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# A Conceptual Framework to Reduce Gaps in the Adoption of Robotic Exoskeletons by Therapists

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**Abstract**

In an era where technological advancements were transforming healthcare practices, the integration of robotic exoskeletons into rehabilitation therapies signified a major advancement. Despite their potential, the adoption rates of robotic exoskeletons among rehabilitation therapists remain low due to various barriers. This study was focused on developing a conceptual framework, utilizing the Technology Acceptance Model (TAM) to identify and tackle the perceptual barriers to the adoption of robotic exoskeletons, aiming to increase their acceptance among rehabilitation therapists through tailored educational initiatives. Methods included a mixed-methods approach, combining quantitative surveys and qualitative interviews to assess therapists' perceptions of the technology's usefulness and ease of use. An educational webinar and workshop will be proposed as interventions to enhance familiarity with the technology and demonstrate its clinical benefits. By addressing misconceptions and operational challenges through tailored educational initiatives, this framework aimed to improve therapists' acceptance of robotic exoskeletons. The study contributed to the ongoing discourse on technology adoption in healthcare, offering actionable insights for overcoming barriers to innovative rehabilitation tools. The proposed framework helps understand the dynamics of technology acceptance and guides effective strategies for increasing the adoption of robotic exoskeletons in clinical settings.

**Keywords**: Robotic Exoskeletons, Technology Acceptance, Rehabilitation Therapists, Conceptual Framework, Perceptions.

## Introduction

In an era marked by rapid technological advancements, healthcare is undergoing a significant transformation, increasingly emphasizing efficiency and patient-centric care. One of the groundbreaking innovations in this sector is the integration of robotic exoskeletons into rehabilitation therapies. These devices offer promising enhancements in patient recovery, particularly for those with mobility impairments due to injury or disease. The adoption of such

advanced technologies reflects a broader trend in the healthcare industry towards leveraging cutting-edge solutions to improve patient outcomes and streamline therapeutic processes.

The integration of technology in healthcare is pivotal for achieving global health targets, including those outlined in the Sustainable Development Goals (SDGs) and initiatives by major health organizations like the World Health Organization's "Rehabilitation 2030: A Call for Action." One key aspect of this global health agenda is Sustainable Development Goal 17, which emphasizes the importance of partnerships in achieving sustainable development. This goal underscores the necessity of collaborative efforts across sectors to foster innovation, enhance capacity, and share knowledge, ultimately improving health outcomes worldwide.

The "Rehabilitation 2030" initiative highlights the need for comprehensive and accessible rehabilitation services to address the growing burden of chronic diseases and injuries. It calls for increased investment in rehabilitation and the integration of technologies to enhance the effectiveness of these services. This global vision aligns with the broader trend in healthcare towards leveraging technological innovations to improve patient care and outcomes.

In Malaysia, the intention of deployment of robotic exoskeletons at the Hospital Kluster Kedah Utara (HOKKU) exemplifies the alignment of healthcare practices with national policy initiatives aimed at fostering innovative interventions. The establishment of HOKKU by the Ministry of Health Malaysia in 2010 underscores the country's commitment to enhancing healthcare services through a cluster approach, promoting collaboration among specialized hospitals. This initiative aims to optimize resource utilization, reduce patient load in tertiary hospitals, and improve access to specialized medical care.

Despite the promising potential of robotic exoskeletons, their adoption in clinical practice, particularly among rehabilitation therapists, has encountered several challenges. These include logistical issues, variance in acceptance among therapists, and the need for comprehensive training and user-centered design (De Eyto, Shore, & O'Sullivan, 2020). Understanding these barriers is crucial for effectively integrating advanced rehabilitation technologies into therapeutic practices.

This study aims to explore the factors influencing the acceptance of robotic exoskeletons among rehabilitation therapists at HOKKU. Utilizing the Technology Acceptance Model (TAM), the research assesses therapists' perceptions of the technology's usefulness and ease of use, which are pivotal for its integration into clinical practice (Davis, 1989; Venkatesh & Davis, 2000). Previous research indicates that perceived usefulness and ease of use significantly impact technology acceptance, highlighting the necessity for addressing these factors to enhance adoption rates (Klaic et al., 2022; Luciani et al., 2023).

**Research Questions**

1. What are the initial perceived gaps and attitudes of rehabilitation therapists at HOKKU regarding the adoption of robotic exoskeletons?
2. How do planned educational interventions affect therapists' perceptions and attitudes in reducing the gaps in the adoption of robotic exoskeletons?
3. How effective are the two cycles of interventions in changing the perceptions and attitudes toward the robotic exoskeletons adoption among therapists at HOKKU?

**Research Objectives**

1. To identify the initial perceived gaps and attitudes among rehabilitation therapists at HOKKU regarding the adoption of robotic exoskeletons, with a focus on understanding existing barriers and facilitators.
2. To assess the impact of educational interventions on altering therapists' perceptions and attitudes in bridging gaps for the adoption of robotic exoskeletons, measuring the effectiveness of educational interventions to clarify misconceptions and improve understanding of the technology's benefits.
3. To evaluate the effectiveness of two cycles of interventions in modifying perceived gaps and attitudes related to the adoption of robotic exoskeletons among therapists at HOKKU.

**Significance of the Study**

Addressing the barriers to the adoption of robotic exoskeletons is essential for aligning clinical practices with the ambitious healthcare reforms outlined in Malaysia's National Fourth Industrial Revolution Policy (2021), and the Health White Paper for Malaysia (2023). By understanding and mitigating the challenges faced by rehabilitation therapists, this study aims to contribute to the broader goal of integrating innovative rehabilitation technologies into clinical practice, ultimately improving patient outcomes and advancing the field of rehabilitation.

**Materials and Methods**

This study will explore the acceptance and integration of robotic exoskeletons in rehabilitation practices at Hospital Kluster Kedah Utara (HOKKU), using the Technology Acceptance Model (TAM) as the framework. The research will investigate the factors influencing rehabilitation therapists' perceptions and attitudes of the technology's usefulness and ease of use.

**Research Design**

A mixed-methods design combining quantitative and qualitative approaches will be used to gather comprehensive data on the acceptance of robotic exoskeletons among rehabilitation therapists.

**Quantitative Data Collection**

A structured online survey based on the TAM framework will be distributed to the physiotherapists and occupational therapists at HOKKU. The survey will include demographic questions and TAM constructs such as intention to use, usefulness, anxiety, time-saving, effort-saving, subjective norms, and ease of use, using a Likert scale for responses.

**Qualitative Data Collection**

Structured virtual group interviews and Q&A sessions will be conducted with senior therapists. Open-ended questions will explore their experiences, perceived barriers, and suggestions for improvement. Sessions will be recorded and transcribed for analysis.

**Educational Interventions**
A webinar and workshop featuring technology demonstrations and patient case studies will be conducted. Pre- and post-webinar surveys will assess changes in therapists' perceptions and knowledge.

**Quantitative Analysis**
Statistical software will be used for data analysis. Descriptive statistics will summarize the data, and inferential tests will identify significant differences in perceptions before and after interventions. Regression analysis will explore relationships between TAM constructs and adoption likelihood.

**Qualitative Analysis**
Thematic analysis will be performed on transcribed interviews and notes, identifying recurring themes and patterns. The qualitative data will be triangulated with quantitative results for comprehensive insights.

**Validity and Reliability**
This study will adopt the well-established TAM questionnaire, which has been validated in prior research, eliminating the need for additional validation procedures. The adopted TAM questionnaire's reliability is well-documented in the previous study, so calculating Cronbach's alpha will be unnecessary. For the qualitative components, reliability will be ensured through collaborative coding and consistent data interpretation by multiple researchers. Rigorous protocols for data collection and analysis will maintain uniformity across all stages of the research.

**Theoretical framework**
The theoretical underpinning of the study was based on the original Technology Acceptance Model (Figure 2.11), which served as a robust framework for understanding the acceptance of new technologies. The model emphasized two main factors—Perceived Usefulness and Perceived Ease of Use—that influenced an individual's decision to adopt a technology. In the context of this study, the TAM was specifically adapted to address additional factors pertinent to the healthcare environment such as time-saving, effort-saving, subjective norms, willingness to interact/participate in the therapy, and anxiety.

The study explored the potential improvements in patient rehabilitation outcomes and overall health through the use of robotic exoskeletons. It also assessed the impact of this technology on therapist-patient interactions, noting possible enhancements in therapy sessions due to more engaging and effective treatment methods. Additionally, the research considered the role of institutional support in the adoption of robotic exoskeletons, highlighting the importance of training, resource allocation, and policy support within healthcare institutions.

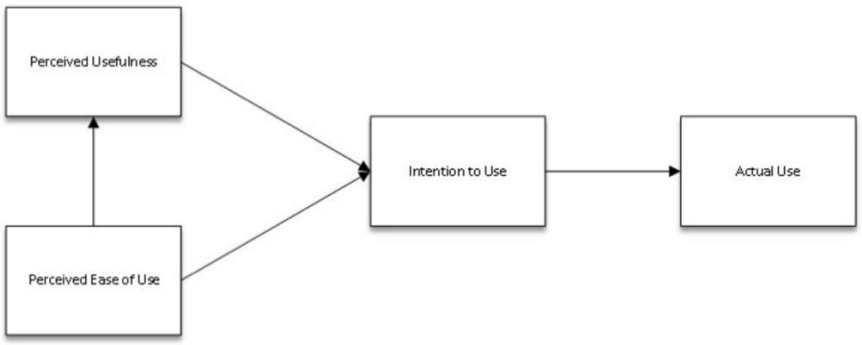


Figure 2.11: The original TAM framework

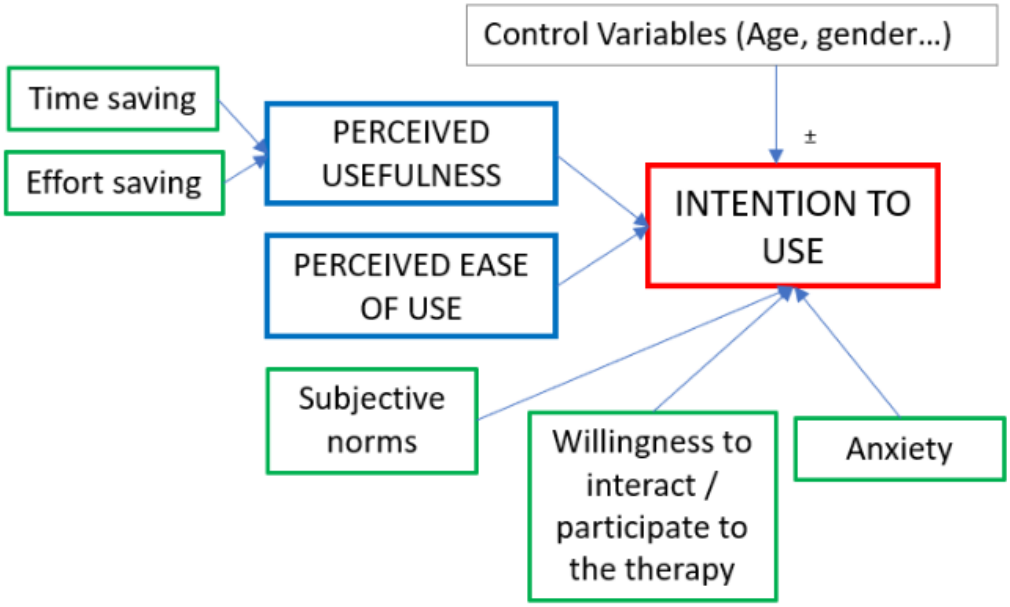


Figure 2.12: The conceptual theoretical framework adopted from Luciani et.al. (2023).

Table 2.13
*Summary of Past Studies and Interventions*

| Authors | Interventions |
|---|---|
| Davis, 1989 | Introduced the TAM framework, focusing on Perceived Usefulness and Perceived Ease of Use. |
| Venkatesh & Davis, 2000 | Developed TAM2, incorporating factors like subjective norm and output quality for a deeper understanding of user acceptance. |
| Venkatesh et al., 2003 | Created the UTAUT, synthesizing earlier models to include broader factors like social influence. |
| Venkatesh & Bala, 2008 | Proposed TAM3, adding factors affecting Perceived Ease of Use, such as computer self-efficacy and enjoyment. |
| Venkatesh, Thong, & Xu, 2012 | Updated UTAUT to UTAUT2, aiming at a comprehensive model for technology adoption in both personal and organizational contexts. |
| Liu et al., 2014 | Applied UTAUT in rehabilitation technology, emphasizing performance expectancy in therapists' acceptance. |
| Linda Shore, et al., 2020 | Explored older adults' acceptance of robotic assistive devices using the TAM framework |
| Klaic et al., 2022 | TAM2 to explore clinicians' acceptance of rehabilitation robotics. |
| Luciani et al., 2023 | Investigated the acceptability of exoskeletons for upper limb rehabilitation using TAM, focusing on perceived usefulness from therapists' perspectives. |
| Michelle et al., 2023 | Applied TAM to evaluate the effectiveness of training and familiarity on the adoption of technology-based interventions for upper limb rehabilitation |

**Proposed Interventions**

The research proposed specific educational interventions to mitigate barriers to adoption and enhance acceptance among therapists. These included:

a) Educational Webinar: An educational webinar will be designed to introduce therapists to robotic exoskeletons, highlighting key features, benefits, and the theoretical science behind the technology. The aim is to improve therapists' understanding and comfort level with the technology, addressing any misconceptions and providing a platform for questions and discussions.

b) Hands-on Workshops: Following the webinars, practical hands-on workshops will be conducted to offer therapists direct interaction with the robotic exoskeletons. These sessions are crucial for demonstrating the practical applications of the technology in a controlled environment, allowing therapists to experience firsthand how the exoskeletons operate and how they could be integrated into their therapy routines.

These interventions designed to not only increase familiarity with the technology but also to showcase its clinical benefits, helping to dispel fears and build confidence among healthcare providers about integrating these advanced tools into their practice. The ultimate goal was to foster a positive perception of robotic exoskeletons, thereby increasing the likelihood of their adoption in clinical settings. Through this framework, the study aimed to contribute

significantly to the ongoing discourse on technology adoption in healthcare, offering actionable insights and strategies to overcome the existing barriers to the use of innovative rehabilitation tools.

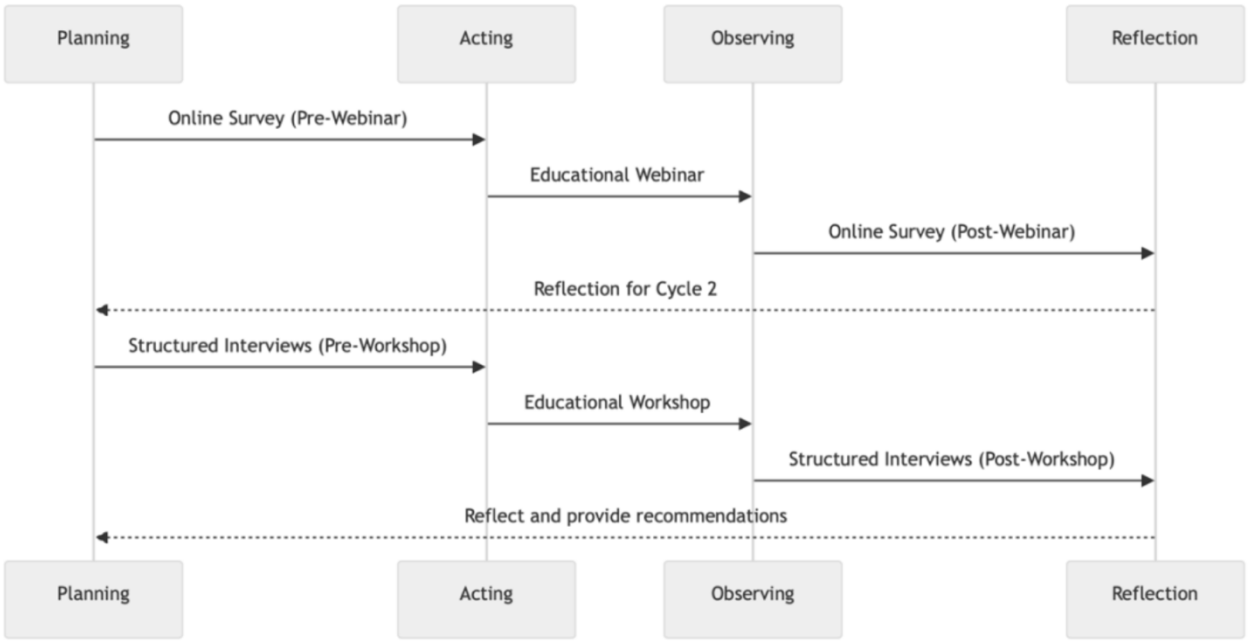


Figure 2.21: Proposed Interventions For Action Research

**Discussion**

In the discussion section, the dialogue explored potential pathways for integrating the proposed framework into existing healthcare practices, taking into account organizational, cultural, and technological factors. It also highlighted the role of continuous professional development and policy support in fostering technology acceptance. This exploration was informed by an understanding that the successful integration of robotic exoskeletons requires a comprehensive approach that addresses not only the technical capabilities of the devices but also the human and systemic dimensions of their use in clinical environments.

The discussion emphasized how organizational support, including leadership endorsement and resource allocation, was crucial for the successful adoption of robotic exoskeletons. The cultural readiness of the institution to embrace innovative technologies also played a significant role, as it influenced therapists' willingness to adopt new practices. Technological factors, such as the compatibility of exoskeletons with existing medical equipment and the infrastructure of healthcare facilities, were considered to ensure seamless integration.

Moreover, the discussion underscored the importance of continuous professional development programs that could provide ongoing education and training for therapists. These programs were seen as vital for ensuring that therapists not only felt competent in using the new technologies but also understood their potential benefits and limitations. Policy support was also deemed essential, as it could provide the necessary guidelines and incentives for adopting such advanced technologies in clinical settings, aligning with broader healthcare objectives and regulations.

By considering these multifaceted aspects, the discussion aimed to outline effective strategies for overcoming barriers to technology acceptance and to ensure that the integration of robotic exoskeletons into rehabilitation therapies was both successful and sustainable.

## Conclusion

In conclusion, the conceptual framework aimed to provide a structured approach for understanding and reducing the gaps in adopting robotic exoskeletons in rehabilitation therapies. It emphasized education and perception management to align the technology with clinical needs and practitioner expectations. Educational interventions like the webinar and workshop were highlighted as crucial for enhancing therapists' familiarity with the technology and addressing operational challenges. This strategic focus was intended to facilitate smoother integration of new technologies into existing healthcare practices, ultimately improving patient outcomes and therapist engagement with robotic exoskeletons.

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