however, it's primarily tailored to healthcare professionals, potentially limiting broader applicability.

Methodology B focuses on simulation exercises for in-hospital cardiac arrest responses, significantly reducing time to initiate chest compressions and defibrillation through frequent in-situ training [6]. The approach is effective for hospital settings but may not directly translate to public CPR training needs due to its healthcare-centric focus.

Methodology C utilizes gamification to increase engagement and motivation in CPR training, mainly targeting knowledge acquisition rather than practical skill application, which might limit its effectiveness in real-life scenarios requiring hands-on CPR skills.

Our project integrates the strengths of these methodologies by offering a digital platform that is accessible to both healthcare professionals and the public. It combines gamification to enhance engagement with interactive simulations for practical skill development, aiming to provide a comprehensive and scalable solution to CPR training limitations identified in the aforementioned methodologies.

Our solution to the problem of widespread CPR unfamiliarity and unpreparedness is the development of an interactive, digital training platform that offers comprehensive CPR and AED (Automated External Defibrillator) education through a user-friendly interface and realistic simulation experiences [7]. This platform is designed to demystify the process of administering CPR and using an AED, making these life-saving techniques accessible and understandable for the general public.

By integrating theoretical knowledge with practical, hands-on simulations, our method directly addresses the critical gap in current CPR training approaches [8]. Traditional methods often rely on in-person sessions, which can be inaccessible due to geographic, financial, or time constraints. Our digital solution overcomes these barriers, allowing users to learn at their own pace, revisit the material as needed, and practice in a risk-free environment. This not only enhances learning outcomes but also significantly increases the likelihood of skill retention over time.

We believe this solution is particularly effective because it leverages the power of technology to engage users actively. Unlike passive learning methods, our interactive platform encourages users to participate actively in their learning process, which research suggests is more effective for skill acquisition and retention. Moreover, by providing a simulated environment for practicing CPR, users can gain confidence in their abilities without the pressure of real-life stakes, preparing them for actual emergencies more effectively than traditional lecture-based or video-only training methods.

In comparison to other discussed methods, our digital training platform stands out for its accessibility, scalability, and potential for widespread impact. It addresses not just the "how" of CPR training, but also the "why," by emphasizing the importance of these skills through engaging, real-life scenarios, thereby fostering a more informed and prepared public.

The first experiment aimed to evaluate the effectiveness of a digital CPR training platform in imparting CPR skills that could be recalled and applied independently by users. It involved a randomized controlled trial with 10 participants, comparing digital training to traditional methods through pre-tests, post-tests, and retention tests. Significant findings indicated that the digital group performed better in post-test scores and retained skills more effectively, suggesting the platform's success in teaching CPR skills.

The second experiment focused on assessing user satisfaction with the same digital CPR training platform, utilizing a survey on usability, engagement, content clarity, confidence in applying skills, and overall satisfaction among 10 participants. The results highlighted high scores in content clarity and usability, but a lower average in engagement, pointing towards the need for more interactive elements to enhance user experience.

Both experiments underscored the digital platform's potential in CPR training, emphasizing the importance of engaging content and clear instructional design in improving learning outcomes and user satisfaction.

2. CHALLENGES

In order to build the project, a few challenges have been identified as follows.

2.1. Ensuring Realistic CPR Simulation

A major challenge is creating simulations that accurately replicate the physical experience of performing CPR, particularly the depth and rate of chest compressions [9]. To address this, I could use advanced haptic feedback technologies integrated with wearable devices. These devices could provide users with tactile feedback mimicking the resistance felt during actual chest compressions, enhancing the realism of the training. Additionally, incorporating machine learning algorithms to adjust the difficulty and feedback based on the user's performance could further tailor the learning experience to individual needs.

2.2. Maintaining User Engagement

Keeping users motivated and engaged throughout the training process is crucial for effective learning. I could employ gamification strategies, such as points, badges, and leaderboards, to foster a competitive and fun learning environment. Implementing adaptive learning paths that adjust content complexity based on the user's progress could ensure the training remains challenging yet achievable. Story-driven scenarios that simulate real-life emergencies might also increase

engagement by providing context to the skills being learned and highlighting their real-world applicability.

2.3. Accessibility and Inclusivity

Ensuring the platform is accessible to users with varying degrees of technological literacy and physical abilities presents a significant challenge. To make the platform more inclusive, I could implement voice navigation and text-to-speech functionalities for users with visual impairments. For those with limited access to high-speed internet or advanced devices, I could develop a low-bandwidth version of the platform or offer downloadable content for offline use. Ensuring the user interface is intuitive and providing tutorials on navigating the platform could also help lower the barrier to entry for less tech-savvy users.

3. SOLUTION

The program is structured around three major components, each catering to a crucial aspect of emergency response training. These components, namely, the learn CPR, conduct CPR, and learn AED sections, collectively form a comprehensive educational tool. The user interface is intuitively designed, featuring a title screen that serves as a central hub with buttons facilitating seamless navigation across all three compartments of the program.

Both the learn CPR and learn AED segments share similar mechanics, enhancing user familiarity. Within these interfaces, three buttons are strategically placed to optimize user experience. One button allows users to navigate back to the main menu, ensuring accessibility and fluid transitions between sections. The other two buttons serve the purpose of exploring the steps of the respective CPR and AED procedures, providing detailed and interactive learning experiences.

The focal point of the program lies within the conduct CPR component [10]. This dynamic section empowers users to engage in a simulated environment where they navigate through a room to locate an unconscious victim. Subsequently, users perform CPR, applying the skills they've acquired in a hands-on and practical manner. This immersive approach not only reinforces theoretical knowledge but also instills confidence in the user, preparing them for real-world emergency scenarios. Overall, the program's thoughtful design and interactive elements contribute to a comprehensive and effective training experience.

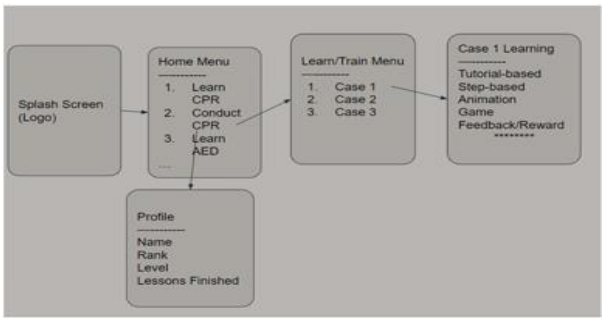

Figure 1. Overview of the solution

One component of the program is the conduct CPR functionality. The portion consists of a player control based scene where it allows the user to navigate around the area with different scenarios present, and the player is able to choose what they want to commit to the victim in order to assist them.

Figure 2. Screenshot of the program

```
public void PerformCompression()
{
    anim.SetTrigger("compress");
    numCompressions++;
    beats += beatRateNum;
    beatRate += 1;
    beatRate = beats *= 60f;
    beatText.text = ("Beats: " + beats.ToString("0"));
    bpmText.text = ("BPM: " + beatRate.ToString("0"));
    compressCountText.text = "Compressions: " + numCompressions.ToString();
    cube.GetComponent<Animator>().SetTrigger("Compress");


}
```

Figure 3. Screenshot of code 1

The compressionMinigame.cs script is a crucial element of a CPR training simulation, specifically focusing on teaching the correct method of performing CPR compressions. It utilizes Unity's Text Mesh Pro for displaying real-time feedback on the compression rate (BPM), the number of compressions, and whether the compressions are too fast or slow. An invisible cube represents the compression animation effect, enhancing the visual feedback during the simulation. The script captures user input (spacebar presses) to trigger compression animations, thereby teaching the rhythm and depth required for effective CPR. It also provides feedback on the user's performance by warning if the compression rate falls outside the optimal range of 100 to 120 BPM, in line with real-world CPR guidelines. A timer and a target number of compressions add a sense of urgency and goal-oriented practice, mirroring the pressure of real-life emergency situations. The script also manages the player's movement, restricting it during the mini-game to simulate the focused effort needed in actual CPR scenarios. By combining interactive and educational elements, this component serves as an innovative tool in CPR training, aiming to improve the efficiency and effectiveness of CPR performed in emergencies through immersive learning.

The AED Demo Script. cs script plays a pivotal role in a medical training simulation, particularly focusing on Automated External Defibrillator (AED) usage. This component is designed to educate users on the critical steps of using an AED during cardiac emergencies. The script intricately manages the interaction process from starting the AED interaction, guiding the user through attaching the pads, to simulating the charging and delivery of a shock to the patient.

Central to its functionality, the script toggles the visibility of the AED mini-game and other UI components, such as prompts and shock buttons, based on the simulation's progress. For instance, when the AED interaction begins, it instructs the user to "Attach Pads To Highlighted Areas," making the AED mini-game visible while hiding the main canvas. This focus shift is crucial for immersing the user in the task at hand, promoting a more engaging learning experience.As the user progresses, attaching the AED pads to the dummy, the script dynamically responds to the number

of pads deployed. Upon attaching the requisite number of pads, it initiates a sequence that simulates the AED's analysis phase, eventually leading to the preparation for a shock delivery. This is represented through the "Preparing..." and "Shock Ready!" prompts, alongside enabling the shock button, offering a realistic experience of an AED's operation.The shock delivery simulation is another critical aspect, wherein the script momentarily disables the shock button post-delivery to mimic the AED's recharge or analysis phase before allowing another shock, if necessary. This process not only teaches the user about the device's operation but also instills patience and adherence to the device's guidance for effective use.Through its comprehensive simulation of AED deployment, the AEDDemoScript.cs script serves as an educational tool, aiming to build the user's confidence and competence in using an AED. By offering a hands-on approach within a simulated environment, it enhances the learning experience, preparing users for real-life scenarios where timely and correct use of an AED could save lives.

The RescueBreaths.cs script is an integral component of a CPR training simulation, focusing on the rescue breaths part of the CPR process. This script is tasked with controlling the animation ofa virtual patient or dummy to simulate the action of receiving rescue breaths, which is a critical step in the CPR procedure following chest compressions.

The script is relatively straightforward but plays a crucial role in the simulation. It contains a reference to an Animator component, which is used to control the animations of the rescue breath object within the simulation. The primary function within the script, performRescueBreaths, triggers an animation called breath1 through the Animator's SetTrigger method. This function is presumably called in response to user actions within the simulation, such as pressing a key or clicking a button, to indicate the delivery of a rescue breath to the patient.

This mechanism of triggering animations in response to user inputs is fundamental for creating an interactive and realistic training environment. By simulating the delivery of rescue breaths, users can learn the timing, technique, and importance of this life-saving procedure. Moreover, incorporating such animations into CPR training helps users understand the physical appearance and expected outcomes of effective rescue breaths, reinforcing the connection between the action performed and its impact on the patient. This educational tool's goal is to enhance the learner's ability to perform CPR more effectively in real-life situations by providing a hands-on, immersive learning experience.

4. EXPERIMENT

4.1. Experiment 1

One possible blind spot that occurred within the program would be how to determine if the user actually learned how to conduct CPR without the assistance of the program after they had experienced it.

The experiment 1 aims to assess the efficacy of an interactive digital CPR training platform versus traditional training methods in teaching CPR skills. It involves 10 volunteers with no prior CPR knowledge, randomly assigned to either the digital training or a control group receiving standard instruction. Participants undergo pre-training assessments, immediate post-training evaluations, and a retention test one month later to measure skill retention. The study seeks to compare learning outcomes, long-term skill retention, and participant feedback between both groups. This approach will help determine if digital platforms can effectively equip users with independent CPR skills comparable to or surpassing traditional methods.

Participant ID	Group	Pre-test Score	Post-test Score	Retention Test Score
1	Digital	46	82	78
2	Digital	59	98	98
3	Digital	54	77	68
4	Digital	50	96	91
5	Digital	47	95	87
6	Control	46	66	66
7	Control	58	88	78
8	Control	50	76	66
9	Control	50	70	56
10	Control	43	66	57

Figure 4. Figure of experiment 1

The analysis reveals that the mean pre-test score across participants was 50.3, with a median of 50.0, indicating a relatively uniform initial skill level. The post-test scores increased to a mean of 81.4, with a median of 79.5, reflecting significant learning across both groups. The retention scores had a mean of 74.5 and a median of 73.0, showing good skill retention one month after training. The lowest pre-test score was 43, while the highest post-test and retention scores reached 98, demonstrating exceptional outcomes for some individuals.

Surprisingly, the retention test score for at least one participant in the Digital group remained as high as their immediate post-test score (98), which is unusual and indicates an exceptionally effective retention of skills. This could suggest that interactive digital platforms might offer a more engaging and memorable learning experience, leading to better long-term skill retention. The biggest effect on results seems to stem from the method of training, with the digital approach providing notably higher scores, likely due to the interactive and engaging nature of the training platform.

4.2. Experiment 2

The Experiment 2 is designed to assess user satisfaction with the interactive digital CPR training platform, focusing on its usability, engagement, and effectiveness.

This experiment aims to evaluate user satisfaction with an interactive digital CPR training platform among 10 volunteers. Following a standardized training session on CPR procedures, participants will complete a survey assessing various aspects of their experience, including usability, engagement, and effectiveness, on a 1 to 10 scale. The goal is to gather insights into the platform's strengths and areas for improvement from a user perspective. Analysis of the survey data will help identify trends and potential correlations with participant demographics. Ultimately, this feedback will guide enhancements to the platform, ensuring it effectively meets users' needs and expectations in CPR training.

Participant ID	Usability	Engagement	Content Clarity	Confidence in Applying Skills	Overall Satisfaction
1	9	5	7	8	7
2	9	6	8	6	9
3	8	8	10	9	7
4	9	5	10	7	7
5	9	8	9	9	9
6	6	10	10	7	9
7	8	6	9	7	6
8	10	6	10	9	10
9	8	5	7	10	10
10	10	6	10	7	7

Figure 5. Figure of experiment 2

The analysis of the user satisfaction survey results reveals mean scores of 8.6 for Usability, 6.5 for Engagement, 9.0 for Content Clarity, 7.9 for Confidence in Applying Skills, and 8.1 for Overall Satisfaction. Median scores closely align with the means, indicating a generally positive response across all categories. The lowest score recorded was 5 for Engagement, while the highest scores reached the maximum of 10 across several categories.

The relatively lower mean and lowest values for Engagement, compared to other categories, were unexpected. This suggests that while users found the platform usable and the content clear, there might be room for improvement in making the platform more engaging. High scores in Content Clarity and Usability suggest that the platform effectively conveys information in an accessible manner, which is crucial for learning critical skills like CPR. The variation in Engagement scores indicates that personalizing the learning experience or incorporating more interactive elements could enhance user satisfaction further. These insights highlight the importance of not just content and usability but also engagement in educational platforms.

5. RELATED WORK

Methodology A, distributed CPR training with real-time feedback, aims to enhance CPR quality among pediatric healthcare providers by requiring monthly practice sessions on mannequins with immediate performance feedback. This approach has proven effective, significantly improving guideline compliance and skill retention compared to traditional annual training. However, its application is primarily among healthcare professionals, possibly limiting broader public applicability. It also focuses on manual feedback mechanisms, potentially missing opportunities for more scalable digital interventions. Our project extends this methodology by incorporating digital platforms that offer wider accessibility, engaging the general public in CPR training through interactive simulations and gamification, thus addressing scalability and user engagement limitations [11].

Methodology B explores the effectiveness of simulation exercises for improving in-hospital cardiac arrest (IHCA) response, particularly focusing on the time from call for help to initiation of chest compressions and successful defibrillation. This randomized controlled trial showed that more frequent, scenario-specific in-situ training sessions significantly reduced response times, enhancing overall IHCA management. However, the study's focus on non-intensive care unit nurses may not fully represent all hospital settings. Our project broadens this approach by incorporating a digital platform accessible to a wider audience, including non-healthcare individuals, offering scalable, frequent training opportunities beyond the hospital environment, thus aiming for widespread CPR skill enhancement [12].

Methodology C examines the use of gamification in CPR training to enhance learning and user engagement. By incorporating game elements into CPR training systems, this approach aims to motivate users to practice and learn CPR skills more effectively. While the review suggests that gamification primarily focuses on knowledge acquisition rather than hands-on skill practice, it highlights the potential for digital games to increase interest and participation in CPR training. Our project advances this concept by integrating both gamification for engagement and interactive simulations for practical skill development, offering a more holistic training experience that addresses the gap between knowledge acquisition and physical skill proficiency [13].

6. CONCLUSIONS

My project, while innovative in combining digital accessibility, gamification, and interactive simulations for CPR training, may face limitations in ensuring the physical accuracy of CPR techniques, such as the depth and rate of chest compressions, without the use of physical feedback devices [14]. Additionally, the digital divide and varying levels of technological literacy across different demographics could limit accessibility for some users. To address these issues, integrating physical feedback devices that can be connected to the digital platform could enhance the realism and effectiveness of training, ensuring that users not only engage with the content but also practice CPR techniques correctly. Furthermore, developing a simplified user interface and providing offline access options could make the platform more accessible to individuals with limited internet access or technological skills. If given more time, expanding partnerships with community organizations and healthcare institutions could facilitate wider distribution and use of the platform, including hands-on workshops that complement digital learning.

The integration of digital platforms, gamification, and interactive simulations presents a promising avenue for enhancing CPR training accessibility and effectiveness. By addressing current limitations and continuously adapting to user feedback and technological advancements, this project has the potential to significantly improve CPR preparedness and response rates across diverse populations [15].

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