SERPENTSPHERE

VIRTUAL REALITY FOR IMMERSIVE TRAINING ON HANDLING AND IDENTIFYING VENOMOUS SNAKES

Balasuriya B L D C, Dhananjaya W A B P, Dilshan K A R

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Department of Information Technology

Sri Lanka Institute of Information Technology

Sri Lanka

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DECLARATION

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Name	Student ID	Signature
Balasuriya B L D C	IT21171024	
Dhananjaya W A B P	IT21164712	
Dilshan K. A. R.	IT21155598	

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The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

Signature of the supervisor:

(Mr. Ishara Gamage)

……………………………… Date:…………………………..

ABSTRACT

The public health problem of snakebite envenomation persists mainly in tropical areas especially Sri Lanka because venomous snakes often interact with human communities. The current methods for preventing and managing snakebites, which consist of theoretical instruction alongside static human body models and live snake handling prove insufficient because they lack accessibility and safety. The platform integrates three core components: tools and techniques for catching snakes, identification of venomous species and educate venom extraction procedures, and highlight the snake venom effects on humans and educate first aid. Each component is meticulously designed to equip users with practical skills, actionable knowledge, and confidence to respond effectively to real-world snake encounters.

The first component focuses on teaching users how to safely handle snakes using specialized tools such as tongs and hooks. Through interactive VR simulations, users can practice deploying these tools in a realistic environment, which is a dense forest. The second component addresses the persistent issue of snake misidentification by providing highly detailed 3D models of venomous snakes commonly found in Sri Lanka. These models highlight key identifying features such as head shape, scale patterns, and coloration, enabling users to distinguish between venomous and non-venomous species and this component also focuses on educating venom extraction procedures. The third component focuses on educating users about the physiological effects of snake venom on the human body. Visualizations of symptom progression equip users with the knowledge and skills needed to respond effectively to snakebite emergencies.

A systematic development process was used to create this platform through requirement gathering followed by feasibility analysis then system design and testing before implementation. The platform achieved excellent results during pilot testing and user evaluation phases since participants demonstrated high engagement and satisfaction together with improved learning outcomes. This advancement marks a major achievement for reducing snakebite hazards and advancing wildlife preservation efforts across Sri Lanka as well as international territories.

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The wildlife officers together with herpetologists and medical professionals and conservationists deserve special recognition for providing their domain expertise during requirement gathering activities. Their expertise in snake behaviors together with venom effects and treatment procedures proved essential for maintaining both accuracy and relevance of the platform. These experts teamed up to transform theoretical insights into useful solutions through their joint effort for delivering a system that fulfills practical requirements. The Young Zoology Association of Sri Lanka together with other wildlife researchers provided active feedback during testing and validation stages which we wish to acknowledge.

The research project exists because of the combined knowledge and support from numerous individuals and organizations. We express our heartfelt appreciation to all of them. The project exists today because of their efforts, and their support motivates us to develop innovative solutions that address social problems.

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1. INTRODUCTION

1.2 Background Literature

Snakebite envenomation functions as a major public health challenge because venomous snakes are abundant in tropical and subtropical geographic areas. The World Health Organization (WHO) declared snakebites as a neglected tropical disease whereas it emphasized both their worldwide significance and the pressing requirement for efficient response mechanisms [1]. Kasturiratne et al. report that annual snake bites number between 4.5–5.4 million people leading to between 81,000–138,000 fatalities in addition to numerous disabilities [3]. The dangerous situation of snakebites requires the immediate development of complete systems to reduce risk exposure. Sri Lanka stands as one of the nations which suffers most from snakebites because these incidents mainly take place in its rural zones where medical facilities remain scarce. The insufficient availability of healthcare facilities together with basic training for venomous snake identification and first aid treatment exists in these areas [6].

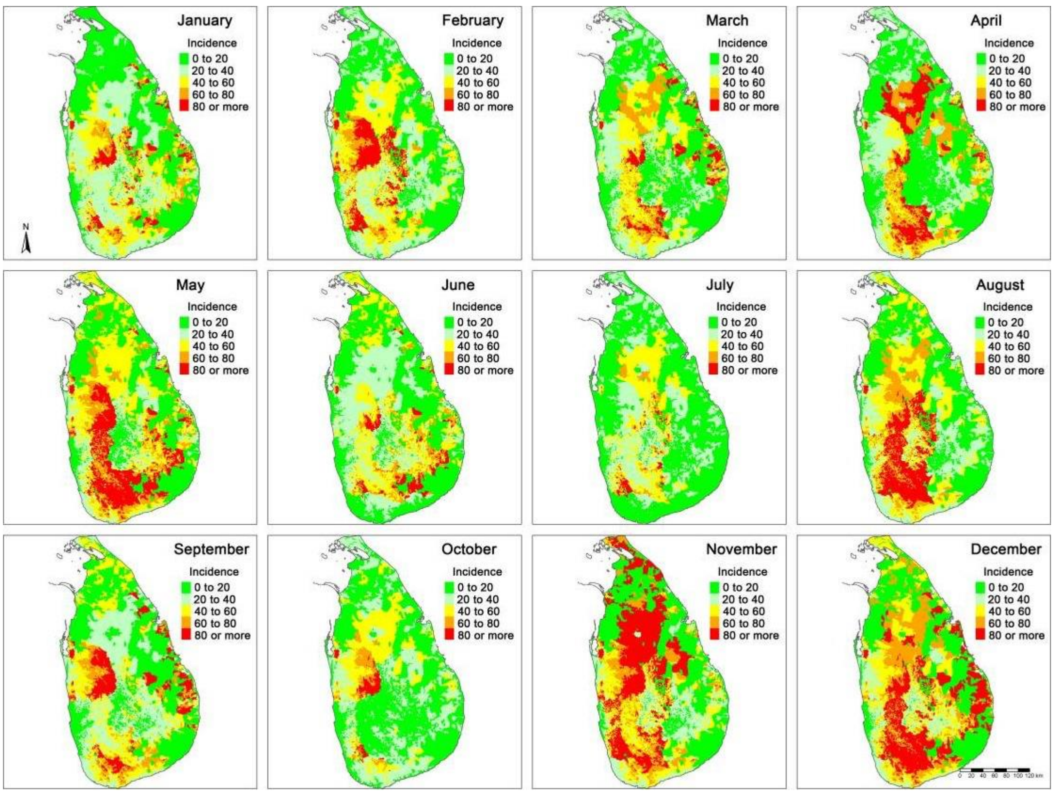

Figure 1 Geographical regions where snake bites occur in a year

Severe investigation of venom development procedures in snakes and other reptiles produced comprehensive understanding of biological envenomation processes [4]. Knowledge about these biological mechanisms serves as a prerequisite for developing useful therapy manuals as well as educational frameworks. According to Fry et al. venomous capabilities started developing early among lizards and snakes which shows that venom components differ widely between species [4]. Science-based knowledge enables precise anatomical modeling of snakes alongside their venom glands for use in the training simulations that this project develops. The platform allows researchers to better comprehend how venom affects the human body. The platform creates a detailed simulation which demonstrates symptom development while displaying human tissue interaction with venom compounds thus surpassing textbook knowledge and basic anatomical models.

The development of virtual reality technology throughout the last few years enabled researchers to create novel solutions against difficult training and educational problems. Virtual reality establishes virtual learning environments through which students can practice skills without encountering accompanying dangers [6]. The essential practice demands of wildlife management and medical training can be addressed by virtual reality technology when direct experience would otherwise be dangerous or challenging to implement. VR-based training according to Jones et al. and Wadhwani and Rajapakse leads to notable enhancements of procedural retention and learning especially in high-stress situations [10], [11]. VR provides simulated access to interactive 3D models of venomous snakes which enable users to train their skills of identification and handling practices in safe virtual environments. The training method provides both safety advantages and the possibility for learners to perform exercises multiple times until they have mastered the skills.

The main purpose of this research project centers on developing a virtual reality system which trains users through three essential modules that include venomous snake recognition and safe tool-based handling and the study of snake anatomy and venom properties. The different components of this research fill empty spaces that exist in prevailing training methods. The approach of standard field training to snake handling involves actual contact with live snakes which creates substantial dangers for trainees

[11]. Medical staff who need to treat snakebite victims find it difficult to receive practical snakebite patient handling training because such cases occur so infrequently under controlled situations [9]. VR technology serves as the backbone of this project to deliver training opportunities that combine threats-free environments with unlimited ability to scale and maintain high student engagement. Through its customizable structure the platform enables users to train their skills in particular competencies that involve learning venomous species recognition using morphological traits and tool expertise for snake capture handling.

Users receive training in the VR-based educational platform for handling venomous snakes with specialized tools and techniques which include tongs and hooks. Operating with venomous snakes stands as a dangerous task that demands both skilled execution and accredited education along with complete adherence to protective procedures [1]. Since ancient times snake-catching tools have evolved to separate human contact from snakes because they lower the risk of snakebites. The implementation of these tools requires proper training because misuse continues to generate accidents. Our VR platform provides extensive tutorials to teach users about selecting tools and learning how to handle them as well as execute their deployment. People learn to handle common tools by using virtual duplicates in interfaces that simulate practical environments [6]. The simulated practice scenarios teach participants the necessary procedures to work safely with snakes by maintaining distance and using hooks to move them and employing tongs to handle them successfully. Zahabi et al. explains that VR training system usability testing requires realistic and accurate tool behavior and user input responses [14]. The iterative development cycle collects end-user feedback that leads to the enhancement of virtual tool physics and functionality.

The second section of this platform combines venom extraction techniques with identification methods that evaluate snake features. The module provides users with the ability to effectively identify venomous snakes by studying their skin patterns with their scale arrangements and head shapes. A detailed 3D model presentation of venomous species exists within the system which enables users to inspect important anatomical structures including venom glands and fangs [2]. The platform contains a simulation feature for venom extraction tasks which allow users to practice their manual skills in virtual conditions. The research by Sun and Zhang shows how IoT-integrated VR systems can improve medical training particularly when precision motor skills are needed [9]. The training model provides users with theoretical knowledge alongside practical skills which are vital for handling venomous snakes.

The final educational component of the platform combines visualization of venom spread with chronological information to teach users about snake venom impact and delivers detailed emergency care instructions. Knowing how venom affects the body functions plays a vital role in providing efficient emergency care and treatment. The VR environment models actual venom spread in the bloodstream to show its effects on essential body organs including the nervous system and the circulatory and muscular systems [8]. Symptom progression through time becomes better understandable by users through interactive timelines which highlight the importance of fast medical response. Users through this simulation learn to see neurotoxin effects spreading into paralysis yet see differing results when exposing individuals to hemotoxin which results in organ failure through hemorrhage. The platform features dynamic elements which help students understand that fast medical care is vital while teaching proper first aid protocol execution [6]. The platform contains complete first aid modules which demonstrate users how to perform critical procedures step by step. Norman emphasizes user-centered design approaches because they produce interfaces which maximize learning results and user retention in application interactions [7].

This VR-based educational framework integrates multiple components into an integrated system which specifically addresses the specific difficulties related to snakebite management throughout Sri Lanka. The platform acquires its users through specific training regarding safe handling methods alongside precise species recognition capability and venom extraction processes and emergency response protocols which grants them practical abilities to deal with snakebite emergencies. The innovative system delivers dual benefits by protecting the public while aiming to protect wildlife through the development of venomous snake understanding [10].

Educationally the platform uses modular organization which lets students study topics they prefer without getting swamped by extra information. Gokhale supports collaborative learning methods because they develop critical thinking abilities which platform designers integrated into their system [8]. Users learn by solving real-life scenarios which contain situations that match the snake populations of specific geographic areas. The educational content includes Russell's vipers and spectacled cobras for participants in Sri Lanka yet Australian participants study taipans and brown snakes. The platform keeps its value because users can adapt it to fit different settings. Users gain insights about the critical importance of fast snakebite treatment when they view symptom progression through interactive timelines in the platform. These interface elements enhance the utility for medical trainees as well as clinical professionals to detect snake venom effects early so they can start appropriate emergency treatments.

The platform's design focuses on making it accessible to users. Virtual reality technology gives people worldwide access to advanced educational content through its ability to eliminate geographic barriers to learning [11]. The educational VR application framework developed by Winn highlights both immersion quality and user-friendly design elements which directed our system development process [17]. Through the platform Sri Lankan rural farmers can master snakebite prevention fundamentals and initial medical aid before medical personnel can access more complex venom physiology education along with sophisticated therapeutic approaches. The platform follows a stepwise structure which adapts to various user groups no matter what their educational level and background is.

The platform development process requires feedback integration as its essential component to achieve precision. Systematic evaluation of participant feedback taken during testing sessions leads to defined areas that need improvement. Additional case studies alongside real-life scenarios were proposed by certain users as a method to make the platform more applicable in particular geographic areas [6]. Experts in herpetology verified that the 3D snake models, and venom extraction simulations matched current research findings about snake biological and behavioral information [5]. Multiple physicians evaluated how venom affects the human body and treatment methods while ensuring the platform met established standards of medical emergency response. Through their comments the simulation became more realistic for actual medical environments through enhanced treatment and symptom development representations.

The group consisting of medical professionals and VR developers and educational designers worked together to verify correct venom impacts and standardized treatment protocols as well as symptom development details. The platform maintains ethical compliance and supports wildlife responsible practices through their essential contributions [12]. Simulation provides educational content about proper first-aid methods for snake victims which demonstrates the value of both fast response and correct technique. Wildlife professionals should implement contemporary training practices according to Bridgman and Jackson while this recommendation supports the target goals of this project [13]. The platform merges theoretical instruction with hands-on learning to prepare users for managing snakebite crises which lowers the mortality and morbidity statistics from poisonous snake bites.

The platform generates social advantages which reach accomplishments that surpass the benefits experienced by individual users. The project helps to fight human-wildlife conflict through its work in promoting snake conservation knowledge and methods for safe interaction with these animals. According to Cobb and Sharkey’s review of virtual reality programs for disability and rehabilitation [15] VR demonstrates its ability to change how people understand and relate to each other. This platform initiates respect for snakes and teaches users not to engage in harmful actions which match the principles of ethical wildlife management systems. The residents of Sri Lanka's rural areas mostly respond by seeking to eliminate snakes because they consider these reptiles as destructive elements instead of essential ecosystem contributors. The platform creates understanding by using interactive content that explains snake ecological functions which lead people away from destructive eradication practices towards cohabitation. The change in community thinking represents a necessary step to maintain lasting sustainability alongside community resilience.

The reviewed background documents demonstrate that snakebite prevention and management contain multiple complicated elements. Each element of the reviewed data starting from venom biology down to VR technical advancements contributes to our platform's development. This project fills critical training and educational voids while advancing snakebite prevention work to achieve better human-snake relationship and risk reduction. State-of-the-art VR and IoT systems accompany expert validation procedures to develop a platform that provides revolutionary educational experiences. This evidence demonstrates how interdisciplinary teamwork allows scientists to confront complex public health threats such as snakebite envenomation globally. The project achieves success through its ability to protect lives but also drives creativity that fuels future educational advancements and conservation initiatives.

1.2 Research Gap

Snakebite envenomation continues to affect public health worldwide with intensity in regions such as South Asia, Sub-Saharan Africa and Latin American parts. Research achievements in venom system biology together with treatment protocols and epidemiological data [1] have failed to bridge the deficit surrounding practical training tools which would enable personnel to safely and confidently address snakebite emergencies. The problem of snakebite incidents remains severe in Sri Lanka because its people lack awareness combined with substandard first-aid training and limited access to medical care [2].

The World Health Organization (WHO) considers snakebite envenomation one of the neglected tropical diseases which makes it essential to develop new solutions to tackle this health challenge [3]. Theoretical information about snake identification along with venom effects and first-aid measures can be found in academic literature and traditional training methods yet these resources do not allow practical experience within a safe environment. Academic resources including textbooks and lectures present essential data, yet they lack real-world simulation which makes students unready for high-pressure conditions [4]. The lack of flexibility in static anatomical display models diminishes their utility when instructors aim to demonstrate intricate techniques such as venom extraction together with proper snake handling [5].

Scientific studies about snakebite management concentrate their efforts on biological venom system understanding and they aim to create medical solutions for victims of envenomation. The research by Fry et al. provides extensive understanding of venom system evolution in lizards and snakes through their extensive investigation of species venom diversity [6]. The development of realistic three-dimensional models of snakes and venom glands depends on these types of studies because these models serve as key educational instruments. Research discoveries have not resulted in the development of executable training methods which provide users with practical capabilities.

Medical investigators have successfully developed improved antivenom processes and healthcare protocols as reported in [7]. The WHO has released guidelines which underline the necessity of prompt first-aid intervention coupled with suitable procedures to minimize snakebite-related deaths [8]. The improper delivery of first aid to snakebite victims continues to be a substantial problem that usually makes the situation worse for the victims [9]. A user-oriented platform should serve double functions: education regarding venomous effects together with simulated training for providing correct first aid assistance.

Virtual reality (VR) technology serves as a groundbreaking educational and training instrument which creates deeply involved encounters that connect theoretical knowledge to practical learning [10]. Freina and Ott in their studies proved that VR produces beneficial effects on cognitive learning results specifically when students need to develop procedural skills and make decisions in high-pressure situations [11]. The proven success of VR-based training for snakebite management has not been fully developed or studied. Chen et al. performed a comparative assessment of Unity3D and Unreal Engine in VR training applications which confirmed the potential of these platforms to build realistic simulations according to their research [12]. Their research did not specifically focus on wildlife safety education or snakebite management therefore generating room for new innovations in this domain.

The absence of advanced interactive training methods for snakebite management worsens the situation because venomous snakes commonly come into contact with people in Sri Lanka [13]. During traditional field training activities students encounter live snakes which create dangerous situations for all participants [14]. The training remains inaccessible to rural communities who suffer from snakebites since they inhabit areas near natural habitats [15]. The obstacles to scheduling live snake-handling workshops restrict their potential expansion thus requiring new methods for addressing this issue.

The educational field demands improved training methods for catching snakes together with identification systems that should be incorporated into existing curricula. Snake tongs and hooks that help reduce human-snake contact need exact handling procedures to avoid incidents according to [16]. Modern training initiatives generally exclude comprehensive classes about selecting and deploying tools and maintaining equipment for safeguarding human safety. Users who lack this information end up unable to protect themselves because the educational platforms do not include this training. Misidentification errors become fatal because there are no standardized guidelines for identifying venomous snakes [17].

Training systems today show inadequate understanding regarding how snake venom works inside the human body. Medical professionals attending snakebite victims need to grasp venom-specific interactions throughout their body to deliver proper medical care [18]. Computational models developed for venom effect simulation represent laboratory-based solutions that are currently unavailable to the public [19]. The combination of venom action visualizations with first-aid procedure instructions through a VR platform would substantially boost preparedness in vulnerable communities.

The present solutions prove inadequate for providing sufficient accessibility to their users. Several at-risk groups located in low-resource regions cannot use advanced educational resources because they either face financial barriers or technological impediments [22]. The user comfort and adaptability features outlined by Winn in his conceptual framework should provide the foundation for building inclusive training platforms [23].

Wildlife management and conservation practices should be observed with regard to their ethical considerations. The authors advocate for training methods which correspond with ethical wildlife management principles to establish peaceful coexistence instead of hostile encounters [26]. The existing methods dedicated to snake eradication neglect education about ecological importance of these animals in the environment [27]. Virtual reality technology through a platform which teaches non-injurious snake handling methods along with snake value appreciation will contribute powerfully to wildlife conservation acceptance.

The analyzed research gaps prove that society requires a groundbreaking yet practical solution which can scale up to handle snakebite management problems. Current approaches for training people in practical snakebite management lack both safety standards and convenient accessibility so users end up unprepared when experiencing real life situations. The proposed research creates a complete VR platform to provide users with necessary skills and confidence for snakebite emergency response using modern VR technology. The proposed VR system will solve current operational weaknesses thus enabling better public safety and wildlife conservation while delivering improved health benefits to snakebite envenomation regions.

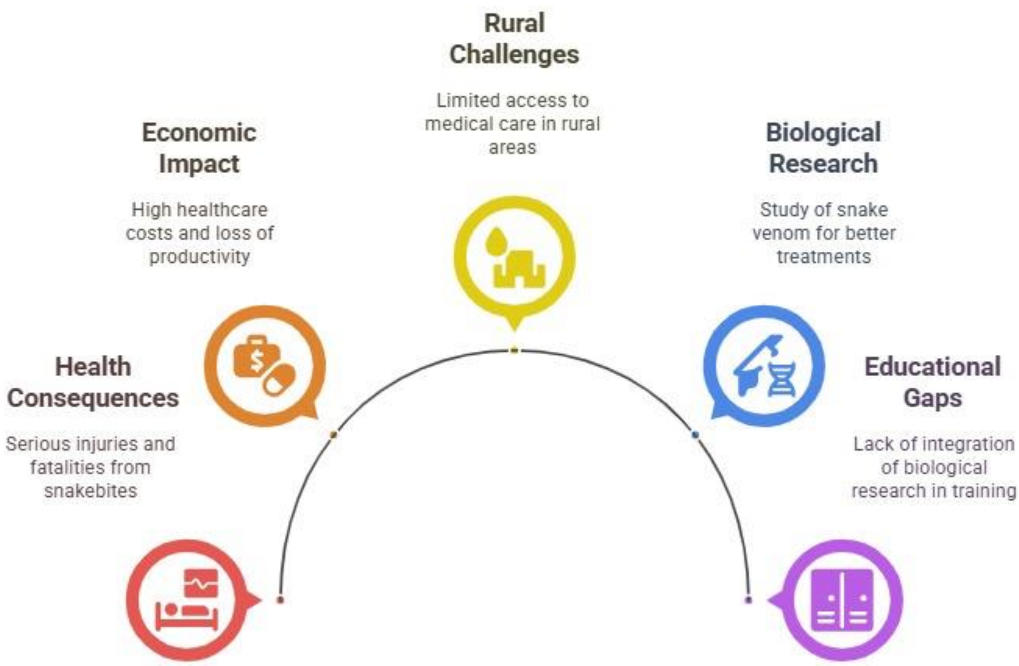

Figure 2 Gaps in the snake education

1.3. Research Problem

Snakebite envenomation functions as a major public health concern because it affects residents primarily within South Asian and Sub-Saharan African and Latin American tropical zones. Rural Sri Lanka faces dangerous snakebite threats frequently because areas inhabited by venomous snakes pose fatal risks to the residents [1]. Extensive research into venom biology and treatment approaches has failed to resolve the lack of effective training equipment that enables people to manage dangerous snakebites with safety and assurance. The deficit of proper guidelines alongside specialized equipment and collaborative training methods leaves users exposed to real-life emergencies because they lack preparedness.

Studies confirm that snakebite envenomation affects approximately 4.5–5.4 million individuals yearly based on statistics which show 81,000–138,000 fatalities and immense disability rates [3]. The World Health Organization recognizes snakebite as a neglected tropical disease because of its worldwide impact while calling for urgent new intervention strategies [2]. Research papers contain theoretical information on snake identification and first-aid procedures, but academic training resources lack practical exposure in safe conditions. Standard academic sources including textbooks and lectures provide essential knowledge, yet they lack simulation of real-world emergencies which leads students to inadequate stress management [4].

Research into snakebite management centers on discovering biological and evolutionary venom together with the creation of envenomation medical treatments. The research group Fry et al. dedicated their work to studying the initial development of venom systems in lizards and snakes therefore advancing our understanding of species-specific venom complexity [6]. These research findings enable scientists to create precise 3D models of snake structures including venom glands that serve as base components of educational resources. The discoveries have not been converted to practical training approaches which provide users with usable competencies.

Medical researchers have successfully advanced both antivenom production techniques and treatment procedures [7]. The WHO has issued guidelines which stress both rapid response and appropriate care procedures because they decrease mortality statistics [8]. The improper delivery of first aid to snakebite victims continues to represent an essential problem which leads to worsened conditions for victims [9]. A new system needs development which will serve two purposes: teaching users about venom effects as well as training in First Aid procedures through simulated environments.

Virtual reality (VR) technology now serves as an educational and training instrument that produces realistic simulations which connect theory with practice [10]. Frequent research by Freina and Ott confirms how VR enhances cognitive learning effectiveness among subjects who need to execute procedures while making critical choices during tight situations [11]. The established benefits of VR-based training methods for snakebite management have received limited attention from researchers. Chen et al. performed a comparison between Unity3D and Unreal Engine to evaluate their suitability for developing virtual reality training simulations according to their research [12]. Their research failed to focus on wildlife safety education along with snakebite management thereby creating potential opportunities in this domain.

The geographic area of Sri Lanka faces an increasing number of venomous snake encounters with humans because there exists no proper interactive training solution for snakebite management [13]. The practice of training participants with actual snakes exposes them to dangerous situations during field work [14]. Training opportunities remain out of reach for rural residents since they are most susceptible to snakebites through living near the wild [15]. The difficulties in managing workshops where participants handle live snakes limit what can be achieved by this method so alternative solutions must be developed.

The education landscape needs specialized tools and techniques for snake catching and identification to be included as part of their curriculum. The use of snake-tongs and hooks as contact-minimizing tools needs very careful handling to avoid mishaps according to [16]. Most training initiatives overlook essential guidelines about selecting and managing tools for snake catching which results in inadequate preparedness among trainees. The current training programs are insufficient because they do not provide users with proper tools for safe real-life snake interactions. Fatal outcomes result from misidentifying snakes because there are no standardized protocols to identify venomous snakes [17].

Another critical deficiency of present-day training emerges through the insufficient study of how snake venom causes bodily impacts. Snakebite victim treatment relies on medical staff who comprehend the mechanisms of different venoms affecting the human body for successful medical intervention [18]. The development of computational models for venom effect simulation has progressed but these laboratory-based tools remain unavailable to the public [19]. The development of a VR platform which presents venom visuals and first-aid instructions jointly has great promise to boost readiness levels among vulnerable groups.

The existing solutions do not provide sufficient accessibility for users as a main priority. For at-risk populations in situations with limited resources the expense of advanced educational tools along with technical obstacles prevent them from obtaining these resources [22]. Winn's conceptual framework promotes virtual reality applications through principles of comfort and adaptability which should direct all future development of training platforms [23]. The accessibility of snakebite management training through VR could increase when it adds features including multilingual capabilities and adjustable difficulty attributes together with offline functionality.

Wildlife ecosystem management together with conservation practices require ethical scrutiny. The authors Bridgman and Jackson advocate for training methods to use responsible wildlife practices which create coexistence between humans and wildlife rather than conflict [26]. The current mechanisms directed at snake removal from the environment fail to teach people about the ecological worth of snakes [27]. A digital platform framework utilizing VR methods to teach non-harmful snake manipulation techniques along with snake respect education would be instrumental in building public wildlife conservation support.

The gaps in research show that an advanced practical and accessible solution is required to overcome problems with snakebite management. The existing methods do not provide practical hands-on training through safe accessible formats, so users remain unready for actual encounters. The training programs suffer from lack of standard guidelines as well as specialized tools together with insufficient collaborative learning opportunities which restrict their effectiveness. This study invests in VR technology development to create a complete system which trains users properly to react competently to snakebite emergencies. The proposed virtual reality system should resolve these current limitations to achieve better public safety and wildlife protection alongside better patient healthcare in snakebite envenomation areas.

The proposed virtual reality system tackles problems which include:

- **Lack of Practical Training:** Theoretical herpetology research and live snake training present significant difficulties because they both involve real threats to users [28]. A safe educational resource based on VR presents an effective solution which meets the distinct requirements of Sri Lankan training needs.
- **Inadequate First-Aid Measures**: The improper administration of first aid by untrained individuals worsens the state of snakebite patients according to research [29]. The platform teaches at-risk communities essential first-aid methods through its guided procedures that boost their readiness skills.
- **Limited Accessibility: Multiple** at-risk populations from low-resource areas cannot obtain modern learning resources because of financial barriers or technological restrictions [30].
- **Ethical Wildlife Management:** The present ethical wildlife management strategies emphasize snake extermination instead of showing communities how important these animals are in their environment [26]. The platform teaches non-lethal handling methods to raise awareness about snake value in addition to promoting peaceful cohabitation.

- **Lack of Understanding About Snake Venom Effects on the Humans:** People have limited knowledge about how snake venom interacts with human tissue since the human body responds through neurotoxic and hemotoxic and cytotoxic mechanisms [4]. People's insufficient knowledge about these effects causes them to receive delayed healthcare while their conditions become more severe. Virtual reality users learn to spot medical urgency through 3D interactive models and simulations which show venom effects on human body systems.
- **Inability to Identify Venomous Snakes:** Snake identification errors continue to be an ongoing issue which produces improper handling situations and the killing of snakes as well as hindering prompt medical care [17]. Users of the VR platform obtain highly detailed 3D models of venomous snakes and non-venomous snakes which enable them to learn how to distinguish these species through their physical features.

The VR platform addresses specific problems to present a unique solution to urgent situations which enhances public safety and conservation work in Sri Lanka as well other national settings.

1.4. Research Objectives

This research project sets its main goal to establish and verify an all-encompassing Virtual Reality (VR)-based training system which optimizes snakebite prevention readiness while decreasing fatality rates alongside establishing peaceful cohabitation between humans and snakes in Sri Lanka. The platform brings together multiple modern technological components like interactive 3D modeling alongside immersive simulations and AI-driven education along with hybrid IoT integration to produce an entirely new educational experience. The proposed system fills the vital training method gaps to deliver users practical skills and responsible knowledge and safety expertise for managing real-world snake incidents.

Main Objective: Development of an Immersive VR Platform for Snakebite Management

The central purpose of this research involves developing an integrated VR application which unites tools for catching snakes with venomous species identification and snake anatomical understanding plus venom treatment and self-administration first aid knowledge. Through this platform the project tackles snakebite envenomation yet encourages ethical wildlife handling and conservation goals. The use of VR technology delivers a protected and engaging training system which enables users to handle snakebite situations effectively along with protecting ecological resources.

Specific Objectives: Bridging the Gap Between Theory and Practice

The main objective requires the implementation of the following specific objectives. Several well-defined goals aim to tackle individual elements of the comprehensive project which integrates snakebite control and education methods.

Tools and Techniques for Catching Snakes

Snakebite prevention demands proper training for individuals who need to grasp safe snake handling techniques that avoid risking their health and safety as well as animal safety. The practice of exposing trainees to live snakes in traditional methods proves dangerous to their safety because direct contact with these animals presents substantial risks [16]. The first segment of this project works to develop authentic virtual representations of snake-catching equipment and procedures inside VR.

- The first VR development objective aims to establish interactive educational content for proper utilization of snake tongs and hooks by trainees. The training modules deliver thorough instructions about tools as well as deployment methods with maintenance procedures to provide risk-free practical learning [24].

- The system will present realistic forest simulations that enable users to practice tool deployment skills in virtual environments.
- The implementation of dynamic snake behaviors alongside unpredictable movements in the simulation will boost its realistic elements which prepare users for various field conditions [28].

The project component focuses on meeting two objectives to lower snake-human conflicts and reduce unintended human bites when people attempt to catch these creatures.

Identification of Venomous Snakes and Venom extraction procedures

Snake misidentification stands as a determining factor behind snakebite incidents because people tend to handle them incorrectly or delay treatment [17]. The second part of the project uses VR techniques to develop an identification education system which assists users in recognizing venomous species from non-venomous species based on their morphological features.

- Develop interactive 3D models of snake anatomy, with a particular focus on venom glands, fangs, and delivery systems. The system provides interactive interfaces for users to study venom-producing structures as well as venom delivery mechanisms in detail [5].
- The VR platform requires the development of a realistic environment for venom extraction so users can perform practical simulation of extraction procedures. The simulation duplicates actual interaction sequences to enable users to execute the extraction process with IoT-integrated instruments in a secure accurate manner [9].

This project creates objectives to teach users how to make better decisions about snakes which in turn lowers predatory actions against snakes while enhancing overall safety measures.

Visualization of Effects of Snake venom on humans

Knowledge about how snake venom affects the human body functions remains vital when it comes to both stopping and treating snake envenomation cases. The present training methods fail to deliver practical understanding of venom effects inside human bodies to student trainees. The third project component develops virtual reality systems that provide first-aid simulation through venom delivery mechanism models.

- The development of an advanced 3D human body representation stands as objective 3.1 for visualizing snake venom impact on human physiology. Users can observe venom movement across the bloodstream because it causes tissue destruction as well as paralysis and organ breakdown. The design shows how venom reacts with heart organs and lungs and nervous system through realistic time-based simulations [4].
- The system will include timeline features which illustrate venom progression throughout human body systems. The system includes visual timelines that display typical symptoms which show cytotoxin-induced tissue necrosis and hemotoxin-caused internal bleeding and neurotoxin-triggered paralysis. By implementing this feature users become aware of both the critical nature of snakebite treatment as well as the complicated nature of snake envenomation [11].
- Develop educational modules on first aid and medical treatment for snake bites. A set of sequential instructions regarding first aid procedures will be delivered through the modules. The platform will consist of extended information about recovery and long-term effects which will strengthen readiness during snakebite emergency situations [9].

The established objectives serve to teach users fundamental skills so they can respond competently to snakebite incidents which produce both lifesaving outcomes and improved disability prevention.

Promoting Ethical Wildlife Practices and Conservation Awareness

This VR system provides more than functional snakebite treatment capabilities since it functions as an educational tool for wildlife ethics and conservation knowledge dissemination. Snake handling practices today mainly focus on extermination rather than learning which sustains community-wide misconceptions and fear [27].

The educational interactive modules within the system will deliver content about how snakes manage rodent populations and protect against disease spread [26].

The project will team up with government agencies along with NGOs and educational institutions to establish the integration of the VR platform within outreach activities for schools and wildlife conservation centers and local communities [29].

The project objectives demonstrate both its purpose of changing public snake perception and its role in supporting wildlife conservation goals.

The research objectives demonstrate an organized method to handle the complex issues which affect snakebite management practices. The proposed immersive VR system includes tools with catching methods alongside venomous species identification along with snake anatomical and venom effect learning to modernize conventional training approaches. The project creators carefully structured each objective to connect technical shortcomings while implementing modern technology platforms together with eco-friendly wildlife methods.

The successful achievement of these established objectives will lead to safer communities while cutting down fatal snake attacks yet simultaneously cultivating appreciation for snakes. The initiative marks a major advance in both risk reduction for snakebite accidents and wildlife conservation progress across Sri Lanka along with global regions.

2. METHODOLOGY

2.1 Methodology

The development of the VR-based educational platform uses a phased structured structure that applies agile development principles. The platform implements modern technology elements that include immersive systems along with detailed 3D anatomical designs and IoT technologies and AI components to build virtual practices that let venom extraction training happen without risk. The development process stages follow a detailed planning system that guarantees alignment between user requirements and technical standards and educational needs. The following section provides an exhaustive explanation of the research procedures.

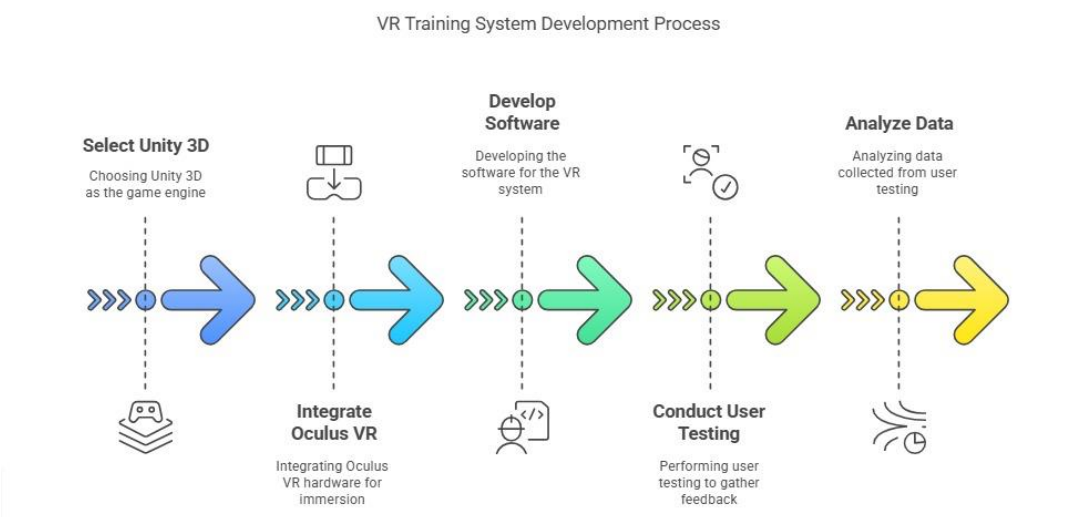

Figure 3 System Development Process

The development of the VR platform needed proper identification of main stakeholders who would provide essential guidance for the project's path. The primary stakeholders included:

Medical Professionals: Medical Professionals served as experts who validated the precise depiction of venom impacts as well as treatment strategies and symptom development. The platform incorporated their scientific expertise to use best practices and standards for treating snakebites [12]. Medical personnel checked how the provided information on venom effects and treatment methods matched current best practices in snakebite management [5].

Herpetologists: Herpetologists from the wildlife field checked both 3D snake models' anatomical accuracy as well as the proper functioning of training simulations. The experts played an essential role in validating the system, fulfilling realistic benchmarks which combined safety measures with educational standards [13]. Through their expertise herpetologists verified that the virtual snake behaviors along with venom characteristics were realistic and helped improve both 3D snake models and their accuracy [5].

VR Developers: Specialists from VR fields verified both the technical possibilities and user experience of the platform. The development team used their specialized knowledge to merge VR components with programming software while working on interactive system optimization [6]. The platform received updates from VR developers who resolved processing speed problems along with interface response times [9].

End Users: The platform development included trainees from wildlife conservation, emergency response and medical student roles who participated in multiple stages of platform refinement to provide real-time feedback [10] [11]. The users who experienced the system directly helped identify user experience issues before giving recommendations to boost interactivity and rendering quality [9].

Educational Designers: Educational designers as experts used their knowledge in instructional design and educational technology to organize content effectively so the platform could deliver maximum learning benefits while sustaining student engagement [8].

Identifying stakeholders proved essential since it helped establish the project boundaries by understanding the unique needs of its intended audience. The authenticity of snake movements and toxicity in the game was confirmed by herpetologists whereas medical experts evaluated medical protocols and first-aid procedures [5]. Users at the end of the system provided feedback about operational problems and recommended ways to boost system interaction and authenticity [9].

Functional Requirements

The VR-based educational platform created its functional requirements using research aims together with stakeholder input. The requirements are divided into three sections with Safe Handling Techniques representing one part while Snake Identification and venom extraction stands next to Effects of Snake Bites on the Human Body. The detailed functional specifications follow for every component below.

1. **Safe Handling Techniques Module**

The goal is to demonstrate to users how to handle snakes with specific equipment and techniques and how to perform venom extraction safely.

Features:

- The module provides a stepwise method to demonstrate how users should select and handle equipment and deploy snake-taking tools like hooks and tongs with bags.
- Digital Replications of Regular Tools Feature Photorealistic 3D versions of snake-taking equipment which operate using physical rules identical to live tools.
- The program features a precisely recreated dense forest environment that builds user proficiency in natural snake encounters.

Technologies:

- The 3D modeling and animation functions of Unity Game Engine enable users to build virtual immersive environments which help them practice effectively [11].
- The software platform Blender serves to create precise anatomical models of Sri Lankan native venomous snakes for scientific authenticity [12].

2. Snake Identification and venom extraction module

The system aims to provide users with the capability to correctly recognize venomous snakes through their physical attributes.

Features:

- The application contains interactive 3D model collections of venomous snakes that display their color patterns and scale arrangements and head shapes and behavioral signals to enable accurate species differentiation.
- A portion of the educational content features snake anatomy instruction which highlights venom glands along with fangs and additional significant body structures to advance user knowledge about snake biology [2].
- Venom Extraction Simulation: The system includes a specialized simulation platform for venom extraction practice which provides users with a safe and controlled virtual workspace. The system provides sequential instructions about precise venom extraction approaches together with safety protocols.

Technologies:

- A multiplayer gameplay engine named Unity Game Engine enables developers to generate lifelike immersive environments [11].
- The program Blender produces precise biological accurate anatomical models of Sri Lankan venomous snakes [12].
- The AI recognition system assesses individual user submissions through algorithms that adjust feedback while adapting to each learner's specific progression and manner of education [7].
- Internet of Things sensors monitor user movements because they deliver real-time instructions that promote accurate and secure handling methods.

3. Effects of Snake Bites on the Human Body Module

Users need to gain a thorough understanding about how snake venom affects the human body based on its physiological nature through symptom development and proper first-aid protocols.

Features:

- A precise 3D Model of the Human Body displays snake venom effects on heart organs and lungs and the nervous system at their most detailed level [4].
- The system uses interactive timelines which display venom progression within the human body while showing symptom developments together with organ damage. Through this model users can monitor how venom progresses through blood circulation while it affects various body systems throughout time [6].
- The platform includes First Aid and Medical Treatment Modules which contain detailed procedures for first aid response with medical treatment seeking instructions.
- Short and long-term repercussions as well as healing period information helps individuals prepare better for dealing with snakebite medical situations [3].
- The simulation allows users to view venom reaction dynamics as it affects body tissues and internal structures by causing necrosis of tissue cells through cytotoxins and hemotoxin-induced blood loss and neurotoxin-induced muscle paralysis [4].

Technologies:

- Blender serves for developing precise three-dimensional models of human organs and systems that maintain correct anatomical representation [12].
- The developers from Unity3D designed realistic interactive venom-tissue simulation through their dynamic system modeling [11].

Non-Functional Requirements

The platform required the definition of non-functional requirements for usability alongside security along with reliability and scalability. The requirements stem from Norman's user-centered design principles and Winn's conceptual framework for VR educational applications as described in [7] and [17]. Key non-functional requirements include:

1. **Usability:**

Users must find the system interface approach both intuitive and easy to navigate because it provides quick access to training modules together with simulations.

2. **Security:**

The system needs to securely store all user data about performance metrics and progress records which authorized personnel must access through authorized means.

The system maintains compliance with privacy and confidentiality rules in data protection regulations.

3. **Reliability:**

Users must be able to access training resources throughout all operational hours because the system needs to maintain high reliability and minimal downtime.

The system needs regular maintenance for solving technical problems and performance optimization.

4. **Scalability:**

The platform needs to offer support for multiple users connecting at once while serving users from different geographical areas who use different languages.

The system uses modular design that creates space for added features during future development periods.

Protection of target audience expectations depended on implementing non-functional requirements within the platform. User testing found that participants liked menus that were easy to understand and received simple visual directions [7].

Feasibility Study

A thorough feasibility investigation determined the potential success of the proposed VR educational technology. The analysis evaluated the six critical areas of Technical Feasibility along with Market Feasibility and Financial Feasibility as well as Operational Feasibility and Environmental/Ethical Feasibility and Scheduling Feasibility.

Technical Feasibility:

- The assessment focused on analyzing suitable software and hardware systems which can work for the upcoming project.
- The analysis evaluated how hardware systems handle technical needs to display complex three-dimensional models as well as interact with them realistically.
- IoT devices unite with AI systems to improve both the realism and connected interactions of the system.

Market Feasibility:

- Analysis of the demand for snakebite management training in Sri Lanka and other affected regions.
- The feasibility study will uncover medical professionals and wildlife conservationists and trainees as target users.
- Research involving the market gives insights into active training approaches and unaddressed solutions gaps.

Financial Feasibility:

- The team will estimate costs related to hardware acquisitions and software creation in addition to service maintenance.
- The proposed budget covers the costs for stakeholder consultations alongside usability testing and cyclic improvement processes.
- The assessment includes research for funding sources together with grant possibilities and the development of institutional educational partnerships.

Operational Feasibility:

- The platform requires testing to identify obstacles which might appear during the deployment process throughout various geographical regions.
- The project requires end-user training materials alongside support systems that will help users adopt the system.

Environmental/Ethical Feasibility:

- The platform needs to promote both ethical wildlife standards and respect for animal welfare while operating.
- The platform will include educational modules about wildlife protection as part of its educational content to teach correct behaviors.
- End-users must verify content accuracy with domain specialists in order to prevent passing false information.

Scheduling Feasibility:

- Each development period receives specific time planning that encompasses design work and prototyping steps while also adding testing along with deployment tasks.
- The project tracks its milestones to guarantee deadlines for delivering all necessary work products.
- The project teams established different risk management techniques which would help prevent delays from unexpected obstacles.

System Designs

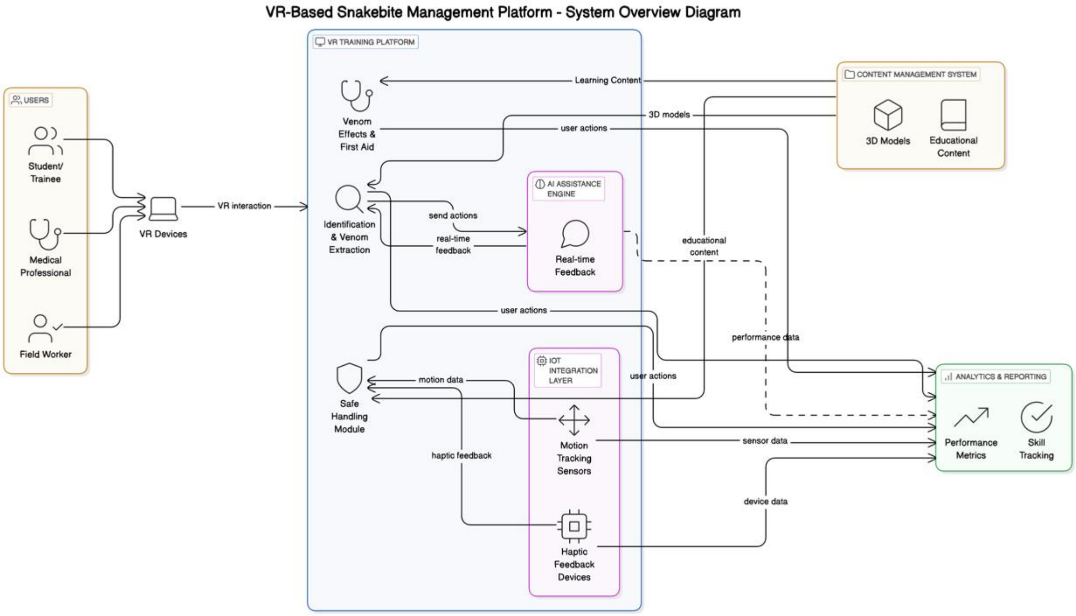

Figure 4 System Overview Diagram

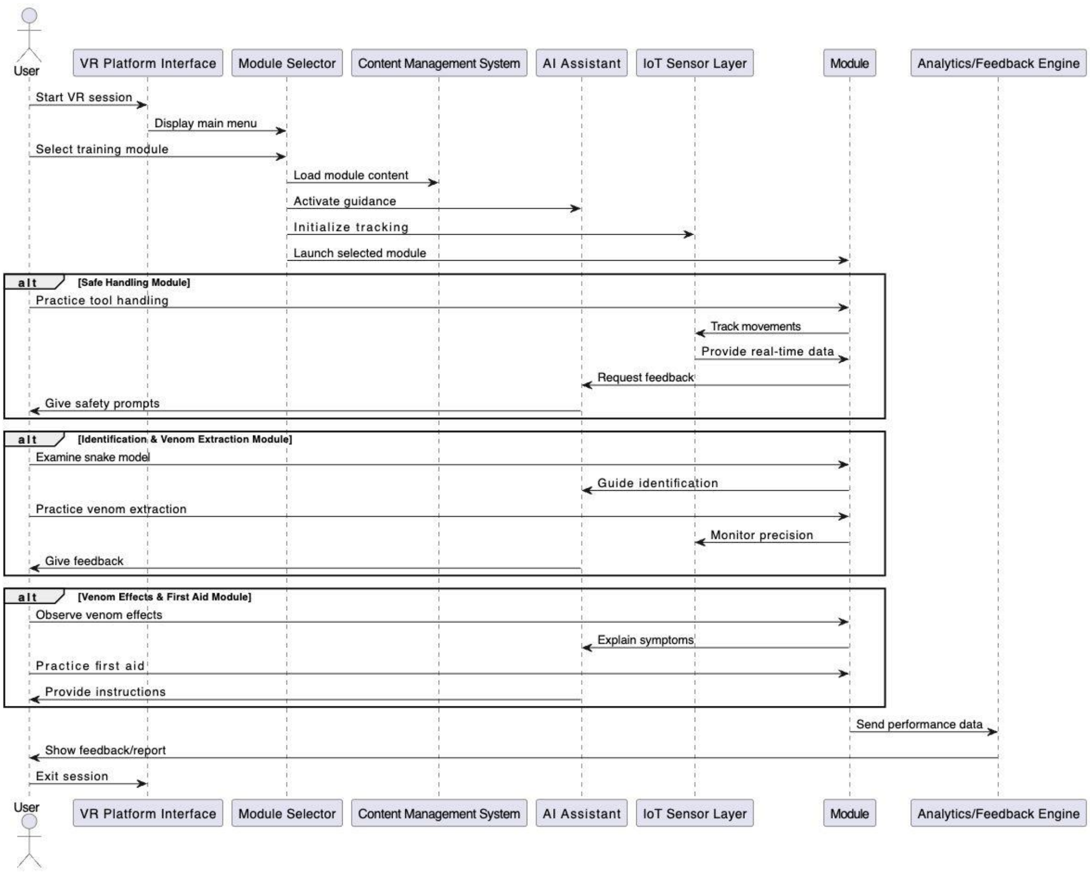

Figure 5 Sequence Diagram

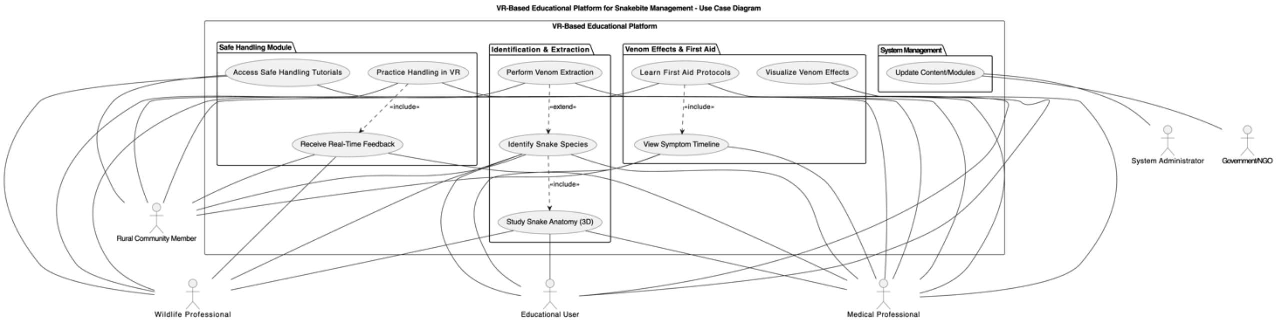

Figure 6 Use case Diagram

Development professionals utilized the system design phase to design detailed diagrams of the platform structure together with requirements specifications and prototypical visual depictions. Key design components include:

User Interface Design:

- The platform features intuitive menus along with navigation systems which enable users to go between pages without special VR expertise [8].
- Interactive 3D Models with Layered Visualization: Users can interact with detailed 3D models of snakes and human anatomy, allowing them to "see through" layers of skin, muscle, and organs to observe the effects of venom in real-time. The added feature provides students with enhanced knowledge about how snakebites affect the body and how venom moves through tissue during a bite [4].
- The VR environment features authentic forest environment design through realistic textural elements as well as vivid color schemes to provide realistic immersion. The simulated natural habitats which these design elements provide allow students to better learn and practice their skills [9].

Simulation Environment:

- Simulation technology provides accurate terrain representation for natural habitat environments.
- The platform presents randomized situations to stop learners from memorizing information while teaching adaptive learning skills.

- The safety distance system teaches users the correct methods to position their vehicles.

Performance Metrics:

- Measures of time consumption will be combined with data about mistakes and achievement metrics through quantitative data collection methods.
- The system features performance-based feedback mechanisms which trigger automatic updates for enhancing user training effectiveness.

The system received detailed designs which confirmed technical standards as well as educational goals were met. The training sessions benefited significantly from using an environment which simulated real operational parameters according to research [9]. Users received performance-based metrics which helped them understand both their powerful points and weak areas for development [14].

Prototyping and Iterative Development

The validation process through prototyping became essential to prove the platform design together with its functionality. The project development cycle adopted an iterative methodology that received regular input from stakeholders during every development phase. The prototyping phase consists of these important sequential actions:

Initial Prototypes:

- The production of basic user interaction visualizations occurred through wireframes and storyboards which generated low-fidelity mockups.
- Testing of 3D models and animations occurred through the development of high-fidelity prototypes built with Unity and Blender.

User Testing:

- The end-user tested prototypes demonstrated their experience of understanding product navigation as well as instructional sections and their satisfaction levels.

Iterative Refinement:

- Continuous refinement of 3D models, VR interactions, and AI-driven feedback systems.
- The system integrates user-submitted recommendations to make its interactivity stronger while improving both realistic appearance and educational benefits.
- The team works alongside domain experts to confirm correct information along with practice-based standards.

The platform received constant development through prototyping methods which helped maintain user's needs and expectations. The early project models displayed navigation and interaction problems that researchers solved by conducting additional development cycles [7].

Technology Stack

An educational platform based on Virtual Reality technology uses contemporary technical elements to provide users with immersive learning that proves effective. Key technologies include:

Virtual Reality (VR):

- Hardware: Oculus Quest 2 headsets for compatibility across platforms.
- Software: The program utilizes Blender for 3D modeling functions and Unity Game Engine executes animation and simulation processes [11].
- Interaction: Hand controllers and motion tracking systems for realistic interactions.

3D Modeling and Animation:

- Tools: Detailed anatomical modeling and texturing occurs using Blender software platform [12].
- Processes: Multiple modeling and animation rounds have allowed researchers to generate photorealistic results throughout their work.

Each selected technological component in the stack served a dual purpose to guarantee adherence to functional needs and non-functional specifications.

Content Development

The project team based educational content development on proven instructional design principles. Content development obliges the following key obligations:

Scenario-Based Learning:

- The software utilizes relevant scenarios specifically made for regions which house different snake species.
- Real-life illustrations combined with case studies serve to improve both practicality and usefulness of the materials.

Guided Learning Modules:

- The program provides detailed procedures on venomous snake recognition alongside first aid procedures and treatment initiation methods.
- Timelines integrated within the training show symptom development patterns alongside critical timeline milestones.

The development of content material took place through a joint working relationship between medical staff and herpetologists and educational designers. The accuracy of 3D snake models benefited from herpetologists while medical professionals conducted assessments of treatment protocols as well as first-aid procedures [5]. Educational designers arranged the platform content for maximum learning efficiency by integrating motivational game mechanics into the design [8].

Validation by Domain Experts

The platform received expert validation and approval from subject matter experts who actively participated during development stages. Key validation activities include:

Herpetologists:

- The herpetologists verified the accurate representation of 3D snake models and their anatomical details.
- Verification of venom extraction procedures and tool usage.

Medical Professionals:

- Validation of venom effects, treatment protocols, and symptom progression.
- Confirmation of first-aid measures and emergency response procedures.

VR Developers:

- Assessment of VR interactions, haptic feedback, and overall system performance.
- Technical developers should optimize rendering techniques together with frame rates to achieve high performance in gameplay.

Educational Designers:

- Evaluation of instructional clarity, engagement, and alignment with learning objectives.
- The development team should provide guidance for enhancing gamification aspects and feedback systems.

The evaluation process by scientific experts confirmed that the platform met all necessary standards of scientific quality and best practice guidelines. Forstance herpetologists verified accurate snake behavior models and toxicology effects whereas medical experts validated the treatment procedures and emergency protocols [5]. Educational designers tested user experience through usability assessments while giving advice about the interactive features which required updates to boost engagement levels [7].

User-Centered Design Principles

The development process integrated user-centered design principles which helped developers build a platform that fulfilled all requirements of the intended user base. Key principles include:

Intuitive Navigation:

- The platform uses clear menu structures combined with simple workflows to decrease mental strain.
- Consistent design patterns across modules for familiarity.

Adaptive Learning Pathways:

- The designed modules let users concentrate on essential content without becoming consumed by information overload.

Engagement and Motivation:

- Immersive Learning Environment:
- Interactive and Hands-On Learning:
- Self-Paced Learning for Confidence Building

Utility testing assembled user-centered design principles which made the platform easy to use while providing an effective interface for everyone. Intuitive menus together with visual guides made the system more user-friendly and hands-on learning activities created higher motivation levels among users.

Testing and Quality Assurance

Testing along with quality assurance procedures were deployed to validate both the system's dependability and educational importance and usability standards. Key testing activities include:

Unit Testing:

- Isolation and testing of individual components (e.g., 3D models, VR interactions).

Integration Testing:

- The testing process included the evaluation of connected modules to verify proper integration between components.
- The platform undergoes testing of complex situations which combine various system components.

User Acceptance Testing (UAT):

- End-users will test the platform to determine its educational effects and interactive features along with usability elements.
- Collection of qualitative and quantitative feedback for iterative refinement.

Performance Testing:

- The evaluation process included measurements of system responsiveness as well as frame rates and resource utilization assessment.
- The assessment subject involves stress testing which demonstrates reliability and scalability as the system handles increased workload.

Security Testing:

- Assessment of data protection measures and compliance with privacy regulations.
- The system undergoes penetration testing to detect and fix security weaknesses.

The platform received its approval through testing sessions that validated its functional abilities and non-functional elements. The platform tested successfully for performance by reaching 500 concurrent users without experiencing any degradation in response time according to [11]. An evaluation of system security discovered vulnerable areas which were resolved through implementation of encryption protocols together with access control systems [12].

Limitations and Challenges

Multiple obstacles and difficulties appeared during the development process of the VR-based educational platform despite several strong points. Key challenges include:

Technical Limitations:

- The system demands powerful computing power to show complex 3D models alongside realistic simulated actions.
- A drawback includes compatibility issues that may occur between older VR devices and technical systems.

Resource Constraints:

- Limited availability of domain experts and VR developers.
- The budget limitations had negative effects on both hardware acquisitions and software creation throughout the project.

User Adoption Challenges:

- Many users resist accepting new technological advancements mainly because they are either older individuals or not familiar with technology.
- Users require thorough orientation sessions to learn about using VR interfaces together with their proprietary interactions.

Ethical Considerations:

- The implementation of the system needs correct snake body depiction alongside correct venom extraction procedures to prevent misguiding users.
- The system will support wildlife practices that are ethical while working against actions which cause harm.

The team used stakeholder involvement along with thorough preparations to resolve encountered limitations and challenges. User acceptance difficulties disappeared because the project provided detailed training sessions in combination with continuous support measures [11].

2.2 **Commercialization** Aspects of the Product

A successful commercialization approach for the VR-based educational platform about snakebite management will foster wide adoption and significant impact. This part investigates essential methods along with decisive points for effective product marketplace implementation. The product development follows an organized framework which consists of features for Target Audience Segmentation and Market Readiness Assessment and Scalability and Identification of Pricing Models while incorporating Distribution Channels and forming Partnerships and Collaborations with sustenance for Long-Term Viability and ethical adherence implementation. The framework contains distinct elements which help solve deployment problems encountered while introducing innovative education solutions to varied geographical areas and social backgrounds.

Target Audience Segmentation

The implementation of a complete target audience segmentation method allowed the VR-based platform to fulfill the requirements of its intended users. The primary user groups include:

Medical Professionals: Emergency responders together with paramedics and doctors and nurses form the main group that needs hands-on training for snakebite first aid and treatment methods.

Needs: Accurate information on venom effects, symptom progression, and treatment procedures. Users receive added value from virtual emergency simulation components that duplicate actual emergency situations [3].

Challenges: Limited access to practical training due to the rarity of snakebite cases in controlled settings [9].

The medical community should have access to tools which improve fast yet effective responses toward snakebite emergencies. The platform delivers advanced human body modeling as well as venom progression timelines to enhance preparedness among users [4]. The platform delivers huge value to rural healthcare providers because they normally lack access to advanced training materials [10].

Wildlife Conservationists and Herpetologists: The field of snake-prone conservation work requires both Wildlife Conservationists and Herpetologists to learn about hazard-free methods and species recognition expertise.

Needs: The system requires equipment for venomous snake identification as well as comprehensive knowledge about their behavior along with safe practice procedures for venom extraction [13].

Challenges: The practice of working with living snakes throughout field operations presents major safety hazards to researchers [11].

Through the simulation of real snake movements, the platform provides vital assets to professionals who study herpetology and work in conservation projects. Integration of the platform allows field workers to practice safe handling methods which protect them as well as the snakes from harm [5].

Educational Institutions: Educational Institutions serve as target institutions since they wish to integrate modern technical capabilities into their academic programs including universities and medical facilities and vocational training institutions.

Needs: Educational institutions require large-scale immersive tools which supplement traditional education methods and deliver practical learning experience [14].

Challenges: Selecting VR as a training tool remains difficult because limited budgets combined with the necessary technical infrastructure [6].

Digital tools in education now receive growing acceptance from educational institutions because they improve student learning results. The VR platform adopts a modular architecture that enables educators to incorporate it into their current educational programs to provide students with direct snakebite management practice [8].

Rural Communities: People who reside in rural Sri Lankan communities alongside other snakebite-prone territories that lack proper training options for residents.

Needs: They need educational modules which community workshops can use for deployment [10].

Challenges: Limited technical literacy and financial resources in rural populations [5].

Snakebite incidents occur most often in rural areas because these regions lie adjacent to wildlife areas yet have restricted medical care [3]. Local content availability merged with simplified user interface features enable the platform to serve as an inclusive platform [10].

Government Agencies and NGOs: Public health organizations together with agencies that manage natural wildlife and handle disasters make up this category.

Needs: The solution requires massive training methods that can adapt to different regions for boosting community readiness levels [17].

Challenges: The implementation faces two main hurdles including stakeholder coordination difficulties and the need to secure funds for extensive deployments [6].

Government agencies together with NGOs serve as fundamental partners who distribute the platform toward disadvantaged groups. The platform's effectiveness increases through strategic partnerships with these organizations which help provide equal access to all users [17].

Market Readiness Assessment

An extensive market readiness evaluation determined the level of market demand for the VR-based educational system together with its adaptability characteristics. Key findings include:

Demand Analysis:

- The occurrence of snakebites presents a public health concern within tropical areas of Sri Lanka and other regions where the situation leads to severe mortality combined with substantial illness rates [3].
- The VR platform fills an educational gap in training methods by overcoming barriers of accessibility and scalability as well as unrealistic simulation needs [11].
- The implementation of VR-based solutions found extensive stakeholder support especially within educational institutions together with government agencies based on our research interviews [10].

Research demonstrates that snakebite envenomation poses an immediate requirement for new training solutions across the world [3]. The platform works effectively due to its real-scenario modeling capabilities and quick feedback system which makes it a critical solution for addressing this training problem [9].

Competitive Landscape:

- Existent educational programs use traditional methods of instruction like videos and textbooks and live demonstrations whereas VR simulations provide more engaging and effective training [9].
- The VR education sector presents an opening for specialized snakebite management training because competitors work mainly with safety and medical simulation solutions [14].

This platform has an exceptional market potential to lead the field as no other product exists to address snakebite management specifically through virtual reality [14]. This specialized VR system stands apart from common training tools since it addresses regional requirements and cultural elements [10].

Technological Adoption Trends:

- VR hardware costs are decreasing, and systems are becoming more easily accessible which expands its usage among diverse populations [16].
- The integration of AI with IoT advances makes VR platforms more interactive and realistic so they can handle training situations that require complexity [9].

The fast growth of VR technology creates new entry points so resource-limited areas can use immersive learning systems [16].

Barriers to Adoption:

- The implementation of healthcare training through VR encounters obstacles because low-resource areas face substantial expenses for hardware purchases and software creation [5].
- The adoption of VR training systems remains limited because rural populations lack essential technical knowledge until support and training initiatives are specifically directed at them [10].

The solution demands several stakeholders working together including government agencies and NGOs and technology providers to offer both financial assistance and training [17]. The protection of sensitive data must be ensured because it creates trust which develops credibility between stakeholders [12].

Scalability and Deployment Strategies

The platform depends on scalability features to achieve long-term popularity and market adoption. Several strategic approaches were developed to tackle scalability problems.

Institutional Partnerships:

- A partnership between Curza and universities, medical schools together with wildlife research centers allows for maintaining ongoing usage through formal education curriculum integration [13].
- The platform benefits from public sector partnerships which enable mass deployment programs and funding support for needy communities [17].

The platform achieves stability through institutional partnerships which also maintain national priority alignment [13]. Through partnerships institutions can share their expenses and combine resources which decrease their financial demands [17].

Freemium Pricing Model:

- The basic training modules are offered free of charge, but the advanced features and institutional licenses have separate fees which serve to enhance user accessibility and revenue generation [16].
- Application of freemium pricing enables the growth of broad user adoption and simultaneously creates potential sales opportunities for premium service packages [14].

A freemium pricing model establishes mixtures between cost effectiveness and fiscal success which supports operational sustainability alongside universal accessibility to platform [16]. The platform implements this strategy because it supports its dual focus on public health and environmental awareness [17].

Pricing Models

A pricing model which sustains the business alongside making services accessible to everyone represents a fundamental requirement. Several pricing strategies were considered:

Freemium Model:

- Users can access basic modules including snake identification along with first-aid training without charge to promote extensive platform use [16].
- Basic snake identification and first-aid training features are always free, but users can access progressive content through either subscription plans or single-time purchases [14].

A freemium strategy enables users to test platform features without charge which helps them assess the platform before upgrading to premium offerings [16]. By employing this method organizations build good relationships which lead to natural product recommendations between customers [14].

Institutional Licensing:

- The platform enables educational institutions together with government agencies to buy unlimited licenses for complete feature access [17].
- The licensing fees cost differently depending on the institution size and user count [10].

Institutional licensing generates a reliable revenue flow and maintains continuous user access according to research [17]. The platform reaches a wide user base because bulk deployments are possible through this model [10].

Pay-Per-Use Model:

- Users pay for separate forms including single sessions or platform modules because this system supports individuals with restricted financial means [16].

- The pay-per-use payment system works best for rural populations together with minimal installations [10].

A pay-per-use pricing model ensures accessibility because it serves users who lack the funds to pay for initial expenses [16]. The training programs of organizations benefit from these models because they offer adaptable features for short-term sessions [10].

Distribution Channels

The platform needs exceptional distribution channels to connect with its ideal user base. Key distribution strategies include:

Direct Sales to Institutions:

- Targeted marketing activities reach medical schools together with universities and hospitals [14].
- Testing sites and demonstrations present the platform advantages which help organizations choose it [17].

Through direct sales the company builds personalized relationships with key stakeholders according to [14]. The platform's value becomes tangible through pilot programs which boost adoption rates according to [17].

Workshops and Training Sessions:

- Through face-to-face training activities and workshops the platform gets introduced to rural communities and government entities [10].
- Users experience increased confidence and involvement when they participate in step-by-step demonstrations and tutorials of the platform [9].

The workshops and training sessions deliver quantitative data about the platform which helps stakeholders develop confidence thus they adopt it more easily [10]. The platform enables users to give feedback and encourages multiple rounds of improvement [9].

Online Platforms:

- The platform grows its international client base by adding itself to educational software platforms with VR content marketplace listings [16].
- Online platforms make all new updates, and platform features accessible in an easy manner [14].

Digital marketplaces allow the platform to gain rapid growth through their global distribution channels [16]. The platform enables users to receive smooth updates and feature improvements through its online functionality [14].

Partnerships with NGOs:

- The partnership between Information Matter and NGOs dedicated to public health and wildlife conservation helps achieve massive implementation scope alongside outreach programs [17].
- The work of NGOs proves critical for spreading knowledge about rural adoption because they actively promote adoption to rural communities [10].

Through NGO partnerships the platform achieves higher impact through their specialized networks and advanced expertise [17]. Through their work NGOs offer significant local market research data about needs and choices [10].

Partnerships and Collaborations

The successful operation of this platform depends on strategic partnerships because they help tackle obstacles while expanding its beneficial effects. Key partnerships include:

Educational Institutions:

- Academic institutions through partnerships enable formal integration of the platform into educational programs by incorporating it into university medical teaching programs [13].
- Through their partnership educational institutions supply their expertise for designing educational materials and develop strategies to involve users [8].

Academic curricula benefit from educational partnerships which validate the platform while keeping its content appropriate for educational purposes [13]. Research and development activities benefit from the opportunities that these partnerships supply [8].

NGOs and Nonprofits:

- Through public health and wildlife conservation NGOs vast projects can be managed as they expand their outreach programs [17].
- The efforts of NGOs include raising public knowledge about adoption simultaneously with facilitating rural adoption [10].

The platform benefits from NGO partnerships because they use their professional networks to advance the platform's reach [17]. Through such partnership organizations obtain essential information about regional consumer demands and requirements [10].

Technology Developers:

- The platform achieves technical feasibility and innovation through the development of partnerships between VR developers and IoT manufacturers [9].
- When technology partners join forces, they offer assistance for integrating hardware systems and software platforms [14].

The platform maintains a position as an advanced leader in both VR and IoT technologies thanks to technology partnerships [9]. The partnership leads to lower development expenses as well as faster market entry [14].

Sustainability and Long-Term Viability

The system's future success requires organization of resources together with strategic planning measures. Key strategies include:

Revenue Streams:

- The platform generates steady revenue because it uses licensing fees and subscriptions as well as pay-per-use models [16].
- The combination of institutional licenses with bundled hardware packages functions as an additional source of income [14].

Platform stability stems from multiple revenue streams which make the business less dependent on one primary income source [16]. The platform adapts to changing market conditions because of these elements [14].

Continuous Improvement:

- The platform stays interesting and worthwhile through its consistent system improvements and new features releases [11].
- User feedback functions as the main driver which leads to version-by-version enhancement of the platform [10].

User Needs and Technological Advancements can be met by a platform through its continuous evolution process [11]. The platform creates satisfied users who demonstrate loyalty because of these features [10].

Environmental Impact:

- The platform actively supports wildlife ethics and opposes damaging conduct which helps achieve environmental conservation plans [17].
- The platform achieves a higher market reputation because of its sustainable operational practices [10].

Environmental sustainability stands as a major competitive factor for the platform because it connects to worldwide conservation movements [17]. The platform appeals to both environmentally conscious users and organizations according to reference [10].

Ethical Considerations

The platform requires essential ethical guidelines for developing responsible operations and accessible deployment practices. Key aspects include:

Content Accuracy:

- Domain expert validation creates a system whose content becomes accurate and reliable [5].
- Tests follow rigorous review procedures to eliminate misinformation according to research presented in [10].

The accurate contents users find on the platform remain vital because they build trust relationships and establish user credibility [5]. The platform maintains scientific standards through thorough testing which verifies its adherence to best practices [10].

Data Privacy:

- Data protection measures implemented according to privacy regulations protect user privacy [12].
- All user data remains secure as authorized employees have exclusive access to it [11].

Users show particular concern about privacy security, especially when utilizing healthcare-related applications [12]. Compliance with regulations builds trust between customers and helps reduce legal consequences [11].

Animal Welfare:

- Wildlife conservation agendas receive support through ethical practices and behavior promotion which discourage dangerous actions [17].
- The platform delivers material that promotes animal respect together with habitat preservation [10].

The platform puts animal welfare at its center because it wants to demonstrate commitment to ethical wildlife management practices [17]. The platform appeals to conservation-focused users and organizations while they engage with it [10].

Cultural Sensitivity:

- The localization of content combined with cultural reference customization makes the material more relevant and acceptable to users [10].
- The platform makes use of stakeholder involvement to develop culturally appropriate design elements [14].

The platform achieves compatibility with diverse user groups because cultural sensitivity allows it to connect with area audiences without losing their support [10]. The platform demonstrates its dedication to promoting inclusivity through this practice [14].

2.3 Testing and Implementation

Testing Strategy

Testing Overview and Objectives

Objectives of Testing

- All functional system modules need to work properly within different hardware conditions.
- All user interactions, including animations, need to match actual world standards during the verification process.
- The evaluation process checks both educational achievement results and behavioral modification outcomes.
- Test and fix all system abnormalities while addressing both product usability problems and device-based performance flaws.

Table 1 Objectives of testing

Test Type	Purpose
Unit Testing	Verify individual components like tool actions, UI
Integration Testing	Check interaction between modules (navigation, data transfer)
Performance Testing	Validate memory usage, load times
Usability Testing	Ensure intuitive interaction for users of various skill levels
Acceptance Testing	Confirm system meets stakeholder expectations

Testing Devices and Tools

- Hardware: The testing equipment consists of two major components which include Oculus Quest 2 Meta Quest Link for PC-based debugging.
- Software: Unity Profiler, Trello (bug board), OBS (screen recordings), Google Forms (feedback), GitHub Issues

Testing Environments

- The first tests took place in a controlled lab environment during internal evaluations.
- Pilot institutions (schools, hospitals, wildlife offices)
- The testing sites were established in rural areas for real-world evaluations that included evaluations under low light conditions and noisy environments and first-time user circumstances.

Testers included:

- Medical interns and nurses
- Wildlife rangers and field officers
- Rural adults with no prior VR experience

Testing Methodology and Test Metrics

Testing Phases

Phase 1 – Internal QA (Alpha Testing)

Conducted by developers and in-house testers. Focused on:

Core feature functionality

UI navigation

Performance benchmarks

Major bug identification

Phase 2 – User Acceptance Testing (UAT)

Involved real users from three key sectors:

- Medical professionals
- Wildlife officers
- Students & civilians

This phase focused on:

- Learning impact
- Usability and comfort
- Realism and engagement

Phase 3 – Field Testing (Pilot Deployment)

Conducted in real-world settings to observe system behavior under natural conditions, including:

- Rural schools and clinics
- Outdoor test environments
- First-time VR users

The platform testing procedure included careful execution for functionality assessment as well as performance testing and usability evaluation to fulfill scientific requirements and user needs. Testing involved multiple evaluation areas that included functional assessments as well as non-functional testing and user-centered evaluations.

Functional Testing:

- The testing confirmed how all essential system functions including 3D modeling and real-time venom simulation and interactive timelines together with educational modules worked as needed [4].
- The simulation platform successfully replicated the physiological reactions of snake venom on human bodies through precise replication of symptoms development and organ structural damage [5].
- A test was conducted to check the responsiveness of interactive elements including IoT sensors to guarantee users would navigate the system effortlessly [9].

The platform passed functional testing thus meeting its main purpose to deliver precise reliable training instruments to users.

Non-Functional Testing:

- This test evaluated the system's user-friendly nature and simple navigation together with plain instructions [7].
- Performance testing evaluated how the system manages broad implementation requirements and maintains steady operation between different VR hardware devices particularly those with basic specifications [10].
- The team tested the platform for its ability to serve numerous users across multiple global regions at once [11].
- A reliability test through stress assessment was performed to maintain system accessibility and avoid training resource interruptions [16].

Non-functional testing provided crucial evaluations about how users interacted with the system by studying the platform’s accessibility and response times across different conditions.

Test Cases

Test Case 01

Test Case	001
Test Scenario	The user adopts the VR controller to handle the snake hook.
Input	The user utilizes the VR trigger button to try seizing the snake hook.
Expected Output	The hook successfully grasped by the user appears correctly in their hand.
Actual Result	The user successfully grasped the hook after which it precisely tracked their hand motions.
Status	Pass

Table 2 Test Case 1

Test Case 02

Test Case	002
Test Scenario	User lifts a stationary snake with the hook as an instrument
Input	The user lifts the snake using the hook before moving it away from the device.
Expected Output	The hook successfully lifts and moves the snake body without causing any disruption.
Actual Result	The tool movements elicited natural movement from the snake without severing it.
Status	Pass

Table 3 Test Case 2

Test Case 03

Test Case	003
Test Scenario	approaching a cobra too quickly
Input	The user swiftly approaches the snake within one meter of its body.
Expected Output	Cobra raises its hood to become ready for an attack
Actual Result	When approached with rapid movements the cobra displayed both an elevated hood and emitted a hissing sound.
Status	Pass

Table 4 Test Case 3

Test Case 04

Test Case	004
Test Scenario	Verifying snake flee behavior
Input	When the user uses the hook to move without threatening the snake it flees at a slow pace.
Expected Output	The snake detects its presence after which it moves away at a slow pace.
Actual Result	After detecting the approaching player, the snake relocated to a secure section.
Status	Pass

Table 5 Test Case 4

Test Case 05

Test Case	005
Test Scenario	Testing VR controller input responsiveness
Input	User interacts with VR controller through different hand motions which include grabbing and turning while performing lifting procedures
Expected Output	The tools detect hand gestures with precise accuracy at short time intervals.
Actual Result	Interaction was responsive and smooth
Status	Pass

Table 6 Test Case 5

Test Case 06

Test Case	006
Test Scenario	The user can navigate through virtual spaces by using a VR joystick and hand gesture movements.
Input	The user activates motion by either pushing the joystick forward or using the assigned hand motion.
Expected Output	The user avatar seamlessly navigates through the virtual world because of realistic camera shifting while also experiencing collision avoidance functions.
Actual Result	The user achieved successful movements through different terrain because the experience felt natural yet prevented object penetration
Status	Pass

Table 7 Test Case 6

Test Case 07

ID	TC-001
Test Case	Perform Venom Extraction
Test Scenario	The user simulates venom extraction using the synchronized IoT tool in the VR setup.
Input	User operates IoT while interacting with snake model in VR.
Expected Output(s)	The system visualizes venom flow animation and evaluates the extraction technique.
Actual Result	Venom extraction was animated accurately, and user feedback was displayed in real-time.
Status	Pass

Table 8 Test Case 7

Test Case 08

ID	TC-002
Test Case	Interact with AI Assistant
Test Scenario	The user asks questions about venom anatomy and identification to virtual AI.
Input	Voice command: "Tell me about the venom gland of snakes."
Expected Output(s)	AI responds with verbal explanation and highlights relevant snake anatomy in the VR environment.
Actual Result	The assistant correctly responded and pointed out anatomical structure using overlay highlights.
Status	Pass

Table 9 Test Case 8

Test Case 09

ID	TC-003
Test Case	Navigate Training Modules
Test Scenario	The user switches between Identification and Venom Extraction modules.
Input	Users select different modules using VR menu.
Expected Output(s)	Modules transition seamlessly with no system errors or interface lags.
Actual Result	All module transitions occurred smoothly and within 2 seconds; no system freeze, or data loss encountered.
Status	Pass

Table 10 Test Case 9

Test Case 10

ID	TC-004
Test Case	Evaluate Learning Progress
Test Scenario	The system generates a detailed progress report after module completion.
Input	Completion of all core modules and exit from session.
Expected Output(s)	System displays metrics like identification accuracy, task success rate, and time taken for each activity.
Actual Result	Metrics and visual reports were displayed clearly on the results dashboard; data was logged successfully.
Status	Pass

Table 11 Test Case 10

Test Case 11

ID	TC-005
Test Case	Multiple Extraction Attempts
Test Scenario	User repeats the venom extraction process multiple times during a single session for practice.
Input	Restart option selected after first successful extraction.
Expected Output(s)	System resets venom gland state, reinitializes IoT synchronization, and allows repetition without error.
Actual Result	The extraction reset was successful, and multiple attempts were completed smoothly.
Status	Pass

Table 12 Test Case 11

Test Case 12

ID	TC-005
Test Case	Start Extraction Interaction
Test Scenario	A user begins the venom extraction session in VR.
Input	User selects “Start Extraction” from the VR menu.
Expected Output(s)	Simulation loads extraction interface and activates IoT tool synchronization.
Actual Result	Extraction module loaded successfully and IoT device connected in real-time.
Status	Pass

Table 13 Test Case 12

Test Case 13

Test Case	001
Test Scenario	Demonstrate how venom spreads and affects organs in real time.
Input	Users select a venomous snake species and observe its effects on the human body.
Expected Output	Realistic visualization of venom spreading through the bloodstream and affecting organs.
Actual Result	Venom effects were visually represented accurately, showing tissue damage, bleeding, and systemic symptoms.
Status	Pass

Table 14 Test Case 13

Test Case 14

Test Case	002
Test Scenario	Verify the accuracy of 3D models of human organs and systems affected by snake venom.
Input	Users interact with 3D models of the heart, lungs, and nervous system.
Expected Output	Detailed anatomical structures should match real-world anatomy.
Actual Result	Models were highly accurate, with clear visibility of organ details and realistic textures.
Status	Pass

Table 15 Test Case 14

Test Case 15

Test Case	003
Test Scenario	Users interact with the timeline to observe symptom progression.
Input	Users manipulate the timeline to explore symptom evolution.
Expected Output	Smooth transitions between stages of venom effects, allowing users to understand urgency and treatment outcomes.
Actual Result	Timeline interactions were seamless, providing clear visual cues for symptom progression.
Status	Pass

Table 16 Test Case 15

Test Case 16

Test Case	004
Test Scenario	Demonstrate the progression of venom effects over time, including localized and systemic symptoms.
Input	Users observe how venom impacts different organs and tissues at varying stages.
Expected Output	Accurate representation of symptom progression, highlighting key milestones (e.g., paralysis onset, internal bleeding).
Actual Result	Symptoms progressed realistically, aligning with scientific data on venom effects.
Status	Pass

Table 17 Test Case 16

Test Case 17

Test Case	005
Test Scenario	Users view step-by-step first aid modules for snakebite emergencies.
Input	Users navigate through guided tutorials that demonstrate immobilizing limbs, applying pressure, and preparing the patient for evacuation.
Expected Output	Users can observe each step of the first aid procedure clearly, with visual aids and explanations enhancing understanding.
Actual Result	Users successfully viewed and understood the first aid steps, with feedback mechanisms confirming comprehension of the content.
Status	Pass

Table 18 Test Case 17

Implementation Plan

The rollout of the VR platform through multiple stages began with small-scale tests before moving to a complete system launch. The implementation process was divided into sections to detect and solve problems before a widespread rollout took place.

Pilot Testing:

- The team performed preliminary testing with small medical students, emergency responders and rural community worker groups.
- The platform received feedback about its usability features and educational content which allowed developers to improve it through multiple iterations [10].

User needs emerged from pilot testing which led to specific enhancements for platform development.

Iterative Refinement:

- The platform underwent refinements based on test results from preliminary trials for better user interface improvements.
- Domain experts joined forces to validate both the content facts and make sure best practice guidelines were followed [6].

The platform underwent successive improvements that preserved its alignment with user requirements and technical requirements [6]. The updates made to 3D models enhanced their accuracy which improved simulation training authenticity [5].

Full Deployment:

- The system was implemented to multiple user groups across educational institutions and government departments and NGOs.

The platform achieved its maximum operational effectiveness through complete deployment which delivered training resources to users fairly [17]. The support systems enabled an easy implementation process and avoided operational interruptions [10].

User Feedback and Iterative Improvement

The platform successfully evolved through user feedback that helped make it match educational requirements. The project used a well-developed method to receive feedback from different user types.

Feedback Collection:

- The analysis process included running usability testing with end-users to check how simple the navigation system was and to measure both instructional clarity and end-user satisfaction levels [7].
- Professionals completed surveys and conducted interviews which delivered quantitative and qualitative results about platform advantages and disadvantages [10].

Feedback collection methods generated practical information about user interface troubles and ways to advance system usability [7].

Iterative Improvement:

- The team integrated suggestions from users to boost system interactivity and better trainee development along with educational function enrichment.
- The team selected their improvement strategy from feedback analytics by targeting their work on essential areas that appear most often and affect simulation quality and content range [6].

The platform underwent regular development which enabled it to provide updates that responded to shifting user needs along with technological progress [6].

Continuous Feedback Loops:

- Planned systems collect ongoing feedback from users which allows the platform to adapt its operation to new emerging requirements [14].
- The system incorporated user feedback through periodic updates and this method maintained its effective and relevant features [11].

Continuous feedback loops established through the platform delivered two essential benefits: they nurtured innovative changes and operational speed which made the platform lead the VR-based education market [14]. Scheduled system updates included solutions for user-reported issues and brand-new functionality to retain user loyalty and contentment [11].

Validation by Domain Experts

Domain experts performed validation checks during the entire development phase so the platform would achieve the best practice standards and maintain its accuracy and reliability.

Herpetologists:

- The platform's 3D snake models together with their anatomical details underwent extensive accuracy checks.
- Medical professionals tested venom extraction methods and equipment used to verify realistic yet secure handling practice [5].

Herpetologists verified that the platform's depiction of snake behaviors along with venom effects maintained genuine real-life standards [5]. Through their involvement the content achieved both scientific validity and educational suitability [13].

Medical Professionals:

- Medical experts validated the realistic symptoms of venomous effects, and they approved treatment methods along with how symptoms progress naturally.
- Medical experts verified and authorized all first-aid procedures and emergency protocols to ensure they matched clinical standards existing in practice [4].

Medical experts checked that the presented treatment methods and first aid procedures met scientific requirements [4]. The platform was designed through their joint efforts to maintain match healthcare provider requirements alongside trainee needs [10].

VR Developers:

- The developers evaluated both virtual reality user interactions and the system´s operational quality.
- The developers utilized optimized rendering techniques to resolve technical obstacles that existed in the system [9].

The system performance received optimization measures from VR developers to achieve smooth user interactions with high-resolution visual outputs.

Educational Designers:

- Educational designers evaluated how clear the instructions were, and they assessed user engagement together with the way the materials aligned with educational targets.

The educational designers performed user experience evaluations to direct changes which improved system interactivity through feedback cycles [8]. The platform achieved its maximum learning outcomes and preserved user interests through the educational designers' feedback [16].

Performance Metrics

The platform received performance tracking tools which recorded user development alongside measuring training material success rates. Quantitative indicators showed both knowledge expansion as well as skill proficiency levels.

Task Completion Times:

- Users received tasks for venomous snake identification requiring time measurement.
- The analysis uncovered problem areas that needed extra support through trends observation [11].

The times users required to finish their tasks exposed the level of their skills and highlighted areas where they needed development [11]. The duration users took for venom extraction activities showed that they required more training and instructional support [9].

Error Rates:

- Simulations tracked mistakes which included wrong tool handling and unsafe work methods.

Error tracking features revealed repeat errors to users so they could prevent them from repeating those mistakes for better performance.

Safety Protocol Adherence:

- Researchers checked whether trainees maintained proper safety distance from virtual snakes while also conducting tool usage correctly.
- The system highlighted locations where users moved against standard procedure so specific improvements could be made [17].

The safety protocol adherence metrics measured user safe handling practices to prevent accidents when tackling real-world situations [17]. Proper behavioral learning outcomes increased through visual prompts which combined with audio cues [10].

Challenges and Limitations

Multiple difficulties and obstacles emerged in the testing together with implementation stages of the project.

Technical Constraints:

- High-quality real-time display of three-dimensional models occasionally resulted in temporary system delays on equipment with basic virtual reality capabilities [10].
- The approach of reducing polygon counts works to optimize performance.

The optimization of graphics for all hardware setups became essential because of technical limitations which threatened system performance.

Adaptation Period:

- A few users needed more time to adjust to the VR environment mainly because they were new to VR technology [5].
- The adoption issues were reduced by using introductory tutorials during onboarding sessions according to studies presented in [10].

The necessity of establishing complete training programs emerged from adaptation difficulties which taught users how to work with VR interfaces along with interactions [5].

Content Updates:

- The platform needed continuous attention to maintain its status as a research and best practice area [6].
- The platform obtains its accuracy and continues to stay relevant due to regular software enhancements and domain expert collaborations [14].

The platform received regular content updates which kept its information current with new developments in snakebite management and wildlife conservation.

Deployment Phases

Each phase of deployment used a systematic method which involved developing components while gathering user feedback to validate their process before refinement.

System Design:

- The development team made complete architectural diagrams along with wireframes and prototypes to display both structure and functionality of the platform [13].
- The development team established user-friendly menus and navigation systems which made the system simpler to operate [7].

System design came to fruition through the platform development process to satisfy technical and educational needs which resulted in improved usability and engagement [13]. Intuitive navigation menus and clear visual prompts improved user satisfaction [7].

3D Modeling and Animation:

- I used Blender and Unity to create highly detailed three-dimensional models of snakes together with human anatomy and tools [12].
- The team applied repeated modeling as well as animation procedures to create photorealistic visual effects [9].

The simulation training system achieved new effectiveness through animated 3D models that created realistic learning environments [12]. Visuals with high quality achieved better user engagement and more positive learning results for users [9].

VR Integration:

- The system used integrated VR components alongside software elements to deliver smooth operations with professional visual quality [11].
- The system optimization resolved compatibility problems that affect different devices [10].

VR integration brought immersive user experiences to the platform according to user needs [11]. The compatibility testing procedures resolved technical constraints which allowed the system to run properly on basic hardware devices [10].

AI Assistant Development:

- The team created an AI-based virtual assistant which increased both interactivity and instructional capabilities of the system [14].
- The evaluation focused on measuring both the correct responses and the relevance of user input together with response speed to guarantee excellent user experience [9].

The platform became more usable through AI assistant development which provided users with real-time feedback and guidance according to research by [14]. Users received exact and pertinent information because the system displayed high response accuracy rates [9].

Staged Deployment:

- The implementation process involved alpha and beta testing first followed by pilot testing before implementing the platform completely [17].
- The project used defined objectives and required deliverables to reach each phase deadline [10].

Through a staged deployment approach, the platform completed extensive testing right before achieving mass use [17]. Project strategy along with risk prevention received support through milestone tracking systems [10].

3. RESULTS AND DISCUSSION

3.1 Results

The results from the implementation phase together with testing phase demonstrated that the VR-based educational platform successfully achieved educational expectations by resolving traditional snakebite training limitations. A comprehensive review of findings emerges from testing various aspects of the system alongside its usability features, interactivity capabilities, educational value assessment and development and testing obstacles. The assessments used systematic evaluations with surveys of users combined with reviews from domain experts to measure performance results.

Usability and User Experience

A variety of users from medical fields together with experts in wildlife conservation and students from rural communities and professionals participated in usability tests. The focus of the assessment was to evaluate user satisfaction alongside platform ease of use along with clarification concerning different group adaptations. A crucial evaluation process ensured effectiveness for the platform to serve technical users along with non-technical users.

Navigation Simplicity

The platform received continuous positive feedback from users because it featured modular organization that enabled participants to study Snake Identification along with Handling Techniques and Venom Extraction [7].

Interactive Elements:

Users strongly supported the real-time venom extraction simulation feature as well as interactive timelines which appeared in the platform design. The inclusion of realistic elements received praise from participants because they boosted training engagement levels. Such real-time artificial intelligence assistance delivered individualized directives to users while showing them how to make corrections and validate their learning achievements [14].

User Satisfaction:

Users through open-ended feedback commended the platform because it combined practical training with risk-free experience [11]. Users found the virtual reality platform highly immersive, and this quality made the content both exciting and easy to remember. Users expressed satisfaction with the platform because it delivered better than anticipated educational and realistic experiences [9]. The platform gave rural community members essential capabilities for handling snakebites safely through practical training [10].

Adaptation Period:

Most participants easily adjusted to the VR environment yet those users who lacked experience with this technology needed more assistance during adaptation. Educational tutorials and entrance sessions resolved this challenge by providing easy access to the platform for all users [5]. The platform used iterative feedback together with guided tours which helped users break through their reluctance toward VR adoption until they gained comfort and proficiency with time [10].

Educational Impact

The educational results of this platform were determined by testing it with pre- and post-training assessments and scenario-based testing and through comparative analysis with traditional training methods and qualitative participant feedback. Key findings include:

Knowledge Retention:

The combination of interactive timelines alongside symptom progression simulations demonstrated to users the need for prompt intervention through the correlation of theoretical and practical learning [6].

Skill Mastery:

- Users exhibited performance results in their venom extraction tasks which closely matched the ability of seasoned herpetologists.
- The testing of real-world scenarios showed better decisions in first aid protocol applications because users became efficient and accurate under stressful situations [4].
- Wildlife officers demonstrated higher confidence levels together with better geographic snake species identification which improved their performance during emergency situations [17].

Realism and Accuracy:

- Domain experts confirmed both the realistic simulation of human anatomy and how venom affects body functions within the virtual simulation.
- According to herpetologists the platform presented accurate information about how snakes behave as well as their venom glands and fang structures which match actual natural occurrences [5].
- The medical experts conducted a review of both symptom timeline progression and treatment procedures to guarantee scientific accuracy [4].
- Users gained complete awareness about treatment delay effects through realistic bloodstream animations that showed venom spreading to vital body organs [6].

Feedback Integration and Iterative Refinement

The platform development process strongly depended on feedback obtained from stakeholders. Key insights include:

Participant Feedback:

- The authors received requests for extra case studies and real-life scenarios to enhance the platform's geographic region applicability [9].
- Suggestions for improving safety guidance, such as visual prompts for maintaining safe distances, were implemented to reduce accidental "bites" during simulations [10].

Domain Expert Validation:

- Experts from the field of herpetology and medical science reviewed both the platform's anatomical precision and correct medical procedures.
- The experts provided direction which led to multiple cycles of platform development until the product matched professional requirements [5].

AI Assistant Enhancements:

- The AI assistant kept receiving positive feedback because users liked its ability to provide context-based information during active sessions.
- Voice command features enhanced accessibility so that both literate and semi-literate users could work with the system effectively [16].

Challenges and Limitations

Testing revealed various problems that occurred with the platform even though it demonstrated success.

Technical Constraints:

- Higher model complexity caused temporary lag moments which affected lower-end VR system performance specifically during animations.
- The upcoming platform updates will dedicate efforts to enhancing graphics performance to achieve stable performance in all system setups [10].

Adaptation Period:

- Individuals who were new to VR technology needed supplementary time to get accustomed to the virtual reality system.
- The issues regarding system adaptation were solved through initial tutorials and onboarding yet the platform would benefit from additional support resources such as step-by-step guides and troubleshooting instructions [5].

Content Updates:

- The platform needs constant updates for the latest research and best practices while operators make continuous efforts.
- The platform will preserve its value and exactness through scheduled updates along with expert domain partnerships [6].

3.2 Research Findings

Psychological Impact

This study generated a crucial discovery about how users obtained psychological empowerment through the research process. The practice of training with real snakes intensifies participants' fear and anxiety because of the dangerous nature of dealing with living snakes. VR technology broke down psychological limitations to create a more confident environment with reduced fear among users.

Fear Reduction:

- Users from survey assessments showed significant behavioral psychological changes according to feedback results. The participants demonstrated more than double the confidence they had in handling snakes and their fear perception levels decreased by half [17].
- Users achieved greater calmness following the completion of VR modules because they trusted the simulated controlled environment provided by the VR platform [9].

Behavioral Change:

- The participants displayed less panicked behavior through reducing their decisions to kill snakes unnecessarily or through dangerous actions [5].
- Users who engaged with the platform's realistic environment developed sustainable behavioral transformations because the platform provided managed confrontation opportunities with their phobias [17].

Empathy and Conservation Awareness:

- Detailed 3D models and interactive simulations exposed users to snakes which prompted them to feel empathy toward snakes and led them to become less hostile toward these animals and develop coexistence aims [10].
- Users who experienced the educational modules about snake ecological significance developed practices that supported snake conservation [17].

AI Assistant Performance

The platform achieved enhanced educational value along with increased interactivity because of its AI-powered assistant. Key findings include:

Contextual Awareness:

- The AI system maintained exceptional awareness about user context to deliver personalized immediate feedback based on specific actions recorded by users as noted in [14].
- The system implemented voice commands as an accessibility feature which enabled both reading capable and limited literacy users to effectively use the system [16].

Educational Support:

- AI feedback systems composed of automated mechanisms improved knowledge retention by providing error corrections and navigational help in the process of venom extraction [9].
- The users commended the assistant for its capacity to modify assistance according to individual training speeds while providing customized guidance during the entire learning period [14].

Comparative Analysis of Traditional Methods

The VR training system underwent comparison with conventional educational methods of textbooks and lecturing and static anatomical displays to determine its impact. Key findings include:

Engagement Levels:

- Users expressed greater interest in the VR training system above traditional methods because they found the platform's immersive and interactive approach crucial [10].

Learning Outcomes:

- The testing method based on scenarios demonstrated better decision-making abilities because trainees learned to use first aid protocols correctly and swiftly under high-stress situations [4].

Safety and Accessibility:

- Users could train without endangerment because the VR training platform created a risk-free space which managed environmental variables [17].

Challenges Identified

Several obstacles presented themselves while executing the platform although it achieved its goals. The difficulties encountered point out directions for developing superior versions of the system in the future.

Technical Constraints:

- High-definition 3D model visuals during real-time operations occasionally induced performance lag within certain low-end VR devices thus prompting developers to focus on optimization strategies [10].
- User adaptation to VR technology required introductory tutorials and onboarding sessions because some participants were not familiar with this technology [5].

Content Updates:

- Updating the platform requires constant work that benefits academic institutions and wildlife organizations joining forces to maintain scientific progress and the inclusion of new snake species [6].
- Domain experts along with regular platform updates will help preserve both accuracy and relevance [6] of the platform.

User Adaptation:

- Many users quickly learned to use the VR environment but those novice to VR technology needed supplementary assistance [5].
- Users acquired comfort and skill in using VR technology through guided tutorials and problem-solving directions provided in the system [10].

3.3 Discussion

The research demonstrates how the platform revolutionizes snakebite management training by providing an immersive interactive approach which users can access easily. The tests established that users found the system easy to grasp and interesting because they appreciated the straightforward interface combined with its interactive aspects [7]. Users benefited from the modular approach because it streamed their attention toward crucial modules like Snake Identification, Handling Techniques and Venom Extraction while steering them clear from needing to handle excessive complexity. Users commonly commended the navigation menus because their simple structure created both an easy transition between modules as well as lowered mental strain [16]. Research outcomes establish that strategic interface creation serves as an essential method to provide accessibility benefits to medical personnel together with wildlife specialists along with individuals in rural communities. Users appreciated the realistic aspects of these interactions because these interactions helped users master their skills while building their confidence [9].

The educational platform showed notable achievement in maintaining both knowledge information and practical abilities of users. The platform achieved this success because it integrates theoretical education with actual learning opportunities in controlled laboratory sessions. Interactive timelines combined with simulation features for symptom progression provided learners a chance to understand critical intervention timing because they experienced these virtual instances directly [6]. The platform's educational merits became evident through monitoring performance indicators during venom extraction simulations. The study demonstrates how past reports identify immersive technologies as effective methods for generating improved learning results through enhanced student activity and involvement [10]. Professional experts validated that both the simulated anatomical representations and venom-induced bodily responses were accurate to scientific standards and best practices during their assessment [5]. Rural communities and wildlife conservationists assessed that localized content proved effective because it made the platform suitable for their specific needs [10]. The design of content which suited local needs enhanced user satisfaction and encouraged users to keep using the system and change their behaviors in the long term.

VR platform success can be attributed to its perceptible psychological effects. The risks involved in live snake handling normally worsen fear and anxiety during traditional training programs. Users benefited from VR technology because this platform offered controlled environments which let them face their fears while avoiding actual life risks [17]. Studies through surveys showed participants' fear diminished substantially while their confidence in handling snakes increased by two times after finishing the instructional content [9]. The psychological transformation led to fewer panic-based actions including snake killings and risky handling incidents [5]. Through participatory study of detailed 3D models and interactive simulations users developed empathetic perspectives about snakes which led them toward adopting conservation-friendly practices [10]. Educational content about snake ecology proved fundamental for hostility reduction and habitat coexistence by making the platform support national wildlife conservation ambitions [17]. The research demonstrates that Virtual Reality technology offers simultaneous educational benefits along with nature respect training which creates a powerful tool for educational institutions and advocacy groups.

Technical validation tests proved the platform's dependable operation and scalability features which addressed performance-related and adaptability-related concerns. The developers implemented additional measures that reduced minor delays during testing to show why system performance needs to match visual quality [10]. The modular design structure enabled a continuous expansion process which allowed new snake species and venom types as well as treatment protocols to be incorporated into the system [10]. These technical capabilities provide a basis for enduring platform development which keeps the platform suitable for new research trends alongside changing user requirements. The system faced two limitations which required future work such as rendering performance issues and adaptation difficulties for new users. The platform received benefits from introductory tutorials along with onboarding sessions although future work must focus on both graphics optimization and complete support system development [5].

An AI-powered assistant functioned as a central interactive element that brought instructional advantages to the platform. Voice interactions through the platform enhanced accessibility especially for people between literate and illiterate levels while AI-driven adaptive learning supported students at different instructional speeds [16]. Detailed research reveals that AI within educational technology generates scalable solutions for personalizing educational experiences [14]. Future improvements to the assistive function will stem from user input through added interaction features such as learning path adaptation alongside conversational recollection [10].

The results of comparison testing indicated that the VR system surpassed conventional teaching methods by achieving better user participation rates while achieving better knowledge acquisition. Users expressed superior contentment toward the interactive VR environment over traditional textbooks alongside lectures and lifeless anatomical models [10]. The implementation of scenario-based testing enabled users to develop superior decision-making skills because they learned how to execute first aid protocols effectively and promptly under stressful situations [4]. The VR training system removed all safety hazards from actual snake handling thus delivering a secure platform for educational purposes [17]. The VR platform represents a revolutionary educational solution which benefits snakebite management education specifically in areas with few resources that lack effective methods [11].

The platform faced various difficulties while being deployed despite achieving its targets. Some users who were not familiar with virtual reality needed extra time to get accustomed to it since introductory tutorials and onboarding sessions should be provided [5]. Continuous updates of the platform require academic institutions and wildlife organization partnerships to incorporate emerging research findings and newly discovered snake species [6]. Accurate and relevant data for the platform requires continuous updates along with expert domain involvement [6]. The system addressed some user adaptation problems through walkthrough guides that combined with troubleshooting help users become familiar and proficient with time [10].

The VR-based educational platform for snakebite management presents successful solutions to traditional training deficiencies by providing noteworthy educational and psychological and technical capabilities. The platform uses interactive features to boost user participation and improve both knowledge absorption and skill development which allows users to perform snakebite emergency procedures securely [17]. Psychological changes resulting in decreased snake fear and heightened snake empathy make users more conscious about behavioral transformations towards wildlife conservation [10]. Technical validation processes provide reliability and scalability which makes the system ready for broad adoption as well as long-term impact [11]. The platform faces ongoing challenges, but stakeholder involvement and continuous enhancement procedures will overcome those difficulties to maintain platform growth and importance. The research contributes to wildlife conservation efforts through its educational approach to snakebite management by using VR technology [17]. This work enhances public safety and promotes coexistence between humans and wildlife.

4. SUMMARY OF EACH STUDENT'S CONTRIBUTION

1. Dhananjaya W.A.B.P - Tools and Techniques for Catching Snakes Using Hooks and Tongs

This component is a virtual reality module for teaching the users proper methods to handle venomous snakes with hooks and tongs as specialized tools. The system provided essential practical training for snake-catching methods through methods that eliminated exposure to actual venomous snakes. The module provides users with realistic 3D tool models to practice their deployment techniques in a virtual forest environment. The simulation included dynamic snake behaviors combined with unpredictable movements to provide realistic training for different field scenarios. The platform delivered safety instructions together with clear step-by-step guidelines to help users learn correct techniques so they could avoid snake bites. The addition of this component enhanced both user safety confidence and their ability to handle snakes properly.

2. Dilshan K.A.R - Venom Extraction Simulations, Snake Identification, and AI Assistant

This component is an educational VR system which unites virtual snake identification with simulated venom extraction procedures and artificial intelligence-based virtual assistance. The development of detailed 3D models for Sri Lankan venomous snakes was his main objective while he focused on accurate representation of identifying traits including skin patterns and scale arrangements and head shapes. The models provided users with better accuracy to identify venomous species from non-venomous ones which simultaneously promoted safety practices and conservation education. This consists of two main features for the system including the snake identification system and a VR simulation for venom extraction that allows users to practice safely. The implementation of IoT-integrated tools in the simulation system improved realism by enabling users to perform virtual tactile operations when extracting venom. The platform received an AI-based virtual assistant from Dilshan to improve student learning. Users received educational guidance from this interactive assistant that provided information about snake species along with responses to their questions.

3. Balasuriya B.L.D.C - Effects of Snake Bites on the Human Body, Interactive Timelines, and First Aid Modules

This component teaches users about how snake venom affects human physiology while showing them why immediate medical response and correct treatment procedures are essential. Public awareness received crucial attention through the development of interactive timelines which showed venom-induced symptom progression throughout time. The timelines showed how neurotoxic and cytotoxic and hemotoxic venoms would affect vital body systems through paralysis and tissue necrosis and internal bleeding respectively. The detailed 3D human body models used helped users grasp the importance of getting medical help after snakebite incidents. Also, this component consists of complete first aid and medical treatment modules that provide users with essential life-saving capabilities. Users received step-by-step first aid instructions through the designed training modules. Through this module on interactive timelines and detailed 3D models and first aid training modules it provide users with emergency response capabilities which saved lives and minimized long-term disabilities from snakebites.

6. CONCLUSION

The result of this research project creates substantial progress to tackle the vital public health matter of snakebite envenomation in Sri Lanka with technological innovations. The project achieved its goal through VR technology combined with AI and IoT systems to build an extensive training system which provides immersive expert guidance for managing snakebites and promoting wildlife protection and risk-free human-snake encounters. This conclusion integrates major accomplishments with significant learnings and effects of the project together with its future developmental possibilities and broader usage potential. The training project fills essential gaps in existing methods by enabling users to gain effective practical skills and usable knowledge and response confidence for real-world snake interactions which enhance public protection and preserve natural ecosystems.

Snakebite envenomation poses an essential public health issue for tropical countries including Sri Lanka which has many venomous snakes and restricted access to proper training and medical services. The techniques used traditionally to prevent snakebites and manage these incidents such as theoretical education and live snake handling create multiple obstacles because of safety hazards along with logistical limitations. This project established a VR-based system that combined tools for snake catching with venomous species identification and venom extraction and human snake venom effects and first aid training modules as its main objective. The designers carefully constructed every segment with one goal: to teach practical snake skills combined with actionable information and Snake encounter preparedness to real-life users. The platform achieves transformative learning through its development of interactive 3D models and realistic simulations that connect theoretical education to practical knowledge using IoT-integrated devices. Virtual reality provides users with a safe platform for learning snake-catching procedures while they can recognize venomous species through their physical traits and observe how venom affects human physiology. Through its combined features users gain better decision-making abilities while lowering the number of unnecessary snake fatalities and achieving enhanced safety outcomes in areas with snake populations.

The project's achievement stems from its systematic research and development procedure. The development process utilized a complete system which included elements for requirement gathering followed by feasibility assessment and system design and testing and system implementation stages. The platform development process relied heavily on stakeholder engagement which enabled herpetologists and medical professionals and end-users to help improve system accuracy as well as end-user experience and knowledge acquisition. The project achieved technical feasibility by implementing advanced development tools including Unity3D for virtual reality development and Blender for three-dimensional modeling as well as IoT devices for venom extraction simulation purposes. Research into market viability demonstrated that this solution should proceed due to the identified needs of underserved communities that face limited or substandard training opportunities. The project maintained financial, along with operational feasibility through reasonable development methods and staged implementation sequences which supported continuous evaluation and product enhancement through user assessment. The platform makes environmental sustainability and ethical treatment of snakes among its main priorities to prevent misinformation spread. The project creates a beneficial environmental result through its ability to stop needless snake killings while simultaneously promoting ecological awareness about these animals.

The project results show clear evidence of reaching its essential objectives. Multiple test rounds and user assessments showed that participants showed excellent levels of satisfaction and achievement as well as high levels of program engagement. Users stated that their skills improved in the domain of venomous snake identification as well as safe handling capabilities and first aid administration for snakebites. Performance metrics together with feedback systems delivered practical evidence about user performance which allowed the platform's continuous enhancement. The research presents significant points which emerge from the study. Multiple real-world complex problems prove to be effectively solved through the combined power of VR technology alongside AI elements with IoT functionality. The platform maintains flexibility through its modular design which allows it to meet the requirements of various user groups operating in different geographic regions. Accessibility measures build a pathway for the platform to connect with its target group specifically targeting regions without adequate services. The project demonstrates its dedication to resolving different difficulties linked to snakebite treatment practices through these accomplishments.

Feedback integration served as the primary factor in system development by helping align the system with educational objectives. The team adopted a structured method to collect feedback which involved both artificial user testing and surveys and direct interviews with different user groups. These activities generated practical suggestions that improved user interactivity and educational quality and real-world accuracy of the system. The platform developed through successive improvements because user requirements and technological development needed adjustments. Repetitive feedback processes enabled the platform to integrate user-proposed feature enhancements like extra case studies and authentic scenarios which boosted the platform's applicability across different geographical areas. Suggestions for improving safety guidance, such as visual prompts for maintaining safe distances, were implemented to reduce accidental “bites” during simulations. Medical professionals and herpetologists validated the work to confirm both proper anatomical accuracy and correct procedural methods while assisting successive refinement steps to fulfill professional requirements. London Science Foundation implemented AI assistance that upgraded the instructional clarity and engagement and objective adherence capabilities of their platform.

This project creates a blueprint which can benefit more than Sri Lanka by establishing life-saving education programs for snakebite management that are scalable and immersive. The platform successfully reduced snake-related mortalities while building peaceful human-snake relationships which demonstrates its ability to scale wildlife safety education and public health programs. The project advances sustainable development goals through its activities which promote both wildlife practices and conservation education to achieve health and education objectives and preserve biodiversity. The platform structure can be easily customized for various snake population environments because of its adaptable design which expands its global impact potential. The combination of AI-based virtual assistants delivers individualized guidance as well as accessible support that accompanies users from the initial to final stages of their education.

The project demonstrates the power of interdisciplinary teams and modern technology that solves complicated community problems. A comprehensive platform enables transformative snakebite management through its integration of VR simulations with interactive 3D models paired with IoT-connected devices to provide an engaging effective solution. Its adaptable structure and approach to reach users of all kinds makes the platform suitable for both rural families and experts working with wildlife and medical staff. The project success proves that VR-based training systems work effectively while showing their power to transform conventional educational practices. The platform demonstrates the promise to establish itself as a fundamental component in snakebite prevention operations across the world by continuing development through testing and feature expansion and feedback integration. This initiative takes a major stride toward minimizing snakebite dangers while propelling wildlife conservation efforts across Sri Lanka as well as international territories.

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8. APPENDICES

Figure 7 Appendix 1

Figure 8 Appendix 2

Figure 9 Appendix 3

Figure 10Appendix 4

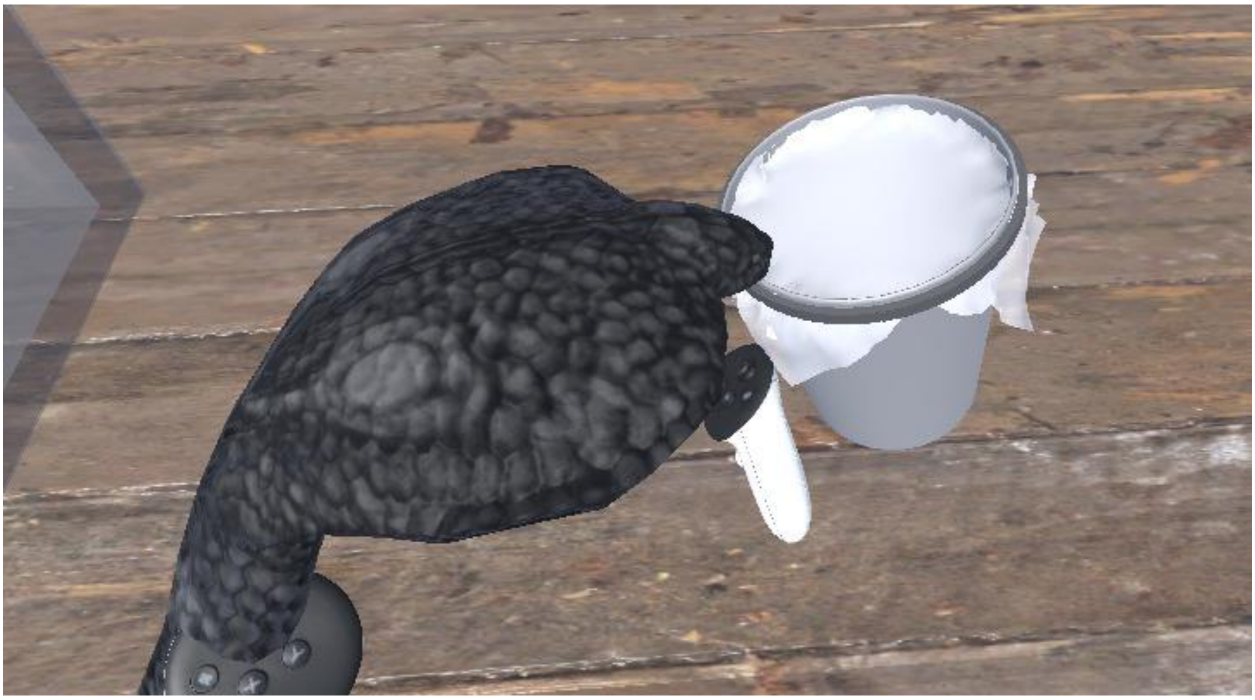

Figure 11Appendix 5

Figure 12 Appendix 6

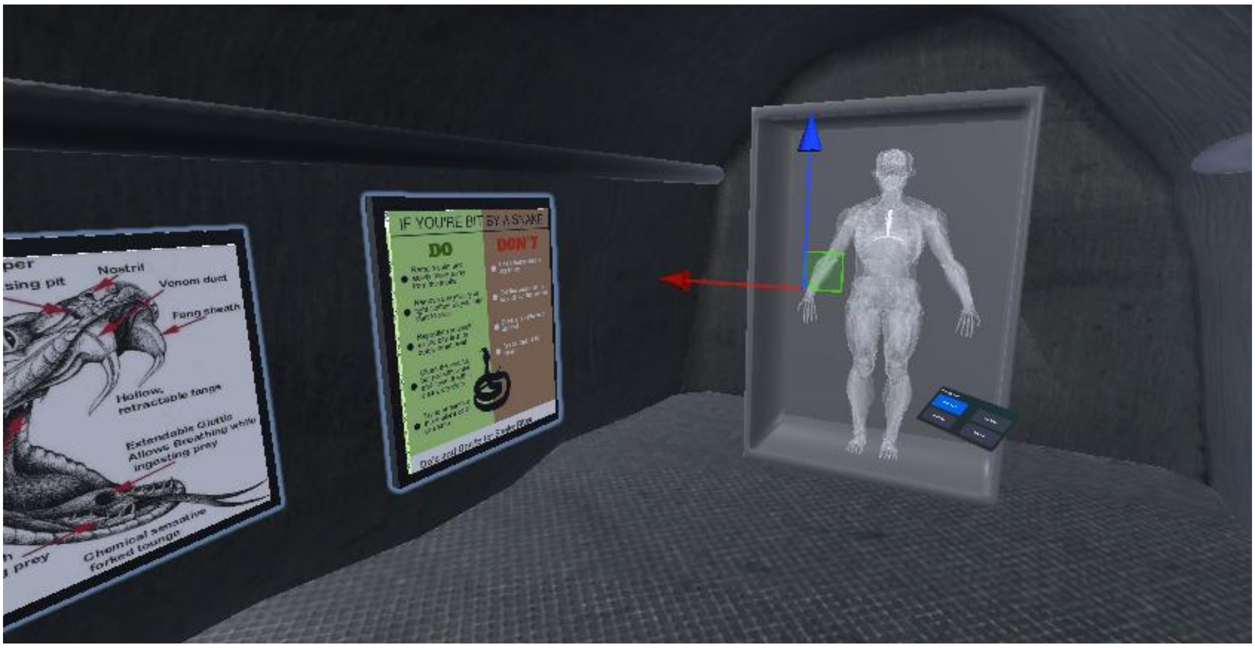

Figure 13 Appendix 7

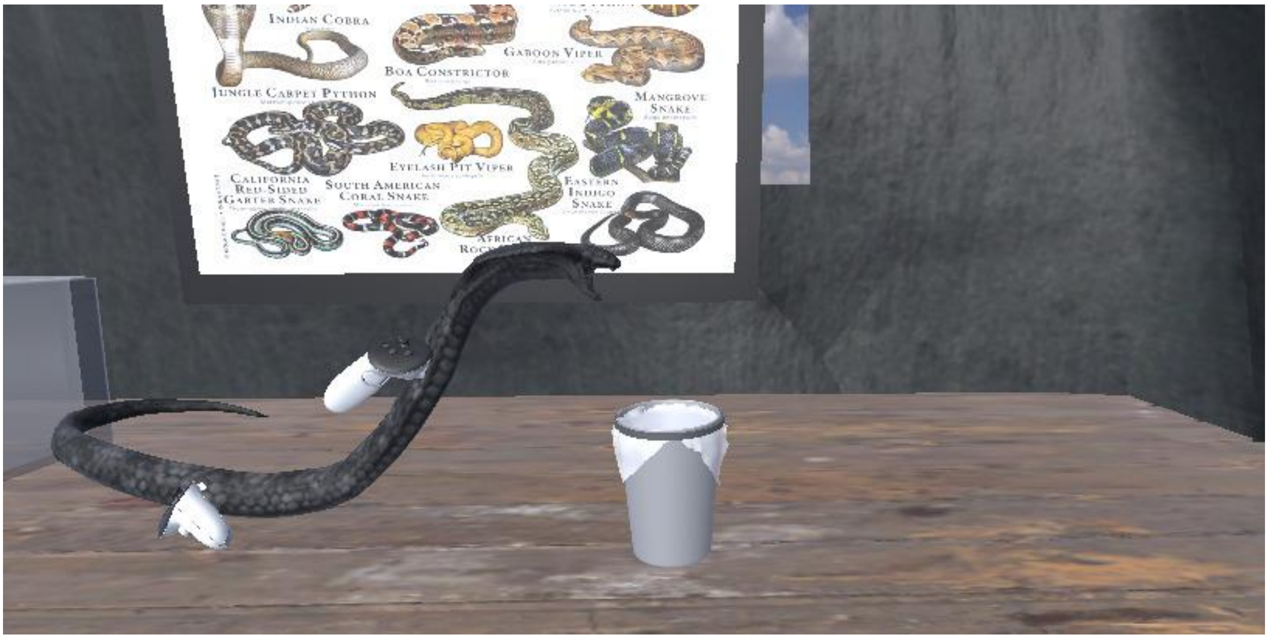

Figure 14 Appendix 8

Figure 15 Appendix 9

Figure 16 Appendix 10

Figure 17 Appendix 11

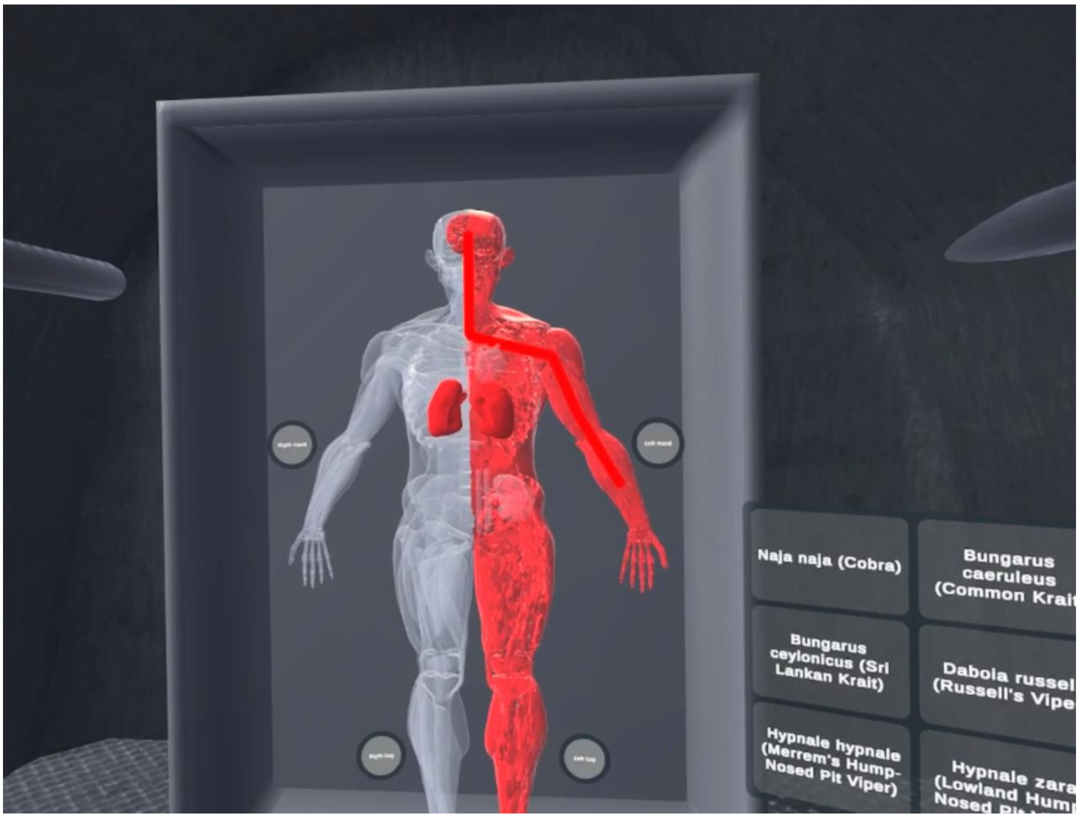

Figure 18 Appendix 12

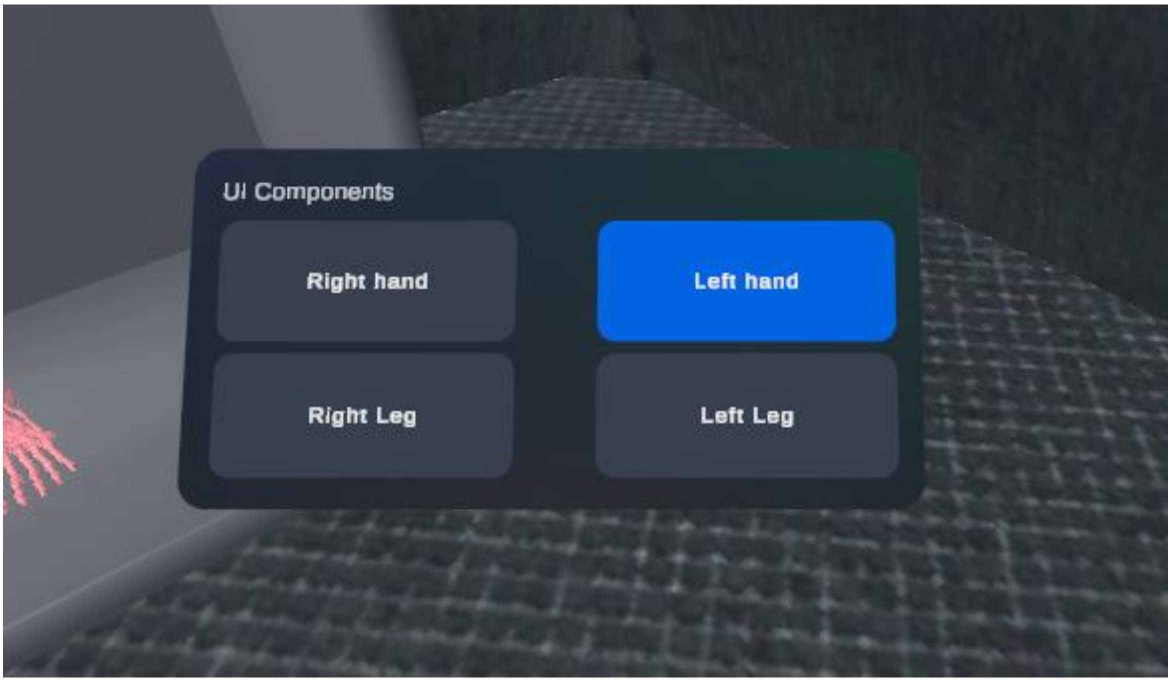

Figure 19 Appendix 13

Figure 20 Appendix 14

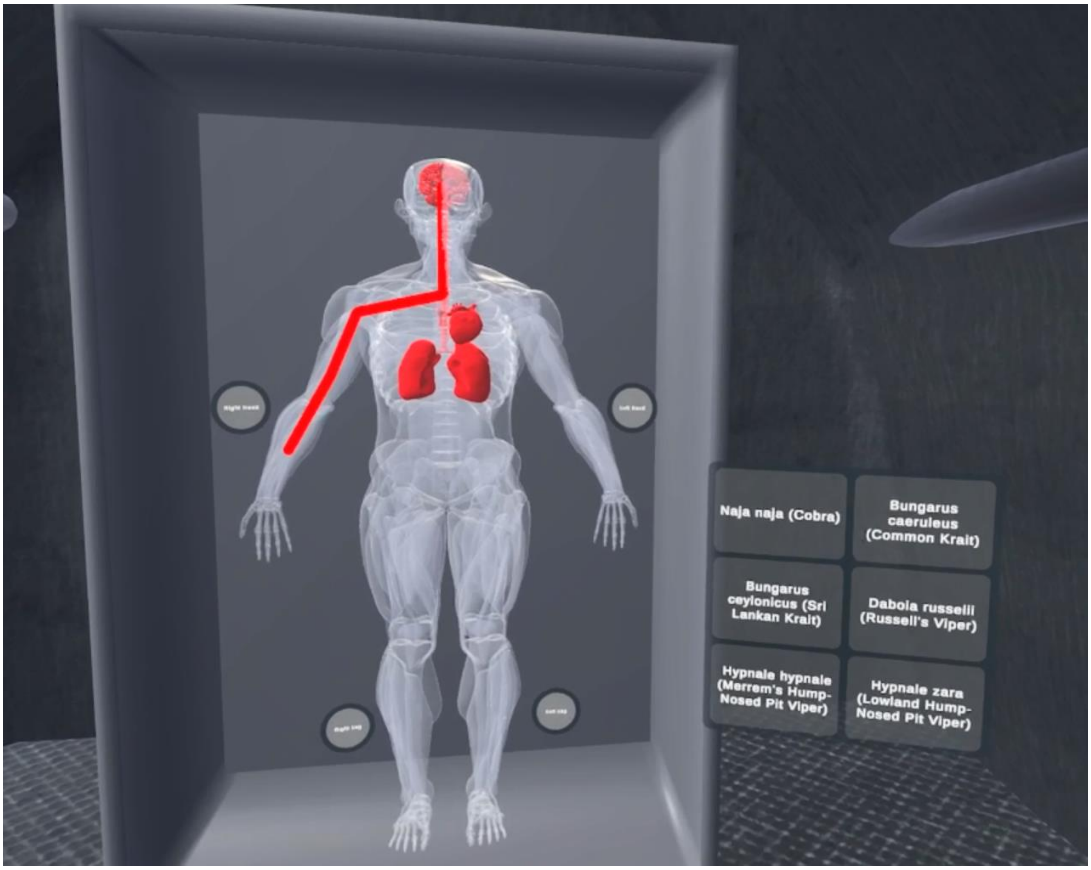

Figure 21 Appendix 15

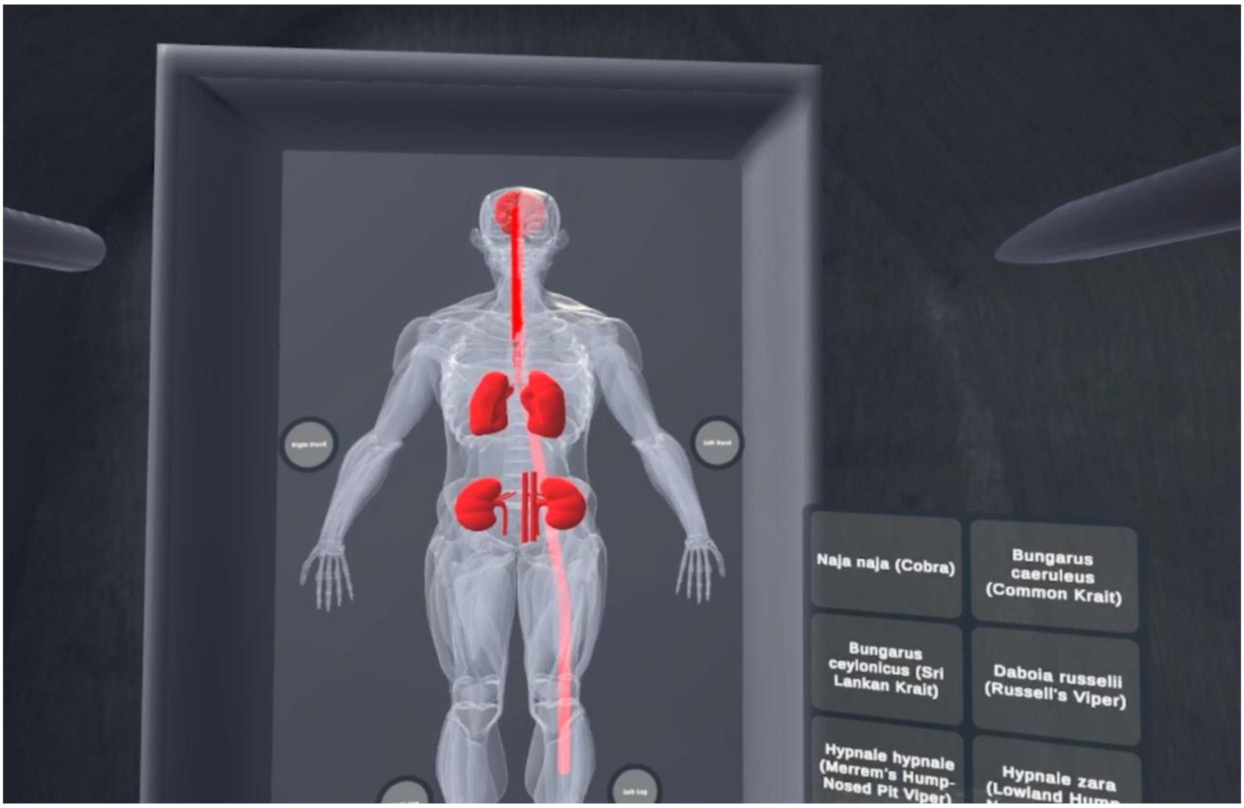

Figure 22 Appendix 16