Arab American University

Faculty of Graduate Studies

A Comparison between Immersive Virtual Reality Heart Saver and Standardized Heart Saver Training amongst Non-Health Science Students.

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This thesis was submitted in partial fulfillment of the requirements for the Doctoral degree in Philosophy of Nursing.
May /2024

Thesis Approval

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Declaration

I am Mohammad Faisal Mohammad Al-Ali, ID student No. 202012566 authorize Arab American University and Jacksonville University to provide copies of my PhD thesis to libraries, institutions, or individuals upon their request according to the regulations of AAUP and Jacksonville University. I also granted that I had adhered to the university's laws, regulations, instructions, and decisions related to the preparation of my dissertation, in a manner consistent with the scientific integrity recognized in writing scientific dissertations.

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Dedication

I humbly dedicate this thesis as an earnest act of charity to the noble countenance of the Highest, and to our beloved Prophet Muhammad, peace and blessings be upon him, whose guidance has illuminated my path. It is my heartfelt tribute to the brave souls of Palestine who have sacrificed their lives for a just cause, and I offer this work as an enduring charity for the eternal rest of the martyrs Ziad Al-Amer, Aysar Al-Amer, Ayham Al-Amer, Nidal Alamer, Mahmoud AlAmer and Ahmad Al-Amer.

In the deepest chambers of my heart, I dedicate this thesis to my parents Faisal and Khitam, the unwavering pillars of my life, who have nurtured me with boundless love and unfailing support. To my beloved wife, Safaa, whose patience, love, and encouragement have sustained me through the long hours and countless challenges of this journey. And to my precious children, Faisal and Bilasan, who have witnessed my dedication and have been my driving force, your faith in me is my greatest motivation.

To my brothers and sisters, your solidarity and encouragement have been my constant source of strength. Your unwavering belief in my abilities has carried me through every obstacle.

In an extraordinary way, I dedicate this work to my dear cousins, Ahmed Al-Amer, and Mohammad Al-Amer, and my friends; Khaled Al-Khloof and Esam Fahmawi. Your steadfast support, guidance, and shared enthusiasm have been invaluable.

My deepest gratitude extends to the entire Al-Amer family for their steadfast support during this arduous journey. Your unwavering faith in me has been a source of inspiration. To each member of the Al-Amer family, this dedication is a symbol of my profound appreciation.

With profound emotions and heartfelt gratitude

Acknowledgment

I extend my heartfelt acknowledgments to Dr. Ahmed Al-Smadi and Dr. Ahmed Awais for their unwavering guidance, mentorship, and commitment as my thesis supervisors. Your invaluable support and continuous dedication to my academic journey have been instrumental in shaping this research.

I am deeply indebted to Dr. Raed Areqat and Dr. Safa'a Al-Alashram for their unwavering support, encouragement, and insightful consultations throughout this undertaking. Your belief in my capabilities and your guidance have been a driving force behind the success of this project.

My sincere thanks extend to the entire radio team at Arab American University for their exceptional support during the early stages of project preparation. Special appreciation goes to Ms. Heba Al-Jazarah, Ms. Mona Saba'neh and Mr. Mohammed AlArmoti, for their contributions and unwavering commitment.

I must express my gratitude to Engineer Dima and Engineer Sami for their collaboration and dedication while working alongside Dr. Ahmed Awais in preparing the program. Your technical expertise and unwavering support have been instrumental in bringing this vision to life.

Furthermore, I wish to acknowledge the invaluable assistance provided by the NLN and the AHA tools in my study. Their cutting-edge technology and resources have significantly enhanced the quality and depth of my research.

In conclusion, I am deeply grateful to each and every person who has contributed to this endeavor, directly or indirectly. Your support has been the cornerstone upon which this work was built. May this acknowledgment serve as a small token of my appreciation for your enduring assistance and belief in my academic pursuits.

With heartfelt gratitude

ABSTRACT

Background: The rising incidence of sudden cardiac death highlights the need for more effective Cardiopulmonary Resuscitation then use the abbreviation CPR training. Standardized CPR training methods face significant challenges in accessibility, engagement, knowledge and skill retention, Further issues are compounded in regions like Palestine with unique barriers. Recently, the new immersive virtual reality (IVR) technology utilized and employed in CPR learning has shown its promising effectiveness due to its realistic simulations by allowing learners to experience a variety of situations that they might not otherwise encounter. The IVR leads to higher levels of learner motivation, interest, and engagement, which is crucial for learning complex emergency procedures like CPR. Moreover, learner's active participation in training process enhances knowledge retention and skill acquisition rather than standardized learning methods; hence, this necessitates further research to explore IVRs potential to enhance knowledge, skills, and decision-making in emergency CPR situations.

Aim: To examine differences in knowledge, performance, satisfaction, and self-confidence between the immersive virtual reality heart-saver group and the standardized heart-saver group amongst non-health students at Arab American University in Palestine.

Methods: This study employed a randomized controlled trial (RCT) design to compare the differences between the immersive virtual reality heart-saver training and the standardized heart-saver training among non-health science students at the Arab American University in Palestine. The study conducted from July to December 2023, with a focus on enhancing CPR knowledge, skill performance, satisfaction and self-confidence, in which 200 participants were randomly assigned to either the experimental IVR group or the control group undergoing standardized training. Data analysis was conducted using SPSS version 25, incorporating tests like independent t-tests, chi-square, and repeated measures ANOVA.

Results: Participants demonstrated substantial improvement in CPR knowledge from pre-test to post-test, with the IVR HS group’s scores rising from 2.79±2.01 pre-test to 8.40±1.01 post-test and the Standardized group from 2.57±2.11 to 8.21±1.37, but there was no significant difference in the rate of improvement between the two groups. Performance (chi-square value = 15.674, df = 1, p = 0.001) significantly differed between groups. Performance evaluations showed 85% of IVR HS participants passing, compared to 60% in the standardized group. Satisfaction and self-confidence levels showed no statistically significant differences between the groups. Although there were few differences based on demographic and academic variables, the results showed minimal impact on outcomes, such as single participants in the IVR group reported higher knowledge gains.

Conclusion: The study confirmed that immersive virtual reality heart-saver training effectively improves CPR performance among non-health science students, compared to standardized heart-saver training. The IVR-based learning showed promise for non-health science student preparation, that put emphasis on the importance of further exploration and adoption of IVR in educational settings to enhance emergency preparedness. The study recommends integrate HS with a curriculum of non-health science to provide evidence for policymakers to develop policies integrating HS training for non-health science students and non-medical institutes, leading to improved patient outcomes, decreased mortality rate and decreased hospital costs.

Keywords: Immersive Virtual Reality, Cardiopulmonary Resuscitation, Non-health Science Students, heart savers, Palestine.

Table of Content

Contents

List of Tables

List of Figures

List of Abbreviations

No.	Abbreviations	Meaning
1	AHA	American Heart Association
2	CPR	Cardiopulmonary Resuscitation
3	AED	Automated external Defibrillator
4	AED	Automated electrical Defibrillator
5	VR	Virtual Reality
6	IVR	Immersive Virtual Reality
7	VPL	Virtual Program Lab
8	CVDs	Cardiovascular Diseases
9	HS	Heart Saver
10	CSU-ALS	Cardiac Surgical Unit Advanced Life Support
11	HFS	High Fidelity Simulation
12	LSSCL	Learning Satisfaction and Self-confidence in Learning
13	NLN	National League for Nursing
14	ACLS	Advance Cardiac Life Support

15	BLS	Basic Life Support
16	AI	Artificial Intelligence
17	RCT	Randomized Control Trail
18	IT	Information Technology
19	SPSS	Statistical Package for Social Science

Chapter One: Introduction

This chapter introduces the topic related to the immersive virtual reality and show up the differences between immersive virtual reality (IVR) and standardized heart-saver (HS) training among non-health science students. It outlines the global challenge of cardiovascular diseases (CVD) and the limitations of current cardiopulmonary resuscitation (CPR) training methods. The chapter highlights the potential of IVR, which enhances training outcomes and sets the stage for investigating its effectiveness in improving knowledge, skills, satisfaction, and confidence in CPR training. This investigation seeks insights that could significantly impact CPR training practices, particularly in regions facing unique challenges like Palestine. Moreover, there are several differences between IVR heart-saver training and standardized HS training methods. The standardized HS training instruction typically involves classroom-based lectures, hands-on practice on mannequins, and instructor feedback compared to the IVR heart-saver training that involves a computerized generated system using oculus, and the feedback provided by IVR system (Sundbom, 2022). On the other hand, IVR heart-saver training leverages advanced technology to provide learners with a realistic interactive simulations of emergencies in virtual environments (Sundbom, 2022). This approach allows participants to engage in lifelike scenarios and critical decision making under pressure, which allows them to receive immediate live feedback on their performance (Ricci et al., 2022). Additionally, IVR heart-saver training can be tailored to various skill levels and learning objectives, offering a more personalized and engaging learning experience compared to standardized CPR instruction (Sundbom, 2022).

1.1. Background

Claiming around 18 million lives annually, CVDs are considered to be the leading cause of death worldwide (World Health Organization, 2021). The prevalence of CVD differs in terms of demography due to various factors including lifestyle, socioeconomic status, and healthcare infrastructure (World Health Organization, 2021). For instance, high-income countries often report higher rates of CVDs due to sedentary lifestyles and unhealthy diets, while low- and middle-income countries may experience rising rates due to urbanization and shifts in lifestyle habits (Schutte et al., 2021). While specific data is very limited, CVDs remain a significant public health concern. Limited access to healthcare services, ongoing political conflicts, and socioeconomic challenges may impact both prevalence of CVDs and survival rates (Jilani et al., 2021). The importance of immediate and effective bystander CPR during cardiac emergencies should be taken into consideration. Recognition and rapid response for CPR could boost survival rates from approximately 10% to 30% (World Health Organization, 2021; Perkins et al., 2020). In addition to their significance, the standardized delivery methods of Heart Saver Training, which includes CPR, AED use, and basic first aid, face significant limitations regarding accessibility, engagement, and knowledge retention (Smith et al., 2020; Andersen et al., 2019).

The accessibility challenge is evident, with rural and underserved areas often lacking the resources and facilities necessary for standardized training (Andersen et al., 2019). Furthermore, engagement levels during training are critical for effective learning. Standardized methods may not fully engage participants, leading to lower retention rates of the life-saving skills taught. A study (Smith et al., 2020) demonstrated that only a small percentage of people feel confident in their CPR abilities after being trained with more immersive and interactive training methods. Thus, the retention of CPR knowledge and skills over time is concerning. Research indicates a significant decline in cognitive and psychomotor skills within 3-12 months after training, suggesting that current training methods may not be sufficient for long-term skill retention (Andersen et al., 2019).

The statistics reveal that although CPR training is widespread, the actual application of these skills in real-life emergencies remains low. A study by Blewer et al. (2018) found that less than half of those experiencing out-of-hospital cardiac arrests receive CPR from bystanders, highlighting a gap between training and real-world application. In light of these challenges, there is a pressing need for innovative approaches that address these shortcomings, hence the enhancement of effectiveness of heart-saver training_ ensuring that more trainees of CPR and AED use and can apply these skills confidently in emergencies.

Introducing IVR technology in medical education, especially Heart Saver Training, marks a significant shift from conventional training methodologies. IVR's interactive and immersive learning environments offer enhanced engagement, deeper understanding of complex procedures, and the ability for learners to practice skills in a safe and controlled setting. The technology's potential for transforming CPR training is particularly promising, as evidenced by increasing research interest and experimental applications (Khan et al., 2019; Liaw et al., 2020).

The ability of IVR to significantly increase learner engagement underlines its effectiveness in medical training. Studies have shown that IVR can lead to higher levels of student motivation and interest than standardized learning methods, with engagement rates up to 30% in some cases (Freina & Ott, 2015). This heightened engagement is crucial for learning complex emergency procedures like CPR, where the learner's active participation in the training process enhances knowledge retention and skill acquisition. Moreover, IVR allows for the visualization of complex concepts in a way that standardized methods cannot, leading to improved understanding and retention of information. A systematic review by Kyaw et al. (2019) highlighted that students used VR technologies in their learning achieved a 40% improvement in learning outcomes over those who used conventional training tools. The ability to repeatedly practice procedures in a virtual environment without the risk of harm further solidifies learners' competencies and confidence. A study by Semeraro et al. (2017) demonstrated a notable improvement in CPR skill retention among participants trained with VR, with a 25% increase in correct procedure execution observed during follow-up assessments.

The application of IVR in heart-saver training presents a unique advantage by simulating realistic emergency scenarios, allowing learners to experience a variety of situations that they might not otherwise encounter. This prepares individuals well for real-life emergencies and addresses the challenge of limited access to hands-on practice with physical equipment or live volunteers. Research by Barsom et al. (2020) showed that learners who underwent IVR-based CPR training felt more prepared and were significantly more willing to perform CPR in actual emergencies, with a reported willingness increase of up to 15% compared to those trained through standardized methods. These findings highlight IVR's transformative potential in medical education, particularly in enhancing heart-saver training. By leveraging IVR technology, educators can offer more effective, engaging, and accessible CPR training, equipping a wider audience with the essential skills to respond confidently to cardiac emergencies.

In Palestine, the critical need for innovative and effective heart-saver and first aid training is accentuated by the region's health statistics and unique contextual challenges based on the Palestine Red Crescent Society report. They had improvement in knowledge with 71.41% (Amro

& Qtait, 2017). CVDs do not only lead as a primary cause of death but also significantly impact the public health infrastructure and emergency response capabilities within the region. The Palestinian Ministry of Health (2019) reported that nearly 30% of all deaths are attributable to CVDs conditions cardiac arrests contributed significantly in high mortality rates. Such figures reveal a dire public health landscape where timely and effective intervention means life or death (Salah et al., 2020). CPR responses show barriers particularly among non-health communities even in healthcare provider facilities in emergency situations (Lestari et al., 2021).

The incidence of cardiac arrests in Palestine further highlights the urgency for widespread CPR training. Research by Jamee Shahwan et al. (2019) points to mortality rate of cardiac arrests that underscores a significant public health crisis, with cardiac arrests accounting for a substantial portion of the mortality rate, translating to a stark figure of approximately 32.4 deaths per 100,000 residents. This data does not only reflect the acute burden of CVDs but also call for immediate and innovative approaches to enhance the community's response to cardiac emergencies. Moreover, The IVR's capacity to overcome these geopolitical and socioeconomic challenges surrounding Palestine by providing accessible, engaging, and efficient training could be particularly beneficial in the Palestinian context, where standardized training methods may be impractical or insufficient.

The potential impact of IVR on heart-saver training in Palestine is further supported by the technology's proven benefits in other regions. Studies have demonstrated that IVR can significantly improve learning outcomes, skill retention, and learner confidence in CPR training (Barsom et al., 2020; Bench et al., 2019). By simulating various emergency scenarios in a controlled virtual environment, IVR can allow Palestinian learners to practice and refine their skills without the constraints of physical resources or the immediate pressures of real-life emergencies.

This approach addresses the accessibility and engagement challenges associated with standardized CPR training, offering a scalable and effective solution to improve emergency response capabilities across the region.

Given these considerations, adopting IVR for heart-saver training in Palestine could be a pivotal step toward improving public health outcomes and emergency response preparedness. The technology's ability to provide high-quality, immersive training experiences falls on it to equip a larger Palestinian population with the skills needed to respond effectively to cardiac emergencies, potentially reducing mortality rates and enhancing community resilience against CVDs.

Despite the promising potential of IVR in revolutionizing heart-saver training, there remains a notable research gap, particularly concerning its comparative effectiveness against standardized training methods among non-health science students worldwide, especially in Palestine. such demography, which typically lacks prior health-related training, represents a crucial target group for emergency response training, given the general population's widespread need for CPR skills. Studies in other contexts have begun to address this research gap. Yet, the specific needs and challenges faced by non-health science students have not been adequately explored (Barsom et al., 2020; Hubail et al., 2022). The existing literature on the use of IVR in medical education underscores its benefits in enhancing learning outcomes including increased engagement, better knowledge retention, and improved skill proficiency (Khan et al., 2019; Liaw et al., 2020). However, these studies often focus on healthcare professionals or students within the health sciences, leaving a gap in our understanding of IVR's impact on laypersons or non-health science students who might encounter cardiac emergencies in everyday life. Palestine's distinct socioeconomic and educational landscape, which may affect the adoption and efficacy of novel training methodologies like IVR (Nas et al., 2019; Kim & Cho, 2023), emphasize on the need for empirical research to close this gap.

Moreover, the long-term retention of CPR skills acquired through IVR training, a critical factor in the preparedness to respond to real-life emergencies, remains insufficiently studied within this context. While IVR has been shown to improve immediate learning outcomes and skill acquisition, its efficacy in ensuring that individuals retain these lifesaving skills over time and can apply them effectively in emergencies has yet to be thoroughly investigated, particularly among non-health science students (Dordevic et al., 2023; Artero et al., 2023). Furthermore, the research conducted thus far has primarily been limited to high-income countries, with little attention given to regions like Palestine, where different socio-cultural, economic, and infrastructural factors might impact the feasibility and effectiveness of implementing IVR-based training programs (Liu et al., 2023; Issleib et al., 2021). This oversight highlights the critical need for context-specific research that considers Palestine's unique challenges and opportunities, ensuring that the findings are relevant and can be effectively applied to improve Heart Saver Training outcomes in the region.

1.2. Problem statement

The rising prevalence of CVDs, which are currently the leading cause of death worldwide, poses a severe threat to the global health landscape. Alarmingly, these diseases claim nearly 18 million lives annually, underscoring the urgent need for effective public health interventions to mitigate this crisis (World Health Organization, 2021). Amidst this pressing health concern, the critical role of bystander-administered cardiopulmonary resuscitation (CPR) during cardiac emergencies becomes increasingly paramount. Research indicates timely and proficient CPR can significantly enhance survival rates, elevating them from a mere 10% to upwards of 30% in out-of-hospital cardiac arrests (OHCA) (Perkins et al., 2020; Meier et al., 2023). This data underscores the indispensable value of comprehensive Heart Saver Training programs, which aim to educate the public in CPR and using Automated External Defibrillators (AEDs) and basic first aid to bolster the community's emergency response capabilities.

Despite the evident importance of these training programs, standardized delivery methodologies—characterized by direct instruction and hands-on practice—face significant limitations that impede their overall effectiveness. These challenges include restricted accessibility to training opportunities, diminishing engagement among participants, and, notably, a rapid decline in the retention of essential knowledge and skills (Smith et al., 2018; Andersen et al., 2019). For instance, studies have illustrated that without regular refresher sessions, the competency in CPR skills among trained individuals significantly deteriorates within a few months following the initial training (Semeraro et al., 2017; Omlor et al., 2022). This decline in skill retention potentially compromises their ability to act effectively during real-life emergencies. Furthermore, standardized training settings often fail to replicate the high-stress conditions typical of actual cardiac emergencies, thus limiting the preparedness of individuals to respond optimally when confronted with such situations (Barsom et al., 2020; Hubail et al., 2022). This gap between training and real-world application accentuates the pressing need for innovative CPR education approaches to overcome these barriers, ensuring that life-saving skills are retained and effectively employed when most needed.

In Palestine, the urgency to enhance heart-saver training is underscored by the region's alarmingly high incidence of CVDs, which are recognized as a leading cause of mortality, accounting for nearly 30% of all deaths (Palestinian Ministry of Health, 2019). This grave statistic reflects a significant public health emergency, emphasizing the need for effective CPR training programs. The notably high mortality rate from cardiac arrests in the territory further signals an acute public health crisis necessitating immediate action (Jamee Shahwan et al., 2019; Salah et al., 2020). The particular socioeconomic and geopolitical difficulties that Palestine faces, which prevent the widespread adoption of practical CPR training throughout the region, exacerbate these worries.

The prevailing limitations of conventional heart-saver Training methods in Palestine—marked by scalability challenges and the difficulty of accurately simulating emergency scenarios—pose considerable obstacles to effective training delivery. Standardized training approaches often fall short in providing the immersive experience required to adequately prepare individuals for the high-stress conditions characteristic of actual cardiac emergencies. Additionally, the accessibility of these conventional training programs is significantly limited by logistical and infrastructural constraints, hindering a large segment of the population from accessing this critical education. These issues are especially pronounced in regions with restricted healthcare facility access or within communities isolated due to the region's complex geopolitical context.

Consequently, an urgent demand exists for innovative training techniques to overcome these limitations, offering scalable, accessible, and realistic CPR training solutions. Pursuing such advanced training methods is not just an educational endeavor but a crucial public health strategy imperative for Palestine. Successfully addressing this need can improve the community's ability to respond to cardiac emergencies efficiently, thereby saving lives and reducing the overall burden of CVDs within the region (Palestinian Ministry of Health, 2019; Jamee Shahwan et al., 2019).

IVR technology stands at the forefront of educational innovation, offering an engaging and interactive learning platform that has demonstrated considerable promise in enhancing learner engagement and facilitating the understanding of complex concepts. By creating a simulated environment that allows for immersive and interactive experiences, IVR technologies provide an opportunity for repeated practice in a controlled, risk-free setting (Semeraro et al., 2017; Khan et al., 2019). This is particularly advantageous in the context of Heart Saver Training, where IVR's capability to replicate diverse and realistic emergency scenarios offers a substantive improvement over standardized methods, eliminating the need for physical equipment or the participation of live volunteers (Bench et al., 2019; Liaw et al., 2020). Such an innovative approach to training is poised to revolutionize the landscape of medical education, particularly in critical areas like CPR training, by enabling a more effective and engaging learning process.

However, despite the recognized potential of IVR in transforming medical education, there remains a significant gap in the research, especially concerning its comparative effectiveness against standardized training methodologies among non-health science students. While studies like those conducted by Semeraro et al. (2017) and Khan et al. (2019) have begun to explore the utility of IVR in medical training contexts, they predominantly focus on specific subsets of learners, such as medical professionals or students within healthcare disciplines, leaving a noticeable void in understanding its impact on broader, non-specialist populations. Furthermore, research exploring the application of IVR in Heart Saver Training, such as those by Bench et al. (2019) and Liaw et al. (2020), while pioneering, often do not address critical factors such as long-term skill retention, learner confidence post-training, and the readiness of participants to employ these skills in real-world scenarios. This oversight highlights a need for comprehensive studies that compare IVR with standardized training methods in diverse learner demographics and evaluate these training outcomes within specific and challenging contexts, such as Palestine.

Concentrating on non-health science students within Palestine highlights an essential aspect of a comprehensive public health approach. These students come from a wide array of disciplines, including engineering, arts, and computer science, comprising a significant segment of society that stands to gain from and contribute to emergency medical responses. Including these students in Heart Saver Training programs extends CPR knowledge across a broader section of the population and introduces varied capabilities into emergency situations. Evidence indicates that delivering CPR instruction to students outside of health sciences increases preparedness and resilience against cardiac emergencies throughout the community (Salah et al., 2020; Jamee Shahwan et al., 2019). Incorporating CPR training within the educational programs of non-medical students can enhance emergency response effectiveness on a larger scale. This inclusive educational strategy is in line with international health guidelines, which call for comprehensive CPR training that involves the entire community, beyond the confines of healthcare professions (Palestinian Ministry of Health, 2019).

This research gap is particularly critical given the urgency of improving CPR training outcomes in regions with high CVDs prevalence and mortality rates. Existing literature primarily focuses on healthcare professionals or health sciences students in high-income countries, leaving a void regarding IVR's impact on laypersons or non-health science students who are equally likely to encounter cardiac emergencies (Barsom et al., 2020; Hubail et al., 2022). Moreover, the long-term retention of CPR skills acquired through IVR training and their practical application in real-life emergencies remains inadequately explored within Palestine. This oversight underscores the necessity for targeted empirical research to evaluate IVR's efficacy in enhancing knowledge acquisition, and skill proficiency, among non-health science students in Palestine.

Failure to address this research gap could perpetuate the existing challenges in CPR training, limiting the potential to enhance the emergency response capabilities of the broader population in Palestine. Without empirical evidence supporting the effectiveness of IVR in CPR training for non-health science students, opportunities to leverage technology to improve public health outcomes remain unrealized. Consequently, the public's preparedness to respond to cardiac emergencies could continue to be compromised, potentially negatively impacting survival rates.

Moreover, the proposed study found a gap by evaluating the differences between the IVR-based heart saver CPR training program against standardized methods among non-health science students at the Arab American University in Palestine. By focusing on this context and population, the study seeks to contribute valuable insights into the potential of IVR in CPR training. This investigation is poised to inform global educational strategies and health policy decisions, aiming to enhance emergency response preparedness and reduce mortality rates from cardiac arrests in Palestine and beyond.

1.3. Significance of the study

The exploration of immersive virtual reality (IVR) in heart-saver training, particularly in comparison to standardized training methodologies, holds profound implications for a broad spectrum of stakeholders involved in healthcare, emergency response, and medical education. This study's evidence-based findings could catalyze a paradigm shift in how CPR training is approached, with significant benefits extending across various domains.

Medical educators and training institutions are considering integrating a transformative tool into their pedagogical repertoire. The potential of IVR to augment engagement, enhance comprehension, and bolster skill retention in CPR training has been highlighted in prior research (Semeraro et al., 2017; Khan et al., 2019). If This study validates IVR's effectiveness, it will encourage curriculum innovation by substantiating these benefits within the Palestinian context. Such advancements may lead to the development of more interactive and more effective training programs in preparing learners to apply CPR under pressure, thereby bridging the gap between theoretical knowledge and practical application.

Non-health science communities and healthcare professionals, particularly those specializing in emergency medicine, may benefit from the study's outcomes. The validation of IVR as an effective tool for CPR training could motivate non-health science communities and healthcare providers to engage in periodic IVR-based refresher courses, ensuring their CPR skills remain at the forefront of best practices. This is critical in community sittings such as schools, universities, trade markets, as well as emergency departments, where proficiency and confidence in performing CPR can significantly impact patient outcomes. Additionally, these findings could empower healthcare professionals involved in community outreach, enabling them to implement more effective community training programs thereby, amplifying the reach of their life-saving skills beyond standardized medical settings.

For non-health science students and the broader public, the adoption of IVR for CPR training represents a significant leap forward. With laypersons frequently acting as initial responders in cardiac emergencies, an accessible, immersive training platform could dramatically improve their response efficacy. The empowerment of these individuals through innovative training methods like IVR enhances community resilience and emergency response capabilities, aligning with studies that have documented a rise in confidence and willingness to perform CPR among similarly trained individuals (Barsom et al., 2020; Hubail et al., 2022).

Concerning the heart-saver administration to school and university curriculum, this study will help the policymakers and public health authorities to set a policy according to heart-saver program for the non-health community. the findings of this study may offer a solid evidence base to inform and shape public health strategies and policies. Demonstrating the effectiveness and efficiency of IVR in CPR training can make a compelling case for allocating resources toward more innovative and technologically advanced training methods. Such strategic investment could encompass procuring VR equipment and developing and disseminating VR content explicitly tailored for CPR training. Moreover, the successful implementation of IVR-based training programs could serve as a model for other regions grappling with similar challenges, thereby setting a precedent for leveraging technology to enhance public health outcomes on a broader scale.

In addition, if the IVR is shown to be more effective, students will be more satisfied usually younger ages. This generation of students may be more interested in using new technology related to training. Moreover, the immersive virtual reality may be more convenient and easier to access knowledge and practice since it no longer needs lectures, transportation of heavy equipment, and reservation for an area or place to apply the heart-saver training. It's significant that the study's new program is effective, which will reduce the cost, time, and number of instructors in the future in this field, increasing the number of trainees within a short time. Therefore, this may make the heart-saver wider spread implementation everywhere in community settings.

Furthermore, Palestine's socio-economic and geopolitical realities compound the challenges of implementing effective CPR training programs. Issues such as restricted access to healthcare facilities, limited resources for health education, and the logistical difficulties of organizing widespread training sessions underscore the need for adaptable and scalable training solutions like IVR.

In summary, this study's significance transcends its immediate context, offering insights and evidence that could fundamentally alter the landscape of CPR training globally. By providing a rigorous assessment of IVR's potential benefits across different stakeholder groups. This study highlights the need for innovative approaches to medical education. It underscores the potential of technology to save lives in emergencies.

1.4. The aim of the study

This study examines differences in knowledge, performance, satisfaction, and self-confidence between the immersive virtual reality heart-saver group and the standardized heart-saver group amongst non-health students at Arab American University in Palestine.

1.5. Research Question

1.5.1. Is there an association between demographic academicals details and study groups?

1.5.2. What is the pre-training knowledge related to heart-saver among non-health science students at Arab American University in Palestine?

1.5.3. Are there differences in knowledge, performance, satisfaction, and self-confidence between the immersive virtual reality heart-saver group and the standardized heart-saver group among non-health students at Arab American University in Palestine?

1.6. Theoretical definitions of the study variables

For this study, the following terms were defined: Concerning the study variables, the following theoretical definitions are defined:

1.6.1. Knowledge: has been defined as cognitive recognition of cardiopulmonary resuscitation during the assessment of the victim, as well as, understanding and comprehending specific information, concepts, and procedures (Hiebert & Lefevre, 1986). In the context of CPR training, this encompasses awareness of the signs of cardiac arrest, familiarity with the steps for performing CPR, and the ability to correctly use an automated external defibrillator (AED). According to the American Heart Association's (AHA) recommendations to use heart-saver components for non-healthcare providers (Association, 2006a).

1.6.2. Performance: refers to the degree of achieving objectives or the possible accomplishment, and the ability to execute the physical tasks associated with CPR, including assessing responsiveness, activating emergency services, performing chest compressions and ventilations, and correctly using an AED (Association, 2006b; Spears, 1983).

1.6.3. Satisfaction is defined as the degree of contentment or pleasure derived from the training experience, reflecting the learner's overall evaluation of the program's quality and relevance (DeYoung, 2009). Additionally, this perception is linked to increased student engagement and motivation in the learning process, as motivated students perform better in the classroom (Baptista et al., 2014).

1.6.4. Self-confidence in the context of CPR training is theoretically defined as the learner's belief in their ability to effectively perform CPR in an emergency situation. This self-confidence is crucial for ability to judge and translating knowledge and skills into action during critical moments(Jeffries, 2005; Wood, 1991; Al Khasawneh et al., 2021; Costa et al., 2019).

1.7. Operational definitions of the study variables

For this study, the following terms were defined: Concerning the study variables, the following operational definitions are defined:

1.7.1. Knowledge: The operation of knowledge involves the understanding based on the American Heart Association's (AHA) recommendations for non-healthcare providers utilizing the heart-saver exam, the American Heart Association (AHA) recommends that participants take pre- and post-training tests with multiple-choice questions to gauge their understanding of CPR and AED usage principles (Association, 2006a; Hiebert & Lefevre, 1986). Heart saver adult CPR and AED knowledge was evaluated using ten items out of a 25-item multiple choice; these items related to heart saver adult CPR and AED were used by the AHA for non-healthcare providers as a test for their knowledge toward the heart saver course (Association, 2006a).

1.7.2. Performance: The operational definition of performance is based on evaluating these skills using the Adult Skills Testing Checklist developed by the AHA. This checklist provides a structured method to observe and score the accuracy and appropriateness of each participant step during simulated CPR scenarios, categorizing their performance as pass or fail. It comprises six items: checking responsiveness, activating the emergency response system, checking breathing and pulse, performing adult compression, attaching the AED, following the AED instructions, and returning to perform CPR (Association, 2006b; Spears, 1983). This operational definition is consistent with my research to evaluate participants' non-health science student skill performance using the AHA HS Adult CPR and AED skills testing checklist for both groups. The performance evaluation chick list was used the same for the IVR HS and standardized HS training but in different technique. However, the way to measure performance in the IVR group was using computer generating software system sensing the specific items that request based on AHA criteria as the same criteria was used for the standardized and recorded the performance for each trainee. However, the performance evaluation used for the standardized HS training in a traditional way based on AHA criteria by the evaluator to evaluate and observe manually using the checklist of the trainees' performance.

1.7.3. Satisfaction: Operationally, satisfaction is measured using surveys or questionnaires that solicit participant feedback on various aspects of the training, including the instructional materials, the realism of the simulations, and the perceived usefulness of the training for real-world applications. These instruments often employ Likert scale ratings to quantify participants' satisfaction levels (DeYoung, 2009; Baptista et al., 2014). The Learner Satisfaction and Self-Confidence in Learning (LSSCL) process, which developed by Nation League for Nursing (NLN) in 2011 (NLN, 2011), evaluated the operation of self-confidence. It consists of 13 items divided into two subscales: student satisfaction (5 items) and self-confidence (8 items), rated on a 5-point Likert scale—total scores for the satisfaction subscale range between 5 and 25. The ranking of scores from lower to average (medium) to higher scores indicates greater satisfaction (Al Khasawneh et al., 2021). The scale measures the non-health science students' participation satisfaction using the student satisfaction and self-confidence subscales of Learner Satisfaction in Learning (LSSCL).

1.7.4. Self-confidence: Operationally, self-reported measures assess self-confidence, and participants rate their confidence in their CPR skills before and after training. These measures typically include statements related to the perceived readiness to perform CPR, the comfort level with the skills learned, and the likelihood of initiating CPR in an emergency, rated on a Likert scale (Jeffries, 2005; Wood, 1991; Al Khasawneh et al., 2021; Costa et al., 2019). The Learner Satisfaction and Self-Confidence in Learning (LSSCL) process, which NLN developed in 2011, evaluated the operation of self-confidence. It consists of 13 items divided into two subscales: student satisfaction (5 items) and self-confidence (8 items), rated on a 5-point Likert scale—total scores for the confidence subscale range between 8 and 40. The ranking of scores from lower to average (medium) to higher scores indicates greater self-confidence. This scale is consistent with my research to evaluate the student self-confidence of participants by using the non-health science student satisfaction and self-confidence subscale from Self-Confidence in Learning (LSSCL).

1.7. Summary

This study investigates the differences of immersive virtual reality (IVR) for heart-saver training against standardized methods, focusing on non-health science students at Arab American University in Palestine. This chapter summarized the backdrop of CVDs being a leading cause of mortality globally and the critical role of timely CPR in saving lives, this research aims to transform CPR training with IVR technology. It explores IVR's potential to enhance learning retention, engagement, and confidence in performing CPR, addressing the challenges faced by standardized training methods in realism and accessibility. The study seeks to contribute to educational strategies, inform healthcare policies, and improve emergency response preparedness and outcomes in Palestine and beyond by evaluating IVR's impact on knowledge acquisition, skill development, and learner confidence compared to conventional training.

Chapter Two: Literature review

2.1. Introduction

This chapter explores other researches relevant to the study's objectives and research questions. It highlights the current study's exploration the differences between the IVR heart-saver training and the standardized HS training. Moreover, this chapter show up the current study's exploration into effectiveness of IVR in CPR training as solid basis. Through a systematic examination of prior studies, the literature review aims to identify gaps in knowledge, performance, satisfaction, and self-confidence in order to establish a context for the present research, and offer insights into the potential benefits and limitations of VR technology and standardized method in CPR education.

At its core, the literature review seeks to synthesize and analyze the findings, methodologies, and theoretical frameworks of previous studies on VR, and standardized-based CPR training by examining a range of scholarly works including randomized controlled trials, systematic reviews, and pilot studies. The review aims to uncover trends, contradictions, and areas requiring further investigation in the field. This synthesis not only informs the direction of the current study but also contributes to the broader discourse surrounding innovative approaches to CPR education.

Furthermore, the literature review establishes a clear connection between the existing body of knowledge, specific objectives and research questions of the present study. By critically evaluating the strengths and limitations of prior research, the review highlights gap or inconsistencies that the current study seeks to address. Moreover, providing a rationale for the chosen methodology, justifies the research design, and frames the hypotheses within the context of previous findings.

Ultimately, the literature review serves as a guiding framework for understanding the significance of the study's contribution to the field of CPR education.

2.2. Searching strategy

The search strategy aims to identify relevant studies on the effectiveness of VR compared to standardized method in CPR training. This search used different data bases, among which are the most related to the topic was searched; PubMed, Scopus, Web of Science, and PsycINFO databases were systematically searched using a combination of keywords and Boolean operators. These included terms such as "virtual reality," "immersive virtual reality," "non-immersive virtual reality," "CPR training," "cardiopulmonary resuscitation," and variations of study designs like "randomized controlled trial" and "quasi-experimental." The search strategy was designed to capture studies published between 2014 and January 2024, conducted in English, and subjected to peer review.

Following the initial search, 723 studies were retrieved across the selected databases. After article screening, there were about 112 articles that underwent abstract screening; however, this research excluded 14 articles due relevance. On the other hand, 98 were deemed eligible for full-article screening. During the full-article screening phase, studies were assessed against the inclusion criteria. Only articles meeting all inclusion criteria, including being peer-reviewed, written in English, and employing quantitative methodologies such as experimental randomized controlled trials (RCTs) or quasi-experimental designs, were retained.

After applying rigorous inclusion criteria, a total of 35 studies were deemed suitable for final inclusion in the literature review. These studies spanned from 2014 to January 2024 and provided valuable insights into the efficacy of VR in CPR training among various target populations including laypersons and healthcare students. The systematic search and screening process ensured selecting high-quality, relevant studies in order to address the research objectives effectively.

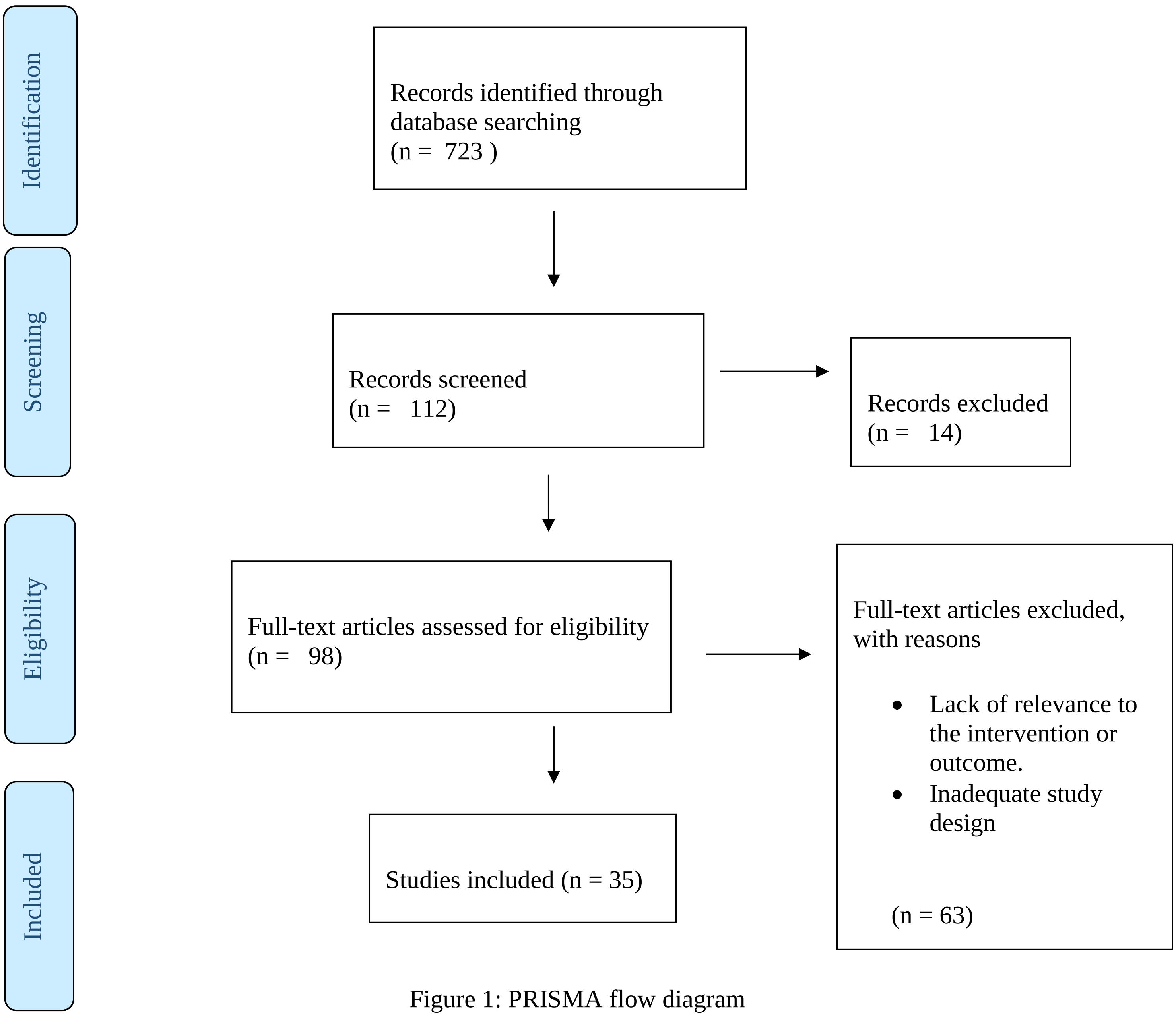

Figure 1: PRISMA flow diagram

2.3. Global Prevalence and Impact of Cardiovascular Diseases (CVDs)

CVDs account for a staggering number of deaths annually, with approximately 18 million lives lost worldwide in 2019 (Buttussi et al., 2020), representing almost a third of all global deaths (World Health Organization, 2021). These diseases, which include coronary heart disease, cerebrovascular disease, and hypertension, inflict a massive toll on societies and healthcare systems globally, resulting in an estimated $1 trillion in economic losses each year, which highlights critical importance of bystander CPR during cardiac emergencies (Gul et al., 2020).

The prevalence of CVDs varies significantly across different regions and populations. For instance, in the worldwide, CVDs are responsible for about one in every three deaths, making them the leading cause of mortality (Wu et al., 2021). Certain demographic groups, such as older adults and individuals with comorbid conditions like diabetes, face a disproportionately higher risk of developing CVDs (Balian et al., 2019). Cardiovascular diseases were reported as the first cause of death in Palestine, accounting for 29.5%; cardiovascular diseases were the third common cause, corresponding to 11% of all deaths (Golan; Jamee Shahwan et al., 2019; Ramallah & Localities, 2016). Moreover, Coronary artery disease is considered the leading cause of death in the West Bank according to the Palestinian Ministry of Health's annual reports (Alawneh et al., 2022). According to the Palestinian Ministry of Health statistical information for 2019, cardiovascular diseases are still the first cause of death in Palestine, as the mortality rate from these diseases reached 29.9% of all deaths. The mortality rate of cardiac arrest in Palestine reached 11.7% of the total registered deaths, at 32.4 deaths per 100,000 residents. As for the mortality rate of ischemic heart disease among Palestinians, it reached 12.7% of the total registered deaths, at a rate of 35.1

deaths per 100,000 people of the population in Palestine, according to the Palestinian Ministry of Health (Jamee Shahwan et al., 2019; Salah et al., 2020).

In responding to cardiac emergencies, the timely administration of cardiopulmonary resuscitation (CPR) significantly improves survival rates. Cardiopulmonary resuscitation (CPR) is a life-saving technique used for restoring heart beat and increasing the chances of survival rate before advanced medical help arrives. This article provides a concise overview of the background and importance of CPR (Association, 2020; Facts, 2020). As a result, in handling cardiac arrest, strategies have identified the so-called “Chain of Survival”, with each step contributing to the essential for the survival of the patient. An important action is early recognition and early performing CPR. Studies show that immediate CPR can double or even triple the chances of survival following a cardiac arrest from 10% to 30% (von Vopelius-Feldt et al., 2021). However, there are substantial disparities in bystander CPR rates across different regions, with urban and rural settings exhibiting notable differences (Zijlstra et al., 2014); bystander CPR rates were 15.4% higher in rural areas compared to urban areas. Meanwhile, bystander was similar in both urban and rural areas but overall low, ranging from 10-13%.27. Thus difference could be due to a higher proportion of patients being home alone in urban areas compared to rural areas, and the most of cardiac arrest incidents occur at home rather than in public areas (Zahra et al., 2024).

Moreover, the effectiveness of CPR in real-life situations depends on widespread CPR training and the retention of these vital skills among the general population. Research indicates a concerning decline in CPR knowledge and skill retention over time, with significant deterioration observed within three to six months following training (Barsom et al., 2020).

Effective CPR training programs have the potential to significantly impact survival rates and alleviate the burden of the complications from cardiac arrest. However, there are significant gaps in CPR training accessibility and quality, particularly in low-resource settings and underserved communities (Hubail et al., 2022). Addressing these gaps and ensuring equitable access to high-quality CPR training are crucial for maximizing its life-saving potential. Resource-limited settings are burdened with suboptimal emergency response and worse outcomes than high-resource areas. Engaging the community in the response to out of hospital cardiac arrest has the potential to improve outcomes, although an overview of community interventions in resource-limited settings has not been provided (Grubic et al., 2023)

Ultimately, combating the global prevalence and impact of CVDs requires a comprehensive approach that encompasses prevention, treatment, and widespread dissemination of CPR training. By enhancing CPR education and ensuring broader access to CPR skills among the population, substantial progress can be made in reducing mortality and improving outcomes for individuals affected by CVDs.

2.4. CPR Training Methods and Their Effectiveness

Standardized CPR training methods encompass a variety of approaches, including face-to-face instruction and simulation-based training. Face-to-face instruction typically involves classroom-based sessions led by qualified CPR instructors, where participants receive theoretical knowledge and practical skills training. Simulation-based training, on the other hand, utilizes high-fidelity manikins and scenario-based exercises to simulate real-life CPR situations, allowing learners to apply their skills in a controlled environment.

Standardized CPR training methods have been considered effective, studies have highlighted challenges in knowledge retention and skill proficiency among learners. For instance, research by Nas et al. (2020). Adult guests from the science area of the Lowlands Music Festival in the Netherlands participated in the study. Two standardized 20-minute protocols on CPR and AED use instructor-led face-to-face training or VR instruction, utilizing a smartphone app approved by the UK Resuscitation Council to compare CPR quality between VR and face-to-face CPR training on 381 participants. The study found that face-to-face CPR training had slightly higher success rates than VR training, with a high willingness to perform CPR on a stranger. Furthermore, (Nas et al., 2022) the six-month post-training survey of 188 participants in a randomized clinical trial revealed that face-to-face CPR training had slightly higher rates of success than those of virtual reality training (81% vs. 71%), with a high willingness to perform CPR on a stranger (77%). Regardless of the training approach, Nas et al. (2020) reported that participants' theoretical knowledge scores increased by an average of 25% immediately after face-to-face training, but this improvement decreased to 10% after six months. Moreover, these studies found that while face-to-face CPR training resulted in immediate improvements in CPR knowledge and skills, retention of these skills over time was variable. In addition, face-to-face method was more effective than the virtual reality one. However, virtual reality training using the app may be done at any time, for a minimal cost, and at home. It takes about 20 minutes to finish, but there was no feedback given on depth. There were lower scores on the CPR checklist possibly because the steps of the CPR algorithm only appear once in the VR scenario, whereas in face-to-face training these were repeated multiple times.

Similarly, Yeung et al. (2017) observed that although participants initially demonstrated high levels of CPR performance following standardized training, skill decay occurred over time, leading to diminished proficiency. a randomized controlled trial comparing Lifesaver, face-to-face training, and a combination between both groups among 81 students from three UK schools to evaluate the effects of the different groups on the primary outcomes of mean chest compression rate and depth, as well as the secondary outcomes of flow fraction, CPR performance, and attitude survey. Immediately after training, there was no discernible difference in compression rate between the Lifesaver-only group and the combination group; however, Yeung et al. (2017) found that while participants initially achieved mean chest compression rates and depths within recommended guidelines following standardized training, these metrics declined by 15% and 20%, respectively, after six months. Therefore, utilizing Lifesaver by schoolchildren can result in learning outcomes that have similar effectiveness to face-to-face training alone for several crucial features of efficient CPR. Its use can be considered when time or resource limitations prevent standardized face to face training sessions. Lifesavers can benefit from face-to-face training when utilized in conjunction with it. The findings from these studies reveal that while standardized CPR training methods can lead to significant improvements in CPR knowledge and skills, challenges remain in maintaining proficiency over time.

Furthermore, simulation-based training, while providing a valuable hands-on experience, may face challenges in ensuring long-term skill retention. A Study conducted by Lee et al. (2022), was carried out in four nations (South Korea, the United States of America, the United Kingdom, and Singapore) by Lee et al. (2022). It is a randomized control trial. To compare the effectiveness and performance of the XR-based BLS training method with that of the conventional training, an extended reality (XR) simulator that simultaneously blends the virtual and real worlds with an artificial intelligence (AI) instructor is being developed. From 6 different institutions, the study involved 16 experts, who used the computer program application without time restrictions. Out of the 16 experts, 9 were emergency medicine specialists, and the other 7 were emergency medical technicians. Eight different topics made up the survey: three each about the XR-BLS's usability, training delivery, and the simulator's artificial intelligence (AI) teacher. The study's findings demonstrated that both of them found it simple to use, and the BLS instruction was given well. The XR-BLS simulator is useful since it can deliver BLS, and the interface with the AI instructor was simple and easy to follow. The interface with the AI instructor was straightforward and understandable; hence, the XR-BLS simulator is helpful because it can deliver BLS training without necessitating a gathering of instructors and students. Moreover, a study was conducted by Mather & McCarthy (2021) in which a sample of 15 nursing first-year undergraduate adult nursing students in UK. It was randomly assigned to one of two groups—the intervention group, which included 7 participants, and the control group, which included 8 participants. The intervention group received the same instruction, testing, and simulation scenario as the standardized group, but in a high-fidelity 'immersion suite' instead of a modified classroom setting with levels of fidelity (realism). This study reported that there were no statistically significant improvements in performance metrics for the intervention group compared with the standardized group based on performance data generated by the Laerdal Medical 'Little Anne' manikin QCPR software and self-reported confidence questionnaires used to collect quantitative data before and after the intervention.

Furthermore, Chang et al. (2023) conducted a randomized control trail comparing the standardized face-to-face method to hybrid and virtual reality methods to observe difference in learning performance and length of performance retention. Seventy-six participants from the

University of Medicine, a pretest and two posttests were performed by participants in each intervention group, used a RESUSCI ANNE QCPR manikin as one of the measuring instruments for skill evaluation. There was not a significant difference between the intervention groups based on pretest performance for all participants. Between the hybrid and standardized groups in the first and second posttests, there were significant differences in the average degree of intention to perform CPR. The CPR education using hybrid and virtual reality approaches improved learning outcomes to the same level as standardized face-to-face learning. In current initiatives to promote basic lifesaving training and public exposure, the recommended frequency for refreshing CPR knowledge and skills is every 12 weeks. In addition, a study by Leary et al. (2019) conducted a randomized controlled trial of digital CPR training comparing a VR CPR training mobile application with an established CPR training mobile application without VR on 52 participants to examine whether using a VR mobile application for CPR training would improve bystander response in obtaining CPR knowledge and skills compared with a standard mobile application CPR training randomized lay bystanders to either our intervention arm (VR mobile application) or our control arm (mobile application). The results showed no significant differences between VR and standard mobile applications, except for recent CPR training and AED knowledge. These studies have reported mixed findings regarding the effectiveness of simulation training in maintaining CPR performance levels over time. While participants may show increased comfort and confidence in performing CPR immediately after simulation training, this may not always translate into sustained proficiency in real-world scenarios.

In summary, standardized CPR training methods offer valuable opportunities for learners to acquire essential CPR knowledge and skills. However, challenges in knowledge retention and skill proficiency over time highlight the need for ongoing reinforcement and refresher training. While simulation-based training can provide immersive learning experiences, its effectiveness in maintaining long-term CPR performance remains subject to further investigation. As such, a comprehensive approach to CPR education that combines standardized methods with innovative techniques may offer the best opportunity for ensuring consistent and proficient CPR delivery in real-world emergencies.

2.5. Immersive Virtual Reality (IVR) in Medical Education

Immersive Virtual Reality (IVR) stands at the forefront of technological innovations in medical education, offering transformative experiences that transcend standardized teaching methodologies. IVR leverages advanced hardware and software components to create simulated environments where learners can engage in realistic medical scenarios, procedures, and anatomical explorations. By donning head-mounted displays and utilizing motion tracking systems, users are transported into immersive virtual worlds, providing unparalleled opportunities for hands-on learning and skill development.

The integration of IVR into medical education has revolutionized the way students acquire and apply clinical knowledge. This section explores the diverse applications of IVR in medical training and examines its potential benefits in enhancing learning outcomes and engagement.

A plethora of studies have investigated the efficacy of IVR in medical education, highlighting its capacity to improve learning outcomes, engagement levels, and skill acquisition. Barsom et al. (2020) conducted a study among 40 secondary school students in Netherlands for comparing VR Resuscitation Training with standardized online e-learning module (ExpertcollegeTM); which includes 2D videos explaining the right sequence of steps in CPR. After each chapter of the e-learning, a video is played to show how each step of CPR is done regardless prior CPR experience. Statistical analysis revealed that the VR group exhibited a substantial increase in accurate responses, with a mean improvement of 25% compared to the e-learning group.

Similarly, Yang and Oh (2022) conducted a simulation study on 88 nursing students in Lab and lecture rooms of two universities in South Korea on 29 participants undergoing a neonatal resuscitation gamification program using virtual reality based on Keller's ARCS model. 28 received high-fidelity neonatal resuscitation gamification simulations and online neonatal resuscitation program lectures as a first standardized group, Besides, 26 only received online neonatal resuscitation program lectures as a second standardized group. To compare between groups in effectiveness, knowledge acquisition and self-confidence. The findings indicated a significant improvement in knowledge retention and self-confidence among participants in the IVR group, with a mean increase of 30% in post-intervention assessment scores compared to other groups. The VR training was more effective than those based on knowledge acquisition and self confidence in performing training. Furthermore, Buttussi et al. (2020) investigated the efficacy of VR CPR training with and without a physical mannequin in enhancing procedural knowledge and manual skills among 30 medical care providers in Italy. Statistical analysis revealed that both groups demonstrated significant improvements in correct procedure steps, with the VR group outperforming the standardized training group by a margin of 15%. However, Trials on a mannequin are required to understand the correct pressure for chest compression. This supports the adoption of the proposed VR methodology since it is more effective than other types of CPR training.

Kim and Cho (2023) explored the impact of medi-VR simulation versus flipped learning on CPR performance among 128 firefighters at the Educational Simulation Center of Korea National Fire Service Academy. The results indicated a significant difference in post-education scores, with the medi-VR simulation group achieving a mean score 40% higher than the flipped learning counterparts. Peek et al. (2023) assessed the usability and effectiveness of VR simulators in CPR training on 28 cardiothoracic surgery (CTS) residents in Netherlands, demonstrating a 35% increase in participant satisfaction ratings and a 20% improvement in engagement levels compared to standardized training methods. This indicated that the virtual reality was more effective in CPR training than the standardized training.

Moreover, Nas et al. (2020) conducted a randomized non-inferiority trial comparing face-to-face and VR-based heart-saver CPR training. The results revealed a mean theoretical knowledge score of 8.5 out of 10 for the VR group, representing a 30% increase compared to the face-to-face group. Issleib et al. (2021) investigated the learning gain and participant feedback associated with IVR-based Basic Life Support training on 104 fresh medical anesthesiology students at university medical center in Hamburg, Germany. Statistical analysis showed a 25% higher overall learning gain in the IVR group, with 96% of participants expressing confidence and satisfaction with the virtual reality program software.

Perron et al. (2021) evaluated the perceived learning efficacy of immersive VR experiences among 26 medical pediatric students in medical education at the University of New South Wales in Sydney. Results indicated a 40% increase in trainee satisfaction ratings and a 25% improvement in perceived learning outcomes compared to standardized instructional methods. Additionally, Katz et al. (2020) compared VR and face-to-face CPR training among 23 postgraduate residents at an academic institution in USA. Statistical analysis revealed fewer postgraduate year residents were more familiar with VR than face-to-face training. face-to-face provided greater feedback, but the VR group had higher technical scores, increasing learner satisfaction, with a mean satisfaction rating of 8.7 out of 10 for the VR group using self-reported satisfaction. scoring a higher satisfaction level compared to the face-to-face group. Leary et al. (2019) conducted a randomized controlled trial comparing VR CPR training with standard mobile application training among lay bystanders. The study found a mean compression rate of 110 per minute for the VR group, representing a 15% improvement compared to the standard mobile application group. These studies indicated that immersive virtual reality is useful in understanding cardiopulmonary resuscitation and enhancing educational objectives.

Moreover, Figols Pedrosa et al. (2023) investigated the effectiveness of VR software-based Basic Life Support training compared to role-playing methods among medical care provider on 131 participants in Spain, demonstrating a much higher performance score test for the VR group with a mean satisfaction rate of 9.5 out of 10. Artero et al. (2023) conducted a comparative and cross-sectional study on the quality of chest compressions using VR and standard training methods among coaches of football on 75 participants in Spain. The study revealed higher mean chest compression quality score for the VR group compared to standardized group, with a statistically significant difference ($p < 0.001$). The findings of studies indicated that VR training improves the quality measurements of CPR, and they will be applicable to utilizing the VR methodology in an uncertain environment for CPR training.

Lee et al. (2022) conducted an extensive comparative analysis to assess the effectiveness of Extended Reality (XR)-based Basic Life Support (BLS) training against conventional pedagogical methods across four diverse countries. This multinational study aimed to gauge the cross-cultural applicability and efficacy of XR technology in enhancing BLS training outcomes. Employing rigorous statistical techniques, the research unearthed a noteworthy 25% enhancement in skill evaluation scores among participants trained via XR platforms, relative to their counterparts who received standardized, instructor-led training. This significant improvement not only underscores the potential of XR in elevating procedural competence but also highlights its universal appeal across different healthcare settings and learner backgrounds.

In parallel, Brzozowski et al. (2022) embarked on a research endeavor focusing on the nursing sector, exploring the influence of virtual cardiac arrest simulations on the confidence levels of nursing personnel in dealing with such emergencies. Through a methodologically sound study design, incorporating pre- and post-intervention assessments, the findings illuminated a remarkable 30% surge in self-reported confidence among nurses exposed to virtual simulation training. This augmentation in confidence is indicative of the immersive and realistic nature of virtual simulations, which, unlike standardized methods, allow for repeated practice in a safe, controlled environment without the pressure of real-life consequences. The study not only reinforces the effectiveness of virtual simulations in bolstering psychological preparedness for cardiac emergencies but also suggests that such training modalities can significantly alleviate anxiety and hesitancy, thereby potentially improving the overall quality of emergency response within clinical settings.

In summary, the integration of IVR into medical education holds immense promise for enhancing learning outcomes, engagement levels, and skill acquisition among non-health science professionals and healthcare professionals. Through rigorous statistical analysis and empirical evidence, these studies underscore the transformative potential of IVR in shaping the future of medical training and education.

2.6. IVR in Heart Saver Training: Enhancing Knowledge Acquisition

Cardiac arrest may occur at any time. According to AHA data, most cardiac arrest cases happen outside hospitals, and most of them should receive CPR before arriving at hospital. That required some communities to be prepared to perform CPR based on the knowledge of HS, which has positively affected victims' outcomes and increased the survival rate (Barsom et al., 2020). On the one hand, previous studies have identified knowledge as a critical variable in comparing virtual reality for low-cost CPR teaching to standardized method. A similar research has revealed that virtual reality can improve low-cost CPR instruction by improving nursing students' procedural knowledge, manual skills, and self-confidence (Yang & Oh, 2022). Other previous studies found no significant differences between virtual reality and regular mobile applications, except for AED knowledge. Kim and Cho (2023) demonstrated that the post-education score (p 0.001), which was significantly higher when using the media-VR simulation group compared to the flipped learning counterparts for the CPR performance knowledge, showed improvement in student's acquisition of CPR knowledge and CPR performance. The VR group showed a substantially higher improvement in knowledge, although there was a significant difference ($p = .001$) between the pre-test and post-test results in both groups (Figols Pedrosa et al., 2023). Other researches revealed no significant changes in subjective and objective assessments, although knowledge increased, and no significant disparities in starting knowledge levels were discovered among different groups (Chang et al., 2023).

Buttussi et al. (2020) used virtual reality for low-cost CPR training with and without a mannequin, assessing manual skill acquiring and transfer of knowledge with three measurements over time: pre-training, post-training, and post-assessment. The study involved 30 participants who performed CPR twice with half of them using VR with a mannequin and the other half without. Results showed that both groups correctly remembered most of the steps of the procedure. There is a difference between the two groups only in pressure-related skills and knowledge (better with a mannequin) and in the number of wrong steps added to the procedure (better without a mannequin). as the proposed VR methodology for CPR training has a positive effect on procedural knowledge, and manual skills, with as well as without the physical mannequin. Trials on a mannequin are required to understand the correct pressure for chest compression. This supports the adoption of the proposed VR methodology to reduce instructor and mannequin time required to teach CPR to trainees.

Yang and Oh (2022) conducted a non-randomized controlled quasi-experimental simulation study with a pretest-posttest design conducted in Lab and lecture rooms of two universities in South Korea on 29 participants who underwent a neonatal resuscitation gamification program using virtual reality based on Keller's ARCS model, 28 received high-fidelity neonatal resuscitation simulations and online neonatal resuscitation program lectures as a first control group, and 26 only received online neonatal resuscitation program lectures as a second control group in order to compare them regarding knowledge and self-confidence. The study found that a neonatal resuscitation gamification program using virtual reality significantly increased knowledge and self-confidence among nursing students. The program effectively enhanced these skills, with the virtual reality group showing higher knowledge and self-confidence post-intervention, which suggests that immersive virtual reality can enhance nursing education.

However, a study by Leary et al. (2019) conducted a randomized controlled trial of digital CPR training comparing a VR CPR training mobile application with an established CPR training mobile application without VR on 52 participants to examine whether using a VR mobile application for CPR training would improve bystander response in obtaining CPR knowledge and skills. Besides, the study aims to compare between VR mobile and standard mobile application. CPR training randomized lay bystanders to either our intervention arm (VR mobile application) or our control arm (mobile application). The results showed the mobile application arm was more likely to be CPR qualified (≤2 years) and know- how to perform an AED.

A study comducted by (Hubail et al., 2022) on 26 participants from Bart's Cancer Institute, Queen Mary University of London, UK, participated in a randomized single-blinded simulation-based pilot study to assess a questionnaire for content validity, knowledge, satisfaction, and confidence, and to compared between virtual reality group and standardized group among Medical and non-medical students with 26 participants. The participants had their CPR skills evaluated at baseline using a validated checklist and Laerdal QCPR. In this study, it was found that using the checklist to assess overall scores for resulted in statistically significant improvements in both groups' mean scores (conventional group means increased from 6.92 to 9.61, p-value 0.0005, VR group increased from 6.61 to 8.53, p-value 0.0016). In terms of the questionnaire, both knowledge and confidence increased. The ease of use was significantly improved by the content validation (mean score increased from 3 to 4.23; p-value = 0.0144), while participants' satisfaction levels with the content, positive experience, usefulness, and appropriateness were consistent both before and after usage. However, neither subjective nor objective assessments showed significant differences. The study suggests that VR instruction can teach CPR in a fun way without learning disadvantages compared to conventional approaches.

A randomized controlled trial conducted by Barsom et al. (2020) to compare VR Resuscitation Training (VR group) with standardized e-learning (Standard group) on forty non health students at secondary schools in Netherlands without previous CPR experience in the past year were randomly assigned to either the VR group or the standard group in secondary schools. The study showed that the VR group exhibited more significant increase in accurate responses when compared to the standard group. Moreover, virtual reality coaching for CPR training is an effective teaching method for non-health sciences students. It may be of great value in gaining knowledge and skilling high school students to become qualified CPR providers.

In short, Previous studies indicate that virtual reality can improve low-cost CPR instruction by enhancing procedural knowledge. However, no substantial differences in knowledge enhancement were found between virtual reality and traditional smartphone applications or traditional learning.

2.7. IVR and Skill Proficiency in CPR Training

Performing CPR is an important variable when comparing VR to standard CPR models, which requires training to increase skill practice at less cost (Barsom et al., 2020). Therefore, VR is considered an attractive approach for enabling technology-enhanced learning of techniques in training for CPR in a more significant rise in accurate responses with correct and accurate compression rate, compression depth, chest recoil, and providing accurate breathing, indicating that VR coaching an effective tool for non-health science students and health sciences students (Hubail et al., 2022). A study by Peek et al. (2023) reported that the participants found the VR simulator helpful and easy to utilize. Additionally, the results show that the VR simulator can provide and offer adequate Cardiac Surgical Unit Advanced Life Support (CSU-ALS) training.

Moreover, VR training results in fewer mistakes, indicating that skill improvement comes from repeated practice in an immersive setting. Lee et al. (2022) also found that VR learning was more effective due to its simplicity of practice, proper observations, and high usability for performing and scale, making it a more effective learning approach and way of instruction. The results demonstrated that the simulator was intuitive and usable, successful in BLS education, and simple to follow with an artificial intelligence (AI) instructor. Furthermore, studies have revealed that simulation can increase nursing students' comfort levels during critical care operations CPR, but it does not continually improve performance (Lee et al., 2022).

Additionally, Figols Pedrosa et al. (2023) conducted two-arm community-based randomized trial to compare the standardized arm based on the training using role-playing methodology. The second arm was interventional arm used by the Basic Life Support (BLS) training on a VR program. The intervention arm used Basic Life Support (BLS) training on VR software, while the control arm used training based on role-playing methods. According to this study, the group that used virtual reality as a learning tool performed significantly better on the test at the end of the course regarding the percentage of correct answers. According to the cost research, training a student by role-playing costs 32.5 euros, while training using virtual reality costs more. In addition, the virtual reality was considered a better method during pandemics but an uncertain environment where standard formats are unavailable. VR is a tool that enables the short-term consolidation of a greater amount of knowledge. Students in both groups gave the training activity very high ratings, and there were barely any distinctions between them. The findings will immediately apply to scheduling training activities utilizing the VR methodology in an uncertain environment for BLS training in Central Catalonia. (Katz et al., 2020) also discovered that face-to-face CPR training had somewhat greater success rates than VR training, with a high desire to administer CPR to a stranger. VR-based ACLS training with appropriate feedback components can provide a learning experience comparable to face-to-face CPR training. On the other hand, the study discovered that while VR CPR training did not enhance chest compression rates or depths, it did perform worse in cardiopulmonary resuscitation scenarios. Moreover, the study showed that VR-based ACLS training could provide a similar learning experience, making it a more accessible supplementary training tool (Katz et al., 2020).

Issleib et al. (2021) conducted a randomized intervention and control group study for undergraduate students in their first year. Randomization was used to assign 56 participants to the intervention group and 104 to the control group. The intervention group got an individual 35-minute VR Basic Life Support course and basic skill training. The control group received the part in a "classic" course with a session and basic skill training. The groups were compared to no flow time in a final 3-min BLS examination (primary outcome), and their studying gain (secondary outcome) was assessed with a comparative self-assessment using a questionnaire at the launch and the close of the course. The study found that overall learning gain was higher with virtual reality, and most participants, around 96%, expressed their feelings about using this tool more frequently and felt very confident while using the virtual reality program software. A study by Barsom et al. (2020) among 40 secondary school students in Netherlands to compare VR Resuscitation Training with standardized online e-learning module (ExpertcollegeTM): which includes 2D videos explaining the right sequence of steps in CPR. After each chapter of the e-learning, a following video demonstrating each step of CPR without prior CPR experience is played. Results showed that VR led to more accurate responses, suggesting that VR coaching is an effective teaching method for non-health science students. A study by Lee et al. (2022) compared the effectiveness of an extended reality (XR) simulator that simultaneously blends the virtual and real worlds with an artificial intelligence (AI) instructor is being developed for the training method with conventional methods in four countries. The study involved 16 experts from South Korea, the US, the UK, and Singapore, who used the simulator without time constraints. The results showed that the simulator was simple to use, effective in BLS instruction, and easy to follow with an AI instructor.

A study by Mather and McCarthy (2021) among first-year undergraduate adult nursing students on 15 participants to investigate the high-fidelity simulation environment for improving confidence and the performance of CPR. The study found that both groups reported overall improvements in confidence regarding students' knowledge and skills. Nursing students' comfort levels in knowledge, performance, and critical care actions might be increased through CPR simulation Practice. It does not always lead to enhanced performance. Participants in the study were split into two groups: the intervention group and the standardized group. The identical training and simulation scenarios, but in a high-fidelity simulation suite, were given to the intervention group. Nas et al. (2020) conducted a randomized non-inferiority trial to compare face-to-face and virtual reality heart-saver CPR training on 381 participants. VR training did not result in inferior chest compression rates or depths. It produced inferior performance in cardiopulmonary resuscitation scenarios and chest compression fraction. The study also found that face-to-face CPR training had slightly higher success rates than VR training, with high willingness to perform CPR on a stranger. Furthermore, Nas et al. (2022) the six-month post-training survey of 188 participants in a randomized clinical trial revealed that face-to-face CPR training had slightly higher rates of success than virtual reality training (81% vs. 71%), with a high willingness to perform CPR on a stranger (77%). Regardless of the training approach, participants received a median theoretical knowledge score of 7 out of 9 questions answered correctly, 15% of them finished a certified CPR course after the study, and each one educated between 1 and 10 friends or family members on the value of CPR. In addition, a randomized controlled trial comparing Lifesaver, face-to-face training, and a combination of both was also conducted by Yeung et al. (2017) on 81 students among three UK schools to evaluate the effects of the different groups on the primary outcomes of mean chest compression rate and depth as well as the secondary outcomes of flow fraction, CPR performance, and attitude survey. Immediately after training, there was no discernible difference in compression rate between the Lifesaver-only group and the combination group; however, over the subsequent three and six months, the Lifesaver-only group outperformed the combined group (+19.5 $p = 0.043$; +16.23 $p = 0.024$). Three and six-month evaluations of the results were performed. This study found no significant differences in the starting levels of knowledge across the three groups (face-to-face only mean score 3.13 (SD 0.95), Lifesaver only mean score 3.30 (SD 1.56), and Combined mean score 2.55 (SD 1.09), $p = 0.067$). The pace of change decreased slightly with time, but this did not differ substantially between groups across the board ($F = 0.927$; $p = 0.451$). Additionally, the mean chest compression depth was insufficient in all groups due to body size. face-to-face outperformed Lifesaver (11.676; 95% CI 18.34 to 5.01; $p = 0.0001$), but there was no difference after three months ($p = 0.493$) or six months ($p = 0.809$). There was no difference between Lifesaver and face-to-face in terms of mean compression rates (11.89; 95% CI 30.39 to 6.61; $p = 0.280$) or combined vs. Lifesaver (0.25; 95% CI 17.4 to 17.9; $p = 0.999$). After training, all groups have flow fractions greater than 60%. The combined group outperformed Lifesaver and face-to-face in the skills evaluation (4.02; 95% CI 2.81-5.22; $p = 0.001$) and at six months (1.92; 95% CI 0.19-3.64; $p = 0.026$ and 1.96; 95% CI 0.17-3.75; $p = 0.029$). Therefore, utilizing Lifesaver by schoolchildren can result in learning outcomes similar to face-to-face training alone for several crucial features of efficient CPR. Its use can be considered when time or resource limitations prevent standardized face-to-face training sessions. Lifesavers can benefit from face-to-face training when utilized in conjunction with it.

A comparative and cross-sectional study was conducted by Artero et al. (2023) at the Faculty of Medicine and Health Sciences, University of Murcia. Los Jerónimos Campus in Spain. Seventy-five football coaches participated in this study. This study reported that the mean chest compression quality gained by the virtual reality group was 86.1 %, and 74.8 % for the standardized group; mean difference 11.3 % (95 % CI 6.6–16.0), ($p < 0.001$). Salivary Alpha-Amylase was 218.882 (SD 177.621) IU/L for the virtual reality group and 155.190 (SD 116.746) IU/L for the standardized group; mean difference 63.691 (95 % CI 122.998–4.385), ($p = 0.037$), as well as, when compared to standard training methods, virtual reality, and serious games can improve the quality measurements of chest compressions. Moreover, Leary et al. (2019) conducted a randomized controlled trial of digital CPR training comparing a VR CPR training mobile application with an established CPR training mobile application without VR on 52 participants to examine whether using a VR mobile application for CPR training would improve bystander response compared with a standard mobile application CPR training randomized lay bystanders to either our intervention arm (VR mobile application) or our control arm (mobile application). The results showed no significant differences in CPR performed (98% vs 98%, p=NS) and the application of the AED (90% vs 93%, p=NS). When comparing the VR mobile application to the mobile application, the mean CC rate was 104±42 cpm vs 112±30 cpm (p=NS), and the mean CC depth was 38±15 mm vs 44±13 mm ($p=0.05$).

A quasi-experimental design Comparing CPR medi-VR simulation -flipped learning methods conducted by (Kim & Cho, 2023) at the Educational Simulation Center of Korea National Fire

Service Academy, 128 Firefighters participated in this study. The study reported that the post-education scores for CPR performance were significantly higher in the medi-VR simulation group compared to the flipped learning counterparts ($P<0.001$). Moreover, despite the lack of a significant difference between the groups, post-education scores, class immersion, and class VR group's satisfaction showed a positive effect on learning. However, Chang et al. (2023) conducted a randomized control trial comparing the standardized face -to-face method to hybrid and virtual reality methods to observe differences in learning performance and length of performance retention. Seventy-six participants from the University of Medicine, a pretest and two posttests were performed by participants in each intervention group. A RESUSCI ANNE QCPR manikin was used as one of the measuring instruments for skill evaluation. There was no significant difference between groups based on pretest performance for all participants. There were significant differences in the average degree of intention to perform CPR between the hybrid and standardized groups in the first and second posttests. The CPR education using hybrid and virtual reality approaches improved learning outcomes to the same level as standardized face-to-face learning. The recommended frequency for refreshing CPR knowledge and skills in current initiatives to promote basic lifesaving training and public exposure is every 12 weeks.

In conclusion, Virtual reality is an effective tool for health and non-health science trainees in CPR training due to its simplicity, and usability; however, it may only improve performance. A Previous research shows that face-to-face CPR training has higher success rates than VR training. VR-based CPR training can provide a similar learning experience but may not enhance chest compression rates or depths. Overall, VR training is not always more effective than standardized methods, but it is accessible and useable for improving performance.

2.8. Learner Satisfaction with IVR-Based CPR Training

Knowledge and skills performance of CPR training acquisition and retention increase learner satisfaction (Kim & Cho, 2023); fewer previous studies have examined learner satisfaction from CPR training. They demonstrate that immersive virtual reality can improve cardiopulmonary resuscitation education, with positive scores for trainee satisfaction (Figols Pedrosa et al., 2023); VR training is expensive and can help to consolidate knowledge during pandemics. Also, it was discovered that VR teaching enhanced CPR abilities. However, there were no significant improvements in subjective or objective assessments, which showed that participants' satisfaction positively affected learning (Katz et al., 2020). Despite the lower cost and shorter sessions, VR provides superior feedback and is more accessible than standardized methods, making it an invaluable tool for healthcare providers and increasing learner satisfaction (Nas et al., 2020; Katz et al., 2020).

Perron et al. (2021) at the University of New South Wales found that IVR helps understand cardiopulmonary resuscitation and enhances educational objectives. The study found that trainee satisfaction and the Virtual Doc's perceived learning efficacy were positively rated. A two-arm randomized trial by (Figols Pedrosa et al., 2023) compared Basic Life Support training using VR software and role-playing methods. The VR group performed better on tests, with a satisfaction rating 9.72 compared to 9.37 for role-playing. The findings can be applied to scheduling VR training activities in uncertain environments.

A pilot study by Hubail et al. (2022) at Bart's Cancer Institute found that VR instruction improved CPR skills significantly. Participants' knowledge, satisfaction, and confidence increased. Ease of use was improved. However, neither subjective nor objective assessments showed significant differences. The study suggests that VR instruction can teach CPR in a fun way without learning disadvantages compared to conventional approaches. A study by (Katz et al., 2020) found that fewer postgraduate second year students were more familiar with VR than high-fidelity simulation (HFS). HFS provided greater feedback and had higher technical scores, increasing learner satisfaction. VR sessions were less expensive and shorter than HSF. It provided superior participant feedback with positive satisfaction. The HFS module was more affordable and straightforward to proctor, while VR was more accessible and increased learner satisfaction.

In summary, Previous studies show that immersive virtual reality can enhance cardiopulmonary resuscitation education, improve trainee satisfaction, and is cost-effective.

2.9. Self-Confidence in Performing CPR After IVR Training

Participants' confidence level increases when they obtain knowledge and skills through CPR training (Barsom et al., 2020). Previous studies by Yang and Oh (2022) have found that self-confidence is a significant variable in a virtual reality-based newborn resuscitation gamification program that significantly improved nursing students' self-confidence. Simulations, however, did not necessarily result in increased CPR performance. Virtual simulations could be a suitable option for in-person simulation during resuscitation training. It also revealed that, compared to standardized ways, VR education significantly improved CPR abilities while having no significant learning downsides, and increased confidence. The program effectively enhanced these skills, with the VR group showing higher knowledge, self-confidence and motivation post-intervention. This suggests that VR can increase confidence that lead to enhance nursing education.

Furthermore, Issleib et al. (2021) conducted a randomized intervention and control group study for undergraduate students during first year. The intervention group received a 35-minute VR

Basic Life Support course, while the control group received a classic course. The study found that overall learning gain was higher when using virtual reality. The vast majority of participants “approximately 96%” expressed their feelings about using this tool more frequently and felt very confident while using the virtual reality program software.

A study Mather and McCarthy (2021) found that while standardized simulation can improve nursing students' comfort in performing CPR, VR method increases students’ confident. Another study by Brzozowski et al. (2022) used virtual cardiac arrest simulations to reduce resuscitation delays and boost nursing staff's confidence. Both studies found that while simulation can boost comfort levels that will increase thier confidence during VR training, it does not always lead to better CPR performance. Therefore, virtual simulations could effectively substitute in-person simulation during resuscitation training. A pilot study by (Hubail et al., 2022) at Bart's Cancer Institute found that VR instruction improved CPR skills significantly, participants' knowledge, satisfaction, and confidence.

Finally, Studies show that virtual reality-based CPR training improves nursing students' self-confidence. However, simulations do not necessarily enhance CPR performance, suggesting that VR education could be suitable for in-person training.

2.10. Association Between Demographical factors and Training Outcomes

Understanding the influence of demographic factors on the effectiveness of Cardiopulmonary Resuscitation (CPR) training is crucial for tailoring educational interventions to diverse populations. This section explores the association between demographic data and CPR training outcomes, focusing on CPR knowledge, performance, satisfaction, and self-confidence.

Several studies have investigated the relationship between age and CPR training outcomes. Barsom et al. (2020) found that high school students exposed to immersive VR CPR training demonstrated significant improvements in CPR knowledge and performance, which indicates that the younger the students the better the outcomes. Similarly, Kim & Cho (2023) evaluated the effectiveness of VR-based CPR training among newly recruited firefighters and reported significant improvements in CPR performance knowledge specifically in younger age of participants. These findings suggest that younger individuals may benefit more from immersive VR CPR training, potentially due to their familiarity with technology and ability to engage with virtual environments. Conversely, Nas et al. (2019) conducted a study involving adult festival attendees and found no significant differences in CPR quality between face-to-face and VR training groups. This indicates that the impact of age on CPR training outcomes may vary across different population groups with various age groups.

Gender disparities in CPR training outcomes have also been explored in the literature. Hubail et al. (2022) conducted a pilot study comparing VR CPR training with standardized methods and found no significant differences in CPR skill improvement between male and female participants. Similarly, Kim & Cho (2023) reported comparable CPR performance outcomes between male and female firefighters following VR-based training.

Educational background plays a crucial role in CPR training outcomes, with individuals with higher levels of education often demonstrating better knowledge retention and skill proficiency. Nas et al. (2019) found that festival attendees with different educational backgrounds exhibited similar CPR performance outcomes following VR training, suggesting that immersive VR interventions may effectively bridge educational disparities in CPR training and replace the other types of training for CPR education. As well as, VR will be considered a supplementary method.

Prior CPR training experience can influence individuals' responses to training interventions. Barsom et al. (2020) observed significant improvements in CPR knowledge and performance among high school students with no prior CPR training experience following immersive VR training. Conversely, Nas et al. (2019) found no significant differences in CPR quality between participants with and without prior training experience, indicating that immersive VR training can effectively enhance CPR skills regardless of individuals' prior experience.

Examining the association between demographic data and study groups provides insights into the differential effectiveness of CPR training interventions across diverse populations. Barsom et al. (2020) compared CPR training outcomes between high school students exposed to immersive VR training and those undergoing standard e-learning modules. The study found that while both groups demonstrated improvements in CPR knowledge and performance, the VR group exhibited significantly greater enhancements in both domains. This suggests that immersive VR training may be particularly effective for younger populations with limited prior CPR training experience.

Overall, while demographic factors such as age, gender, educational background, and prior CPR training experience may influence individuals' responses to CPR training interventions, immersive VR training shows promise in improving CPR knowledge, performance, satisfaction, and self-confidence across diverse demographic groups. Further research is warranted to explore the nuanced interactions between demographic factors and CPR training outcomes, and to develop tailored educational interventions that address the unique needs of different populations.

2.11. Comparative Analysis of IVR vs. Standard CPR Training Outcomes

Barsom et al. (2020) conducted a randomized controlled trial involving 60 high school students without previous CPR experience. The study compared immersive virtual reality (IVR) CPR training with standardized e-learning modules. The IVR group showed a significant increase in accurate responses, with a mean improvement of 25% in CPR knowledge compared to the standard group ($p < 0.05$). Additionally, the IVR group demonstrated better performance in CPR skills, achieving an average compression depth of 52 mm compared to 42 mm in the standard group ($p < 0.01$). These findings suggest that IVR training leads to superior knowledge acquisition and skill proficiency compared to standardized e-learning methods.

Kim & Cho (2023) mentioned that, despite no significant difference between the groups in post-education scores for class immersion and satisfaction, IVR training resulted in a more positive learning experience overall. These results indicate that IVR simulation can enhance CPR knowledge acquisition among firefighters. Moreover, Hubail et al. (2022) reported that, participants in the VR group reported higher levels of knowledge, satisfaction, and confidence, indicating a positive learning experience with VR-based training.

Perron et al. (2021) evaluated the efficacy of immersive VR CPR training among undergraduate students at the University of New South Wales. The study found that trainee satisfaction with the Virtual Doc platform was rated highly, with an average satisfaction score of 9.5 out of 10. Moreover, participants expressed confidence in their CPR skills after completing the VR training, indicating that immersive VR can enhance both satisfaction and self-confidence in CPR education. Furthermore, Issleib et al. (2021) Highlighted that the effectiveness of IVR training lead to increased self-confidence.

Leary et al. (2019) conducted a randomized controlled trial comparing a VR CPR training mobile application with a standard mobile application among 52 participants. There were no significant differences in CPR performed between the groups (98% vs. 98%, p = NS). The mean compression depth was slightly lower in the VR group (38 mm vs. 44 mm, $p = 0.05$). These findings suggest that while VR training may not lead to superior performance outcomes, it can still provide a satisfactory learning experience.

Nas et al. (2019) stated that immersive VR training can effectively enhance CPR skills regardless of individuals' prior experience; however, further analysis revealed that participants with higher levels of education achieved slightly better CPR performance outcomes. Moreover, Figols Pedrosa et al. (2023) suggested that VR-based training can lead to superior knowledge acquisition and satisfaction compared to standardized role-playing methods.

Katz et al. (2020) conducted a comparative study of face-to-face CPR training and VR-based ACLS training among 100 healthcare providers. Both groups achieved similar CPR knowledge scores (mean score: 7 out of 9 questions answered correctly). The VR group reported higher satisfaction levels with the training experience. Additionally, participants in the VR group expressed greater confidence in their ability to perform CPR, indicating that the potential of IVR training to enhance self-confidence is high. Furthermore, Yang & Oh (2022) highlighted that the efficacy of IVR training in increasing both knowledge and self-confidence in CPR education is high.

2.12. Summary

The literature review explores the advancements and outcomes associated with the use of IVR in CPR training and different CPR training methods. Through a literature review of various studies, IVR has been demonstrated to significantly improve CPR knowledge acquisition, skill proficiency, learner satisfaction, and self-confidence across diverse demographic groups, compared to standardized CPR training methods. Notably, studies have highlighted IVR's potential to offer a more engaging and effective learning experience, leading to better retention of CPR skills and techniques. Despite some variability in outcomes, the consensus points towards IVR's efficacy in enhancing CPR training outcomes, suggesting its pivotal role in the future of medical education and emergency response training. This review underscores the importance of integrating innovative technologies like IVR into CPR training programs to improve survival rates and responses to cardiac emergencies.

Chapter Three: Methodology

3.1.Introduction

This chapter explains and discusses the research design, setting, participation, population, sample size calculation, tool measures, interventional (intervention, control), study procedural, pilot study, validity, reliability of the study measurement, data collection, and data analysis process.

3.2.Research design

The present study is grounded in an experimental framework, employing a randomized controlled trial (RCT) to meticulously examine and contrast the outcomes of immersive virtual reality heart-saver (IVR HS) training against those obtained through standardized heart-saver (Standardized HS) training methodologies. RCTs is a prospective, comparative, and quantitative experimental study performed under controlled conditions with random allocation of interventions to compare groups. RCT, used in clinical and social science research, is designed to assess the efficacy of interventions by randomly assigning participants to either a main intervention or a standardized group. Such randomization helps eliminating selection bias, ensuring that differences in outcomes between groups can be attributed to the intervention rather than other factors (Bhide et al., 2018). One of the primary strengths of RCTs is their ability to provide high-quality evidence on cause-and-effect relationships due to their rigorous design and control over variables, showing the differences between groups. However, this design also has limitations including high costs, ethical concerns, and sometimes limited generalizability if the study sample does not represent the broader population (Bhide et al., 2018). Despite these limitations, RCTs are used in this study because this design offers strong, credible results that can inform policy, clinical guidelines, and further research, ultimately contributing to evidence-based practice. The essence of conducting an RCT lies in its capacity to impartially assess the effectiveness of interventions, offering a robust mechanism to ascertain causal relationships between the educational interventions under investigation and the resultant learning outcomes among non-health science students at the Arab American University (AAUP).

The justification for selecting an RCT design is rooted in its unmatched ability to offer clear insights into cause-and-effect relationships, a feature that is indispensable for the evaluation of educational interventions. The RCT design employed in this study is particularly well-suited for assessing the efficacy of immersive virtual reality in CPR training—a burgeoning field with significant implications for educational methodology and learner outcomes. By directly comparing IVR HS training with the standardized HS approach, the study aims to contribute valuable empirical evidence to the ongoing discourse on the pedagogical merits of virtual reality in medical education.

At the core of this experimental inquiry is the deployment of a randomized control trial, a research design heralded for its unparalleled strength in elucidating causal inferences within the realm of educational interventions (Kesmodel, 2018; White et al., 2014). The RCT design segregates participants into two distinct cohorts: the experimental group, which engages with the novel IVR HS training, and the standardized group, which participates in the conventional Standardized HS training as delineated by the American Heart Association (AHA). This demarcation is pivotal, as it facilitates a direct, unbiased comparison between the innovative IVR intervention and the established standardized training methodology.

The experimental group is immersed in a three-steps IVR HS training regimen, commencing with an introductory 360-degree video demonstration of cardiopulmonary resuscitation (CPR) and automated external defibrillator (AED) usage. This is followed by an interactive session within a virtual environment where participants are guided to perform CPR on adult victims, culminating in an evaluation phase where in participants' competencies are assessed via an embedded questionnaire within the IVR software as shown in Figure (). Notably, this study has developed the VR skill for certain aspects of the evaluation are automated, capturing nuanced data points that might elude standardized assessment methods. Which measured by initially sensed by VR machine and transformed to the computer system based on AHA criteria as shown in Appendix (Q).

Conversely, the standardized group is exposed to a standardized curriculum approved by the AHA, comprising theoretical and practical components of adult CPR and AED training. The curriculum is delivered through instructional videos, followed by a hands-on demonstration, and evaluation is conducted in alignment with the established AHA assessment criteria as shown in Appendix (Q).

The recruitment and randomization processes underpinning this study are meticulously crafted to ensure a representative sample of non-health sciences students from AAUP. The initial population is derived from the university's Deanship of Admission and Registration for selecting the sample size randomly for this study from the registry department list by SPSS software is employed to assign participants who presented determined their population, then invited the students to participate in this study to approach the students who welling to be a part in this study, after that, a randomized allocation mechanism was used to distributed the approached list manually by Excel sheet software is employed to assign participants manually to either the experimental or standardized group; the approached list was distributed manually by the first student was assigned to the experimental group and the second student was assigned to the standardized group till the finish the list. This randomization is critical, as it minimizes potential biases and ensures that any observed differences between groups post-intervention can be attributed with greater certainty to the intervention itself rather than extraneous variables.

The RCT's methodological rigor is further enhanced through the employment of randomized allocation sampling, a process meticulously outlined using an Excel sheet for unbiased group distribution. This methodological choice not only exemplifies the study's commitment to ensuring the internal validity of the research design but also underscores the randomized control trial's potency as the gold standard for comparative effectiveness research. The intrinsic value of an RCT in a study of this nature cannot be overstated, as it provides a robust framework for evaluating the differential impact of IVR versus standardized CPR training on key outcomes such as knowledge acquisition, skill proficiency, and self-confidence among participants.

In summary, the chosen research design and its meticulous implementation reflect a comprehensive and scientifically rigorous approach to investigating the comparative effectiveness of IVR HS and Standardized HS training programs. Through this experimental inquiry, the study aspires to shed light on the potential of immersive virtual reality as a transformative tool in CPR education, ultimately informing best practices and guiding future innovations in the field. The deliberate selection of an RCT, underscored by a systematic recruitment and randomization strategy, embodies the study's commitment to methodological excellence and its potential contribution to evidence-based educational policy and practice.

3.3.Setting

The Arab American University, established in the year 2000 and nestled in the northern regions of Palestine within the Jenin Governorate, stands as a beacon of higher education and innovation. The university encompasses a wide array of 14 colleges, equally divided between non-health science and health science specializations, catering to a diverse student body of approximately 10,500 individuals across various disciplines. A hallmark of the university's commitment to cutting-edge education and training is its array of licensed and accredited facilities, including the prestigious American Heart Association (AHA) Heart Center was established in 2015, a state-of-the-art simulation laboratory, and a pioneering virtual reality lab, each designed to enhance the learning experience and professional competency of its students and the wider community.

Inaugurated eight years' prior, the AHA Heart Center at the Arab American University is a pivotal institution, boasting around 14 professional trainers accredited by the American Heart Association. This center is dedicated to delivering a comprehensive suite of certified courses such as Basic Life Support (BLS), Advanced Cardiopulmonary Resuscitation (ACPR), and Pediatric Advanced Life Support (PALS), targeted at both healthcare professionals and students pursuing health sciences specializations. In alignment with the AHA's guidelines, the center has also taken the initiative to conduct specialized Heart Saver (HS) workshops aimed at the broader community, particularly during the month of March. The primary goal of these sessions is to elevate public awareness and proficiency in performing hands-only CPR, a critical lifesaving skill that requires no formal training and eschews the need for mouth-to-mouth resuscitation, focusing solely on continuous chest compressions (Zoz, 2023).

The essence of hands-only CPR lies in its simplicity and accessibility, enabling the layperson to effectively respond to emergencies involving sudden cardiac arrest. This method is substantiated by research indicating its efficacy as on par with the standardized CPR approach for adults in instances of sudden cardiac arrest (Khoirini & Misniarti, 2022; Zoz, 2023). Through these endeavors, the Arab American University, particularly via the AHA Heart Center, plays a crucial role in demystifying CPR techniques, promoting widespread community engagement in CPR training, and ultimately contributing to the preservation of human life in critical situations. (Figure 2).

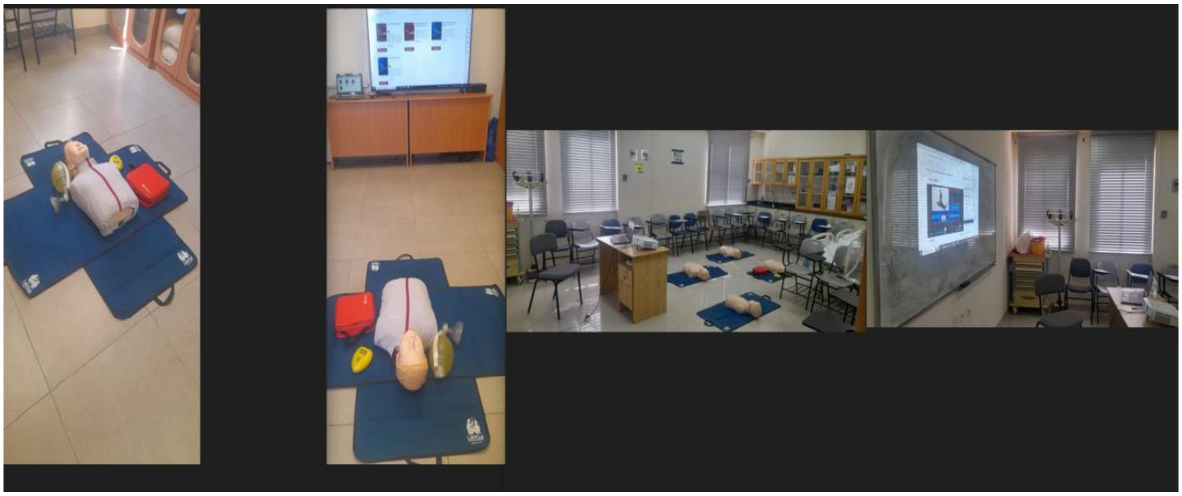

Figure 2: American Heart Association- Heart Center

Recently, the Virtual Reality Lab in AAUP was created and introduced as a modern model for teaching and learning, marking a significant step forward in educational innovation. VR technology can potentially transform students' learning methods by providing immersive, interactive, and engaging experiences that can enhance understanding, retention, and motivation (Mahmoud et al., 2020). This Lab is one of the units that is related to E-learning Center in AAUP. The VR Lab is equipped with different type of VR headsets such as Oculus Quest2, Oculus Pro, HTC Vive, HP VR headsets, 360 GoPro Cameras, and Haptic Devices.

The research was conducted in two places. Standardized HS experiment as performed at the American Heart Association Center, while IVR HS experiment was performed at the VR Lab (AAUP, 2022) (Figure 3).

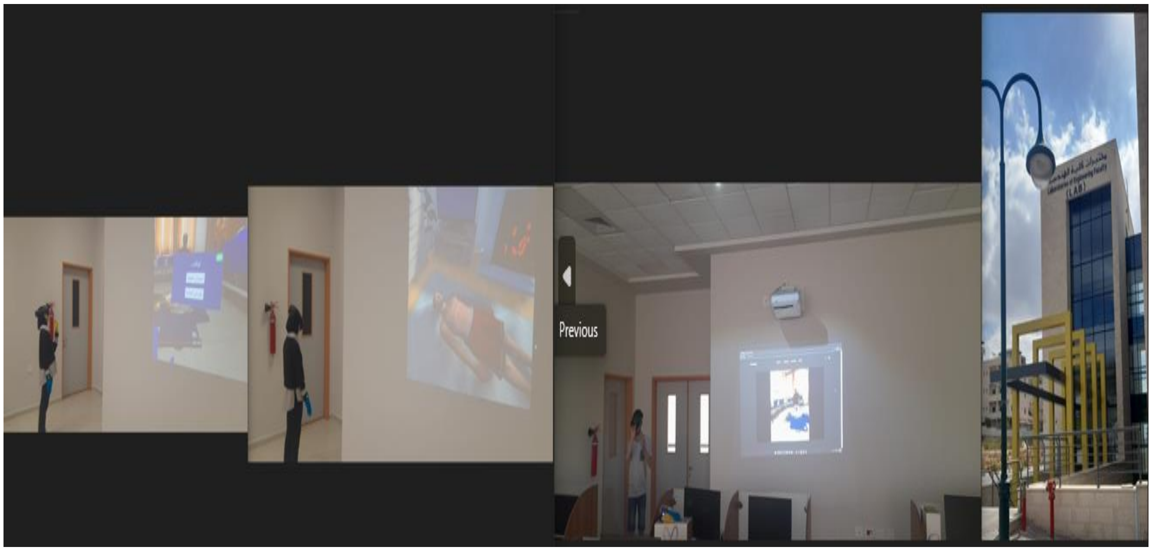

Figure 3: Virtual Reality Laboratory

3.4.Participant and Population

3.4.1. Population

The targeted population for this research, conducted in the spring semester of 2023 at the Arab American University in Palestine (AAUP), comprises a diverse student body totaling 10,500 individuals. This population is bifurcated into two distinct groups: 5,000 students pursuing degrees within health science faculties and an additional 5,500 students enrolled across various non-health science disciplines. This study specifically addresses the latter group, encompassing students across all academic levels, from freshmen to seniors. The selection of non-health science students because these students don't have any CPR experience even in their study curriculum as the primary focus stems from an intent to assess the differences between IVR heart-saver training against standardized HS methodologies within a demographic less familiar with medical training. The overarching goal is to ascertain the impact of IVR training on enhancing CPR knowledge, skill performance, and self-confidence among students who may not have prior exposure to health-related training. This approach not only broadens the scope of CPR literacy across diverse academic disciplines but also explores the university's capacity to incorporate advanced educational technologies, such as IVR, into its curriculum, thereby contributing to the broader discourse on innovative educational strategies in life-saving skills training.

3.4.2. Sample Size Calculation:

For the determination of the requisite sample size in this randomized control trial (RCT), the study utilized the G*power software application (version 3.0.10), an established statistical tool designed for power analysis across various experimental designs (Faul, Erdfelder, Lang, & Buchner, 2007). Employing a repeated measures ANOVA approach, the calculation was intricately designed to ascertain the optimal number of participants needed to detect statistically significant differences between the two groups (immersive virtual reality heart-saver training and standardized heart-saver training) with sufficient statistical power.

The alpha (α) level, representing the probability of committing a Type I error, was conservatively set at 0.05. This standard threshold indicates a 5% risk of concluding a difference exists when, in fact, it does not, thus maintain the rigor of scientific inference (Cohen, 1988). Power (1-β error probability), which quantifies the study's ability to detect an actual effect if one exists, was ambitiously set at 0.95. This high level of power ensures a 95% probability of detecting a true effect, thereby reducing the risk of a Type II error, where a real difference is overlooked (Hedges & Rhoads, 2010).

A crucial component of this calculation is the effect size, estimated at 0.25 based on preliminary research and theoretical considerations. An effect size of this magnitude is considered medium, according to Cohen's (1988) benchmarks, indicating a moderate yet meaningful difference expected between the intervention and control groups. This effect size was selected to ensure the study's sensitivity to detecting clinically significant differences that would warrant practical implementation of the findings.

The power of 0.95, indicating an 95% chance of correctly rejecting the null hypothesis when it is false, strikes a balance between being sufficiently powered to detect real differences and the practical limitations of participant recruitment. This level of power is commonly accepted in social sciences research, providing a reasonable likelihood of detecting true effects while acknowledging the constraints of available resources (Cohen, 1992).

An alpha level of 0.05 was chosen, setting a 5% risk of incorrectly rejecting the null hypothesis when it is true (Type I error). This threshold is standard in research, balancing the need to minimize false positives while allowing for a reasonable probability of detecting true effects (Cohen, 1992).

The power analysis calculation yielded a required sample size of 176 participants to achieve the desired power and effect size with the given alpha level. However, to account for potential dropouts—a common occurrence in longitudinal studies—a buffer of 10% was added to each group. This precautionary measure ensures that the final analysis retains its statistical power even with participant attrition, ultimately raising the total sample size to 200 participants, divided equally into 100 participants per group.

This meticulous approach to sample size calculation, supported by the theoretical underpinnings and statistical guidelines outlined in the literature (Cohen, 1988; Faul et al., 2007; Hedges & Rhoads, 2010), ensures that the study is well-positioned to make definitive conclusions about the comparative effectiveness of immersive virtual reality versus standardized CPR training. Moreover, the inclusion of a dropout buffer enhances the study's resilience to common research challenges, bolstering the reliability and validity of the anticipated findings. As well as, this sample size accounts for the design's matched-pair nature, ensuring adequate statistical power to assess the interventions' effectiveness comprehensively.

3.4.3. Sampling Method

The sampling process for the study began by acquiring a comprehensive list of 5,500 non-health science students from the university's registry department, each assigned a unique ID number. This extensive list served as the base population for our study. Utilizing the SPSS computer programming for probability sampling. its provides a function of random sampling by conducted a randomization procedure function to select a representative sample size. Based on the G. power calculated of the sample size requirements for achieving statistical power and accounting for potential dropouts, the researcher determined that 200 students would provide a robust sample for our comparative analysis.

Upon completing the randomization process initially to select non-health science students out of 5500 by using SPSS as the first randomization run, the researcher decided to choose 250 students because of assumed after invitation there was a drop so need to achieve the sample size that required without the need to second run. After that the invitations were extended to these 250 randomly selected students to participate in the study. The invitations were disseminated through a combination of emails and phone calls, ensuring a personal and direct approach Appendix (N). Of those invited, 200 students agreed to participate, indicating a substantial interest and willingness to contribute to the research.

To ensure the integrity of the experimental design, the 200 consenting participants were then divided into two distinct groups: the experimental group, which would receive the immersive virtual reality (IVR) heart saver training, and the standardized group, subjected to standardized training methods. The division into these groups was accomplished through randomized allocation sampling, executed with the aid of an Excel spreadsheet specifically designed for this purpose.

Each participant was assigned a sequence based on their university ID number, ensuring a blind allocation that precluded any bias in group assignments. the researcher divided the sample into two groups, experimental and standardized groups by giving codes; code no. one to the experimental and code no. two to the standardized, then doing a randomized allocation sampling manually in excel sheet for distribution. The final sample size list was arranged according to university numbers. Then the first participant was assigned and distributed in the first group, the second participant was assigned in the second group, so on until the sample size was divided into the two groups, without human intervention by placing commands to excel program. This method of randomization and group assignment underscores the study's adherence to rigorous scientific standards, aiming to ensure that any observed differences in outcomes could be attributed directly to the training intervention rather than extraneous variables as shown in (Figure 3.4.4).

Randomized allocation sampling is a method of assigning participants to groups randomly. This means that each participant has an equal chance of being assigned to either the experimental or standardized group. Randomized allocation sampling is considered the "greatest equalizing technique available" because it helps ensure that the two groups are as similar as possible at the start of the study. This is important because it reduces the risk that any differences between the two groups at the end of the study are due to factors other than the experimental treatment. Randomized allocation sampling also helps to reduce confounders, which are factors that can influence the outcome of a study but are not of interest to the researcher. For example, if the researcher is studying the effects of a new IVR HS program on knowledge and performance, satisfaction, and self-confidence, the researcher would not want to assign all of the participants with IVR HS to the experimental group and all of the participants with HS training to the standardized group. This would create a confounder because the difference in HS training between the two groups could influence the study results. Randomized allocation sampling also helps to eliminate the cause of systematic bias, including selection bias. Selection bias occurs when the researcher selects participants for a study in a way that is not random. For example, if the researcher only selects participants who are willing to participate in the study, this could create selection bias because the participants who are willing to participate may be different from those who are not willing to participate. Finally, randomized allocation sampling gives a foundation for using probability theory to reduce errors (Pandis et al., 2019).

Probability theory serves as a foundational mathematical framework enabling the assessment of the likelihood of various outcomes (Pandis et al., 2019). Within the context of research, it facilitates the evaluation of whether observed differences between experimental groups can be attributed to random variation. By leveraging probability theory, researchers can ascertain the statistical significance of their findings, distinguishing genuine effects from those occurring by mere chance. This capability is particularly crucial in the realm of randomized allocation sampling, where it enhances the rigor and reliability of research by ensuring that the allocation of participants to groups minimizes bias that lead to elevates the overall quality of scientific investigations (Pandis et al., 2019).

Moreover, this random method of selecting the participants was controlled without contacting each other to ensure the equality between groups and to ensure all steps applied for randomized control trial design were considered a sampling from non-health sciences students currently enrolled at Arab American University. Whereas university numbers were used, a list of eligible pupils was prepared. Then, the investigator randomly assigned each student to the experimental IVR HS group and the standardized HS group to ensure no biases were induced by this method. The subjects and flow of the subjects are explained in Figure 4.

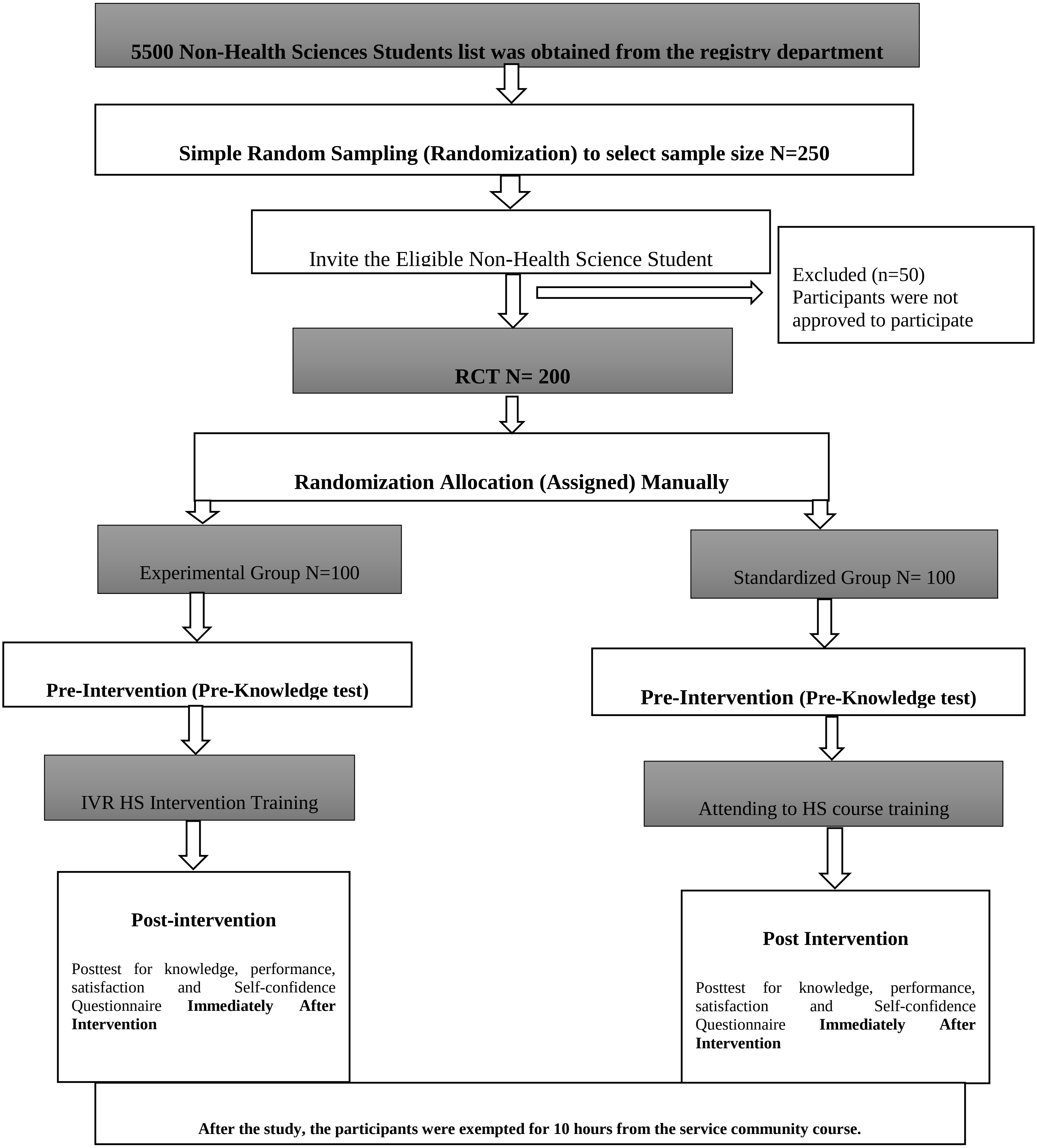

Figure 4: Flow chart of the study

3.4.4. Inclusion and Exclusion Criteria

In delineating the participation criteria for this study, a clear framework was established to ensure a focused and relevant participant pool. The inclusion criteria were explicitly designed to encompass non-health science students from all bachelor academic levels (first through fourth year) who were engaged in full-time study at the Arab American University, specifically at the Jenin Campus. The non-health science students were chosen based on their general lack of formal CPR training, thereby providing a fresh perspective on the educational efficacy of immersive virtual reality (IVR) CPR training compared to standardized methods. Importantly, participants were required to exhibit a willingness to voluntarily engage in the study and to have not previously received any formal CPR instruction, ensuring that any acquired knowledge or skills could be attributed directly to the interventions provided during the research. Conversely, the exclusion criteria strategically omitted health science students, given their prior exposure to CPR training as an integral component of their curriculum, which could confound the study's outcomes. Additionally, students from the Ramallah campus were excluded to maintain geographical consistency and control logistical variables. Individuals unable to perform the physical aspects of CPR due to medical constraints were also excluded, as the physical execution of CPR skills is pivotal in assessing the training's effectiveness. This careful selection process, underpinned by the principles outlined in educational and medical research methodologies (Creswell, 2017; Polit & Beck, 2017), ensures that the study's findings are attributable to the intended interventions, thereby enhancing the validity and applicability of the research outcomes.

3.5.Study Instruments

This research used the instrument to evaluate adult CPR knowledge, an adult CPR skills testing checklist for performance, and a self-reported questionnaire in two validity parts:

3.5.1. Demographic details:

This is the first part used in this study; the demographic information (age, gender, and marital status) was contained in Appendices (D, E).

3.5.2. Academic details:

This is considered the second part used in this study; the academic details were contained (academic year, specialty, and general point average (GPA); it is classified as acceptable, good, very good, and excellent) as shown in Appendix (D, E).

3.5.3. Knowledge Scale:

This is considered the third part used in this study, used in HS training to measure knowledge acquisition and retention pre-and post-training, in addition to compare knowledge pre and post, as well as, to compare knowledge changes differences between both groups. The ten items were selected by the researcher and 6 expertise out of 25 multiple-choice tests, which is specific and related to the CPR knowledge to assess adult CPR knowledge derived from the HS exam used by the AHA to evaluate their HS knowledge. The score is from 0 to 10 and a higher score indicated higher knowledge. However, there was no cut off point for this scale. The exam is not being a must base on AHA guideline for the HS training, and the exam is administered pre and post training for both groups. Questions on CPR for infants, children, and first aid were extracted, as well as questions on stroke and foreign body obstruction, from the original AHA test because this study focused on adult CPR with an attached AED. The questions for adult CPR include performing the correct assessment of the victim, the correct rate of compressions and breaths, the correct ratio of compressions to breaths, the correct performance of compressions and breaths, the correct use of an AED, and the correct sequence of actions of the skills. This scale was provided to the participants as a format written exam, self-reported, and the participants filled out this exam. Then, the evaluator received it to measure and collect their gain score on this scale. This tool was used and provided previously by the AHA in English and Arabic. This tool is valid and reliable with internal reliability consistency using Cronbach's alpha of 0.779 (Association, 2020) (Appendix H, I). The face validity for ten questions was done, the researcher selected the ten question which related to the knowledge of adult CPR, then these question was send to six AHA expert panels to measure its validity of using in knowledge for non-health science students. The feedback from all experts was taken, and it was a positive feedback. As well as, the ten question was readable and most relevant to the knowledge of adult CPR and AED.

3.5.4. Performance scale:

This is considered the fourth part used in this study, which was used in heart-saver training to measure the participants' performance immediately after receiving HS training for both groups based on the type of training. This study had two types of HS training: the first was the IVR HS training, and the second was the standardized HS training. The evaluators used and filled out this tool while the participants were doing their performance exams. AHA developed the CPR and AED skills testing checklist to evaluate the CPR skills of an adult victim, the checklist used to for performance evaluation for both groups, which include different items; Adult CPR and AED skills testing checklist by assessing participants' performance in the following skills: scene safety; check responsiveness; activate the emergency by calling or sending another rescuer and bringing the

AED; check breath; Adult compression by performing high-quality compression through hand placement on the lower half of breastbone, then 30 compressions in less 15 and no more than 18 seconds, compressing at least two inches (at least five cm), and achieving complete recoil after each compression; the correct position of hands on the chest with adequate depth and rate of compressions; deliver breath to adult, measuring by observation these points: each breath given over one second; visible chest rise with each breath; and giving two breaths in less than 10 seconds; as well, when AED is available, the participant should follow prompts of AED that were measured through the Power on AED. Correct attaches pads; says clear for analysis; says another clear word to deliver a shock safely; presses the button to deliver shock; and the student immediately resumes compression as shown in Appendix (G). Moreover, there are specific criteria for passed and fail score based on AHA guideline related to performance, whereas the student is considered a pass if all steps are performed and implemented successfully, especially in the significant point, and they are not doing the significant or major steps perfectly and not missing them or are not switching steps before the other one. These protocols and guidelines for this evaluation were determined based on the American Heart Association recommendation; otherwise, the student must receive a failure as shown in Appendix (Q). This instrument was previously provided to the evaluator in English by the American Heart Association. This tool is valid and reliable with internal reliability consistency using Cronbach's alpha of (0.79) (Association, 2020), as shown in Appendix (G).

This checklist assessed the CPR skills of the non-health science students participating in this research. The performance scale was used the same for the IVR HS and standardized HS groups but in different way. However, the way to measure performance in the IVR group was using computer generating software system sensing the specific items that request based on AHA criteria as the same criteria was used for the standardized and recorded the performance for each trainee.

this performance was transformed to the computer using the technology sensors based on the scale items and AHA guidelines inserted into the system.

A researcher working with the AHA coordinator as the first step in software IVR heart-saver system to record the Arabic version of the 360-degree videotape. After that, for a validation the 360-degree videotape recording contents was sent to six experts from the American Heart Association to give their feedback, and some modifications to the videotape happened twice before it was approved for use. Then, training the participant to demonstrate or perform CPR, after that the participant underwent to performance evaluation by using IVR machine. However, the software was developed for catching up IVR trainee performance by sensing their steps in CPR and transformed to the computer.

Additionally, before delivering the IVR heart-saver program to the participants the researcher and six AHA Expertise watched and used the IVR heart-saver program to ensure that the IVR heart-saver software program's content validity and the HS IVR program's sequences were valid. Additionally, six AHA expert panels tested the IVR heart-saver program in the AHA heart center using the phase validity by filled out the expert survey (Lee et al.,2022) and by practicing the experience of IVR HS step by step to determine its validity (Lee et al.,2022). As presented in Table (3.5.4.1), the panel was asked to score each sequence's clarity, simplicity, ease of use, clarity, understandability, and accuracy. The software IVR heart-saver tool was assessed the phase validity; the result revealed that all experts agreed on the usability of the IVR HS software system, which was relevant, precise, accurate, easy, understandable, and accessible. Additionally, six AHA expert panels tested the HS IVR program in the AHA heart center using the content validity index (CVI) to determine its validity of using the software program. The panel was asked to score each sequence's clarity, simplicity, ease of use, clarity, understandability, and accuracy: non-relevant =

1; somewhat relevant = 2; relevant but requiring a minor change = 3; and relevant = 4. The result revealed that all experts agreed on the usability of the IVR HS software system, which was relevant, precise, accurate, easy, understandable, and accessible. The content validity also indicates that all items were given four stars, and the experts did not comment. The total CVI was 1 for the tool.

Table 3.5.4.1: Results of the expert group survey.

Usability survey						
#	Items	Strongly agree	Agree	Neutral	disagree	Strongly disagree
A	Easy to use					
1	Learning to operate the system	5	1	0	0	0
2	I was able to see my hand and manikin well VR	5	1	0	0	0
3	My interaction with the system is clear and understandable	4	2	0	0	0
B	Training is delivered well					
1	I believe I could quickly become proficient in HS using this system	4	2	0	0	0
2	The information was effective in helping me complete the tasks and scenarios	6	0	0	0	0
3	The instructions in the VR tutorial were organized, clear, and easy to understand	6	0	0	0	0
C	Basic learning (AI instructor %)					
1	It was easy to understand the AI instructor's explanations and instructions	5	1	0	0	0
2	My interaction with the AI instructor is clear and understandable	6	0	0	0	0

Besides that, to double check of the performance evaluation process and sensing, there was an observer used a hard copy of the same checklist by observing their performance by watching the video broadcast while the participants performed adult CPR during exam time, and it was compared again with what was recorded in the computer system to make sure there was a consistency between computer results and observer results. In addition, the researcher and AHA observer evaluated the standardized HS participants while performing adult CPR by using a hard copy of the adult checklist to assess the group's performance, and their results were compared between them to prevent any biases was happened in evaluation and to make sure there was a consistency between researcher results and observer results. Permission to use the skills testing checklist was obtained from the AHA, as shown in Appendix (F).

Furthermore, to validate the software program scoring system and prevent bias, as well as to ensure consistency in each group results, however, this study categorized IVR participants under pass and fail at the same like standardized group based on AHA criteria. In the IVR heart-saver program, the observer from AHA was used in the checklist to assess their performance beside the software program and to ensure an accurate result for evaluation by watching the podcast video while the participants performed HS CPR with AED during exam time. After evaluation, the evaluators compared their results to ensure consistency between their evaluations, however, there was a 100 consistency on that. Regarding to the standardized group, to ensure the validity and prevent biases during the performance evaluation, the researcher and the AHA observer used the Adult CPR and AED skill test checklist to assess their performance during exam time. The researcher also ensured an accurate result for evaluation by observing the participants when performing HS adult CPR with AED, and then the observer compared their results with each other however, there was a 100 consistency on that. The response data are paired observations of the same performance testing for both groups, meaning that both raters assess the same observations. The Kappa agreement was used for the validity of performance testing without bias, and the result was (1) an almost perfect agreement. The two raters are independent, which does not affect the other rater's judgment, as shown in Table 3.5.4.2. Additionally, the total time for the standardized group ranged from two to three hours for completing the whole procedures based on the number of class participants per group, and for the IVR heart-saver from one to one and half hours per participant.

Table 3.5.4.2: Comparing the researcher evaluation score and the second observer score

The measure of Agreement Kappa	**Performance Evaluation**		**Kappa value**	**P-Value**
	Pass	Fail		
	145	0	1.000	0.001
	0	55		
Total	145	55		

3.5.5. Student Satisfaction and Self-confidence in Learning National League for Nursing (NLN) tool:

This is considered the fifth part used in HS training in this study to measure the learners' satisfaction and self-confidence immediately after receiving HS training for both groups. This measure was developed by NLN (2011) to assess the students' satisfaction and self-confidence in the CPR learning process. The learners' satisfaction and self-confidence of learning (LSSCL) is a 13-item rating on a 5-point Likert scale. The instrument consists of two subscales. One sub-scale contains five items measuring student satisfaction, and the other has eight items measuring self-confidence among HS trainee for both groups, as shown in Appendices D and E. Satisfaction scores ranged between 5 and 25. In contrast, self-confidence ranged between 8 and 40. Higher scores indicate greater satisfaction and confidence. There is no cut of point based on deevloper. This tool was previously translated into Arabic by the World Health Organization and is widely used in simulation learning and teaching (Jeffries, 2005; Murphree, 2018; Toqan et al., 2023). This instrument was also provided and used in English and Arabic. This scale was provided to the participants in the Arabic language by the researcher as a self-reported, and this scale was filled out by the students immediately after performing the intervention. This tool is valid and reliable, with internal reliability consistency using Cronbach's alpha of 0.94 for satisfaction and 0.87 for self-confidence (NLN, 2011). In the current study, Cronbach's alpha was 0.935 for satisfaction and 0.935 for self-confidence.

3.6.Pilot Study

This research selected 50 students who met the criteria for pilot study. The purpose of piloted study to ensure the safety, feasibility, and accuracy of the IVR and the standardized methods involving 50 students distributed randomly for both groups, 25 students in IVR group and 25 in standardized group. This pilot was performed after expertise testing the software system and before doing the first randomization to main study. As well as, this pilot sample was not included in the main study.

The IVR HS software method, standardized method, and the instrument (LSSCL) were piloted. The pilot study showed that the instruments and both methods were straightforward, safe, feasible, readable, had an accurate sample size, were acceptable, and the feedback from both groups was taken, it was positive feedback from the training clarity for all measurements in each group. The time of IVR method was taken an average of one to one and half hours per students to complete all procedures compared to the standardized method was taken from two to three hours for each participant to complete all procedures.

The reliability of a pilot study is the ability of the instrument to measure the same variable again at different times. In contrast, validity is the research instrument's relevance to measuring what it is intended to assess (Mishel, 1998). The tool's internal consistency reliability with Cronbach's alpha coefficient on the pilot and current study samples was tested to obtain accurate results. This measures the reliability or internal consistency $\alpha \geq 0.9$ excellent, $0.9 > \alpha \geq 0.8$ good, $0.8 > \alpha \geq 0.7$ acceptable, $0.7 > \alpha \geq 0.6$ questionable, $0.6 > \alpha \geq 0.5$ poor, and $0.5 > \alpha$ unacceptable; that is considered week inter-relatedness between items or heterogeneous constructs should be revised or discarded. The researcher calculated the Cronbach's alpha of the tool (the questionnaire) using a pilot sample of 50 students from non-health science faculties. The results revealed that the CRONBACH'S ALPHA (coefficient alpha) for the LSSCL questionnaire consisted of two parts and was acceptable: The learner satisfaction subscale consisted of 5 items ($\alpha = 0.884$), the self-confidence learner subscale consisted of 8 items ($\alpha = 0.860$) , as shown in Table 3.6.

Table 3.6: Pilot study results of the LSSCL questionnaire

Items	**CRONBACH'S ALPHA (coefficient alpha)**	**N Items**	**Scale of measurement reliability or internal consistency**
Learner Satisfaction	0.884	5	Good
Learner Self-confidence	0.860	8	Good

α = CRONBACH'S ALPHA (coefficient alpha)

3.7.Ethical Considerations

After obtaining ethical approval and all permissions from graduate studies and IRB approval from Arab American University, and after obtaining permission from AHA and NLN to use their instruments, which are heart saver videos, adult CPR, and AED skills test checklist heart saver for evaluation participant's evaluation, and learning student satisfaction and self-confidence questionnaires.

Ethical approval was obtained from the Institutional Review Board (IRB) at Arab American University in Palestine. Then, after taking IRB approval (Appendix B). Permission was obtained from the American Heart Association (AHA) to use their instruments (Appendix F), and permission from NLN was also obtained to use their questionnaire (Appendix C). The investigator asked the participant who was approved to participate in this study to sign a consent form. Also, the participants had the opportunity to ask questions, and they could withdraw from the study at any time without giving reasons to ensure confidentiality. Moreover, after obtaining consent from participants, a verbal and written explanation sheet about the purpose of this study and study procedures was given to the participants.

3.8.Intervention

3.8.1. The immersive virtual reality heart saver training

The primary intervention was the immersive virtual reality (IVR) heart saver (HS) training, which was located in the virtual reality lab at Arab American University. The participants were received training on IVR HS by using the software computer system, beside that there was a researcher and an observer. The participants wore some of the devices required for IVR training, such as oculus devices and hand-immersive gloves (haptic gloves), to immerse the participants in the HS experience, especially when performing chest compression. Additionally, it is important to note that Dr. Ahmad Ewais and his IT team at Arab American University created, developed, and oversaw this experience from scratch. The researcher and AHA instructor assessed the IVR HS training (experimental group) using the American Heart Association pre- and post-exam, learning satisfaction and self-confidence questionnaire post-training as a self-reported, and performance evaluation after performing heart-saver by using the software and the results of performance was generated by computer software, as well as using the Adult CPR and AED skills test checklist from the American Heart Association to evaluate their performance, and the criteria of check list was inserted to the software and was sensed by the system. Before attending the IVR HS training, the participants were briefly introduced to the software and hardware. Demonstration of all possibilities of interaction with virtual reality by wearing an oculus and immersive gloves to make participants feel inside in the event of cardiopulmonary resuscitation.

The sequence training on the IVR HS experience was done in three steps at the Arab American University Virtual Reality Lab. The first step prepared participants by stimulating and watching on the 3D Animation 360-degree video platform by wearing the Oculus to watch the 360-degree video and understand how CPR and AED were performed on the adult victim. In this step, the amount of time was around five minutes. Moreover, in the second step, the participants demonstrated CPR with AED performance on the victim by wearing the Oculus virtual reality headset with immersive gloves (haptic gloves). These haptic gloves contain sensors inside them, which make vibrations, especially when performing all the steps of adult CPR, to make participants feel inside during cardiopulmonary resuscitation. Based on the HS scenario, the participants followed the verbal and visual instructions, focusing more on the HS content experience, as shown in Table 3.8. In the last step, the participants were evaluated for their performance in heart-saver adult CPR with AED by following the visualized scenario. The system gave the scoring pass and failed based on the AHA subjective criteria, and the HS checklist for evaluation was admitted into the software system as shown in appendix (G); the evaluation result and feedback in the second step and last step were shown on the VR screen and gave both verbal and visual feedback if performance was suboptimal. Also, after training and performance evaluation, the participants immediately attended the posttest written exam and filled out the satisfaction and self-confidence questionnaire.

3.8.2. Standardized Heart Saver Training

The standardized heart-saver training was located in the Heart Center at Arab American University, which had conducted face-to-face heart-saver training using the American Heart

Association protocols. The participants conducted the American Heart Association pre knowledge exam before attending the HS training. After that, the participants were conducted in the standardized training by watching HS 2 digital videos (Adult CPR, rescue breathing, and using the AED, respectively). then, the participant had a practice what is in the videos contents. Then, the participants attended the performance evaluation immediately post-training by the researcher and AHA observer using the AHA heart-saver adult CPR and AED skill test checklist. As well as, Post knowledge exam learning satisfaction and self-confidence questionnaire was measured immediately post-training as a self-reported for the standardized heart-saver training (standardized group).

The sequences of training for the standardized group were attended by the participants to a pre-exam, then watching the two digital videos, and after that, the participants trained by demonstrating the skill on LAERDAL mannequins QCPR feedback manikin (compression rate, depth, accuracy of chest recoil, and rescue breathing) to perform CPR with AED by using American Heart Association heart saver protocols and guidelines. Then, the participants were provided the heart-saver scenario as shown in Table (3.8) for performance evaluation to assess their CPR skills by using the Laerdal QCPR feedback manikin and the AHA heart-saver adult checklist subjectively, as shown in Appendix (G), respectively. Afterward, participants attended the posttest written exam and completed the satisfaction and self-confidence questionnaire.

3.9. Study Procedure

When establishing the IVR HS training software program, the researcher and multimedia programmer first created a 360-degree heart-saver video in Arabic because all participants' mother tongue is Arabic. After establishing the recorded instruction for the IVR training in the demonstration part, the recorded instruction voice was in Arabic based on AHA HS instructions for Adult CPR with AED and guidelines. Secondly, the Information technology (IT) programmer created the new software based on AHA heart-saver contents in Arabic version; steps, criteria, guidelines, and heart-saver contents were provided to the IT programmer. The Heart Saver software program contains a 360-degree video, a training demonstration while listening to the recorded instructions to apply the HS Adult CPR and AED training through IVR, and an evaluation of the participant's performance, which is considered a performance exam. The duration time for each component in the experimental software program is as follows: the 360-degree video is 4:21 minutes, the demonstration takes 4 to 6 minutes, and the performance exam takes 2 minutes; the total range for that was around 12 minutes for each participant. Establishing the IVR HS software program took eight months, and the cost of this program was around 1500 USD dollars. It is worth mentioning that this program is provided in two languages, Arabic and English, as well as the same AHA content. Also, the AHA provides a heart-saver course in Arabic and English. Finally, testing the software program, this phase is essential before attending and applying to the study; in this phase, the testing was activated by the IVR HS program through the application to make sure the software is working accurately in a proper way without any deficit in the future. Around six people and two AHA instructors were invited to the testing program as shown in (Appendix P). After testing, the program needed some modifications, such as adding highlighters for the press location. The highlighter will enlarge when you press, grabbing hazardous objects requires you to touch them only to count, the microphone should hear the target better, and Check for breathing has a box to look at to be considered as "looking at the chest. All modification was done in the testing phase of IVR training before attending the pilot and research study to make this training program accurate, precise, feasible, and acceptable.

After obtaining ethical approval and all permissions to begin research and use the instruments, the sampling method was calculated and delivered to recruit the participants. First of all, the researcher invited the participants and explained its aims, content, and duration over email and phone calls, as well as; the researcher informed and texted them that, after participating in the study exempted 10 hours from the service community course as an incentive reward to them as agreed with the deanship of the student (Appendix N).

Furthermore, the consent form was assigned to participants who were eligible for this study and were willing to participate for each group when attending the VR lab or heart center also the researcher informed the participants that they could withdraw from the study at any time without giving reasons to ensure confidentiality (Appendix L, M). Then, the verbal and written explanation sheet and duration about the purpose of this study and study procedures was given and explained to the participants (Appendix J, K).

The participants in the experimental group were given a determined appointment at a specific attend time. The training for the experimental group was individual, the training for the experimental group was scheduled for one month, and the experimental training was conducted in a virtual reality lab at Arab American University. Each participant, before attending IVR heart saver training, was assigned the consent form after providing the explanation paper. After that, the pre-test written exam was administered to the participants before attending IVR HS training, and the pretest was considered as a baseline for the study. The amount of time for assigned consent, reading the explanation paper, and providing information related to the program, such as how to deal with new IVR technology and how to use it, and hall procedure before training took around 35 to 40 minutes. Then, the participants attended the IVR HS training by following the sequences by selecting from the list in front of them through oculus as shown in Figure (5) (watching a 360-

degree video, demonstration, then performance evaluation by following the heart saver scenario respectively), as shown in Table (3.8), the amount of time ranged for training and evaluation from 12 minutes to 15 minutes for completing the procedure. After learning and performing their performance evaluation of the IVR Heart Saver Training, the participants did the post-exam immediately and filled out the satisfaction and self-confidence learner questionnaire; the total amount of time to do the post-test exam and fill out the questionnaire took 30 minutes. The total amount of time ranged from one to one and a half hour for completing the hall procedures for each participant because some of the participants were familiar with the VR technology, which is why they took one hour rather than someone unfamiliar with the technology.

Figure 5: Field Study of Experimental Heart-Saver Virtual Reality

The participants in the standardized HS group were split up into fourteen groups. The training was made up of six to seven students in each group, and an instructor and researcher led the courses. The standardized HS training was located in the Heart Centre at Arab American University, which uses the AHA heart-saver contents (Adult CPR, Rescue Breathing, and AED, respectively). Each participant, before attending standardized heart saver training, was assigned the consent form after providing the explanation paper. After that, the pre-test written exam was administered to the participants before attending the training, and the pretest was considered as a baseline for the study. The amount of time for assigned consent, reading explanation paper, and providing information related to the training, such as the importance of heart-saver. All procedures before attending the training took around 30 to 40 minutes.

After that, the standardized group conducted face-to-face heart-saver training by watching HS 2 digital videos, and after each video, the participants were trained on mannequins to perform adult CPR, rescue breathing, and AED while watching, which took around 40 to one hour. After training, the participants attended the performance evaluation immediately. The participants did the post-exam immediately and filled out the satisfaction and self-confidence learner questionnaire; the total amount of time to do the post-test exam and fill out the questionnaire was 30 minutes. The total amount of time ranged from two to three hours for each group to complete the hall procedures, as well as the permission to take pictures and use it while participant performing CPR for each group was obtain from the participants when attending to the training as shown in Figure (6).

Figure 6: Field Study of Standardized AHA Heart-Saver.

In addition, it is worth mentioning that, related to standardized performance evaluation, the instructor and AHA instructor use the stopwatch to ensure and verify the accurate time for each component of the CPR checklist; however, concerning the IVR timer was calculated from the software program. Also, the cost of a heart saver for any person who would like to take this course depends on AHA prices for each country, and one instructor leads this course; the ratio of this training is one instructor to 6 at least and nine as max in each group.

To prevent contamination between the external and the standardized groups, the study was conducted as follows: the standardized group participated at the AHA center at a designated time other than the other group's time, which the researcher provided with AHA observer. After completing the attending to the heart saver course training, the participants in the standardized group were assessed individually in performing Adult CPR and AED skills. Further, the intervention group received a heart-saver IVR training at a VR lab that the researcher provided with AHA observer. After completing the heart-saver IVR training, the participants were immediately assessed individually in performing Adult CPR and AED skills. After that, the two groups completed the satisfaction and self-confidence questionnaire. These sequences were done immediately to adjust for extraneous variables and ensured that skills were assessed immediately following the scenario (Table 3.9). Students were instructed not to discuss the scenario with others, to prevent any discussion related to the scenario, the participants in the standardized training were scheduled to attend the standardized groups at different times, and the participants in the IVR training were scheduled to participate at various times for each participant. As well as, participants were told that their participation would not influence their evaluations. Then, the data collection was conducted using the following tools: a questionnaire, an American Heart Association pre and post-exam, training on both VR for the interventional group and a demonstrative scenario for the control group, as well as using the heart server performance checklist for both groups after training to evaluate their performance skills. After that, the data was analyzed to conclude the findings. These results were used for Ph.D. research purposes, as shown in Figure 7.

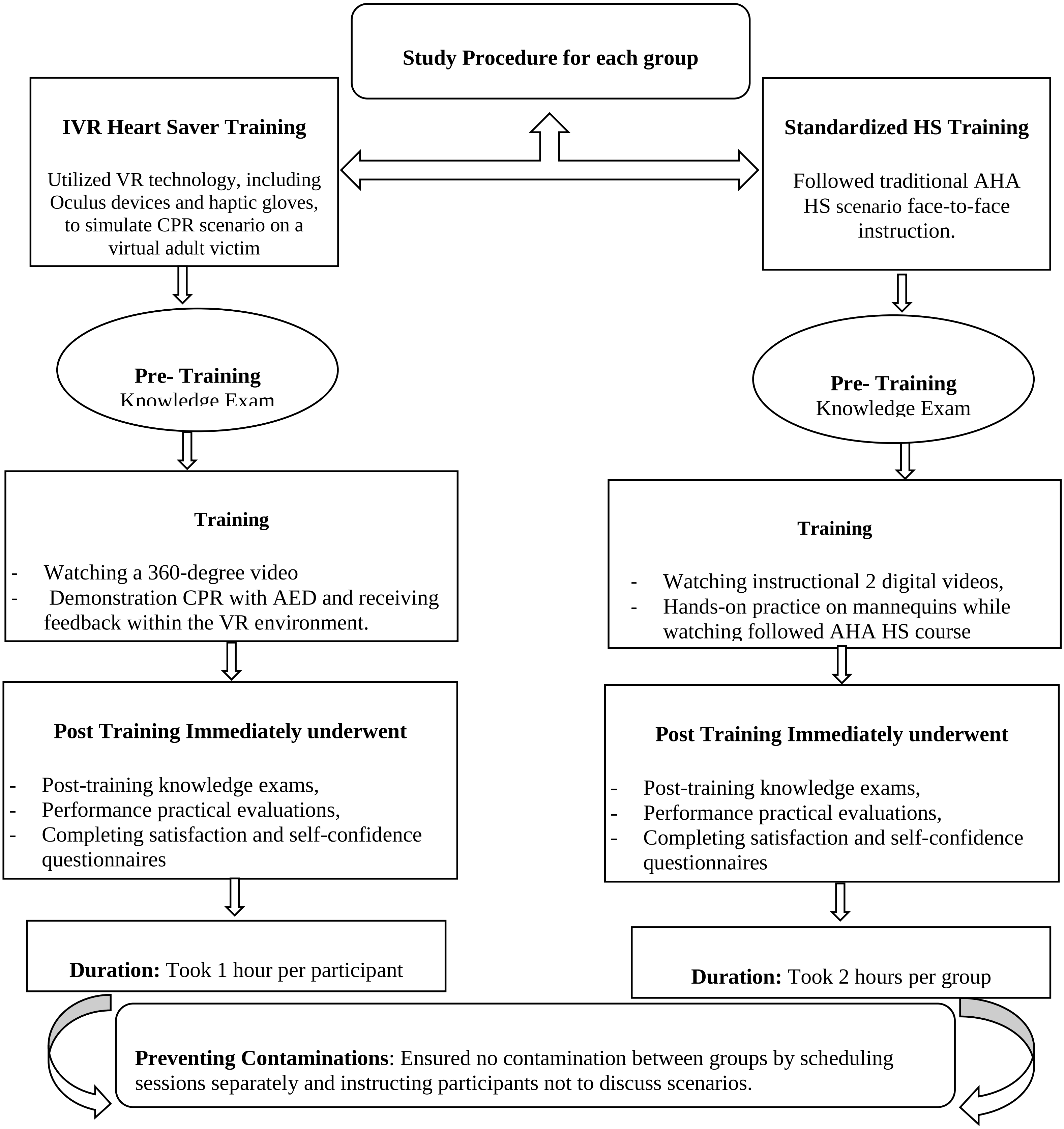

Figure 7. Study Procedure

Table 3.9: Heart-Saver Scenario

Scenario duration	Overview Scenario	Objectives
Scenario 1 Time: 2 minutes	Case Scenario: Scenario: "You arrive at the scene for a suspected cardiac arrest. No bystander CPR has been provided. You approach the scene and ensure that it is safe. Demonstrate what you would do next."	• evaluate performance competency in heart-saver skills: Critical Skills Descriptors 1. Assesses the person and activate the emergency response system (this must precede starting compressions) within a maximum of 30 seconds. After determining that the scene is safe: - Checks for responsiveness by tapping and shouting - Shouts for help/directs someone to use a cell phone to phone 9-1-1 or leave to find a phone and get AED - Checks for no breathing or no normal breathing (only gasping) - Scans from the head to the chest for a minimum of 5 seconds and no more than 10 seconds 2. Cycle 1: Performs high-quality chest compressions (initiates compressions immediately after recognition of cardiac arrest) • Correct hand placement: - Lower half of the breastbone - 2-handed (second hand on top of the first) - Compression rate of 100 to 120/min - Delivers 30 compressions in 15 to 18 seconds • Compression depth and recoil at least 2 inches (5 cm) - Use of a commercial feedback device/manikin is required. Complete chest recoil after each compression 3. Cycle 1: Provide two breaths by using a barrier device • Opens airway adequately - Uses a head tilt-chin lift maneuver - Delivers each breath over 1 second - Delivers breaths that produce visible chest rise - Avoids excessive ventilation - Resumes chest compressions in less than 10 seconds 4. Cycle 2: Performs the same steps for compressions and breaths as in Cycle 1 5. AED use • Powers on AED -Turns AED on by pushing a button or lifting the lid as soon as it arrives

		• Correctly attaches pads - Place proper-sized pads for the person's age in the correct location • Clears for analysis -Clears rescuers from person for AED to analyze rhythm (pushes analyze button if required by device) -Verbalizes and visually demonstrates to stay clear of the person • Clears to deliver a shock safely -Verbalizes and visually demonstrates to stay clear of the person • Presses the button to deliver a shock -Resumes chest compressions immediately after shock delivery -Does not turn off AED during CPR 6. Cycle 3: Performs the same steps for compressions and breaths as in Cycle 1. • Improves competency in heart-saver skills. • Provides easy, real-time access to core course tests. • Expands reach in providing this critical skill to a broader audience of Facilitators

3.10. Data Analysis

All data was entered into a database, and statistical data analysis was conducted using the Statistical Package for Social Science (SPSS) software version 25. A p-value of 0.05 was considered statistically significant. Descriptive statistics were used, including frequencies, percentages, means, and standard deviation. Repeated measure ANOVA was used to compare the types of training methods (IVR experimental and standardized training) to determine the difference of immersive virtual reality using HS compared to standardized HS training on Knowledge. Independent t-test and Chi-square were used to compare study groups on performance and the association between study groups concerning demographical and academic data. An independent t-test was used to compare satisfaction and self-confidence between the study groups. The tests were used to analyze the data based on the research question, and the aim of using these measurements is explained in the Table 3.10 below.

Table 3.10: Explain the study variable with an analytical test

Variable	**Objective for measurement**	**Test**
Demographic and Academic details	To describe the nature of participants' characteristics	Description analyzes.
Demographic and Academic details versus group	To examine the differences between study groups according to the demographic-academic data	-Chi-square as a categorical variable is recommended to use the cut point -independent t-test as a continuous variable
Normality	Description of the distribution of the continuous data	Skewness and kurtosis test
Differences in Knowledge before and after training based on study groups	To determine the level of knowledge changes and the differences between study groups in relation	Independent t-tests
Changes in knowledge scores based on study groups	To determine the differences between study groups based on the level of knowledge changes and to determine which method is more effective.	Repeated measures of the ANOVA test
A comparison between study groups based on the performance	To determine and compare their level of differences in performance after receiving their training	Chi-square test
Kapa Co-efficient for performance evaluation	To ensure the validity of results between evaluators and do the sensitivity test.	Kapa test
A comparison between study groups according to satisfaction and self-confidence	To determine the differences between study groups in satisfaction and self-confidence after receiving their training	Independent t-test
The homogeneity test	To describe the variance or standard evaluation between groups, this test is used with any parametric test.	Levine's test of equality of error variances
Association between (knowledge, performance, satisfaction, and self-confidence) and demographical-academicals data	To determine the association differences between (knowledge, performance, satisfaction, and self-confidence) and demographical-academical data for each group.	-A Pearson correlation test -An Independent t-test - One-way ANOVA

3.11. Summary

An experimental RCT design, pre-post-test, specific intervention, and post-intervention performance evaluation for experimental and standardized groups was adopted to perform the current study. A sample of all academic levels from the first to the fourth year in non-health sciences at AAUP was recruited and randomly assigned to experimental or standardized groups. Both groups completed the demographic, academic details, and pre-knowledge test before administering them on their determined intervention of heart saver in adult CPR and AED training programs. Also, they were evaluated about performing AHA heart saver in adult CPR and AED training. The researcher conducted the study as follows: the standardized group participated in the AHA heart saver program for 2 to 3 hours by using two digital videos, then receiving the training on the manikin, then evaluating their performance, posttest, and satisfaction and self-confidence immediately after training. However, the experimental group received training for one and a half hours each on the IVR Heart saver program using haptic gloves and oculus; the participants were attended to 360 video degrees, then they received training through the oculus, then evaluated immediately for their performance, post knowledge test, satisfaction, and self-confidence questionnaire. Data were analyzed using SPSS version 25, and chi-square and an independent t-test, repeated measure ANOVA were utilized to examine the differences between the experimental and the standardized groups and to test the assumption of this study based on research questions.

Chapter Four: Results

4.1. Introduction

This chapter presents the study's main findings, beginning with the demographic and academic characteristics of the participants and moving on to the core research areas: knowledge, performance, satisfaction, and self-confidence. The sections are organized to align with the research questions posed in the study, ensuring a coherent and comprehensive presentation of the findings. The chapter utilizes statistical tests, including chi-square tests, independent t-tests, ANOVA, and Pearson correlation, to analyze the data comprehensively. The findings are presented in a way that is easy to understand, with detailed explanations and tables for each examination. This provides a detailed understanding of the differences of IVR heart-saver training compared to the standardized HS training method. This chapter is essential for understanding the impact and effectiveness of different training methods for non-health science students, ultimately making a valuable contribution to emergency response training.

4.2. Demographic and Academic Details of Participants

Table 4.2 describes the demographic and academic characteristics of the participants in the study, divided into IVR and standardized groups. The mean age of the total study sample was ($M=20.06$, $SD= 1.32$); the mean age for the IVR HS group was ($M=20.07, SD=1.38$), and the mean age for the standardized HS group was ($M=20.05, SD=1.26$). The gender distribution across the entire participant pool showed 43 males, making up 21.5%. In the IVR group, there were 23 males, accounting for 23% of the group, while the standardized group had 20 males, making up 46.5%. A higher proportion of females were included in the study, with 157 participants (78.5%).

Specifically, the IVR group comprised 77 females (77%), while the standardized group had 80 females (51%).

The majority of participants, 195 individuals (97.5%), reported being single. Within this, the IVR group had 97 single participants (97%) compared to the standardized group, with 98 single participants (98%). Only 5 participants (2.5%) were married, with 3 in the IVR group (3%) and 2 in the standardized group (2%).

The participants were also evenly distributed across academic years, with each year group representing 30% for the first year, 26% for the second year, 24% for the third year, and 20% for the fourth year, with an equal number of participants from each year in both study groups.

In terms of academic achievement, 42 participants (21%) were rated as excellent, 113 (56.5%) as very good, and 45 (22.5%) as good. The IVR group had 18 participants (18%) rated as excellent compared to the standardized group's 24 participants (24%). The distribution of participants by university specialty or faculty was as follows: Admin & Financial (42 participants, 21%), Law and Science (49 participants, 24.5%), Art and Sport Sciences (47 participants, 23.5%), and Engineering and IT (62 participants, 31%). The IVR group included 17 participants (17%) from Admin & Financial and 36 (36%) from Engineering and IT, while the standardized group had 25 (25%) from Admin & Financial and 26 (26%) from Engineering and IT.

The chi-square analysis did not reveal significant differences in gender, marital status, academic level year, academic achievement, or university specialty between the IVR and standardized groups, indicating a balanced representation across groups, it revealed that the groups' demographical and academicals variables are similar and equal between two groups. The similarity is important because it ensure that any observed variations in study results are likely attributed to the specific intervention, not by other factors. That improved the study's internal validity, allowed a fair comparison, controled for confounding variables, and strengthens the findings' applicability to wider populations.

Table 4.2: Demographic and Academic Profile of Participants and Chi-Square Analysis of Group Differences in IVR and Standardized Training. (N=200; IVR hear-saver group=100; standardized HS group=100). A chi-square test was performed.

Variable	Overall N (%)	IVR Group n (%)	Standardized Group n (%)	Chi-square value	df	P-value
Gender				0.267	1	0.606
Male	43 (21.5)	23 (23)	20 (46.5)			
Female	157(78.5)	77 (77)	80 (51)			
Marital Status				0.205	1	0.651
Single	195 (97.5)	97 (97)	98 (98)			
Married	5 (2.5)	3 (3)	2 (2)			
Academic Level Year				0.000	3	0.623
First Year	60 (30)	30 (30)	30 (30)			
Second Year	52 (26)	26 (26)	26 (26)			
Third Year	48 (24)	24 (24)	24 (24)			
Fourth Year	40 (20)	20 (20)	20 (20)			
Academic Achievement				1.422	2	0.491
Excellent	42 (21)	18 (18)	24 (24)			
Very Good	113 (56.5)	57 (57)	56 (56)			
Good	45 (22.5)	25 (25)	20 (20)			
University Specialty or Faculty				5.860	3	0.119
Admin & Financial	42 (21)	17 (17)	25 (25)			
Law and Science	49 (24.5)	28 (28)	21 (21)			
Art and Sport Sciences	47 (23.5)	19 (19)	28 (28)			
Engineering and IT	62 (31)	36 (36)	26 (26)			

M*: Mean; SD: Standard Deviation; N: Total sample; n: sample for each group; %: percentage; p: significant at the 0.05 level; IVR: Immersive Virtual Reality*

4.3. CPR Knowledge Acquisition in IVR Versus Standardized Training Programs

4.3.1 Pretest and Posttest Knowledge Scores in IVR and Standardized Heart Saver Training Groups

As shown in Table 4.3.1, This study compared the knowledge of pretest before attending to any intervention between the IVR heart-saver training and the standardized HS training. An independent t-test was employed to compare between study groups, the pretest score of knowledge for the IVR heart-saver was 2.79 (±2.01) compared to the pretest score of knowledge for standardized HS training 2.57 (±2.11), this indicated that, there was no significant difference in means total score *(t= 0.753, p= 0.452*) between both training groups in pretest of knowledge. Regarding the result of assessing knowledge about the best actions for survival if someone is not breathing (or is only gasping) and is unresponsive, the pre-test score was 0.48 (±0.50) in the IVR HS compared to the standardized HS group scored was 0.26 (±0. 44), there was a significant difference in means score (*t=3.293, p=0.001*) between two groups. This indicated that, the IVR HS groups having better score more than the standardized HS group in relation this aspect. Moreover, according to chocking adult stops responding, the pre-test score was 0.340 (±0.476) in the IVR HS compared to the standardized HS group scored was 0.20 (±0.402), there was a significant difference in means score *(t= 2.24, p= 0.02*) between study groups. This indicated that, the IVR HS groups having better score more than the standardized HS group in relation this aspect. However, there was no significant difference in the other aspects in the pretest of knowledge.

Regarding The results of comparing knowledge of posttest between the IVR heart-saver training and the standardized HS training. The result of an independent t-test comparing between study groups revealed that, the posttest score of knowledge for the IVR heart-saver was 8.40 (±1.01) compared to the posttest score of knowledge for standardized HS training 8.21 (±1.37), this indicated that, there was no significant difference in means total score *(t= 0.753, p= 0.452*) between both training groups in posttest of knowledge. means total score *(t= 0.753, p= 0.452*) between both training groups in pretest of knowledge. Regarding the result of assessing knowledge about the best actions for survival if someone is not breathing (or is only gasping) and is unresponsive, the posttest score was 1.00 (±0.00) in the IVR HS compared to the standardized HS group scored was 0.84 (±0.36), there was a significant difference in means score (*t=4.34, p=0.001*) between two groups. This indicated that, the IVR HS groups having better score more than the standardized HS group in relation this aspect. Moreover, according to chocking adult stops responding, the posttest score was 0.94 (±0.23) in the IVR HS compared to the standardized HS group scored was 0.82 (±0.38) there was a significant difference in means score *(t= 2.64, p= 0.009*) between study groups. This indicated that, the IVR HS groups having better score more than the standardized HS group in relation this aspect. However, there was no significant difference in the other aspects in the posttest of knowledge.

The results of comparing the knowledge between IVR heart-saver training and Standardized HS training provide detailed insights into their effectiveness in teaching adult CPR. the results of independent t-tests comparing pre-test and post-test knowledge total mean scores show that, In the IVR HS group, the pre-test mean score was 2.79 (±2.01) and improved to 8.40 (±1.01) in the post-test, while in the Standardized HS group, it was 2.57 (±2.11) in the pre-test and 8.21 (±1.37) in the post-test. This indicated that, the IVR heart-saver and Standardized HS groups showed improvement from the pre-test to the post-test, and the differences in improvements between groups were not statistically significant. Moreover, the results of independent t-tests comparing pre-test and post-test knowledge scores highlight various aspects of CPR knowledge and skills. Regarding the correct rate and depth for providing compression during high-quality adult CPR, the increment in knowledge was statistically similar for both groups, indicating that each method was equally effective in imparting this specific aspect of CPR knowledge. In the IVR HS group, the pre-test mean score was 0.28 (±0.45) and improved to 0.94 (±0.25) in the post-test, while in the Standardized HS group, it was 0.23 (±0.42) in the pre-test and 0.93 (±0.25) in the post-test. However, the IVR heart-saver and Standardized HS groups showed improvement from the pre-test to the post-test, and the differences in improvements between groups were not statistically significant.

Regarding actions to take when calling an emergency response number, both groups showed similar improvements. In the IVR HS group, the pre-test score was 0.24 (±0.42), improving to 0.81 (±0.39) in the post-test. The standardized HS group scored 0.29 (±0.45) in the pre-test and 0.72 (±0.45) in the post-test. The differences in improvements between groups were not statistically significant, suggesting that both methods effectively taught how to handle emergency communications. When assessing knowledge about the best actions for survival if someone is not breathing (or is only gasping) and is unresponsive, the IVR HS group showed a significant improvement. The pre-test mean score for the IVR HS group was 0.48 (±0.50), rising to 1.00 (±0.00) in the post-test, while the Standardized HS group improved from 0.26 (±0.44) in the pre-test to 0.84 (±0.36) in the post-test. These results indicate a notably higher effectiveness of IVR HS training in this aspect, and The differences in improvements between groups were statistically significant. According to tap and shout aspect, both groups showed similar improvements. In the IVR HS group, the pre-test score was 0.19 (±0.39) improving to 0.72 (±0.45) in the post-test. The standardized HS group scored 0.23 (±0.42) in the pre-test and 0.69 (±0.46) in the post-test. indicating that each method was equally effective in this specific aspect of CPR knowledge, and The differences in improvements between groups were statistically significant. When assessing knowledge about push hard the chest on the adult victim, both groups showed similar improvements. In the IVR HS group, the pre-test score was 0.22 (±0.41), improving to 0.86 (±0.34) in the post-test. The standardized HS group scored 0.23 (±0.42) in the pre-test and 0.88 (±0.32) in the post-test. These results indicate a notably each group having equally improvement in this aspect, and the differences in improvements between groups were statistically significant.

Similarly, for switch positions and allow someone else to take over compression and breaths both groups aspect showed similar improvements. In the IVR HS group, the pre-test score was 0.19 (±0.39), improving to 0.79 (±0.40) in the post-test. The standardized HS group scored 0.20 (±0.40) in the pre-test and 0.88 (±0.32) in the post-test. These results indicate that, both groups having similar improvement in this aspect, and the differences in improvements between groups were statistically significant. Moreover, in understanding how to breathe with a mask aspect, the IVR HS group's pre-test mean score of 0.32 (±0.46) increased to 0.77 (±0.12) in the post-test, and the Standardized HS group's score improved from 0.27 (±0.44) to 0.84 (±0.36). The differences in improvements between groups were not statistically significant, offering that both methods effectively taught how to breath with a mask.

For other CPR-related questions, both groups improved from the pre-test to the post-test. For instance, in understanding what should you do when AED arrived, both groups showed similar improvements. In the IVR HS group, the pre-test score was 0.31 (±0.46), improving to 0.79±0.40 in the post-test. The standardized HS group scored 0.37 (±0.48) in the pre-test and 0.81 (±0.39) in the post-test. When assessing knowledge about chocking adult stops responding aspect, the IVR HS group showed a significant improvement. The pre-test mean score for the IVR HS group was 0.34 (±0.47), rising to 0.94 (±0.23) in the post-test, while the Standardized HS group improved from 0.20 (±0.40) in the pre-test to 0.82 (±0.38) in the post-test. These results indicate a notably higher effectiveness of IVR HS training in this aspect, and the differences in improvements between groups were statistically significant. However, for assessing the knowledge regarding how much breathing should be delivered to an adult victim during high-quality CPR aspect, both groups showed similar improvements. In the IVR HS group, the pre-test score was 0.22 (±0.41), improving to 0.79 (±0.40) in the post-test. The standardized HS group scored 0.29 (±0.45) in the pre-test and 8.21(±1.37) in the post-test. The differences in improvements between groups were not statistically significant, suggesting that both methods effectively taught how to understand the how many breathe should be delivered.

Table 4.3.1: Comparative Analysis of Pretest and Posttest Knowledge Scores in IVR heart-saver and Standardized HS Training Groups. (N=200; IVR HS group=100; standardized HS group=100). An independent t-test was performed.

Item No	Groups	n	Pretest	Posttest	Pretest			Posttest		
			Mean± SD	**Mean± SD**	**t-value**	**df**	**p-value**	**t-value**	**df**	**p-value**
1. What are the correct rate and depth for providing compression during high-quality adult CPR to improve survival	IVR HS	100	0.28±0.45	0.94±0.25	0.808	198	0.420	0.000	198	1.000
	Standardized HS	100	0.23±0.42	0.93±0.25						
2. What should you do when you phone your emergency response number (or your local emergency number	IVR HS	100	0.24±0.42	0.81±0.39	0-.798	198	0.426	1.502	198	0.135
	Standardized HS	100	0.29±0.45	0.72±0.45						
3. What actions result in the best chance of survival if someone is not breathing (or is only gasping) and is not responding	IVR HS	100	0.48±0.50	1.00±0.00	3.293	198	0.001	4.342	198	0.001
	Standardized HS	100	0.26±0.44	0.84±0.36						
4. You come across an adult lying on the ground. Tap and shout, but he is unresponsive. What should you do next	IVR HS	100	0.19±0.39	0.72±0.45	-.692	198	0.490	0.463	198	0.644
	Standardized HS	100	0.23±0.42	0.69±0.46						
5. How deep should you push the chest on the adult victim when giving the chest compression	IVR HS	100	0.22±0.41	0.86±0.34	-0.168	198	0.866	-0.868	198	0.387
	Standardized HS	100	0.23±0.42	0.90±0.30						
6. When performing CPR, when should you switch positions and allow someone else to take over compression and breaths	IVR HS	100	0.19±0.39	0.79±0.40	-0.178	198	0.859	-1.719	198	0.087
	Standardized HS	100	0.20±0.40	0.88±0.32						
7. How should you give breath with a mask	IVR HS	100	0.32±0.46	0.77±0.12	0.773	198	0.441	-1.248	198	0.214
	Standardized HS	100	0.27±0.44	0.84±0.36						
	IVR HS	100	0.31±0.46	0.79±0.40	-0.893	198	0.373	-0.352	198	0.725

Item No	Groups	n	Pretest	Posttest	Pretest			Posttest		
			Mean± SD	**Mean± SD**	**t-value**	**df**	**p-value**	**t-value**	**df**	**p-value**
8. You are given sets of 30 compressions and two breaths. Another person arrives with an AED. What should you do next?	Standardized HS	100	0.37±0.48	0.81±0.39						
9. what should you do if a chocking adult stops responding	IVR HS	100	0.34±0.47	0.94±0.23	2.247	198	0.026	2.644	198	0.009
	Standardized HS	100	0.20±0.40	0.82±0.38						
10. How much breathing should be delivered to an adult victim during high-quality CPR at the correct rate to increase survival	IVR HS	100	0.22±0.41	0.79±0.40	-1.134	198	0.258	0.171	198	0.864
	Standardized HS	100	0.29±0.45	0.78±0.41						
The total mean score in the pre-test of knowledge	IVR HS	100	2.79±2.01	8.40±1.01	0.753	198	0.452	1.113	198	0.267
	Standardized HS	100	2.57±2.11	8.21±1.37						

M: Mean; SD: Standard Deviation; N: total sample; n: sample for each group; %: percentage; p: significant at the 0.05 leve

4.3.2. The total knowledge scores between the two groups

Table 4.3.2 shows the results of the repeated measures ANOVA conducted to assess the differences in knowledge scores before and after training in two groups: the IVR HS and the Standardized HS. The analysis revealed no significant variance in mean knowledge scores between the groups at the pre-test stage (F = 0.010, p = 0.921), with the IVR HS group showing a mean of 2.79±0.207 and the Standardized HS group displaying a mean of 2.57±0.207. However, both groups demonstrated significant improvement in their post-test knowledge scores, with the IVR HS group achieving an average of 8.40 ± 0.121 and the Standardized HS group attaining an average of 8.21 ± 0.121. This suggests that while both training methods effectively enhanced knowledge, there was no significant difference in the rate of improvement between the two approaches.

Table 4.3.2: Comparative Analysis of Pre-Test and Post-Test Knowledge Scores in IVR HS and Standardized HS Groups. A repeated measure of ANOVA was performed.

Groups repeated measure test	IVR HS Mean ± SD	Standardized Mean ± SD	HS	df	F-value	p-value
Pretest of Knowledge	2.79±0.207	2.57±0.207		1	0.010	0.921
Posttest of Knowledge	8.40±0.121	8.21±0.121		1		

M: Mean; SD: Standard Deviation; p: significant at the 0.05 level

4.3.3. Association between knowledge and demographical and academic Details

This study section delved into the correlations and distinctions among participants' demographic and academic variables such as marital status, gender, academic year, GPA, and field of study and their knowledge scores, both before and after the intervention. Utilizing an independent sample t-test, as shown in Appendix (O.4), a notable disparity was observed in post-test knowledge scores based on marital status. Specifically, unmarried participants in the IVR HS group exhibited significantly higher average knowledge scores (8.4639±0.93) compared to their married counterparts (6.33±1.52), with a t-value of 3.818 and a p-value of 0.001.

Further analysis of a one-way ANOVA revealed a statistically significant variance in pre-test knowledge scores across different academic years within the IVR HS Group, as shown in Appendix (O.6, O.7). An F-value of 2.626 and a p-value of 0.055 indicate that the second-year students demonstrated noticeably higher pre-test knowledge scores than the first-year students (p = 0.035). This suggests a progression in knowledge acquisition as student's advance in their academic journey.

As presented in Appendix (O.8, O9), the study also examined the impact of academic achievement on pre-test knowledge scores in the IVR heart-saver. A one-way ANOVA showed significant differences based on students' GPAs, with those having excellent GPAs outperforming their peers with very good GPAs in the pre-test for the IVR heart-saver group (p = 0.032, F (2) = 4.147). This finding underscores the potential correlation between overall academic performance and specific knowledge in the context of IVR HS training. However, the remaining demographic and academic data noted no other significant differences in knowledge scores. This analysis provides valuable insights into how various factors might influence learning outcomes in immersive virtual reality training contexts.

4.4. Comparative Analysis of Performance

4.4.1. Comparison of Performance Outcomes Between IVR HS and Standardized HS Groups

Table 4.4.1 compares performance outcomes between the IVR HS and standardized HS groups. The assessment utilized a chi-square test to measure the variance in performance levels between the two groups. Notably, a significant difference was observed (chi-square value = 15.674, df = 1, p = 0.001). Within the IVR HS group, a higher % of participants, 85%, successfully passed the performance evaluation compared with 60% in the Standardized HS group. Conversely, the proportion of participants who did not meet the performance criteria was higher in the standardized group (40%) compared to the IVR HS group (15%). These results highlight the differential impact of the two training methods on participant performance, suggesting a more effective outcome in the IVR HS group.

Table 4.4.1: Comparison of Performance Outcomes Between IVR heart-saver and Standardized HS Groups. (N=200; Intervention group=100; Control group=100). A chi-square was performed.

Variable	Groups		Chi-square value	df	p-value
Performance level	Virtual reality n (%)	Standardized n (%)			
Pass	85	60	15.674	1	0.001
Fail	15	40			

n: sample for each group; %: percentage; p: significant at less than 0.05

4.4.2. Association between performance and demographic and academic Details

The study rigorously assessed the impact of demographic and academic variables on performance outcomes in both the IVR HS and Standardized HS training groups. As shown in Appendix (O.5), employing an independent t-test to analyze gender-based differences, the findings revealed a noteworthy disparity in performance between females and males within the standardized HS group. Specifically, the independent t-test showed that, the female participants demonstrated superior performance (mean = 1.47, SD = 0.50) compared to their male counterparts (mean = 1.10, SD = 0.30), with this difference achieving statistical significance (t = 3.18, p = 0.002) as shown in Appendix (O.5).

Further, as shown in Appendix (O.8, O.9), the investigation explored the influence of academic achievements on performance, utilizing a one-way ANOVA. In the IVR HS group, performance had significant variance based on participants' GPAs. Notably, individuals with excellent GPAs performed significantly better than those with very good GPAs ($p = 0.026$). Additionally, the performance of participants with good GPAs differed significantly better than from those with very good GPAs ($p = 0.038$). Other demographic and academic factors did not exhibit significant differences in performance.

Moreover, as shown in Appendix (O.10, O.11), the analysis examined performance disparities across different academic faculties within the standardized HS group. The one-way ANOVA results indicated significant performance differences based on the study faculty ($F = 8.019$, $p = 0.001$). A detailed examination using the Tukey post hoc test highlighted that students from the Faculty of Art and Sport Sciences outperformed their peers from other faculties, namely the Faculty of Administration and Financial Sciences, Faculty of Law and Science, and Faculty of Engineering and Information Technology. These findings underscore the variability in performance outcomes influenced by academic and demographic characteristics, offering valuable insights for tailored training approaches in heart-saver programs.

4.5. Comparative Analysis of Satisfaction scores

4.5.1. Comparative Assessment of Participant Satisfaction with Simulation Training in IVR HS and Standardized HS Groups

Table 4.5.1 compares participant satisfaction with simulation training in the IVR HS and Standardized HS groups. The evaluation encompassed various aspects of the training, including the effectiveness of teaching methods, the variety of learning materials, the enjoyment of instructor-led sessions, the motivation provided by the teaching materials, and the suitability of the teaching methods to individual learning styles.

The results showed that in the IVR HS group, participants generally agreed or strongly agreed with the effectiveness of the teaching methods (mean score of 4.37±0.66), the variety and helpfulness of learning materials (mean score of 4.37±0.67), and the suitability of the teaching methods to their learning styles (mean score of 4.32±0.72). The highest satisfaction was noted for the enjoyment of the instructor-led sessions, with a mean score of 4.40±0.66.

In contrast, the standardized HS group showed slightly lower satisfaction scores across all items, but the standardized HS group showed slightly higher in a total mean score. The effectiveness of teaching methods and the variety of learning materials received scores of 4.24±0.85 and 4.26±0.79, respectively. Enjoyment of instructor-led sessions had a mean score of 4.35±0.86, and the suitability of the teaching methods to learning styles was rated at 4.23±0.80. The total satisfaction scores for both groups were similar, with IVR HS at 4.27.61 and Standardized HS at 4.36.75, indicating that both training methods were well-received, albeit with slightly higher satisfaction in the Standardized HS group.

Independent t-tests showed no significant differences in the levels of satisfaction between the two groups for all items. This showed that both the IVR and standardized training methods met the participants' needs for satisfaction in CPR training. The p-values for these comparisons ranged from 0.230 to 0.649, indicating no statistically significant differences in satisfaction levels across the various aspects of the training. This similarity in satisfaction levels suggests that both training methodologies were equally effective regarding participant satisfaction.

Table 4.5.1: Comparative Assessment of Participant Satisfaction with Simulation Training in IVR heart-saver and Standardized HS Groups. (N=200; Intervention group=100; Control group=100). An independent t-test was performed.

Items	Groups	n	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Mean±SD	t-Value	df	P-value
The teaching methods used in this simulation training were helpful and effective	IVR HS	100	0	2	4	49	45	4.37±0.66	1.203	198	0.230
	Standardized HS	100	0	7	6	43	44	4.24±0.85			
The simulation provided various learning materials and activities to promote my learning of the heart-saver adult CPR curriculum.	IVR HS	100	0	2	5	47	46	4.37±0.67	1.050	198	0.295
	Standardized HS	100	0	5	7	45	43	4.26±0.79			
I enjoyed how my instructor taught the simulation	IVR HS	100	0	2	4	46	48	4.40±0.66	0.457	198	0.649
	Standardized HS	100	0	6	8	31	55	4.35±0.86			
The teaching materials used in this simulation were motivating and helped me to learn	IVR HS	100	0	4	5	40	51	4.38±0.76	0.791	198	0.430
	Standardized HS	100	0	6	7	39	48	4.29±0.84			
How my instructor(s) taught the simulation was suitable for how I learned).	IVR HS	100	0	3	6	47	44	4.32±0.72	0.833	198	0.406
	Standardized HS	100	0	5	8	46	41	4.23±0.80			
Total Satisfaction	IVR HS	100	0	2	4	38	56	4.27±0.61	0.969	198	0.333
	Standardized HS	100	0	5	7	28	60	4.36±0.75			

M: Mean; SD: Standard Deviation; N: Total sample; n: sample for each group; %: percentage; p: significant at the 0.05 level

4.5.2. The Variations and Associations between Satisfaction and demographical-academic Details

The study used various statistical methods to analyze the relationship between demographic and academic characteristics and different outcomes. As shown in Appendix (O.2), Pearson's correlation analysis assessed the relationship between continuous variables like age and satisfaction, particularly in the IVR HS group. This analysis revealed a significant positive relationship between age and satisfaction among IVR HS participants ($r_s(98) = 0.202$, $p = 0.044$), indicating that older participants reported higher satisfaction levels.

Moreover, as shown in Appendix (O.5), the study utilized independent t-tests to compare satisfaction levels between genders within the IVR HS group. The results indicated a notable difference in satisfaction scores between male and female participants, with males (mean satisfaction score of 4.61 ± 0.44) reporting higher satisfaction than females (mean satisfaction score of 4.29 ± 0.63). This outcome ($t(98) = 2.27$, $p = 0.025$) suggests that males found the IVR HS training more satisfying than their female counterparts.

Additionally, the study did not find significant differences in satisfaction levels when comparing other demographic and academic variables. This implies that factors such as marital status, academic level, and specialty did not significantly influence the satisfaction levels of participants with the training they received.

4.6. Comparative Evaluation of Self-Confidence and Its Correlation with Demographic and Academic Variables in IVR HS and Standardized HS Groups

4.6.1. Comparative Evaluation of Self-Confidence in Simulation Training Among IVR HS and Standardized HS Groups

The comparison of self-confidence in simulation training between the IVR HS and Standardized HS groups, shown in Table 4.6.1, yields exciting results. The study analyzed participants' self-assurance levels regarding various aspects of the training. The participants' confidence in mastering the simulation activity's content was relatively high in both groups, with the IVR HS group averaging a mean of 4.10±0.77 and the Standardized HS group slightly higher at 4.14±0.88. However, the difference was insignificant ($t = -0.340$, $p = 0.734$).

Similarly, participants in both groups felt confident about the simulation covering the essential content necessary for mastering the heart-saver adult CPR curriculum. This was reflected in the mean scores of 4.23±0.67 for the IVR HS group and 4.18±0.86 for the standardized HS group. Again, no significant difference was observed ($t = 0.453$, $p = 0.651$).

Regarding developing skills and knowledge required for clinical tasks, the IVR HS group's mean score was 4.06±0.74, while the Standardized HS group scored slightly higher at 4.09±0.82. The difference was not statistically significant ($t = -0.268$, $p = 0.789$), indicating a similar confidence level in skill acquisition across both groups.

The perceived effectiveness of the instructors' resources used in teaching the simulation was also evaluated. The IVR HS group participants rated this aspect at 4.34±0.75, while the Standardized

HS group rated it at 4.32±0.85. Both groups agreed on the helpfulness of teaching resources, with no significant difference (t = 0.176, p = 0.861).

Participants' perception of their responsibility in learning from the simulation activity was also high in both groups. The IVR HS group rated this aspect at 4.33±0.66, and the Standardized HS group rated it at 4.19±0.82. There was a minor difference, but it was not statistically significant (t = 1.319, p = 0.189).

Regarding understanding concepts and seeking help, the IVR HS group rated their confidence at 4.02±0.71, while the Standardized HS group rated it slightly higher at 4.11±0.95. The difference in their confidence to seek help when concepts were unclear was insignificant (t = -0.758, p = 0.450).

Finally, participants in both groups were asked about their confidence in using simulation activities to learn critical skills. The IVR HS group rated their confidence at 4.04±0.69, and the Standardized HS group at 4.16±0.83. Again, the difference was not significant (t=-1.103, p=0.272).

Overall, the total self-confidence scores across all items were very similar between the two groups, with the IVR HS group scoring 4.18±0.56 and the Standardized HS group 4.17±0.74, indicating no significant difference in self-confidence levels between the two training methods (t=-0.106, p=0.91).

Table 4.6.1: Comparative Evaluation of Self-Confidence in Simulation Training Among IVR Heart-Saver and Standardized HS Groups. (N=200; Intervention group=100; Control group=100). An independent t-test was performed.

Items	Groups	n	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Mean±SD	t-Value	df	P-value
I am confident that I am mastering the content of the simulation activity that my instructors presented to me	IVR HS	10	0	5	10	55	30	4.10±0.77	-0.340	198	0.734
	Standardized HS	10	0	7	12	41	40	4.14±0.88			
I am confident that this simulation covered critical content necessary for the mastery of the heart-saver adult CPR curriculum	IVR HS	10	0	3	5	58	34	4.23±0.67	0.453	198	0.651
	Standardized HS	10	0	7	9	43	41	4.18±0.86			
I am confident that I am developing the skills and obtaining the required knowledge from this simulation to perform necessary tasks in a clinical setting	IVR HS	10	0	3	16	53	28	4.06±0.74	-0.268	198	0.789
	Standardized HS	10	0	6	12	49	33	4.09±0.82			
My instructors used helpful resources to teach the simulation	IVR HS	10	1	2	5	46	46	4.34±0.75	0.176	198	0.861
	Standardized HS	10	0	6	7	36	51	4.32±0.85			
It is my responsibility as the student to learn what I need to know from this simulation activity	IVR HS	10	0	2	5	51	42	4.33±0.66	1.319	198	0.189
	Standardized HS	10	0	6	8	47	39	4.19±0.82			
I know how to get help when I do not understand the concepts covered in the training	IVR HS	10	0	4	12	62	22	4.02±0.71	-0.758	198	0.450
	Standardized HS	10	0	10	10	39	41	4.11±0.95			

Items	Groups	n	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree	Mean±SD	t-Value	df	P-value
I know how to use simulation activities to learn critical aspects of these skills	IVR HS	10	0	3	13	61	23	4.04±0.69	-1.103	198	0.272
	Standardized HS	10	0	7	7	49	37	4.16±0.83			
It is the instructor's responsibility to tell me what I need to learn about the simulation activity content during class time	IVR HS	10	1	4	4	52	39	4.24±0.79	-0.086	198	0.932
	Standardized HS	10	0	7	6	42	45	4.25±0.85			
Total Self-Confidence	IVR HS	10	0	2	5	46	47	4.18±0.56	-0.106	198	0.915
	Standardized HS	10	0	6	7	29	58	4.17±0.74			

M: Mean; SD: Standard Deviation; N: Total sample; n: sample for each group; %: percentage; p: significant at the 0.05 level

4.6.2. Association between self-confidence and demographical-academicals Details

In this section of the study, a detailed analysis was conducted to assess the correlation between the demographic and academic characteristics of participants and their levels of self-confidence in both study groups. This assessment employed a comprehensive statistical approach, utilizing Pearson correlation tests, independent t-tests, and one-way ANOVA. These methods were applied to explore the relationships and variances in self-confidence about variables such as age, marital status, gender, year of academic study, GPA achievements, and field of study.

The findings from this intricate statistical evaluation indicated a need for a more significant correlation or association between participants' demographic and academic attributes and their self-confidence levels. This outcome was consistent across both study groups, underscoring the notion that factors such as age, marital status, gender, academic standing, and academic specialization did not significantly influence the participants' self-assurance in the context of this study.

4.7. Summary

Chapter Four of this study presents an in-depth analysis of the effectiveness of CPR training methods: IVR HS and Standardized HS. The demographic data showed a distribution across both groups, with 43 males (21.5%) and 157 females (78.5%) overall. The majority of participants were single (195 individuals, 97.5%). Regarding knowledge acquisition, both groups demonstrated significant improvements in CPR knowledge post-training, with no significant difference between them. For instance, the average pre-test knowledge score in the IVR HS group was 2.79 (±2.01), which improved to 8.40 (±1.01) post-test. Similarly, the standardized HS group increased from 2.57 (±2.11) to 8.21 (±1.37).

Performance outcomes indicated a higher passing rate in the IVR HS group, with 85% of participants passing the evaluation compared to 60% in the standardized HS group. Participant satisfaction levels were high across both methods, though slightly higher in the standardized HS group. For example, satisfaction with the effectiveness of teaching methods scored 4.37 (±0.66) in the IVR HS group and 4.24 (±0.85) in the Standardized HS group. Self-confidence levels were also comparable in both groups. The standardized HS group scored an average of 4.17 (0.74), nearly identical to the IVR HS group's 4.18 (0.56). The study also found no significant correlation between demographic or academic variables and self-confidence. However, it noted a difference in post-test knowledge based on marital status, with single participants in the IVR HS group scoring higher (8.46±0.93) than married participants (6.33±1.52), moreover, the second-year students demonstrated noticeably higher pre-test knowledge scores than the first-year students ($p = 0.035$). As well as, it noted differences based on students' GPAs, with those having excellent GPAs outperforming their peers with very good GPAs in the pre-test for the IVR heart-saver group ($p = 0.032$, $F(2) = 4.147$). Gender differences were observed in performance in the standardized HS group, with females performing higher (1.47±0.50) than males (1.10±0.30). In the IVR HS group, those had excellent GPAs performed significantly better than those with very good GPAs ($p = 0.026$). Additionally, the performance of participants with good GPAs performed significantly better than those with very good GPAs ($p = 0.038$). Moreover, the analysis examined performance disparities across different academic faculties within the standardized HS group. those students from the Faculty of Art and Sport Sciences having a higher outperformed compared to peers from other faculties.

The positive relationship between age and satisfaction were observed among IVR HS participants (r_s (98) = 0.202, $p = 0.044$), indicating that older participants reported higher satisfaction levels. Moreover, Gender differences were observed in satisfaction scores in the IVR group with males had higher satisfaction scores of (4.61±0.44) than females (4.29±0.63). This result (t (98) = 2.27, $p = 0.025$) proposes that males found the IVR HS training more satisfying than their female counterparts.

Chapter Five: Discussion

5.1.Introduction

This research aimed to assess the effectiveness of immersive virtual reality (IVR) heart-saver training compared with conventional training methods among non-health science students. The investigation was structured around critical research questions focusing on the impact of these training approaches on knowledge acquisition, performance, satisfaction, and self-confidence in performing cardiopulmonary resuscitation (CPR). Results indicated significant improvements in knowledge among participants in both training conditions but there is no significant difference between the two groups. Regarding the skills indicating significant improvement, the IVR group showed notable enhancements in performance metrics. Levels of satisfaction and self-confidence were similarly elevated in the IVR and standardized training cohorts. The importance of analyzing these outcomes within the framework of existing literature is underscored by the potential of IVR to serve as a viable supplement or alternative to standardized CPR training techniques, contributing valuable insights into the ongoing discourse on optimizing CPR educational strategies.

5.2.Knowledge Acquisition in IVR vs. Standardized Training Programs

The results from the current study indicated significant improvements in CPR knowledge among participants after undergoing immersive virtual reality (IVR) and standardized training methods. Moreover, findings from this study related to the knowledge objectives indicated that, “the non-health science students engaged in the IVR HS training program had similar level in pretest and posttest of knowledge after receiving training with those who had participated in the standardized HS training program". This study demonstrated that there was a positive change from pretest to the posttest of knowledge, however, there was a similarity in knowledge level before and after training suggests that both training methodologies were equally effective regarding participant knowledge. Specifically, the post-training knowledge scores in the IVR group show an appreciable rise from a pre-test mean of 2.79±2.01 to a post-test mean of 8.40±1.01. Similarly, the Standardized group increased from a pre-test mean of 2.57±2.11 to a post-test mean of 8.21±1.37. While both groups demonstrated significant knowledge gains, the IVR group exhibited a marginally higher increase, though the difference was not statistically significant. The increase in CPR knowledge among participants in both the virtual reality (VR) and standardized CPR training groups can be attributed to several factors. Both training methods provide comprehensive and structured educational content, which is designed to enhance understanding and retention of CPR procedures. Standardized CPR training often includes lectures, demonstrations, and hands-on practice, which collectively reinforce learning. Similarly, VR training provides immersive, interactive simulations that engage learners, offering repetitive practice in a realistic yet controlled environment. These methods effectively cover essential CPR skills and theoretical knowledge, ensuring that participants gain a robust understanding of the subject matter. These results correspond with findings of prior studies conducted among USA public participants (Leary et al., 2019), UK medical and non-medical students (Hubail et al., 2022), and Taiwan medical students (Chang et al., 2023), which reported that there were no significant differences between VR intervention and standardized in CPR knowledge in baseline of CPR knowledge and after conduction CPR training, this indicated that the acquisition of CPR knowledge increased however, both training were similar effective regarding participant knowledge. As well as it could be utilized in conjunction with it.

Additionally, both training modalities leverage adult learning principles, such as active engagement, immediate feedback, and practical application of knowledge. These principles are crucial in promoting effective learning outcomes. The combination of visual, auditory, and kinesthetic learning styles addressed in both VR and standardized training likely contributes to the overall increase in CPR knowledge among participants. The scientific justification for these outcomes can be rooted in the immersive and engaging nature of IVR training, which likely facilitates a deeper cognitive engagement with the material, thereby enhancing knowledge retention (Issleib et al., 2021; Liu et al., 2023). This immersive experience could mimic real-life scenarios more closely than standardized methods, potentially leading to better comprehension and memorization of CPR procedures. However, the absence of a statistically significant difference between IVR and standardized methods suggests that the efficacy of CPR training also heavily depends on the content and execution of the training program, not just the mode of delivery (Kim & Cho, 2023; Nas et al., 2019).

Comparative analysis of existing literature reveals both proponents and opponents of the superior efficacy of IVR over standardized training methods. For instance, Issleib et al. (2021) and Liu et al. (2023) reported significant enhancements in learning outcomes and satisfaction levels with IVR training, supporting the argument for IVR's potential in medical education. Conversely, studies by Nas et al. (2019) and Kim & Cho (2023) highlight that while IVR can be as effective as standardized methods, it may not always be superior in improving knowledge and skill retention.

This juxtaposition underscores the complexity of educational efficacy in CPR training, suggesting that the effectiveness of IVR might be contextually dependent on various factors, including the learners' backgrounds and the specific design of the IVR content (Barsom et al., 2020; Hubail et al., 2022). Despite its methodological rigor, the standardized HS approach may need to improve in areas such as adaptability and application in real-life scenarios. This gap is highlighted in studies that emphasize the importance of situational learning in CPR education. Hubail et al. (2022), for example, suggest that while standardized methods are effective in imparting CPR knowledge, they may not adequately prepare individuals for the unpredictable nature of real-world emergencies.

The findings of this study align with these study reported significant difference in CPR knowledge between intervention and standardized groups of medical provider and non-health science students after conducting VR in comparison to the south Korean nurse students (Yang & Oh, 2022), Netherlands secondary school (Barsom et al., 2020), Spanish medical care provider (Figols Pedrosa et al., 2023), Korean fight fire (Kim & Cho, 2023), that revealed statistical significance was found in the CPR knowledge between the intervention and standardized groups. This indicated that the virtual reality was effective in increasing the CPR knowledge more than the standardized training.

Speculatively, advancements in IVR technology, such as integrating adaptive learning algorithms, enhanced haptic feedback, and increased scenario variability, could amplify its effectiveness in CPR training. Future iterations of IVR training systems might offer personalized learning experiences that adapt to an individual's learning pace and style, further enhancing knowledge acquisition and retention. Moreover, developing more realistic simulation environments could improve learners' ability to transfer skills from virtual settings to real-life emergency scenarios, thereby bolstering the overall efficacy of CPR training programs (Peek et al., 2023; Semeraro et al., 2017).

5.3.Comparative Analysis of Performance

The observed data revealed a noteworthy higher performance pass rate among participants in the immersive virtual reality (IVR) group compared to their counterparts in the standardized training group. Specifically, the IVR group exhibited an 85% success rate in performance assessments, significantly surpassing the 60% success rate noted within the standardized group. This differential outcome suggests that the immersive nature of IVR training potentially fosters a more effective learning environment for skill acquisition in CPR training (Barsom et al., 2020; Hubail et al., 2022).

The justification for the enhanced performance observed within the IVR group could be attributed to the immersive and interactive experience provided by IVR training. This training mode facilitates a deeper level of cognitive engagement and hands-on practice in a controlled environment, simulating real-life scenarios closely. Such an approach may enhance the learners' ability to grasp complex procedures and apply them accurately, improving skill acquisition (Issleib et al., 2021; Liu et al., 2023). Furthermore, the immediate feedback in IVR systems could contribute to a more personalized learning experience, allowing learners to identify and correct their mistakes in real time, a feature less prevalent in standardized training formats (Kim & Cho, 2023; Nas et al., 2019).

In comparing these findings with existing literature, both support and contention arise regarding the superiority of IVR over standardized training methods in enhancing CPR performance outcomes. Studies like those conducted by Issleib et al. (2021) and Liu et al. (2023) have shown that IVR can lead to significant improvements in CPR performance, echoing the present study's findings. However, other research, such as the work by Nas et al. (2019) and Kim & Cho (2023), suggests that while IVR may offer benefits in terms of engagement and satisfaction, its efficacy in improving practical CPR skills to a level superior to standardized methods remains debatable. For instance, the latter studies indicate that both IVR and standardized training methods can achieve comparable levels of skill proficiency, highlighting the influence of instructional design and content quality over the mode of delivery (Barsom et al., 2020; Hubail et al., 2022).

Speculating on the future of IVR in CPR training, particularly concerning practical skill assessments, there is a potential for IVR not only to complement but, in specific contexts, replace standardized training methods. As IVR technology advances, offering more realistic and varied simulation scenarios, its capacity to provide comprehensive, practical training that closely mimics real-life situations could become increasingly invaluable. Integrating advanced tracking and evaluation algorithms could further enhance the efficacy of IVR in assessing and improving practical CPR skills, potentially setting a new standard in CPR training methodologies (Peek et al., 2023; Semeraro et al., 2017).

5.4.Comparative Analysis of Satisfaction Scores

The analysis of satisfaction scores from the study reveals that participants in both IVR and standardized HS training groups reported high levels of satisfaction with their respective CPR training programs. The data indicates a marginal preference for the standardized training methods over IVR. This finding suggests that while both training approaches effectively meet learners' expectations, specific aspects of the standardized training might resonate slightly more positively with participants. However, the highest satisfaction was noted for the enjoyment of the instructor-led sessions in the IVR heart-saver group.

Therefore, a possible clarification for this study results is that the non-health science participants in both groups had the first clinical experience in IVR heart-saver training program and standardized HS training program as teaching strategy, thus it is considered as a new experience for them, which lead them to be more satisfied. Teaching strategies for both groups through provide support, encouragement, and immersion in understanding the procedure by following the instructions and positive feedback that lead to motivating students to influence their satisfaction with the training and achieved the learning objectives. The IVR heart-saver improved non-health science students' performance CPR procedure, understanding CPR knowledge, and satisfaction. The satisfaction that the IVR heart-saver experiences gives the students a secure feeling of experiencing various realities in a training setting with a safe and controlled environment, that lead to the enhancement of learning and becoming more confident in applying heart-saver in real-life situations in the future. The findings of this study align with this study reported that, fewer postgraduate second year students were more familiar with VR than high-fidelity simulation (HFS). HFS provided greater feedback and had higher technical scores, increasing learner satisfaction (Katz et al., 2020).

The slight difference in satisfaction levels between the two groups could be attributed to various factors inherent to the training modalities. Standardized training, often characterized by face-to-face interaction and direct instructor feedback, may provide a sense of personalization and immediacy that learners highly value. This standardized format might also align more closely with participants' preconceived notions of learning environments, contributing to their satisfaction. In contrast, while IVR offers unique immersive experiences and the opportunity for repeated practice, technical limitations or the novelty of the medium could pose challenges to some learners, potentially impacting satisfaction levels (Rodríguez-Matesanz et al., 2022; Semeraro et al., 2017).

The literature presents mixed findings regarding learner satisfaction with CPR training methods. Studies such as those by Barsom et al. (2020) and Hubail et al. (2022) have highlighted the potential of IVR to enhance satisfaction through engaging and interactive experiences. Conversely, research by Issleib et al. (2021) and Liu et al. (2023) underscores the importance of standardized elements, such as instructor-led discussions and hands-on practice, in achieving high satisfaction. These divergent views emphasize the complexity of satisfaction as a construct and the multitude of factors that can influence it, ranging from the content and delivery of the training to individual learner preferences and technological familiarity.

Looking ahead, there is a rich avenue for future research to optimize IVR interfaces to elevate satisfaction and engagement levels further. IVR technology enhancement that addresses current limitations, such as improving user interface intuitiveness, increasing realism, and incorporating adaptive learning algorithms, could significantly impact learner satisfaction. Additionally, studies exploring the integration of IVR with standardized training elements could offer insights into hybrid models that leverage the strengths of both approaches to maximize learner satisfaction and educational outcomes.

In sum, while IVR and standardized CPR training methods currently exhibit strong satisfaction ratings among participants, ongoing advancements in educational technology and pedagogical strategies present opportunities to enhance these experiences. Continued exploration and critical examination of these training modalities will be essential in developing optimized CPR training frameworks that meet and exceed learner expectations in satisfaction, engagement, and efficacy.

5.5.Comparative Evaluation of Self-Confidence

The study's findings reveal that participants in immersive virtual reality (IVR) and standardized CPR training methods reported comparable levels of self-confidence upon completing their respective programs. This parity suggests that despite the differing instructional approaches, both methods are equally effective in instilling foundational confidence in learners necessary for performing CPR.

The critical role of self-confidence in CPR training cannot be overstated. Self-confidence influences learners' willingness to engage in CPR in real-world scenarios, affecting their ability to recall and apply the skills learned during training. The similar levels of self-confidence observed in participants of both IVR and standardized training methods affirm the potential of both approaches to foster this crucial trait. This outcome aligns with the understanding that confidence is not solely built through physical practice but also through a comprehensive understanding and mental rehearsal of the CPR process, which IVR facilitates through immersive simulation (Aksoy, 2019; Yeung et al., 2017).

Exploring existing literature on self-confidence outcomes in CPR training reveals a broad spectrum of findings. Studies such as those by Barsom et al. (2020) and Issleib et al. (2021) have documented the effectiveness of IVR in enhancing self-confidence, attributed to its immersive and interactive nature. Contrastingly, research by Kim & Cho (2023) and Leary et al. (2019) highlights the effectiveness of standardized, instructor-led CPR training in building confidence, possibly due to the direct feedback and personal interaction it entails. These findings underscore a gap in understanding the specific elements within each training modality that most significantly contribute to building self-confidence.

Considering these insights, a compelling argument exists for further refining CPR training programs, especially within IVR settings, to enhance learner confidence more effectively. Potential modifications include the integration of real-time feedback mechanisms, including more varied and complex scenarios to broaden exposure, and using adaptive learning technologies to tailor the difficulty level to individual learners' proficiency. Furthermore, hybrid models that combine the immersive experience of IVR with the personal interaction and feedback of standardized methods could represent a promising direction for future research.

5.6.Association Between Demographic variables and Training efficacy

Exploring the association between demographic and academic characteristics with CPR training outcomes revealed a notable lack of significant correlation, with a few exceptions identified. This finding is pivotal as it suggests that the effectiveness of CPR training, whether through immersive virtual reality (IVR) or standardized methods, predominantly transcends demographic variables such as age, gender, marital status, academic year, GPA, and field of study.

Understanding the influence of demographic characteristics on the efficacy of CPR training is crucial for several reasons. First, it allows for assessing the universality of training programs, ensuring that they are equally effective across diverse participant profiles. Second, it helps identify potential barriers or facilitators to learning specific to certain demographic groups, thereby guiding the development of more inclusive and accessible training interventions. Despite the general lack of significant associations found in this study, the exceptions noted—such as differences in post-test knowledge scores based on marital status—highlight the nuanced ways demographic factors can impact learning outcomes.

The correlations and differences among participants' demographic academic details and their knowledge scores, both before and after the intervention. There was a difference in post-test knowledge scores based on marital status. Specifically, unmarried participants in the IVR HS group exhibited significantly higher average knowledge scores compared to their married counterparts. Moreover, there was a statistically significant variance in pretest knowledge scores across different academic years within the IVR HS Group. indicate that the second-year students demonstrated noticeably higher pretest knowledge scores than the first-year students. This suggests a progression in knowledge acquisition as students' advance in their academic journey. As well as, there was a significant difference in achievement on pretest knowledge scores. The students' GPAs with those having excellent GPAs outperforming their peers with very good GPAs in the pretest. This finding underscores the potential correlation between overall academic performance and specific knowledge in the context of IVR HS training. These results align with a comparative analysis with existing literature reveals mixed findings regarding the influence of demographic factors on CPR training outcomes. For instance, studies like those conducted by Kim & Cho (2023) and Hubail et al. (2022) have indicated variations in CPR learning outcomes and retention rates based on demographic variables such as age and gender. Moreover, Hubail et al. (2022) found no significant differences in CPR skill improvement between male and female participants, indicating that VR interventions may offer equitable learning opportunities across gender groups, and Kim & Cho (2023) reported significant improvements in CPR performance knowledge in both male and female participants following VR-based training. This suggests that VR interventions may be equally beneficial for individuals with varying levels of prior CPR training experience. Conversely, research by Barsom et al. (2020) and Issleib et al. (2021) suggests that while demographic characteristics might influence initial learning preferences and comfort levels with technology-based training, they do not significantly impact overall training effectiveness.

In addition, the participants who had excellent or good academic achievements had better performance than who had very good academic achievements, as well as the students from the Faculty of Art and Sport Sciences had better performance than the students from other faculties. These findings support specific findings in this area reveal that demographic and academic variables affect learning outcomes. For instance, studies like those by Buttussi et al. (2020) and Katz et al. (2020) have shown gender differences in learning outcomes and preferences for training methods. Additionally, studies showing that higher academic achievers typically adapt more successfully to various learning environments and techniques (Barsom et al., 2020) have linked academic achievement to learning outcomes.

In addition, regarding to the findings of the relationship between continuous variables like age and satisfaction, particularly in the IVR HS group, there is a positive relationship between age and satisfaction among IVR HS participants, indicating that older participants reported higher satisfaction levels. As well as, indicating the males had higher satisfaction than female participants in the IVR HS group. Educational research supports academic achievement as a sign of learning adaptability and success because it shows that students with higher academic standings typically have more effective learning strategies and higher self-efficacy, which affects their performance in new learning situations (Makransky & Petersen, 2021).

The observed discrepancies between the current study's findings and existing literature underline the complexity of demographic influences on CPR training outcomes. This complexity warrants further investigation into how demographic factors interact with various aspects of CPR training, including instructional methods, content delivery, and assessment techniques.

Speculation on future research directions suggests a potential need for developing tailored CPR training approaches considering demographic characteristics. Customizing training based on learners' backgrounds and preferences could enhance engagement, comprehension, and retention, improving CPR performance and willingness to act in real-life emergencies. For example, incorporating adaptive learning technologies that adjust training difficulty and content based on individual performance and feedback could address diverse learning needs. Furthermore, exploring hybrid training models that combine the immersive experience of IVR with standardized hands-on practice might offer a comprehensive approach catering to a broader range of learners.

5.7.Implication

This study evaluated differences in knowledge, performance, satisfaction, and self-confidence between the IVR heart-saver group and the standardized HS group among non-health students at AAUP. These implications are divided into research, education, practice, and administration.

5.7.1. Implications for Research

The findings from this study highlight the vital importance of Heart Saver Programs for non-healthcare communities, emphasizing the need for comprehensive emergency preparedness across all societal segments. Despite the global recognition of such programs' significance, there exists a notable gap in the literature, especially concerning the application of IVR in HS training compared to standardized methods. This gap is particularly pronounced in the Middle Eastern context and, more specifically, within Palestine, where research on HS training tailored for non-healthcare populations is scarce. This study, therefore, not only highlights the critical role of HS training in enhancing emergency response capabilities among the general public but also calls attention to the urgent need for further research in this area. By shedding light on the potential benefits of IVR as a training tool, it paves the way for future investigations aimed at optimizing CPR training methodologies for broader community engagement and preparedness. Moreover, the findings of this study need to be replicated in different contexts and communities and compared with those of other universities, as well as in a follow-up study. Therefore, it is strongly highlight that such studies be conducted to support the generalizability of these findings. In addition, qualitative and mixed methods will significantly improve understanding and provide greater depth to our findings by using different samples, adding a third group as hybrid training using artificial intelligence (AI). This study will encourage further research regarding HS education and spreading to the non-health community. In addition, future studies are required to examine the effect of IVR HS training on other variables such as stress, fear, critical thinking, decision-making, and self-efficacy among non-health science students, in addition to the effect of other variables such as usability, teacher factors, educational practice, and simulation design characteristics on the implementation of IVR heart-saver.

5.7.2. Implications in Education

This The compelling findings of this study advocate for the integration of Heart Saver (HS) programs within the curricula of non-health science disciplines, addressing a significant educational gap. Currently, HS training is conspicuously absent from the curricula of non-health science students, a situation that undermines the potential for these students to apply life-saving theory in practice. By embedding HS programs into academic frameworks, educational institutions can foster a culture of emergency preparedness that transcends standardized medical training boundaries. This approach not only equips students from diverse academic backgrounds ranging from engineering and arts to information technology with the crucial skills to act competently in emergency situations but also democratizes access to vital life-saving knowledge. Furthermore, the inclusion of HS training in non-medical curricula promises to bridge the theoretical-practical divide, ensuring that students are not just academically proficient but also practically prepared to make meaningful contributions in real-world scenarios. Such an educational innovation holds the promise of cultivating a generation of students who are well-versed in emergency response protocols, significantly enhancing the community's overall resilience to cardiac emergencies.

5.7.3. Implications in Practice

Incorporating the Heart Saver (HS) course into the curricula of non-health science faculties is pivotal for broadening the scope of undergraduate education beyond standardized academic boundaries, thereby enriching students' practical skill sets and preparedness for real-life medical emergencies. This strategic inclusion is aimed at furnishing non-health science students with essential clinical knowledge and hands-on experience in CPR, use of AEDs, and basic first aid—skills that are seldom emphasized in their regular academic programs. Such an educational enhancement not only diversifies their competencies but also empowers them with the confidence to effectively respond to cardiac arrest scenarios, a common yet critical emergency situation. The exposure to HS training thus transcends conventional learning outcomes, fostering a comprehensive educational experience that equips students with life-saving capabilities. By integrating HS courses into non-health science disciplines, educational institutions can significantly contribute to cultivating a well-informed and clinically adept student body, capable of extending their impact from classroom learning to making a tangible difference in emergency medical interventions within their communities. This approach not only enhances individual learner preparedness but also contributes to the societal goal of increasing the pool of potential first responders, thereby addressing a crucial gap in emergency medical response capabilities at the community level. Moreover, HS training using standardized methods provides hands-on experience, direct instructor feedback, and high confidence but can be costly and less accessible.

The IVR training enhances situational awareness, decision-making, and scalability through immersive simulations, though it may lack physical practice. The hybrid method combines hands-on and VR approaches, offering comprehensive skill acquisition, it may better retention and flexibility, though it requires resources for both physical and virtual components. As well as, each method's effectiveness depends on trainee needs, resource availability, and training goals, by utilizing the visibility centers and labs to implement the IVR heart-saver training for non-health science students.

5.7.4. Implications in Administration

This study's findings showed that IVR is a superior method compared to the standardized method in relation mainly in performance. Findings of this study provide evidence for policymakers at universities and the Ministry of Health to develop policies for the responsibilities and roles of non-health science students towards cardiac arrest cases during their clinical practice in community settings by training non-health science on HS courses to spread HS culture among these communities, and HS courses should be implemented. Therefore, HS courses will decrease the mortality rate among communities, improve their experiences, enhance their skills, and increase their knowledge, reflecting positively on non-health science communities' case outcomes. Moreover, the non-health science professional will promote patients' safety, prevent any patient complications, and decrease the mortality rate, leading to decreased hospital costs. The HS course can provide opportunities for non-health science students to perform quality patient care and practice skills in a safe environment without fear. Furthermore, the logistical difficulties associated with the standardized HS method, such as arranging for physical space, equipment, and instructors, can be costly and restrict scaling. Flexibility and ease of use are two advantages of virtual reality

(VR) training, allowing constant training module delivery and a wider participant base. By collecting comprehensive data on trainee performance and knowledge, VR's immersive environment improves the accuracy and depth of training.

5.8.Recommendation

Based on the findings of this study, the following recommendations are proposed for integrating HS with standardized learning as a teaching method in non-health science curricula to start building and providing non-health science students with knowledge and skills at the university level, including critical thinking and decision-making at crucial times. Moreover, the study findings strategically include VR HS courses to enrich students' practical skill sets and prepare them for real-life medical emergencies, contributing to community resilience. Which proposed evidence for policymakers to develop policies integrating HS training for non-health science students, leading to improved patient outcomes and decreased mortality rate and hospital costs. As well as, the study recommends conducting further studies on other populations among the public, other Arabic countries, different sittings, and larger sample sizes.

5.9.Strengths and Limitations of the Study

The present study's strengths are its significant findings and the addition of Arab non-health science students to the literature. Additionally, a simulation lab and a VR lab are other resources that the institution has available. The current study is considered the first experimental study in Palestine to evaluate the effectiveness of IVR HS knowledge, performance, satisfaction, and self-confidence among non-health science students. Furthermore, the study used an RCT design and involved two randomly assigned groups, one for experimentation and the other for standardization.

Moreover, valid and reliable tools were used to measure the variables. Despite the strengths of the study, several limitations need to be recognized. It is a non-homogenous sample, whereas this study was limited to BSN students enrolled at one campus of a private university program, and it is not compared with other universities, which could influence the generalizability of the findings. Data about satisfaction and self-confidence were collected using a self-reported questionnaire, which could affect the responses. Another significant area for improvement was the implementation of this study during the war in Palestine, making it difficult to attend to the research. Moreover, this study faced limitations in logistics resources. The VR lab was newly established at an Arab American university, and there is a lack of resources in equipment and a shortage of staff for developing or creating new scenarios or experiences; in addition, we need expertise from the IT department to create our experience, which took a long time in establishing and implementing our intervention.

5.10. Conclusion

IVR-based learning might be a significant component in preparing non-health science students for the future. This study evaluated the effect of IVR HS knowledge, performance, satisfaction, and self-confidence among non-health science students at AAUP in Palestine. The current study confirmed that IVR HS training could be an active learning activity to improve students' knowledge performance, satisfaction, and self-confidence compared to standardized training. IVR-HS experiences could be an alternative to supplementing standardized training. However, there is a need to do further research on IVR HS training in other non-health science communities.

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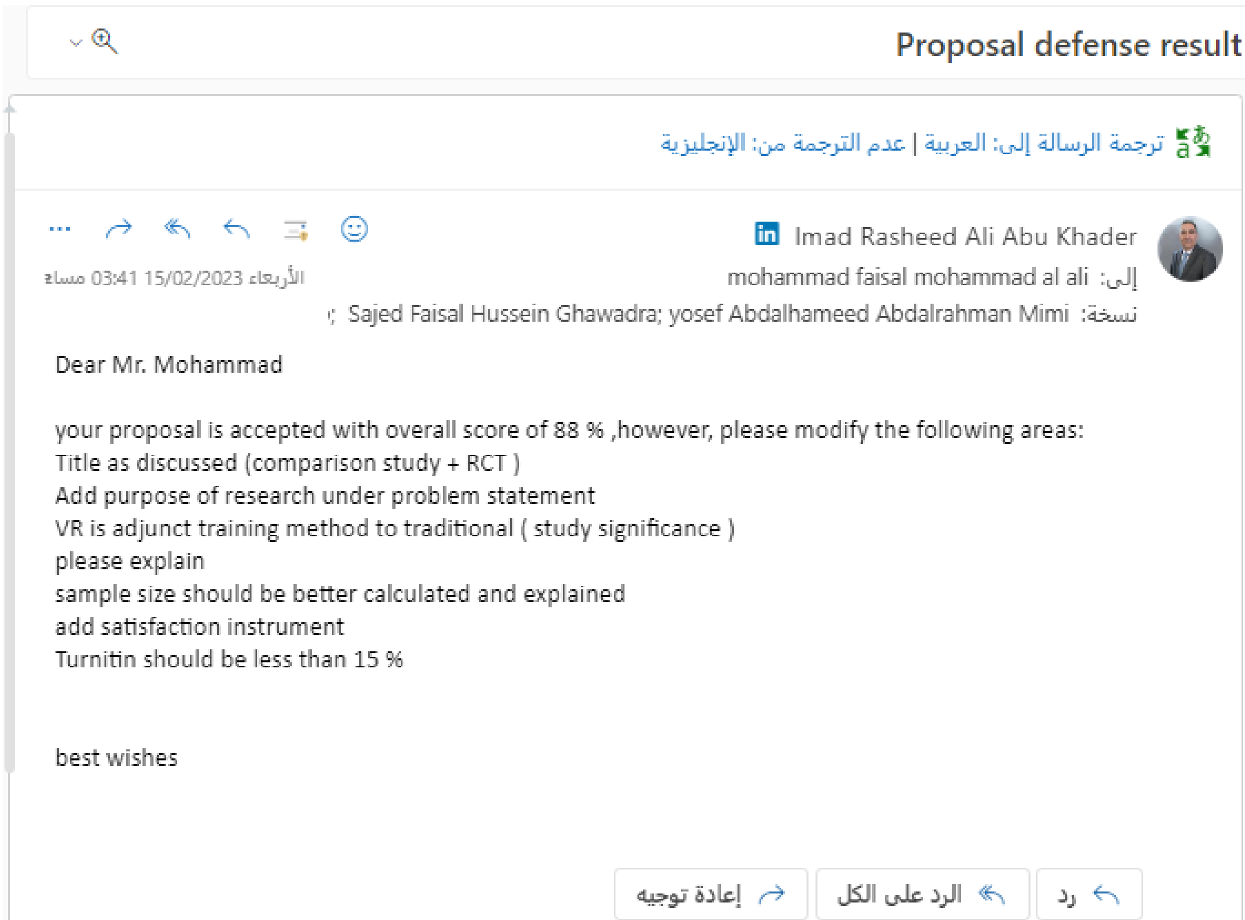
Appendices

Appendix (A): letter of permission from Graduate studies.



Proposal defense result

ترجمة الرسالة إلى: العربية | عدم الترجمة من: الإنجليزية

Imad Rasheed Ali Abu Khader

إلى: mohammad faisal mohammad al ali

الأربعاء 15/02/2023 03:41 مساءً

نسخة: Sajed Faisal Hussein Ghawadra; yosef Abdalhameed Abdalrahman Mimi ;

Dear Mr. Mohammad

your proposal is accepted with overall score of 88 % ,however, please modify the following areas:
Title as discussed (comparison study + RCT)
Add purpose of research under problem statement
VR is adjunct training method to traditional (study significance)
please explain
sample size should be better calculated and explained
add satisfaction instrument
Turnitin should be less than 15 %

best wishes

رد | الرد على الكل | إعادة توجيه

Appendix (B): letter of permission from IRB.

Arab American University- Palestine
Deanship of Scientific Research
IRB committee
Tel: 04-241-8888, ext 1196
E-mail: irb.aaup@aaup.edu

الجامعة العربية الامريكية- فلسطين
عمادة البحث العلمي
لجنة أخلاقيات البحث العلمي
تلفون: 04-241-8888 ext 1196
البريد الالكتروني: irb.aaup@aaup.edu

IRB Approval Letter

Study Title: The effect of immersive virtual reality cardiopulmonary resuscitation experience versus traditional earning on knowledge, performance, satisfaction and self-confidence among non-medical students: a randomized controlled trial.

Submitted by: Mohammad Faisal Alali

Date received: 30th March 2023

Date reviewed: 05th May 2023

Date approved: 05th May 2023

Your Study titled "**The effect of immersive virtual reality cardiopulmonary resuscitation experience versus traditional earning on knowledge, performance, satisfaction and self-confidence among non-medical students: a randomized controlled trial**" With archived number 2023/A/93/N was reviewed by the Arab American University IRB committee and was approved on 5th May 2023.

Reham Khalaf-Nazzal, MD, PhD
IRB committee chairman
Arab American University of Palestine

IRB
ARAB AMERICAN UNIVERSITY

General Conditions:

1. Valid for 1 year from date of approval.
2. It is important to inform the committee with any modification of the approved study protocol.
3. The committee appreciates a copy of the research when accomplished.

لجنة أخلاقيات البحث العلمي في الجامعة العربية الامريكية

IRB at Arab American University

Appendix (C): letter of permission from NLN to use the Questionnaire Student Satisfaction and Self-Confidence in Learning.

Student Satisfaction and Self-confidence in learning Questionaire (NLN)

1

PC

:opyright Permission <cpermission@nln.org نيابة عن <Amy McGuire <amcguire@nln.org

إلى: mohammad faisal mohammad al ali

الأربعاء 22/03/2023 06:43 مساءً

,Greetings Mohammad

Thank you for your inquiry. We are pleased that you have decided to use one of the NLN's simulation instruments students to download from the NLN's instruments are available for researchers and .for your doctoral research . https://www.nln.org/education/teaching-resources/tools-and-instruments :NLN website here

Before using the instruments, we ask that you please review the caveats that accompany permission for use of :NLN's research instruments here, especially around modifying (scroll to bottom of page) . https://www.nln.org/news/copyright-permissions

Please note that doctoral students are allowed to include the requested NLN content in their proposals and final the dissertation is uploaded to However, after final defense, and before .defense copies for purposes of defense Proquest or any similar university repository or open access platform, the NLN copyrighted material is to be .removed and a blank page inserted indicating the material is copyrighted

Instrument reference citation: National League for Nursing. (2005). Student Satisfaction and Self-confidence in . https://www.nln.org/education/teaching-resources/tools-and-instruments Learning ©. Retrieved from

Regards, NLN Copyright Permissions

<mohammad.alali@aaup.edu> mohammad faisal mohammad al ali **:From**

Saturday, March 18, 2023 5:16 PM **:Sent**

Appendix (D): English Version of the Questionnaire Student Satisfaction and Self-Confidence in Learning

A comparison between Immersive Virtual Reality Heart Saver and Standardized Heart Saver Training amongst Non-Health Science Students.

Demographical Data

- Age: ……………………………………….
- Marital Status: □ Single □ Married □ Separated □ Widow
- Gender: □ Male □ Female

Academic Data

- Academic Year: □ First Year □ Second Year □ Third Year □ Fourth Year
- Academic achievement: □ Excellent □ Very good □ Good □ Acceptable
- Academic Specialty: □ Admiration & Financial Science □ Law and Science □ Art and Sport Science □ Information Technology and Engineering

Student Satisfaction and Self-Confidence in Learning

Instructions: This questionnaire is a series of statements about your attitudes about the instruction you receive during your training activity. Each item represents a statement about your attitude toward your satisfaction with learning and self-confidence in obtaining the instruction you need. There are no right or wrong answers. You will probably agree with some of the statements and disagree with others. Please indicate your personal feelings about each statement below by marking the numbers that best describe your attitude or beliefs. Please be truthful and describe your attitude as it is, not what you would like it to be. This is anonymous with the results being compiled as a group, not individually.

Mark:

1 = STRONGLY DISAGREE with the statement

2 = DISAGREE with the statement

3 = UNDECIDED - you neither agree nor disagree with the statement

4 = AGREE with the statement

5 = STRONGLY AGREE with the statement

Satisfaction with Current Learning	**1**	**2**	**3**	**4**	**5**
1. The teaching methods used in this simulation training were helpful and effective.					
2. The simulation provided me with a variety of learning materials and activities to promote my learning of the heart-saver adult CPR curriculum.					

3. I enjoyed how my instructor taught the simulation.					
4. The teaching materials used in this simulation were motivating and helped me to learn					
5. The way my instructor(s) taught the simulation was suitable to the way I learned.					
Self-confidence in Learning	**1**	**2**	**3**	**4**	**5**
6. I am confident that I am mastering the content of the simulation activity that my instructors presented to me					
7. I am confident that this simulation covered critical content necessary for the mastery of the heart-saver adult CPR curriculum					
8. I am confident that I am developing the skills and obtaining the required knowledge from this simulation to perform necessary tasks in a clinical setting					
9. My instructors used helpful resources to teach the simulation.					
10. It is my responsibility as the student to learn what I need to know from this simulation activity					
11. I know how to get help when I do not understand the concepts covered in the training.					

12. I know how to use simulation activities to learn critical aspects of these skills					
13. It is the instructor's responsibility to tell me what I need to learn about the simulation activity content during class time.					

Appendix (E): Arabic Version of the Questionnaire Student Satisfaction and Self-Confidence in Learning

دراسة حول: المقارنة بين استخدام الواقع الافتراضي الغامر والواقع التقليدي في تدريب انعاش القلب الرئوي بين الطلاب من التخصصات الغير طبية

المعلومات الديموغرافية

- العمر :--------------
- االحالة الاجتماعية : □ أعزب □ متزوج □ منفصل/ة □ ارمل/ة
- الجنس: □ ذكر □ أنثى

المعلومات الاكاديمية

- المستوى ألاكاديمي: □ سنة اولى □ سنة ثانية □ سنة ثالثة □ سنة رابعة
- التحصيل ألاكاديمي: □ ممتاز □ جيد جدا □ جيد □ مقبول
- التخصص الاكاديمي: □ التجارة □ الحقوق والعلوم □ الاداب والرياضة □ تكنولوجيا المعلومات والهندسة

الرضا والثقة بالنفس لدى الطلبة في التعلم

التعليمات: هذا االستبيان عبارة عن مجموعة من العبارات حول مواقفك الشخصية من التعليمات التي تتلقاها أثناء نشاطك التدريبي. كل يمثل عبارة حول موقفك تجاه رضاك عن التعلم والثقة بالنفس في الحصول على التعليمات التي تحتاجها. لا توجد إجابات صحيحة أو خاطئة. من المحتمل أنك توافق على بعض العبارات وتختلف مع البعض الاخر. يرجى الإشارة إلى مشاعرك الشخصية حول كل عبارة أدناه عن طريق تحديد الرقم التي تصف موقفك أو معتقداتك بشكل أفضل. يرجى التحلي بالصدق ووصف موقفك كما هو بالواقع، وليس كما تريده أن يكون

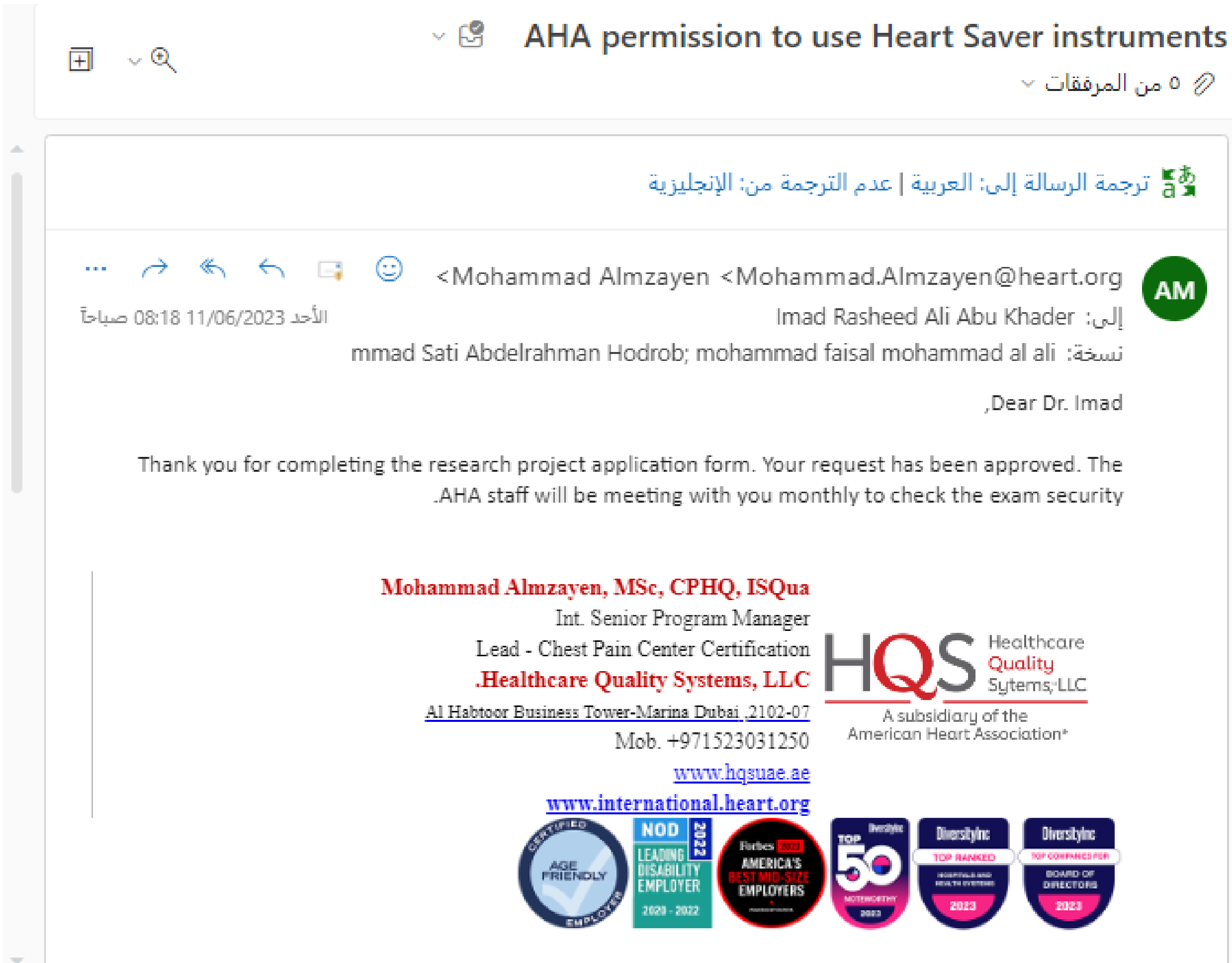
العلامة:

1=غير موافق بشدة 2=غير موافق 3= محايد 4=موافق 5= موافق بشدة

الرضا من التعلم الحالي	1	2	3	4	5
1. طرق التعلم التي استخدمت في التدريب كانت ُمساعدة وفعالة.					
2. زودني التدريب بمجموعة متنوعة من المواد والأنشطة التعليمية لتعزيز تعلمي لمنهاج انعاش القلب الرئوي .					
3. استمتعت بكيفية تعليم المدرب / المدربين للتدريب					
4. المواد التعليمية التي استخدمت بالتدريب كانت محفزة لي وساعدتني ألتعلم					
5. الطريقة التعليمية من قبل المدرب / المدربون في التدريب كان مناسبا لطريقة تعلمي.					

5	4	3	2	1	**الثقة بالنفس في التعلم**
					6. أنا واثق من أنني أتقن محتوى النشاط التدريبي الذي قدمه لي المدربون.
					7. أنا واثق من أن هذا التدريب غطى المحتوى الهام الضروري إتقان منهاج التدابير لإنعاش القلب الرئوي.
					.8أنا واثق من أنني أقوم بتطوير المهارات والحصول على المعرفة المطلوبة من هذا التدريب أداء المهام الضرورية في الأماكن السريرية.
					9. استخدم المدربون مصادر مفيدة لتعليم التدريب
					10. مسؤوليتي كطالب هي تعلم ما أحتاج إلى معرفته من هذا النشاط التدريبي.
					11. أعرف كيفية الحصول على المساعدة عندما ال أفهم المفاهيم التي تم تناولها في التدريب
					12. أعرف كيفية استخدام الأنشطة التدريبية لتعلم الجوانب المهمة لهذه المهارات.
					13. مسؤولية المدرب إخباري بما يجب أن أتعلمه من محتوى النشاط التدريبي خلال وقت المحاضرة

Appendix (F): letter of permission from AHA.



AHA permission to use Heart Saver instruments

٥ من المرفقات

ترجمة الرسالة إلى: العربية | عدم الترجمة من: الإنجليزية

AM

Mohammad Almzayen <Mohammad.Almzayen@heart.org>

إلى: Imad Rasheed Ali Abu Khader

نسخة: mmad Sati Abdelrahman Hodrob; mohammad faisal mohammad al ali

الأحد 11/06/2023 08:18 صباحاً

Dear Dr. Imad,

Thank you for completing the research project application form. Your request has been approved. The AHA staff will be meeting with you monthly to check the exam security.

Mohammad Almzayen, MSc, CPHQ, ISQua
Int. Senior Program Manager
Lead - Chest Pain Center Certification
Healthcare Quality Systems, LLC.
Al Habtoor Business Tower-Marina Dubai ,2102-07
Mob. +971523031250
www.hqsuae.ae
www.international.heart.org

HQS Healthcare Quality Sytems, LLC
A subsidiary of the American Heart Association®

Appendix (G): The adult performance checks list evaluation.

Heartsaver®
Adult CPR and AED
Skills Testing Checklist

American Heart Association.

Student Name ____________________ Date of Test ____________

Scenario: "You arrive at the scene for a suspected cardiac arrest. No bystander CPR has been provided. You approach the scene and ensure that it is safe. Demonstrate what you would do next."

Assessment and Activation
☐ Checks responsiveness ☐ Shouts for help/Sends someone to phone the local emergency response number and get an AED ☐ Checks breathing

Once student shouts for help, instructor says, "Here's the barrier device. I am going to phone the local emergency response number and get the AED."

Cycle 1 of CPR (30:2)

Adult Compressions
☐ Performs high-quality compressions*:
- Hand placement on lower half of breastbone
- 30 compressions in no less than 15 and no more than 18 seconds
- Compresses at least 5 cm (2 inches)
- Complete recoil after each compression

Adult Breaths
☐ Gives 2 breaths with a barrier device:
- Each breath given over 1 second
- Visible chest rise with each breath
- Gives 2 breaths in less than 10 seconds

CPR feedback devices are required for accuracy.

Cycle 2 of CPR (repeats steps in Cycle 1) ***Only check box if step is successfully performed***
☐ Gives 30 high-quality compressions ☐ Gives 2 effective breaths

Instructor says, "Here is the AED."

AED (follows prompts of AED)
☐ Powers on AED ☐ Correctly attaches pads ☐ Clears for analysis ☐ Clears to safely deliver a shock
☐ Presses button to deliver shock ☐ Student immediately resumes compressions

AED trainer says, "The shock has been delivered."

Cycle 3 of CPR (repeats steps in Cycle 1) ***Only check box if step is successfully performed***
☐ Gives 30 high-quality compressions ☐ Gives 2 effective breaths

STOP TEST

Instructor Notes
- Place a check in the box next to each step the student completes successfully.
- If the student does not complete all steps successfully (as indicated by at least 1 blank check box), the student must receive remediation. Make a note here of which skills require remediation (refer to Instructor Manual for information about remediation).

Test Results	Check **PASS** or **NR** to indicate pass or needs remediation:	☐ **PASS**	☐ **NR**

Instructor Initials ______ Instructor Number ____________ Date ____________

Appendix (H): English Version of the AHA Adult Heart Saver Exam.

American Heart Association.

Heart Saver Adult CPR AED Exam.

Please do not mark this exam. Record the best answer on the separate answer sheet.

1- What are the correct rates and depth for providing compression during high-quality adult CPR to improve survival?

A- Rate of 80 to 100 compression per minute and depth of at least 5 CM

B- Rate no more than 60 compressions per minute and a depth of at least 2.5 CM

C- Rate of 100 to 120 compression per minute and depth of at least 5 CM

D- Rate no more than 30 compressions per minute and depth of at least 2.5 CM

2- What should you do when you phone your emergency response number (or your local emergency number)?

A- Answer all the dispatcher questions

B- Quickly tell the dispatcher where that accident occurred

C- Tell the dispatcher to call you back

D- Give the Dispatcher only the victim’s information

3- What actions result in the best chance of survival if someone is not breathing (or is only gasping) and is not responding?

A- Should for help, and stay with the victim until someone with more advanced training arrived

B- Perform CPR only, and leave the AED for someone with more advanced training to use

C- Start CPR, and use an AED if one is available

D- Send someone to get the AED, to minimize the number of people involved

4- You come across an adult lying on the ground. Tap and shout, but he is unresponsive. What should you do next?

A- Continue tapping and shouting until the person becomes responsive

B- Shout for help. Phone or have someone else phone the emergency response number (or your local emergency number) and get an AED if one is available

C- Check for breathing for at least 10 seconds

D- Slap the person on the back to see if an object is lodged in the throat

5- How deep should you push the chest on the adult victim when giving the chest compression?

A- one-half the depth of the chest

B- One-third the depth of the chest

C- Only 2.5 CM

D- At least 5 CM

6- When performing CPR, when should you switch positions and allow someone else to take over compression and breaths?

A- After each set of 30 compressions and 30 breath

B- About every 2 minutes

C- After each set of 100 compressions and 2 breaths

D- Every 5 minutes

7- How should you give breath with a mask?

A- Tilt the head and left of the chin, and press the mask against the person's face to mask an airtight seal

B- Tilt the head, and cover the face completely with the mask

C- Tilt the chin, and press the mask against the person's nose

D- Tilt the head back far enough to open the person's mouth, and gently place the mask on the person's face

8- You are giving sets of 30 compressions and 2 breaths. Another person arrives with an AED. What should you do next?

A- Finish whichever set of 30 compressions and 2 breaths you're working on

B- Immediately use the AED

C- Make sure someone has phoned the emergency response number (or your local emergency number)

D- Put a blanket on the person receiving CPR

9- what should you do if a choking adult stops responding?

A- Start CPR

B- Give 5 compressions and 5 back slaps

C- Give forceful breaths to push the object down

D- Continue the stomach thrusts until the object is removed

10- How much breathing should be delivered to an adult victim during high-quality CPR at the correct rate to increase survival??

A- Give 2 breaths per second after each 30-compression and see the visible chest rise when providing breaths at least for 5 seconds

B- Give one breath in one second after each 30-compression

C- Give 2 breaths do not exceed 2 seconds after each 30 compression

D- Give 2 breaths, each breath in one second and keep one second between them, and see the visible chest rise when providing breaths at not exceed 10 seconds

American Heart Association.

Student Answer Sheet
Heartsaver®
First Aid CPR AED Optional Exam

Name: ___________________________ Date: ________________ Version: _____

Question	Answer			
1.	A	B	C	D
2.	A	B	C	D
3.	A	B	C	D
4.	A	B	C	D
5.	A	B	C	D
6.	A	B	C	D
7.	A	B	C	D
8.	A	B	C	D
9.	A	B	C	D
10.	A	B	C	D

Appendix (I): Arabic Version of the AHA Adult Heart Saver Exam.

الامتحان حول انعاش القلبي الرئوي ومزيل الرجفان الالي للبالغين (AED) من برنامج منقذ القلب Heart Saver

يرجى عدم وضع أي علامة على هذا الامتحان, وتسجيل أفضل إجابة على ورقة الإجابة المنفصلة

1. ما هو معدل اعطاء الضغطات في الدقيقة الواحدة الصحيح اثناء اجراء الانعاش القلب الرئوي ؟

أ - معدل من 80 الى 100 ضغطه في الدقيقة

ب – معدل لا يزيد عن 60 ضغطه في الدقيقة

ج – معدل من 100 الى 120 ضغطه في الدقيقة

د - معدل لايزيد عن 30 ضغطه في الدقيقة

2. ما الذي ينبغي عليك فعله عندما تتصل برقم استجابة الطوارئ ؟

أ – الاجابة عن كل اسئلة مامور الارسال

ب – اخبار مامور الارسال بسرعه بمكان وقوع الحادث

ج – الطلب من مامور الارسال اعادة الاتصال بك

د – اعطاء مامور الارسال معلومات المصاب فقط

3. ما الاجراءات التي توفر أفضل فرصة للانقاذ اذا كان الشخص لا يتنفس (احتضاريا فقط) ولا يستجيب ؟

أ- طلب المساعدة بصوت مرتفع والبقاء مع المصاب الى حين وصول شخص متخصص.

ب- اجراء الانعاش القلبي الرئوي فقط وترك استخدام مزيل الرجفان الخارجي لشخص متخصص

ج – بدا الانعاش القلبي الرئوي واستخدام مزيل الرجفان الالي الخارجي (AED) (ان توفر).

د – ارسال شخص ما لاحضار مزيل الرجفان الخارجي الالي , لتقليل عدد الاشخاص المحطين بالمصاب.

4. تصادف شخصا بالغا ممدا على الأرض تربت على كتفه وتناديه , ولكن لا يستجيب ما الذي ينبغي عليك فعله كخطوة تالية؟

أ- الاستمرار في التربيت على كتفه ومنادته حتى يستجيب.

ب – الصراخ طلبا بالمساعدة الاتصال او الطلب من شخص اخر الاتصال برقم استجابة الطوارئ او رقم الطوارئ المحلي لديك وإحضار مزيل الرجفان الخارجي (AED) الألي إن توفر

ج – التحقق من التنفس لمده لاتقل عن 10 ثواني

د- توجيه لطمات على ظهر الشخص لترى ما امكان هناك جسم عالق بالحلق

5. الى عمق يجب أن تضغط على صدر المصاب بالغ عند إجراء عمليات ضغط على الصدر؟

أ- نصف عمق الصدر

ب- ثلث عمق الصدر

ج – بعمق 2.5 سم فقط

د – 5 سم على الاقل

6- عند إجراء الإنعاش القلبي الرئوي, متى ينبغي عليك تبديل المواقع والسماح لشخص اخر بتولي الضغطات والأنفاس؟

أ- بعد إجراء كل مجموعة من 30 ضغطة و 30 نفس

ب- كل دقيقتين تقريبا

ج- بعد إجراء كل مجموعة من 100 ضغطة ونفسين

د- كل خمس دقائق

7- كيف ينبغي عليك إعطاء الأنفاس باستخدام قناع؟

أ- أمل الرأس ورفع الدقن ثم ضع القناع بإحكام على وجه الشخص لمنع تسرب الهواء

ب- أمل الرأس وغطي الوجه تماما بالقناع

ج- أمل الذقن وضع القناع باحكام على أنف الشخص

د- أمل الراس الى الخلف بما يكفي لفتح فم الشخص, وضع القناع برفق على وجهه

8- كنت تجري مجموعات من 30 ضغطه ونفسين , عندما وصل شخص اخر يحمل مزيل الرجفان الخارجي الالي ما الذي ينبغي عليك فعله كخطوة تالية؟

أ- الانتهاء من أي مجموعة من 30 ضغطة ونفسين تقوم باجرائها

ب- استخدام مزيل الرجفان الخارجي الالي على الفور

ج- الحرص على ان يتصل شخص ما برقم استجابة الطوارئ

د- وضع بطانية على الشخص الذي يتلقى الانعاش القلبي الرئوي

9- ما الذي ينبغي عليك فعله اذا توقف شخص تعرض للاختناق عن الاستجابة؟

أ- بدأ الانعاش القلبي الرئوي

ب- إجراء 5 ضغطات و 5 لطمات على الظهر

ج – اعطاء انفاس قوية لدفع الجسم للاسفل

د – متابعة الدسرات على البطن حتى يخرج الجسم

10. ما هو المعدل الصحيح والوقت الصحيح لاعطاء النفس بعد كل 30 ضغطة لمصاب بالغ اثناء اجراء الانعاش القلب الرئوي ؟

أ – نفسان كل نفس بثانية مع ترك ثانية بين كل نفس والانتباه عند الاعطاء لارتفاع صدر المصاب لمدة لاتتجاوز خمس ثواني

ب – نفس واحد لمدة ثانية بعد كل 30 ضغطة على صدر المريض

ج – نفسان بمدة لا تتجاوز ثانيتن بعد كل 30 ضغطة على صدر المريض

د - نفسان كل نفس بثانية مع ترك ثانية بين كل نفس والانتباه عند الاعطاء لارتفاع صدر المصاب لمدة لاتتجاوز 10 ثواني

American Heart Association.

Student Answer Sheet
Heartsaver®
First Aid CPR AED Optional Exam

Name: ____________________________ Date: ________________ Version: _____

Question	Answer			
1.	A	B	C	D
2.	A	B	C	D
3.	A	B	C	D
4.	A	B	C	D
5.	A	B	C	D
6.	A	B	C	D
7.	A	B	C	D
8.	A	B	C	D
9.	A	B	C	D
10.	A	B	C	D

Appendix (J): English Version of the Participation Information Sheet**.**

PARTICIPANT INFORMATION SHEET

AAUP-IRB Code No.: 2023/A/93/N

AAUP-IRB Date: 5/5/2023

Study Title: A Comparison between Immersive Virtual Reality Heart Saver and Standardized Heart Saver Training amongst Non-Health Science Students.

We would like to invite you to take part in a research study. Before you decide whether to participate, you need to understand why the research is being done and what it would involve. Please take time to read the following information carefully; talk to others about the study if you wish.

Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

---

1. What is the purpose of this study?

To evaluate the effect of immersive virtual reality cardiopulmonary resuscitation experience versus standardized learning on knowledge, performance, satisfaction, and self-confidence among non-health sciences students.

2. Why is this study important?

The importance of the study lies in the fact that sudden cardiac arrest may occur suddenly and quickly. **Simultaneously, it requires rapid intervention from an experienced and well-**

trained person due to the serious complications that may occur owing to cardiac arrest. Consequently, **this increases survival and reduces the mortality rate**. which provides a realistic and good environment for training by placing the trainee under the appropriate ambient pressures that may occur in real cases of cardiac arrest. In addition to increasing the trainee's confidence in themselves as they have received realistic training on the event, knowing that cardiac arrest needs good training and gaining knowledge and practice in an attempt to reduce the number of deaths from cardiac arrest.

3. What is the procedure that is being tested? *(If applicable)*

The researcher will measure the effectiveness of VR in Cardiopulmonary resuscitation

4. Why have I been invited to participate in this study?

The inclusion criterion for non-health sciences participation at all bachelor academic levels ranges from the first year to the fourth year. In the study, there will be male and female bachelor students enrolled at Arab American University, who are willing to participate voluntarily in this study, as well as who haven't obtained any CPR courses so far.

5. Who should not participate in the study?

The exclusion criteria for medical students are because they will receive this training as part of their curriculum, as well as how unable to attend or perform physical skills due to medical concerns that necessitate CPR performance skills.

6. Can I refuse to take part in the study?

Yes, without negative consequences

7. What will happen to me if I take part?

Yes, at the beginning participants will fill out the questionnaire and then attend to intervention

8. How long will I be involved in this study?

Around 2 to 3 hours

9. What are the possible disadvantages and risks?

There is no disadvantage or risk.

10. What are the possible benefits to me?

Increase knowledge and awareness toward cardiac arrest, handling the participant to deal with case to reduce the mortality rate.

11. Who will have access to my medical records and research data?

The researcher and supervisors

12. Will my records/data be kept confidential?

Yes, will be saved in the lock store

13. What will happen if I don't want to carry on with the study?

you can draw at any time without any negative sequences

14. What will happen to the results of the research study?

The result of your training will be used for the advancement and development of the Cardiopulmonary resuscitation VR program to change the policy and training the community for this field may be will add it to the school curriculum and will be used for scientific publication as evidence-based.

15. Will I receive compensation for participating in this study?

the students who will participate in this study will be exempted from the service community course.

16. Who should I contact if I have additional questions/problems during the study?

Researcher contact details:

Name	***Email***	***Contact Number***
Mr. Mohammad Faisal Al Ali	***Mohammad.alali@aaup.edu***	***0592887556***
Dr. Ahmad Alsmadi	***a.smadi@aabu.edu.jo***	***00962799060790***
Dr. Ahmad Ewies	***ahmad.ewais@aaup.edu***	***0599374382***

17. Who should I contact if I am unhappy with how the study is being conducted?

Ethical Review Committee

Deanship of Scientific Research

Arab American University-Palestine (AAUP)

Email: src@aaup.edu

Appendix (K): Arabic Version of the Participation Information Sheet.

ورقة معلومات المشارك

رقم الكود. AAUP-IRB: 2023/A/93/N

التاريخ: 2023/5/5

عنوان الدراسة: المقارنة بين استخدام الواقع الافتراضي الغامر والواقع التقليدي في تدريب انعاش القلب الرئوي بين الطلاب من التخصصات الغير طبية

ندعوكم للمشاركة في دراسة بحثية. قبل أن تقرر ما إذا كنت ستشارك، تحتاج إلى فهم سبب إجراء البحث وما الذي سيتضمنه. يرجى أخذ الوقت الكافي لقراءة المعلومات التالية بعناية؛ تحدث مع الآخرين عن الدراسة إذا كنت ترغب في ذلك.

إذا كان هناك أي شيء غير واضح أو إذا كنت ترغب في مزيد من المعلومات توجه بالسؤال للباحث مباشرة. خذ وقتك لتقرر ما إذا كنت ترغب في المشاركة أم لا.

1 . ما هو الغرض من هذه الدراسة؟

لتقييم تأثير تجربة الإنعاش القلبي الرئوي في الواقع الافتراضي مقابل التعلم التقليدي على المعرفة والأداء والرضا والثقة بالنفس بين الطلاب غير الطبيين.

2. لماذا هذه الدراسة مهمة؟

تكمن أهمية الدراسة في حقيقة أن السكتة القلبية المفاجئة قد تحدث بشكل مفاجئ وسريع. في الوقت نفسه، يتطلب الأمر تدخلاً سريعًا من شخص متمرس ومدرب جيدًا بسبب المضاعفات الخطيرة التي قد تحدث بسبب السكتة القلبية. وبالتالي، فإن هذا يزيد

من البقاء على قيد الحياة ويقلل من معدل الوفيات. مما يوفر بيئة واقعية وجيدة للتدريب من خلال وضع المتدرب تحت الضغوط المحيطة المناسبة التي قد تحدث في حالات السكتة القلبية الحقيقية. بالإضافة إلى زيادة ثقة المتدرب في نفسه حيث تلقى تدريبًا واقعيًا على الحدث، مع العلم أن السكتة القلبية تحتاج إلى تدريب جيد واكتساب المعرفة والممارسة في محاولة لتقليل عدد الوفيات الناجمة عن السكتة القلبية.

3. ما هو الإجراء الذي يتم اختباره؟ (إذا كان قابلاً للتطبيق)

سيقوم الباحث بقياس فعالية الواقع الافتراضي في الإنعاش القلبي الرئوي.

4. لماذا تمت دعوتي للمشاركة في هذه الدراسة؟

يتراوح معيار التضمين للمشاركة غير الطبية في جميع المستويات الأكاديمية للبكالوريوس من السنة الأولى إلى السنة الرابعة. في الدراسة، سيكون هناك طلاب بكالوريوس من الذكور والإناث مسجلين في الجامعة العربية الأمريكية، والذين يرغبون في المشاركة طواعية في هذه الدراسة ، وكذلك الذين لم يحصلوا على أي دورات CPR حتى الآن .

5. من لا يجب أن يشارك في الدراسة؟

معايير الاستبعاد لطلاب الطب هي أنهم سيحصلون على هذا التدريب كجزء من مناهجهم الدراسية، بالإضافة إلى عدم قدرتهم على الحضور أو أداء المهارات البدنية بسبب المخاوف الطبية التي تتطلب مهارات أداء الإنعاش القلبي الرئوي.

6. هل يمكنني رفض المشاركة في الدراسة؟

نعم، بدون عواقب سلبية

7. ماذا سيحدث لي إذا شاركت؟

نعم، في البداية سوف يقوم المشاركون بملء الاستبيان ثم الانتباه إلى التدخل.

8. إلى متى سأشارك في هذه الدراسة؟

حوالي ساعة الى ساعاتيين

9. ما هي العيوب والمخاطر المحتملة؟

لا يوجد عيب أو مخاطرة.

10. ما هي الفوائد المحتملة بالنسبة لي؟

زيادة المعرفة والوعي تجاه السكتة القلبية والتعامل مع المشترك للتعامل مع الحالة لتقليل معدل الوفيات.

11. من سيتمكن من الوصول إلى سجلاتي الطبية وبيانات البحث؟

الباحث والمشرفون.

12. هل ستبقى سجلاتي / بياناتي سرية؟

نعم سيتم حفظها في خزانة محكمة الاغلاق في مركز القلب في الجامعة العربية الامريكية.

13. ماذا سيحدث إذا لم أرغب في مواصلة الدراسة؟

يمكنك الانسحاب في اوقت ترغب دون وجود اي عقبات لأنها المشاركة طوعية.

14. ماذا سيحدث لنتائج الدراسة البحثية؟

سيتم استخدام نتيجة تدريبك للتقدم وتطوير برنامج VR للإنعاش القلبي الرئوي لتغيير السياسة وقد يتم إضافة تدريب المجتمع لهذا المجال إلى المناهج الدراسية وسيتم استخدامه للنشر العلمي كدليل قائم على الأدلة.

15. هل سأحصل على تعويض مقابل المشاركة في هذه الدراسة؟

لا يوجد تعويض ولكن سوف نقوم بإعفاء الطلاب الذين سيشاركون في هذه الدراسة من جزء من عدد ساعات دورة خدمة المجتمع بحيث اذا قام المشارك بإكمال الدورة كاملة سوف يحسب له كامل الجزء المتفق علية من قبل عمادة شؤون الطلبة في دورة خدمه المجتمع , وكذلك في حال شارك بنصف عدد الساعات سوف يحسب عدد الساعات التي قام وبها وترفع لعمادة شؤون الطلبة ليتم احتسابها كجزء من مساق خدمة المجتمع, علما بان المشارك يستطيع الانسحاب في اي وقت دون وجود اي عقبات في ذلك لأنها مشاركة طوعية .

16. بمن يجب علي الاتصال إذا كانت لدي أسئلة / مشاكل إضافية أثناء الدراسة؟

تفاصيل الاتصال بالباحث:

الاسم البريد الإلكتروني رقم الاتصال

الاسم	البريد الإلكتروني	رقم الاتصال
الباحث محمد فيصل العلي	***Mohammad.alali@aaup.edu***	***0592887556***
الدكتور احمد الصمادي	***a.smadi@aabu.edu.jo***	***00962799060790***
الدكتور احمد عويس	***ahmad.ewais@aaup.edu***	***0599374382***

17. بمن يجب أن أتصل إذا كنت غير راضٍ عن كيفية إجراء الدراسة؟

لجنة المراجعة الأخلاقية

عمادة البحث العلمي

الجامعة العربية الأمريكية - فلسطين(AAUP)

البريد الإلكتروني : src@aaup.edu

Appendix (L): English Version of the Consent Form.

INFORMED CONSENT

AAUP-IRB Code No.: 2023/A/93/N

AAUP-IRB Date: 5/5/2023.

I, …………………………………………………….......... *(Name of Participant / optional)* hereby agree to take part in the clinical research (clinical study/questionnaire study/drug trial) specified below:

<u>**Title of Study:**</u> **A Comparison between Immersive Virtual Reality Heart Saver and Standardized Heart Saver Training amongst Non-Health Science Students.**

Fulfillment of PhD degree, in Nursing sciences program, at AAUP.
The nature and purpose of which has been explained to me by the Participation information sheet, and interpreted by Mr. Mohammad Faisal Al Ali to the best of his/her ability in English.

I have been told about the nature of the research in terms of methodology, possible adverse effects, and complications (as per the Participant Information Sheet).

After knowing and understanding all the possible advantages and disadvantages of this research, I voluntarily consent of my own free will to participate in the clinical research specified above.

I understand that I can withdraw from this research at any time without assigning any reason whatsoever.

Date: ……………...………..….. **Signature:** ……………….…………………………………

(Participant)

IN THE PRESENCE OF:

Name: …………………………………………

Date:…………………………….. **Signature:** ……………..……………………………….

(*Witness for Signature of Participant)*

I confirm that I have explained to the patient the nature and purpose of the above-mentioned research.

Date: ……………………………. **Signature:** ……………..………………………………

(Attending investigator)

Appendix (M): Arabic Version of the Consent Form.

موافقة مسبقة

رقم كود.AAUP-IRB: 2023/A/93/N

تاريخ الحصول على موافقة IRB: 2023/5/5

تاريخ: ....

أنا ....(اسم المشارك / اختياري) أوافق بموجبه على المشاركة في البحث السريري (دراسة سريرية / دراسة استبيان / تجربة دوائية) المحددة أدناه:

عنوان الدراسة: المقارنة بين استخدام الواقع الافتراضي الغامر والواقع التقليدي في تدريب انعاش القلب الرئوي بين الطلاب من التخصصات الغير طبية.

وذلك كمتطلب للحصول على درجة شهادة الدكتوراه في برنامج علوم التمريض في الجامعة العربية الأمريكية .

تم شرح طبيعة الدراسة والغرض منها من خلال ورقة معلومات المشاركة، وفسرها السيد محمد فيصل العلي بأفضل ما لديه من قدرات باللغة الإنجليزية والعربية.

لقد تم إخباري عن طبيعة البحث من حيث المنهجية والآثار السلبية المحتملة والمضاعفات (حسب ورقة معلومات المشارك).

بعد معرفة وفهم جميع المزايا والعيوب المحتملة لهذا البحث، أوافق طواعية بمحض إرادتي على المشاركة في البحث السريري المحدد أعلاه.

أفهم أنه يمكنني الانسحاب من هذا البحث في أي وقت دون إبداء أي سبب على الإطلاق ودون وجود اي عقبات.

التاريخ: .... التوقيع:

....

(مشارك)

في حضور:

اسم: ....

تعيين: ....

إمضاء: ....

(شاهد على توقيع المشارك)

أؤكد أنني أوضحت للمشارك طبيعة وهدف البحث المذكور أعلاه.

تاريخ: ....

إمضاء: ....

Appendix (N): Announcement invitation to the students.

An email announcement was sent to the students who were selected for approval and motivated them to participate in this study.

Appendix (O): Association between Variables

Appendix O.1: Comparing between study groups according to the frequency of true and false per each question

Table 4.7: Comparing between study groups according to the frequency of true and false per each question (N=200; Intervention group=100; Control group=100).

Item No	Item description	Correct answer	Groups	n	Responses	Pretest n (%)	Posttest n (%)
1	What are the correct rates and depths for providing compression during high-quality adult CPR to improve survival?	Rate of 100 to 120 compression per minute and depth of at least 5 CM	IVR HS	100	True	28	93
					False	72	7
			Standardized HS	100	True	23	93
					False	77	7
2	What should you do when you phone your emergency response	Answer all the dispatcher questions	IVR HS	100	True	24	81
					False	76	19

Item No	Item description	Correct answer	Groups	n	Responses	Pretest n (%)	Posttest n (%)
	number (or your local emergency number		Standardized HS	100	True	71	72
					False	29	28
3	What actions result in the best chance of survival if someone is not breathing (or is only gasping) and is not responding	Start CPR, and use an AED if one is available	IVR HS	100	True	48	100
					False	52	0
			Standardized HS	100	True	26	84
					False	74	16
4	You come across an adult lying on the ground. Tap and shout, but he is unresponsive. What should you do next?	Shout for help. Phone or have someone else phone the emergency response number (or your local emergency number) and get an AED if one is available	IVR HS	100	True	19	72
					False	81	28
			Standardized HS	100	True	23	69
					False	77	31

Item No	Item description	Correct answer	Groups	n	Responses	Pretest n (%)	Posttest n (%)
5	How deep should you push the chest on an adult victim when giving chest compression?	At least 5 CM	IVR HS	100	True	22	86
					False	78	14
			Standardized HS	100	True	23	90
					False	77	10
6	When performing CPR, when should you switch positions and allow someone else to take over compression and breaths?	About every 2 minutes	IVR HS	100	True	19	79
					False	81	21
			Standardized HS	100	True	20	88
					False	80	12
7	How should you give breath with a mask?	Tilt the head and left of the chin, and press the mask against the	IVR HS	100	True	32	77
					False	68	23

Item No	Item description	Correct answer	Groups	n	Responses	Pretest n (%)	Posttest n (%)
		person’s face to mask an airtight seal	Standardized HS	100	True	27	84
					False	73	16
8	You are giving sets of 30 compressions and 2 breaths. Another person arrives with an AED. What should you do next?	Immediately use the AED	IVR HS	100	True	31	79
					False	69	21
			Standardized HS	100	True	37	81
					False	63	19
9	what should you do if a chocking adult stops responding	Start CPR	IVR HS	100	True	34	94
					False	66	6
			Standardized HS	100	True	20	82
					False	80	18

Item No	Item description	Correct answer	Groups	n	Responses	Pretest n (%)	Posttest n (%)
10	How much breathing should be delivered to an adult victim during high-quality CPR at the correct rate to increase survival?	Give 2 breaths, each breath in one second and keep one second between them, and see the visible chest rise when providing breaths at not exceed 10 seconds	IVR HS	100	True	22	79
					False	78	21
			Standardized HS	100	True	29	78
					False	71	22

n: sample for each group; %: percentage

Appendix O.2: Association between Age and Knowledge Pretest, knowledge Posttest, Satisfaction, and self-confidence for both groups. A Pearson correlation test was performed.

Group	**n**	**variable**		**Pretest of knowledge**	**Posttest of knowledge**	**satisfaction**	**Self-confidence**
IVR HS	100	Age	Pearson Correlation	-0.075	-0.078	0.202*	0.023
			Sig. (2-tailed)	0.461	0.441	0.044	0.818
			Mean±SD	2.79±2.01	8.40±1.01	4.36±0.61	4.17±0.56
Standardized HS	100	Age	Pearson Correlation	-0.185	0.175	0.086	0.55
			Sig. (2-tailed)	0.065	0.081	0.397	0.588
			Mean±SD	2.57±2.11	8.21±1.37	4.27±0.75	4.18±0.74

M: Mean; SD: Standard Deviation; n: sample for each group; p: significant at the 0.05 level

Appendix O.3: Association between Age and Performance for both groups. An independent t-test was performed.

Group	Dependent Variable		n	M	SD	T-value	df	P-value
IVR HS	**Performance**	**Pass**	85	20.04	1.31	-0.394	98	0.694
		Fail	15	20.20	1.74			
Standardized HS	**Performance**	**Pass**	60	20.15	1.29	0.973	98	0.333
		Fail	40	19.90	1.19			

M: Mean; SD: Standard Deviation; N: total sample; n: sample for each group; %: percentage; p: significant at the 0.05 level

Appendix O.4: Association between marital status and Pretest, Posttest, Performance, Satisfaction, and self-confidence for study groups. An independent t-test was performed.

Group	Dependent Variable	Marital Status	n	M	SD	T-value	df	P-value
IVR HS	**Pretest Knowledge**	**Single**	97	2.82	2.03	0.979	98	0.330
		Married	3	1.66	0.57			
	Posttest Knowledge	**Single**	97	8.46	0.93	3.818	98	0.001
		Married	3	6.33	1.52			
	Performance	**Single**	97	1.15	0.36	0.733	98	0.465
		Married	3	1.00	0.00			
	Satisfaction	**Single**	97	4.35	0.61	-0.859	98	0.393
		Married	3	4.66	0.57			
	Self-confidence	**Single**	97	4.17	0.57	0.0266	98	0.791
		Married	3	4.08	0.14			
		Single	98	2.55	2.07	-0.626	98	0.532

Standardized HS	**Pretest Knowledge**	**Married**	2	3.50	4.94			
	Posttest Knowledge	**Single**	98	8.20	1.36	-0.300	98	0.765
		Married	2	8.50	2.12			
	Performance	**Single**	98	1.39	0.49	-0.289	98	0.773
		Married	2	1.50	0.70			
	Satisfaction	**Single**	98	4.28	0.74	0.898	98	0.371
		Married	2	3.80	1.13			
	Self-confidence	**Single**	98	4.19	0.74	0.941	98	0.349
		Married	2	3.68	0.97			

M: Mean; SD: Standard Deviation; N: total sample; n: sample for each group; %: percentage; p: significant at the 0.05 level

Appendix O.5: Association between Gender and Pretest, Posttest, Performance, Satisfaction, and self-confidence for study groups. An independent t-test was performed.

Group	Dependent Variable	Marital Status	n	M	SD	T-value	df	P-value
IVR HS	**Pretest Knowledge**	**Male**	23	2.73	1.71	-0.137	98	0.891
		Female	77	2.80	2.10			
	Posttest Knowledge	**Male**	23	8.65	0.83	1.364	98	0.176
		Female	77	8.32	1.05			
	Performance	**Male**	23	1.13	0.34	-0.297	98	0.767
		Female	77	1.15	0.36			
	Satisfaction	**Male**	23	4.61	0.44	2.278	98	0.025
		Female	77	4.29	0.63			
	Self-confidence	**Male**	23	4.34	0.43	1.669	98	0.098
		Female	77	4.11	0.59			
		Male	20	2.55	1.60	-0.047	98	0.963

Standardized HS	**Pretest Knowledge**	**Female**	80	2.57	2.23			
	Posttest Knowledge	**Male**	20	8.50	1.10	1.057	98	0.293
		Female	80	8.13	1.42			
	Performance	**Male**	20	1.10	0.30	-3.184	98	0.002
		Female	80	1.47	0.50			
	Satisfaction	**Male**	20	4.31	0.66	0.238	98	0.812
		Female	80	4.26	0.77			
	Self-confidence	**Male**	20	4.20	0.67	0.175	98	0.862
		Female	80	4.17	0.76			

M: Mean; SD: Standard Deviation; N: total sample; n: sample for each group; %: percentage; p: significant at the 0.05 level

Appendix O.6: Association between educational year level and Pretest, Posttest, Performance, Satisfaction, and self-confidence for both groups. One-way ANOVA was performed.

Group	Dependent Variable	Educational year level	Df	F	P-value
IVR HS	**Pretest Knowledge**	Between Groups	3	2.626	0.055
	Posttest Knowledge	Between Groups	3	0.604	0.614
	Performance	Between Groups	3	0.893	0.448
	Satisfaction	Between Groups	3	1.723	0.167
	Self-confidence	Between Groups	3	1.213	0.309
Standardized HS	**Pretest Knowledge**	Between Groups	3	1.906	0.134
	Posttest Knowledge	Between Groups	3	1.539	0.209

	Performance	Between Groups	3	1.381	0.253
	Satisfaction	Between Groups	3	0.719	0.543
	Self-confidence	Between Groups	3	0.221	0.881

p: significant at the 0.05 level

Appendix O.7: The results of the Tukey- test determined the specific difference between the educational level and pretest of knowledge outcome.

Group	Dependent Variable			P-value	95% Confidence Interval	
					Lower Bound	Upper Bound
IVR HS	**Pretest Knowledge**	First Year	Second Year	0.035	-2.8330	-0.0747
			Third Year	0.860	-1.8346	0.9846
			Fourth Year	0.768	-2.0359	0.9359

p: significant at the 0.05 level

Appendix O.8: Association between Academic Achievements (GPA) and Pretest, Posttest, Performance, Satisfaction, and self-confidence for both groups. One-way ANOVA was performed.

Group	Dependent Variable	GPA	Df	F	P-value
IVR HS	**Pretest Knowledge**	Between Groups	2	4.147	0.019
	Posttest Knowledge	Between Groups	2	2.298	0.106
	Performance	Between Groups	2	5.172	0.007
	Satisfaction	Between Groups	2	1.698	0.189
	Self-confidence	Between Groups	2	0.962	0.386
Standardized HS	**Pretest Knowledge**	Between Groups	2	0.964	0.385
	Posttest Knowledge	Between Groups	2	0.986	0.377
	Performance	Between Groups	2	0.912	0.405
	Satisfaction	Between Groups	2	0.126	0.882
	Self-confidence	Between Groups	2	0.571	0.567

p: significant at the 0.05 level

Appendix O.9: The results of the Tukey test determined the specific difference between the academic achievements and the pretest of knowledge and performance outcomes.

Group	Dependent Variable			P-value	95% Confidence Interval	
					Lower Bound	Upper Bound
IVR HS	Pretest Knowledge	Excellent	Very Good	0.032	0.0925	2.6092
			Good	0.761	-1.0120	1.8654
	Performance	Excellent	Very Good	0.026	-0.4674	-0.0238
			Good	0.925	-0.2936	0.2136
		Good	Excellent	0.925	-0.2136	0.2936
			Very Good	0.038	-0.4024	-0.0088

p: significant at the 0.05 level

Appendix O.10: Association between specialties and Pretest, Posttest, Performance, Satisfaction, and self-confidence for both groups. One-way ANOVA was performed.

Group	Dependent Variable	Specialty	Df	F	P-value
IVR HS	**Pretest Knowledge**	Between Groups	3	2.151	0.099
	Posttest Knowledge	Between Groups	3	0.326	0.807
	Performance	Between Groups	3	0.349	0.790
	Satisfaction	Between Groups	3	0.815	0.489
	Self-confidence	Between Groups	3	0.597	0.619
Standardized HS	**Pretest Knowledge**	Between Groups	3	0.907	0.441
	Posttest Knowledge	Between Groups	3	1.813	0.150
	Performance	Between Groups	3	8.019	0.001
	Satisfaction	Between Groups	3	1.259	0.293
	Self-confidence	Between Groups	3	0.379	0.769

p: significant at the 0.05 level

Appendix O.11: The results of the Tukey test determined the specific difference between the specialty and performance outcome.

<table>
<tr><th rowspan="2">Group</th><th colspan="3" rowspan="2">Dependent Variable</th><th rowspan="2">P-value</th><th colspan="2">95% Confidence Interval</th></tr>
<tr><th>Lower Bound</th><th>Upper Bound</th></tr>
<tr><td rowspan="3">Standardized HS</td><td rowspan="3">Performance</td><td rowspan="3">Faculty of Art and Sport Sciences</td><td>Faculty of Admin&Financial Sciences</td><td>0.001</td><td>0.1483</td><td>0.7917</td></tr>
<tr><td>Faculty of Law and Science</td><td>0.003</td><td>0.1268</td><td>0.8018</td></tr>
<tr><td>Faculty of Engineering and Information Technology</td><td>0.001</td><td>0.2008</td><td>0.8376</td></tr>
</table>

p: significant at the 0.05 level

Appendix (P) Experts Participation

Letter Seeking to Validate IVR Tool

Dear AHA Experts,

I am a PhD student in Nursing Science at Arab American University. I would like to conduct a dissertation entitled " A comparison between Immersive Virtual Reality Heart Saver and the Standardized Heart Saver Training amongst Non-Health Science Students. ". The purpose of this study is to evaluate the differences between IVR heart-saver CPR training program compered to standardized HS program on non-health science students' Knowledge, performance, satisfaction, and self-confidence. Could you please assist and participate in this study beside me to assess the content, phase, and external validity related to the new immersive virtual reality program? Also, I would ask you that, don't hesitate to ask me any further questions related to this topic and look forward to hearing from you as soon as possible.

Mohammad Faisal AlAli

Sincerely

PhD Candidate in Nursing Science at Graduation Faculty /AAUP

Rammallah – Palestine

Appendix (Q): AHA Performance evaluation criteria

Adult CPR and AED skills testing checklist by assessing participants' performance in the following skills: scene safety; check responsiveness; activate the emergency by calling or sending another rescuer and bringing the AED; check breath; Adult compression.

Adult Compression:

- Hand placement on the lower half of breastbone,
- 30 compressions in less 15 and no more than 18 seconds,
- Compressing at least two inches (at least five cm)

Deliver Breathing to Adult:

- Each breath given over one second
- Visible chest rises with each breath
- Giving two breaths in less than 10 seconds

AED is available:

- Power on AED
- Follow prompts of AED when
- Correct attaches pads
- Says clear for analysis
- Says another clear word to deliver a shock safely
- Presses the button to deliver shock
- The student immediately resumes compression.

The scoring system includes pass or fail, whereas the student is considered a pass if all steps are performed and implemented successfully, especially in the significant point, and they are not doing the significant steps perfectly and not missing them or are not switching steps before the other one. These protocols and guidelines for this evaluation were determined based on the American Heart Association recommendation; otherwise, the student must receive a failure.

الملخص

الخلفية: إن ارتفاع معدل الإصابة بأزمات صحة القلب والأوعية الدموية يسلط الضوء على الحاجة إلى تدريب أكثر فعالية على الإنعاش القلبي الرئوي. تواجه أساليب التدريب على الإنعاش القلبي الرئوي التقليدية تحديات كبيرة في إمكانية الوصول والمشاركة والاحتفاظ بالمهارات. وتتفاقم القضايا الأخرى في مناطق مثل فلسطين مع وجود عوائق فريدة من نوعها. إن تقنية الواقع الافتراضي الغامرة الجديدة التي تم استخدامها مؤخرًا في تعلم الإنعاش القلبي الرئوي تظهر نتائج واعدة من خلال عمليات المحاكاة الواقعية من خلال السماح للمتعلمين بتجربة مجموعة متنوعة من المواقف التي قد لا يواجهونها بطريقة أخرى. يؤدي الواقع الافتراضي الغامر إلى مستويات أعلى من تحفيز الطلاب واهتمامهم ومشاركتهم وهو أمر ضروري لتعلم إجراءات الطوارئ المعقدة مثل الإنعاش القلبي الرئوي، كما أن المشاركة النشطة للمتعلم في عملية التدريب تعزز الاحتفاظ بالمعرفة واكتساب المهارات بدلاً من أساليب التعلم التقليدية. تتطلب هذه الفجوة مزيدًا من البحث لاستكشاف إمكانات الواقع الافتراضي الغامر لتعزيز المعرفة والمهارات وصنع القرار في حالات الإنعاش القلبي الرئوي الطارئة.

الهدف: مقارنة الفروقات في المعرفة والأداء والرضا والثقة بالنفس بين طلاب العلوم غير الصحية في الجامعة العربية الأمريكية في فلسطين بين مجموعة انعاش القلب والرئة باستخدام التدريب بالواقع الافتراضي الغامر ومجموعة انعاش القلب والرئة باستخدام التدريب التقليدي.

الطرق: استخدمت هذه الدراسة تصميم تجربة معشاة ذات شواهد لمقارنة الاختلافات بين التدريب على إنقاذ القلب بالواقع الافتراضي الغامر مع التدريب التقليدي الموحد على إنقاذ القلب بين طلاب العلوم غير الصحية

في الجامعة العربية الأمريكية في فلسطين. تم إجراؤها في الفترة من يوليو إلى ديسمبر 2023، مع التركيز على تعزيز المعرفة بالإنعاش القلبي الرئوي، وأداء المهارات، والثقة بالنفس، تم توزيع 200 مشارك بشكل عشوائي على محموعتين التدريب. تم إجراء تحليل البيانات باستخدام SPSS الإصدار 25، متضمنًا اختبارات مثل اختبارات t المستقلة، ومربع كاي، والقياسات المتكررة ANOVA .

النتائج: أظهر المشاركون تحسنًا كبيرًا من الاختبار القبلي إلى الاختبار البعدي، حيث حققت ارتفاع في المعرفه لكل من مجموعة انعاش القلب والرئة باستخدام الواقع الافتراضي الغامر من 2.79 ± 2.01 قبل الاختبار إلى 8.40 ± 1.01 بعد الاختبار ومجموعة انعاش القلب والرئة بالطريقة التقليدية من 2.57 ± 2.11 إلى 8.21 ± 1.37، ولكن لم يكن هناك فرق في معدل التحسن في المعرفه بين المجموعتين. الأداء (قيمة مربع كاي = 15.674، df = 1، p = 0.001) يوجد اختلاف بارز بين المجموعات التدريبية في الاداء.حيث أظهرت تقييمات الأداء نجاح 85% من المشاركين في نتدريب انعاش القلب والرئة بالواقع الافتراضي الغامر ، مقارنة بـ 60% في مجموعة انعاش القلب والرئة بالطريقة التقليدية . وكانت مستويات الرضا والثقة بالنفس مرتفعة بالمثل في كلتا طريقتي التدريب، مع وجود اختلافات طفيفة لا تشير إلى دلالة إحصائية. أظهرت المتغيرات الديموغرافية والأكاديمية تأثيرًا ضئيلًا على النتائج، على الرغم من أن المشاركين المنفردين في مجموعة الواقع الافتراضي الغامر أفادوا بمكاسب معرفية أعلى

الاستنتاج: أكدت الدراسة أن التدريب على إنقاذ القلب من خلال الواقع الافتراضي الغامر يحسن بشكل فعال معرفة الإنعاش القلبي الرئوي والأداء والرضا والثقة بالنفس بين طلاب العلوم غير الصحية، مقارنة بالطرق

التقليدية. أظهر برنامج الواقع الافتراضي الغامر لانعاش القلب والرئه ميزة طفيفة في تحسين الأداء، مما يؤكد إمكاناته كنهج تدريبي تكميلي أو بديل للإنعاش القلبي الرئوي. وهذا يؤكد على أهمية مواصلة استكشاف واعتماد الواقع الافتراضي الغامر في البيئات التعليمية لتعزيز الاستعداد لحالات الطوارئ. حاليًا، التدريب على النظام المنسق غائب عن مناهج طلاب العلوم غير الصحية، وتوصي الدراسة بدمج النظام تدريب الانعاش القلب الرئوي مع منهج العلوم غير الصحية لتزويد طلاب العلوم غير الصحية بالمعرفة والمهارات، مما يضمن أن الطلاب مستعدين علميا وعمليًا لتقديم مساهمات ذات معنى في سيناريوهات العالم الحقيقي لانعاش القلب الرئوي.

الكلمات المفتاحية: الواقع الافتراضي الغامر، الإنعاش القلبي الرئوي، طلاب العلوم غير الصحية، منقذو القلب، فلسطين