**Concept Paper**

**A. Basic Information**

**Project Title:**
SafeScape: An Inclusive AI-Driven Platform for Digital Fire Safety, Risk Assessment, Education, and Community Preparedness in Sta. Cruz, Laguna

**Topic:** AI, Digital Twin, Fire Risk Prediction, VR/AR Simulation, Disaster Preparedness, Community Education

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**B. Technical Description**

In Sta. Cruz, Laguna, fire safety is a major concern. Many residential homes and establishments are built closely together, which means a single fire can easily spread and endanger a whole neighborhood. Because Sta. Cruz is a mix of urban and rural areas, it is hard for the usual fire safety programs to reach everyone effectively.

The Bureau of Fire Protection (BFP) in Sta. Cruz is doing its best, but their current programs do not go far enough. Based on consultations with Chief FINSP Cesar Morfe Jr. and FO3 Lorena Nanale, the main problems are the lack of a single platform for information, educational materials that are too general, and not having content that is right for different age groups. Right now, their main approach is posting on Facebook and holding occasional community talks. While helpful, these efforts are limited by not having enough staff and a lack of interactive tools to keep the community engaged.

This problem is not unique to Sta. Cruz. According to Salindo and Salindo (2024), there is a big difference between how prepared local communities in the Philippines think they are and how prepared they actually are. Their study found that even when officials believed their programs were working, the community was not truly ready for a disaster. This shows the limits of older teaching methods and points to the need for better, community-focused tools that build real skills and awareness.

New technology like web platforms and AI offers a chance to make fire safety programs better and more suited to local needs. As noted by Nagaraju et al. (2024), mobile applications are now more than just alert systems; they can be used for teaching people about disasters, mapping hazards, and helping them check their own preparedness. These digital tools help fill information gaps and guide local decision-making, especially where face-to-face outreach is difficult.

In addition, digital twin technology shows great promise for improving fire preparedness. Abbas et al. (2024) showed how digital twins can create simulations of real-world places to find fire hazards before they become a danger. When used for home layouts or community zones, these

models let people see how a fire might spread and check how at-risk their own environment is in real-time.

Training can also be improved with immersive simulations. Kang et al. (2023) created an AR/VR fire drill system that turns a real space into a virtual fire scenario. Their study revealed that users learned faster and understood safety responses better with this type of interactive training. This approach is very useful where physical drills are too risky or difficult to do regularly.

Parekh (2024) also highlighted the role of artificial intelligence in detecting hazards and forecasting how a fire might progress in real-time. By using historical fire data and other environmental factors, AI systems can give predictive insights and personalized safety advice, shifting the focus from reacting to emergencies to proactively reducing risk.

To address these issues, this study proposes the development of SafeScape, a web-based, AI-driven platform for fire safety education and risk assessment designed specifically for Sta. Cruz, Laguna. SafeScape will bring together several tools: digital twin simulations of residential homes, interactive educational lessons for different age groups (inspired by platforms like Sparky.org), and an AI-powered chatbot for safety questions based on BFP protocols. The platform will also introduce basic training modules using AR and VR technologies, starting with residential fire scenarios.

With the support of BFP Sta. Cruz and by following the Standard Public Fire Education Manual, SafeScape aims to modernize fire safety education. It will turn static information into interactive, accessible, and local tools. The goal is to equip residents with not just knowledge, but with practical digital tools to strengthen preparedness, encourage participation, and support a more coordinated emergency response within the community.

**Statement of the Problem:**

The Bureau of Fire Protection (BFP) in Sta. Cruz, Laguna, struggles to provide effective fire safety education. Current methods like social media posts and occasional talks are too general and reactive for the community's needs, and are hard to sustain with limited staff. The main problem is the absence of a modern, centralized digital platform for interactive, age-specific education and household risk assessment. This technology gap means existing safety materials are passive and fail to engage many residents, especially younger ones, leaving the community underprepared.

This study aims to address the following research questions:

1. How can AI be used to assess and predict fire risks based on user-reported and environmental data in Sta. Cruz?
2. What role can digital twin technology play in simulating fire hazards in residential environments?
3. How can immersive VR/AR simulations enhance fire safety training for the public and BFP personnel?
4. What platform design features are essential to ensure accessibility and usability for diverse age groups?
5. How effective will the proposed system be in improving fire safety awareness and preparedness in Sta. Cruz?

**Objectives: General and Specific General Objective:**

The main goal of this study is to design and develop SafeScape, an AI-driven web platform for Sta. Cruz, Laguna, that improves community-wide fire safety and preparedness through modern, interactive tools.

**Specifically, it aims to:**

1. To build a web-based system with separate, age-appropriate sections for kids (ages 1-12) and the general public (13+) that offers interactive lessons, games, and official BFP materials.
2. To use AI to create a predictive model that can assess and forecast fire risks in specific areas based on historical data and user-reported information from Sta. Cruz.
3. To design and build a 2D digital twin feature that lets users simulate fire hazards in common home layouts and see risk assessments visually.
4. To develop a simple VR/AR prototype that demonstrates basic fire response training, such as how to properly use a fire extinguisher, for initial testing.
5. To test the platform's ease of use, accessibility, and overall effectiveness by gathering feedback from BFP personnel and different user groups in Sta. Cruz.

**How did others solve the problem?**

1. The study examined disaster resilience in Guihulngan City by assessing the preparedness levels of barangay and local government officials. Using a quantitative descriptive approach, the researchers found a discrepancy between perceived readiness and actual disaster capabilities, emphasizing the need for integrated, community-driven educational programs. Their findings highlight the importance of localized interventions to strengthen awareness and long-term preparedness. (Advancing Disaster Resilience in the Philippines: Blueprint for Education Extension, Salindo & Salindo, 2024)

2. This study explored the role of mobile applications in disaster safety management, emphasizing their use beyond simple alert systems. The researchers highlighted how mobile apps can act as comprehensive tools by offering hazard maps, emergency planning guides, and preparedness checklists. The findings suggest that mobile platforms can empower communities with real-time, accessible, and context-relevant safety information. (Mobile Application for Disaster Safety Management, Nagaraju et al., 2024)

3. The researchers developed a hybrid AR/VR fire drill training system using a head-mounted display to provide immersive and safe fire emergency simulations. The system overcame traditional training limitations such as cost, logistics, and space by transforming real environments into interactive virtual fire scenarios. Results showed that the integrated AR/VR experience improved user engagement and safety behavior. (Integrated AR and VR Technologies for Realistic Fire Drill Training, Kang et al., 2023)

4. This paper proposed the integration of artificial intelligence in building fire safety systems, highlighting AI's role in real-time hazard forecasting and intelligent fire prevention. The study presented models for AI-driven design, digital twins for monitoring, and a Super Real-time Forecast (SuRF) system for anticipating fire progression. It concluded that AI can enhance the speed and accuracy of building safety interventions. (Applications of Artificial Intelligence in Enhancing Building Fire Safety, Parekh, 2024)

5. This study applied digital twin technology to model real building environments for fire risk analysis. By enabling real-time hazard detection and simulation, the system improved preparedness and allowed faster emergency response. The researchers concluded that digital twins significantly enhance fire safety planning by identifying high-risk areas and supporting proactive mitigation. (Optimizing Fire Safety in Construction via Digital Twins, Abbas et al., 2024)

**How do you intend to solve the problem?**

The researcher intends to solve the problem of limited fire safety awareness in Sta. Cruz, Laguna, by designing and developing SafeScape, a comprehensive AI-driven web-based platform. This approach will shift the community from a reactive stance to a proactive one by using digital technologies to deliver accessible education, interactive risk assessment, and foundational training. The development will adopt an iterative and adaptable methodology, suitable for a solo thesis project within a five-month timeline, allowing for continuous feedback and refinement.

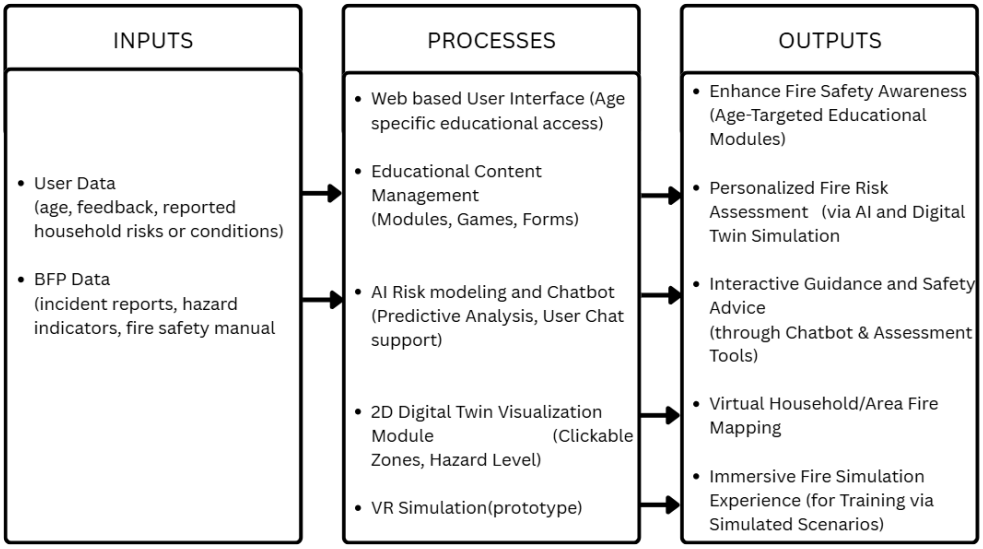


Figure 1. Conceptual Framework

As shown in the framework, the system will take Inputs from both the BFP and users. These inputs will then go through several Processes within the SafeScape platform, including educational content management, AI risk modeling, and simulation. The platform will then produce tangible Outputs, such as personalized risk assessments and interactive safety guidance. The development of SafeScape will proceed through distinct modules. An Educational Content Module will feature separate sections for the "Kids Zone" and "General Public," with interactive games and quizzes to maximize engagement. All official BFP manuals and handouts will be digitized to form the platform's educational content and chatbot knowledge base.

An AI-Powered Module will handle the predictive risk modeling and the chatbot. It will use an NLP-based approach to understand user queries and provide answers based on its knowledge of BFP manuals.

A 2D Digital Twin Module will enable users to interact with simplified floor plans of common residential layouts. The system will use the AI's assessment to create dynamic risk visualizations on the 2D map, such as changing a zone's color to indicate higher risk.

Finally, a VR/AR Prototype Module will be developed to demonstrate the potential of immersive training. It is important to note that given the thesis timeframe, this will be a proof-of-concept, likely a video-based simulation of a basic skill like using a fire extinguisher (the PASS method).

To make sure everything works as planned, the system will be thoroughly tested from start to finish. This includes getting direct feedback from BFP Sta. Cruz personnel and different user groups in the community. Their suggestions will be used to continually improve the platform and make sure it is both effective and easy to use.

**Target users / Beneficiaries:(Describe each Beneficiary)**

1. Children (Ages 1-12) – Learn fundamental fire safety concepts like "Stop, Drop, and Roll" through engaging games and videos.
2. Teens and Adults (Ages 13+) – Access in-depth safety information and use digital tools to assess fire risks in their own homes.
3. BFP Sta. Cruz Personnel – Gain a modern digital platform to support public education efforts and augment internal training.
4. Schools and Educational Institutions – Use interactive, BFP-standard resources for more effective fire safety lessons and drills.
5. Barangay Leaders and LGUs – Utilize the platform to enhance community-wide preparedness campaigns and identify local risk areas.

**Significance of study:**

This study addresses a key challenge in Sta. Cruz, Laguna: the community's need for modern, engaging tools for fire safety. Unlike traditional methods that are often passive and one-size-fits-all, this research proposes the development of SafeScape, an interactive, AI-driven web platform. What makes this study significant is its unique approach of combining age-specific education with practical tools like a 2D digital twin for risk assessment and a prototype for VR/AR training. It offers a localized and accessible solution tailored specifically to the needs of the community.

Ultimately, this project contributes to enhancing public safety by empowering residents with the knowledge and tools they need to be more prepared. It also supports the operational capabilities of the Bureau of Fire Protection (BFP), providing a practical model for how technology can be used to improve disaster resilience in other municipalities.