Design and Evaluation of a Smart Jacket for Enhancing Safety in Individuals with Hearing Loss and Non-Verbal Impairments

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Abstract

Technology plays a crucial role in enhancing the quality of life for individuals with hearing loss and non-verbal impairments, particularly through advancements in the Fourth Industrial Revolution (4IR). This study focuses on designing a smart jacket to improve personal safety by integrating features such as global positioning system (GPS) tracking, light emitting diode (LED) signalling, and a life-saving mechanism activated by a single button. When the button is pressed, it triggers global system for mobile communications (GSM) and GPS modules, sending visual and audible alerts while tracking the user's location. A survey involving 50 respondents, including members of the Malaysia Federation of the Deaf and students from Politeknik Ibrahim Sultan, was conducted to evaluate the jacket's design, usability, and overall acceptance. The results revealed high levels of satisfaction, with mean scores of 3.76 for design, 3.89 for usability, and 3.85 for overall acceptance. These findings suggest that the jacket meets user expectations and demonstrates significant potential to enhance outdoor safety for the target population. The practical implications of the jacket include reducing the vulnerability of people with hearing loss and non-verbal impairments in emergencies by providing reliable communication and location tracking. Moreover, it underscores the importance of user-centred design in assistive technology, paving the way for further innovations in wearable safety devices for individuals with disabilities. By leveraging the 4IR technologies, this multifunctional jacket addresses critical safety needs and contributes to improving the independence and well-being of individuals in modern society.

Keywords: Assistive Technology, Fourth Industrial Revolution, Hearing Loss and Non-Verbal Impairments, Smart Jacket, Wearable Safety Devices

1.0 Introduction

Individuals with disabilities encounter greater probabilities of abuse, harassment, and exploitation due to their vulnerabilities. The Department of Social Welfare Malaysia reports that 220,250 individuals are registered with various disabilities, including physical, hearing, intellectual, speech, and

visual impairments [1]. Individuals with hearing loss and non-verbal impairments are particularly at risk, as their challenges are often underestimated or overlooked, making them frequent victims of bullying and abuse. Their limited communication abilities contribute to their vulnerability, highlighting the urgent need for innovative solutions to enhance their safety and security [2], [3], [4].

Current assistive technologies provide insufficient solutions specifically developed for emergency response for these persons, highlighting a significant gap in accessibility customised to their requirements. This study proposes a unique method to wearable safety technology by designing a security-enhanced jacket specifically for hearing and speech-impaired individuals. Unlike conventional assistive devices that focus on general accessibility, this design emphasizes immediate safety in emergency situations, which is particularly critical given the worsened risks faced by these individuals. The jacket aims to provide a convenient, integrated security system that protects users while also serving as a communication device in an emergency. It involves subtle yet efficient signalling mechanisms that engage upon sensing distress, enabling immediate reactions from bystanders. The jacket prioritises safety and social interaction, successfully addressing the essential needs of this demographic and providing a practical answer to the communication barriers that frequently leave individuals with disabilities more vulnerable to victimisation [5], [7], [8], [9].

The development of this jacket offers both academic and practical innovations, especially in the field of inclusive wearable technology. It addresses a research gap by focusing on the intersection of safety and communication in wearable technology for disabled individuals, an area that has been under-explored in recent studies. This study enhances understanding of how communication features can be integrated into protective wearables, paving the way for further advancements in assistive technologies [10], [13], [14]. Moreover, the jacket's design offers scalable solutions that could inspire the development of similar technologies prioritising the safety of vulnerable populations. This research provides valuable insights for designers and developers, fostering the creation of effective, user-friendly protective gear tailored to individuals with specific communicative and physical needs, thereby promoting inclusivity and safety in everyday life [10],]11], [12], [15].

2.0 Methodology

Designing a multi-functional jacket begins with a detailed analysis, which includes sketching the design, identifying the problems, and outlining the strategies for problem-solving, along with planning the product’s functions, as illustrated in Figure 1. It is essential to assess the fabric’s strength, durability, and design techniques, as well as the process of combining different fabrics in line with current fashion trends. In addition, the selection of fabrics, patterns, and the integration of system functions should consider the overall effectiveness of the fabric and system combination [6].

The design of this multi-functional jacket consists of two parts. Part I focuses on the jacket's design, with an emphasis on aesthetics, materials, and techniques, as shown in Figure 2. Part II involves the development of the control and telecommunications systems integrated into the smart jacket, as depicted in Figure 3.

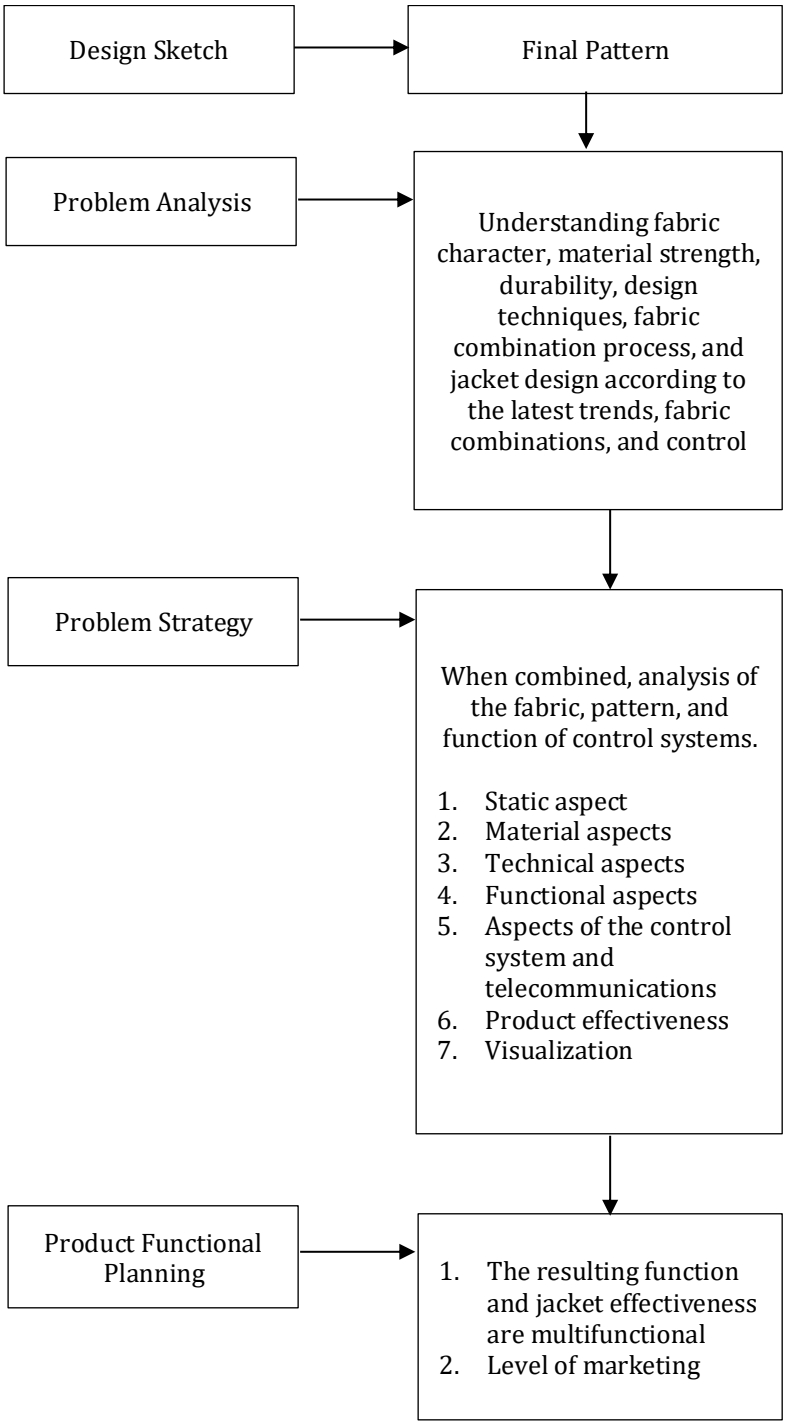

Figure 1: The design process and technology system

This study uses the ADDIE model—a systematic, phased methodology covering Analysis, Design, Development, Implementation, and Evaluation—to develop a versatile safety jacket specifically designed for individuals with impairments. During the Analysis Phase, specific requirements and obstacles experienced by individuals with disabilities, especially those with hearing and speech impairments, are identified. A survey using a five-point Likert scale collects descriptive knowledge regarding usability, functionality, and design preferences from a sample of 30 individuals with hearing impairments and 20 special needs students affiliated with the Malaysia Federation of the Deaf and Politeknik Ibrahim Sultan. The initial feedback highlights the specifications for functional wearable safety equipment, guaranteeing that it complies with user requirements and preferences.

In the Design Phase, the multi-functional jacket is developed with an emphasis on harmonising functionality and aesthetics. Design issues include material strength, durability, and the incorporation of electronic components to enhance comfort and wearability. The jacket comprises two segments: an aesthetic and material design component, highlighting appearance, fabric selection, and ergonomic fit, and a control and telecommunications component, incorporating vital safety features such as LED indicators, sound alarms, and notification systems operated by a microcontroller. These characteristics have been carefully designed to align with contemporary fashion trends, hence boosting user attraction and acceptance. The Development Phase involves the prototype of the jacket featuring integrated hardware and software elements. This includes GSM and GPS devices for location monitoring and real-time notifications, triggered by a concealed button on the jacket. The SIM900A GSM module facilitates communication at 900/1800 MHz frequencies, whereas the Arduino microcontroller monitors the LED and audio alerts to deliver visual and sound notifications during emergencies. The integration is engineered for flexibility, merging electrical components with suitable textile materials to provide user comfort and durability.

Figure 2: The design of the jacket

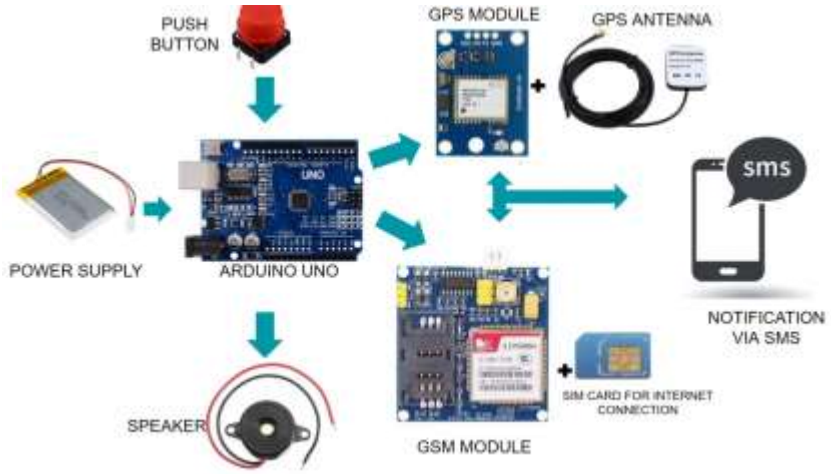

Figure 3: Circuits and parts that are utilised in the system

During the Implementation Phase, the prototype is tested by participants in simulated real-world scenarios to assess functionality, comfort, and ease of use. Data from these evaluations are utilised to enhance the jacket's design and performance, hence improving the reliability of communication features and the durability of materials. The Evaluation Phase involves the final assessments of user satisfaction, usability, and the effectiveness of the jacket's safety features, using the five-point Likert scale with the 30 individuals with hearing impairments and 20 special needs students affiliated with the Malaysia Federation of the Deaf and Politeknik Ibrahim Sultan sample group. Performance is assessed using key measures including GPS response time, battery longevity, fabric resilience, and overall comfort. The assessment additionally examines user approval, particularly about the usefulness of safety features and comfort during prolonged use. This systematic methodology guarantees a user-centred approach to creating a dependable and functional safety jacket, thus enhancing the safety and assurance of individuals with disabilities. By using ADDIE methodical strategy, the study ensures a user-centred approach for creating a useful and efficient safety jacket. The integration of comprehensive design analysis, focused user feedback, and iterative testing produces a dependable and functional solution that improves the safety and confidence of those with disabilities.

3.0 Results and Discussion

Survey findings before product is develop display significant challenges encountered by those with disabilities in expressing distress, mostly due to the public's insufficient awareness in identifying their signals. Participants mentioned that during situations, they often remain mute or struggle to signal for aid, resulting in delays in obtaining assistance from bystanders or authorities. In cases of harassment or social offenses—such as assault, abuse, or robbery—delays in assistance increase emotional turmoil and physical danger. These findings emphasise an urgent necessity for

technologies that can facilitate communication in emergencies, especially for individuals with hearing loss and non-verbal impairments. To solve these issues, a smart jacket with integrated technology that converts into a backpack was created to improve user safety and accessibility.

After its development, the evaluation of the product focused on measuring user satisfaction, usability, and the efficacy of the jacket's safety features. The study's findings revealed consistently high mean scores for each item across all tables, signifying robust acceptability and perceived utility of the smart jacket among respondents. In Table 1, scores for elements such as 'Complete jacket' and 'GPS' attained 3.89, indicating that respondents strongly valued both the multifunctional design and tracking capabilities. The bag's capacity received a score of 3.67, suggesting a possible area for enhancement if users prefer additional storage alternatives.

Table 1: Justification of types of achievements and creation

No	Item	Mean Score
1	Complete jacket	3.89
2	Bag capacity	3.67
3	GPS	3.89
4	Durable	3.73
5	2-function jacket	3.89
6	Disabled Respondents	3.89

Table 2 demonstrates that categories such as 'Individuals with disabilities requirements' and 'Receive SMS and location' had the highest ratings (3.89), emphasising the importance of these specific features for the target demographic. In comparison, the 'fabric test' received a score of 3.68, indicating that although fabric durability is appreciated, it may not be as essential as functional attributes like as GPS or emergency communication. This suggests that future versions of the jacket should prioritise the preservation of critical technology components while investigating improvements in material durability.

Table 2: Adjustment of targets and achievements

No	Item	Mean Score
1	Requirements of individuals with disabilities	3.89
2	GPS	3.87
3	Durable jacket fabric	3.79
4	Night/day Usable Jacket	3.71
5	Receive SMS and location	3.89
6	Fabric Test	3.68

The high mean scores in Table 3 (3.76 for design, 3.89 for usability, and 3.85 for acceptance level) indicate a positive response to the jacket's appearance, functionality, and usability. The findings support the conclusion that a smart jacket, especially one integrating accessibility and safety features, could significantly aid individuals with hearing loss and non-verbal impairments during outdoor activities.

Table 3: Smart jacket design

No	Item	Mean Score
1	Jacket Design	3.76
2	Jacket usability	3.89
3	Stages of reception of the jacket	3.85

The smart jacket serves a dual purpose as both a protective clothing and a backpack, incorporating advanced safety features like GPS and GSM-based tracking, thereby demonstrating the potential of 4IR technology to tackle the distinct issues encountered by those with disabilities. The significant user approval indicates that this jacket may be a feasible choice for further implementation within the impaired community. Future study may concentrate on enhancing the design, improving fabric durability, and evaluating the jacket's performance throughout a broader spectrum of real-world conditions. Furthermore, incorporating additional customisable features could increase its attractiveness and utility. Overall, this study emphasises the significance of innovative, user-centred designs in enhancing the quality of life for OKU people.

4.0 Conclusion

The outcomes of this study demonstrate that the smart jacket, designed to enhance personal safety through the integration of features such as GPS tracking, LED signalling, and a live-saving mechanism, is highly accepted by individuals with hearing loss and non-verbal communication impairments. This highlights the success of the jacket in achieving its primary objective of creating a multifunctional and user-friendly safety solution. This illustrates that the smart jacket achieves the main objective of developing a safety jacket that is both multifunctional and user-friendly. Several important features, such as the integrated safety system and the ability to convert into a backpack, effectively address user needs in outdoor contexts, enhancing both safety and independence. Future work should focus on refining the jacket’s design based on user feedback, alongside conducting field tests to optimise its performance in real-world environments. Given its significant commercialisation potential within the adaptive clothing market, this innovation aligns with the advancements of the 4IR, setting a new benchmark in inclusive design. It paves the way for greater independence and protection for individuals with disabilities, offering an opportunity to expand the scope of wearable safety technology and fostering further innovations in assistive devices.

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Author Contributions

N. A. Azhan: Conceptualization, Initial study, Methodology, Analysis, Design Jaket, Writing-Original, Draft Preparation; **A. A. Hasbollah:** Editing, Technical Content, Writing, Supervision; **N. A. Jalil:** Design, Data Collection; **M. T. Riyanti:** Writing-Reviewing, Proofreading.

Conflicts of Interest

The manuscript has not been published elsewhere and is not under consideration by other journals. All authors have approved the review, agree with its submission, and declare no conflict of interest in the manuscript.

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