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A USABILITY STUDY OF THE AUDIO-TACTILE MAP FOR VISUALLY IMPAIRED USERS AT THE MALAYSIAN ASSOCIATION FOR THE BLIND (MAB)

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Abstract:

At the Malaysian Association for the Blind (MAB) building, the audio-tactile map has been installed on the ground floor to help and guide visual impairments in wayfinding. However, the usability of the audio-tactile map in helping them in wayfinding at the MAB has not been tested yet. In fact, the understanding of the users' motivation for using the audio-tactile map has still not been studied. Thus, this research aims to describe the usability and to understand users' motivation in using the audio-tactile map for visually impaired users in wayfinding at the MAB. Furthermore, a qualitative method study will be conducted by doing a user test and an interview with six participants from the MAB, focusing on the usability and users' motivation in using the audio-tactile map to help them in wayfinding. Nielson Usability Model and Thematic Analysis with Affinity Diagram tools were applied in this research to analyze the data. The findings from this research have described the usability of the audio-tactile map among visually impaired users at the MAB, which includes efficiency, learnability, satisfaction, errors, and memorability. Also, the findings showed that the audio-tactile map features affected the users' motivation to use the audio-tactile map for wayfinding at the MAB.

Keywords:

Visually Impaired, Wayfinding, Audio-Tactile Map, Usability, Motivation

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Introduction

The Vision Loss Expert Group (VLEG) estimates that 596.3 million people worldwide are affected by visual impairment: 258 million with mild impairment, 295 million with moderate to severe impairment, and 43.3 million who are blind. Griffin et al. (2020), stated that people with visual impairments can experience numerous challenges in their daily lives, including navigating unfamiliar environments.

In this modern era, some technologies operating as wayfinding tools such as sensor-based walking sticks and interactive maps can assist users with visual impairments, yet the application is still limited. Besides, a deficiency of mobility is a severe limitation for visually impaired users as mentioned by Brouwer et al. (2005), and according to Hina Alam (2019), fewer visually impaired users can read braille because it is used for textual descriptions only.

In Malaysia, the audio-tactile map has just been developed and installed on the wall of the ground floor at the Malaysian Association for the Blind (MAB). This audio-tactile map was made up of a raised-line map overlay placed atop a multi-touch screen, a computer linked to the screen, and audio for speech output. Users could examine the raised-line map on top of the screen with both hands just as they would a tactile paper map. Instead of reading a braille legend, users could acquire street and building names by touching the map items (Brock & Jouffrais, 2015). However, the audio-tactile map is still not well known and has only been used by MAB's visually impaired students and staff. Hence, the usability of the audio-tactile map in giving wayfinding to them has not been tested yet.

Significantly, it is important to develop, enhance, and apply a new way of wayfinding for people with visual impairments, such as using the audio-tactile map. From the Tactile-speaking plan, an audio-tactile map is a wayfinding technology that is ideal for transferring environmental information in a visual, tactile, and sound way.

Thus, this research will be conducted to describe the usability and to understand users' motivation in using the audio-tactile map for visually impaired users in wayfinding at the MAB.

Literature Review

Visual Impairment

Visual impairments, which include low vision and blindness, relate to any degree of impairment to a person's ability to see that interferes with his or her everyday activities. Although blindness strictly refers to a complete loss of vision, the term is frequently used to refer to significant visual impairments that necessitate the primary use of nonvisual sensory input. Low vision is a term that refers to visual impairments that are less severe than blindness but nonetheless affect a person's ability to carry out daily activities. Individuals with low vision may require the use of tools and procedures to augment their ability to use their limited vision, or they may need to do activities through nonvisual means (Sapp, 2003).

According to Kidshealth.org. (2016), visual impairment is a term or phrase used by professionals to refer to any type of vision loss, whether the individual is completely blind or has just partial vision. While some individuals are totally blind, many others suffer from what is known as legal blindness. They haven't fully lost their sight but have lost enough eyesight that they would need to stand 20 feet away from an object to see it as clearly as someone with

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perfect vision could from 200 feet away. In 2006, the National Health Service in England revised its definition of visual impairment as follows: "Due to a change in the terminology used in the registers, blind and partially sighted individuals should now be referred to as severely sight impaired (blind) and sight impaired (partially sighted). This adjustment was requested by service users/patients because it more accurately depicts their status, as those who are technically blind or partially sighted may retain functional residual vision" (Hayhoe, 2012).

Wayfinding

The phrase "wayfinding" refers to orienting and navigating across an environment. It is the ability of travellers to know where they are and where they are going based on where they have previously been (Parker, A. T. et al., 2021). Wayfinding is critical in complicated constructed contexts such as metropolitan centres, healthcare and educational institutions, and transit hubs. As architectural surroundings get increasingly complex, people require visual clues such as maps, directions, and symbols to assist them in navigating. Effective wayfinding systems add to a sense of well-being, safety, and security in these frequently high-stress circumstances.

Another definition of wayfinding by Symonds et al. (2017), is the cognitive and bodily process and experience of locating, following or discovering a path through or to a particular location. Wayfinding in the past was wrongly classified as a cognitive and decision-making process, but recent and updated research demonstrates that wayfinding is a complex activity that spans multiple fields of study. Wayfinding is a highly sociological activity. In many instances, such as while looking for a sports stadium, we follow other individuals. The concept of group behaviour is quite prevalent in wayfinding. Similarly, psychology is critical, as we make conscious choices in order to travel from A to B.

As stated by Wiegand (2021), for years, we've relied on navigational systems such as the Global Positioning System (GPS) to assist us in navigating outside, yet this form of positioning is incapable of penetrating the enormous, complex structures that populate our globe. Indoor positioning systems (IPS) are the technology that enables this approach. Modern smartphones are the most often used devices for wayfinding, as they contain an array of sensors that may be combined with GPS technology. It enables consumers to grab their phone, locate the map, and navigate indoors, just as they can with Google Maps outdoors.

From the Tactile-Speaking Plan (2024), the audio-tactile map (the facility layout) is ideal for conveying environmental information visually, tactilely and audibly, especially for visually impaired users. It has a common structure but varies in application facilities such as entrance units, a water closet, a park, an underground route, a public transportation station, and many more. The use of audio-tactile maps during the adaptation of social infrastructure facilities enhances the status and accessibility of such facilities significantly, focusing on the difficulties of individuals with visual impairment.

Furthermore, one of the essential features of the audio-tactile map is its ability to adapt to multiple foreign languages at the same time. According to Landau et al. (2006), audio-tactile maps, which may be accessed via a touchpad device, appear to compensate for the limitations of tactile maps. Tactile assistance appears to entail extensive braille labelling, whereas the volume of information and intricate images necessitate a higher memory load, which affects spatial coding and representation. Incorporating soundscape and audio information about names of locations (cities, streets, etc.), spatial relations, descriptions of buildings, and major

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features, such as traffic signals or barriers, into a tactile map can be extremely beneficial to people with visual impairments. It has been proposed that merging auditory and tactile information may result in a more comprehensive concept by presenting information in a more effective manner.

Furthermore, Papadopoulos & Barouti (2015) stressed that because touchpads allow for the incorporation of environmental auditory cues into the tactile map, they may aid in an individual's orientation, as individuals with visual impairments have been shown to use auditory cues to determine and maintain orientation within an environment. It also associates the soundscape with the structural and spatial configuration of the landscape and, finally, creates cognitive maps. Individuals with visual impairments can construct a cognitive map utilizing an audio-tactile map and a touchpad device.

Usability in Human-Computer Interaction (HCI)

Nielsen J. (2012) stated that usability is a quality criterion that evaluates how simple user interfaces are to use. The term "usability" also refers to strategies for enhancing ease-of-use during the design phase. Furthermore, five quality components define usability such as learnability, efficiency, memorability, errors, and satisfaction. Meanwhile, The Interaction Design Foundation defined human-computer interaction (HCI) as a multidisciplinary topic of study that focuses on the design of computer technology and, more specifically, the interaction of humans (users) and computers. While it began with computers, HCI has grown to encompass nearly all aspects of information technology design.

Usability and HCI are increasingly critical components of the system development process in order to improve and increase system capacities and meet the demands and requirements of users. HCI will aid designers, analysts, and users in determining system requirements based on text style, fonts, layout, colour, and also graphics. Furthermore, usability will determine whether the system is efficient, effective, safe, useful, easy to learn, remember, use, and assess, as well as practical and visible to the users (Issa & Isaias, 2015).

Nielson’s model of usability was among the first to establish usability attributes. Nielsen's previous approach had only four attributes such as effectiveness, efficiency, satisfaction, and learnability. He eventually dropped the effectiveness and replaced it with memorability and errors in his new model. He identified the following attributes, which are shown in Table 1 below.

Table 1: Nielsen’s Usability Attributes

Attributes	Explanations
Efficiency	Resources are used in completing a task accurately to achieve user goals.
Learnability	The ease with which the system can be learned is that the user can start using it to perform tasks in the minimum amount of time.
Satisfaction	The product should provide comfort and also give the user a positive attitude towards using it.
Errors	The system's error rate should be minimal so that the user makes the least number of errors when using the system. If some errors are made, they should be

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	recovered easily. Finally, catastrophic errors should be avoided.
Memorability	One should be able to easily memorize the system to the extent that when even a casual user begins using it after a substantial period, they do not have to put effort into learning everything from the beginning.

On the other hand, Norman's model of interaction in usability (Thuseethan & Kuhanesan, 2015) focuses on the user's point of view. Norman characterizes the user's cognitive process as the engagement with technology in daily life using psychology. Norman's paradigm involves two phases which are execution and evaluation. Each phase comprises seven unique steps in total. The identified steps are shown in Figure 1 below.

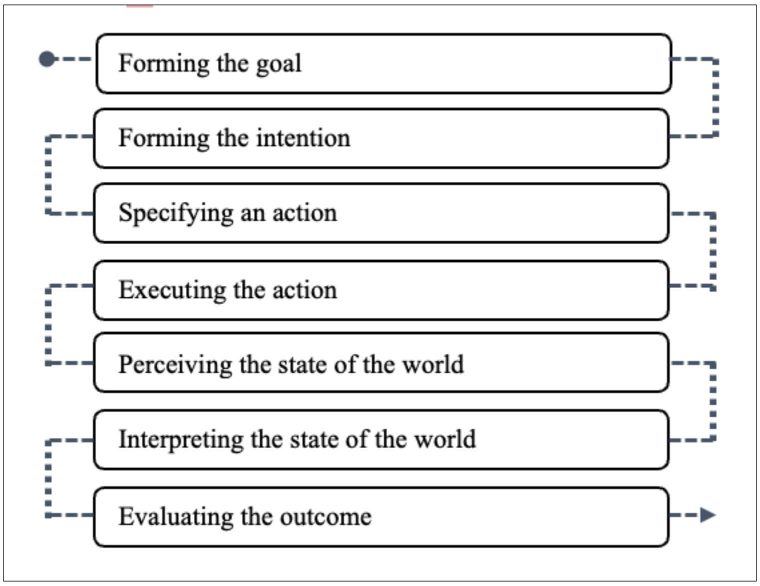

Figure 1: The 7 Steps in Norman's Model of Interaction

Motivation in Human-Computer Interaction (HCI)

In the Market Business News (2021), Nordqvist mentioned that motivation can be defined as the reason why a person acts or behaves in a certain manner. It also motivates people's desire and readiness to act. Enthusiasm is there when there is motivation. Motivation is an internal phenomenon; it resides inside us. It influences our actions and behaviours. Motivation may also refer to the arguments or evidence used to support a proposition. Consider the following phrase: "We hereby offer the following proposal and justification for consideration". In HCI, every technology can have a purposeful or unintentional influence on psychological well-being, such as user motivation. For instance, consider the nuanced impacts emerging from the instant connectivity made possible by smartphones. There are two theories of motivation that are related to this research.

Firstly, Maslow's hierarchy of needs by McLeod S. (2007) stated that motivational theory in psychology consists of a five-tier model of human needs, sometimes represented hierarchically as a pyramid. Prior to addressing wants that are higher on the hierarchy, individuals must satisfy demands that are lower on the hierarchy. As shown in Figure 2, the hierarchy of needs is comprised of physiological, safety, love and belonging, esteem, cognitive needs, aesthetic

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needs, self-actualization, and transcendence. In general, there are several sources of motivation, such as goals, values, and the drive for accomplishment, as well as biological requirements and relatedness. Maslow's hierarchy aims to reach the self-actualization level or stage.

This implies that, according to the theory by Kroth M. (2007), in order for motivation to emerge in the next step, each preceding stage must be met. The hierarchy has been used to describe the relationship between effort and motivation in the context of human behaviour. Each of these levels requires a particular degree of internal sensation in order for an individual to reach the top of their hierarchy. In both practitioner and academic publications, Maslow's Hierarchy of Needs is frequently cited as an example of motivational theory. However, a substantial amount of motivational research is being undertaken that is neither publicly recognized nor implemented in practical contexts.

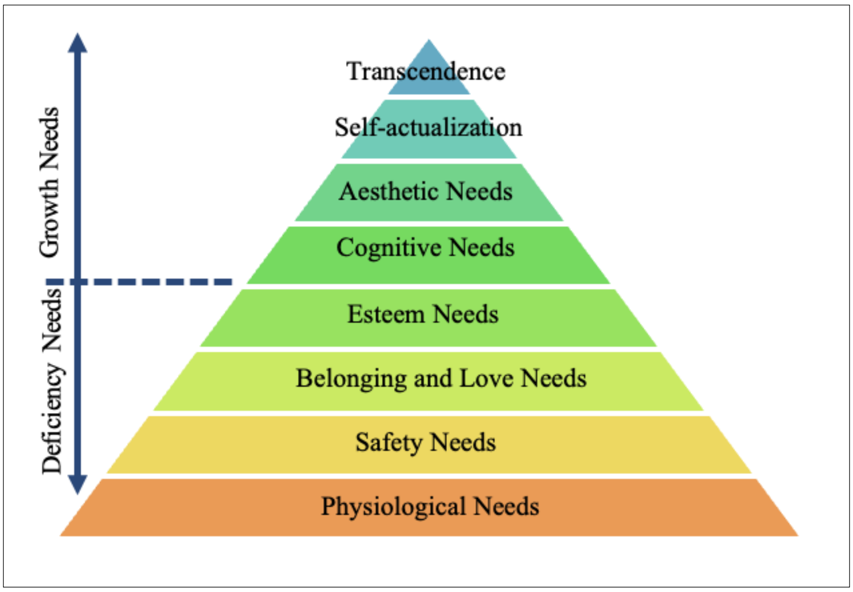

Figure 2: Maslow's Hierarchy of Needs

Secondly, according to Legault (2017), the Self-Determination Theory (SDT) is a wide theory of human motivation and personality that looks at how people interact with and depend on their social environments. The SDT identifies intrinsic motivation as well as many extrinsic incentives and describes how these motivations affect personality, social and cognitive development, and situational reactions in several areas. The core of SDT is the psychological need for relatedness, competence, and autonomy and how important they are to self-determined motivation, well-being, and growth.

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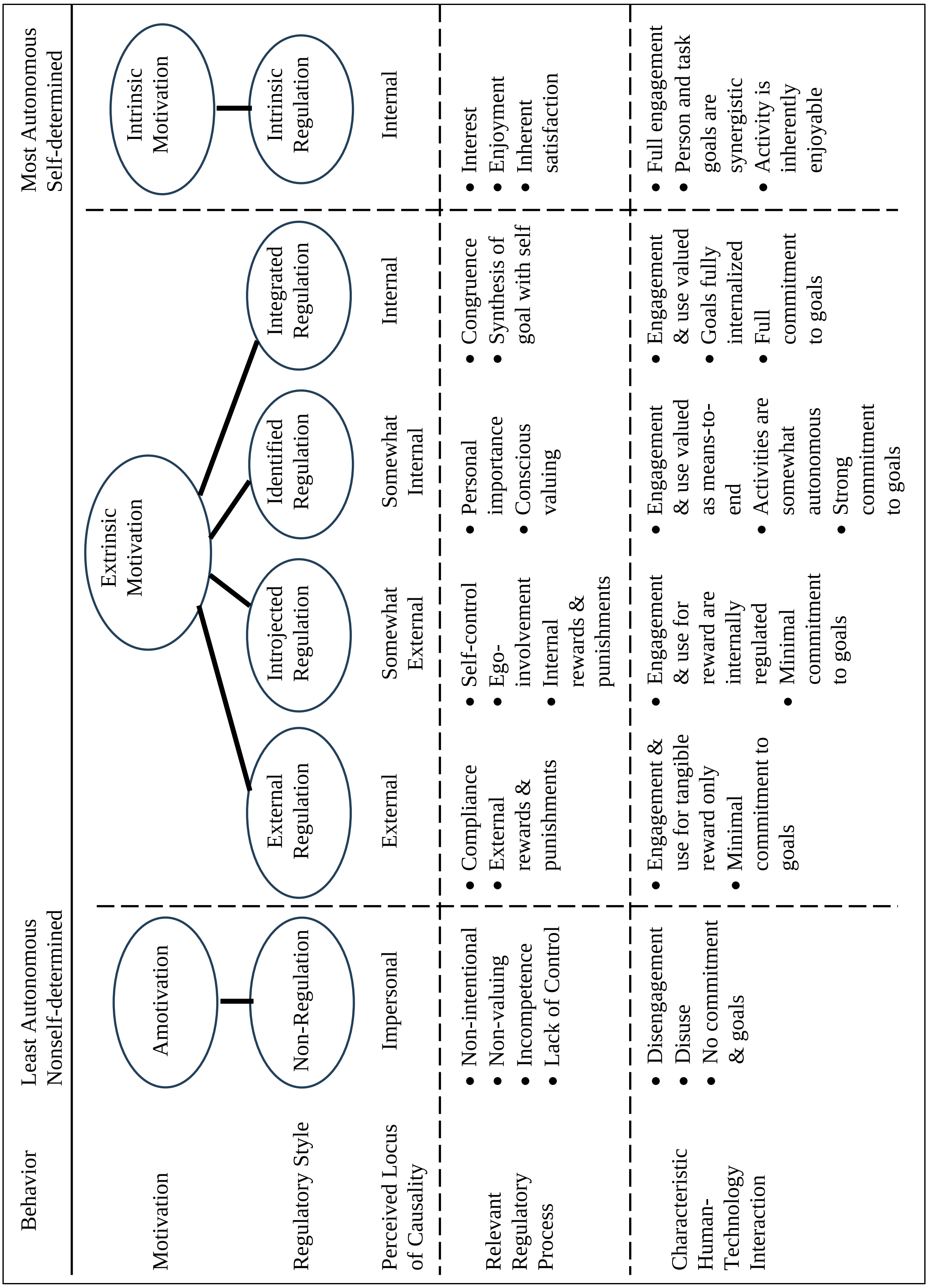

SDT is a comprehensive paradigm for analyzing human motivation. SDT articulates a meta-theory for structuring motivational investigations, a formal theory that specifies intrinsic and diverse extrinsic sources of motivation, and a description of the relative roles of intrinsic and extrinsic motivation in cognitive and social development as well as individual variations. In addition to people's well-being and performance quality, SDT proposals also examine how

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social and cultural variables promote or inhibit their feeling of volition and initiative. Conditions that promote the individual's feeling of autonomy, competence, and relatedness are believed to encourage the most volitional and high-quality kinds of motivation and engagement with activities, such as improved performance, persistence, and creativity (Selfdeterminationtheory.org., 2024).

Methodology

The method used in this research is qualitative, which are the user test, and an interview will be conducted to collect the data. Generally, qualitative research is a method for examining and comprehending the meaning assigned by individuals or groups to a social or human situation. The research process entails developing study questions and procedures, collecting data in the natural environment of the participant, analyzing the data inductively by progressing from particulars to broad themes and making judgements about the meaning of the data. Table 2 below shows the research design for this research.

Table 2: Research design

Research question	Research objective	Method	Deliverable
How useful is the audio-tactile map in helping visually impaired users in wayfinding at Malaysian Association for the Blind (MAB)?	To describe the usability of the audio-tactile map that helps visually impaired users in wayfinding at the Malaysian Association for the Blind (MAB).	User test	Usability of the audio-tactile map in wayfinding for visually impaired users at the Malaysian Association for the Blind (MAB).
What motivates visually impaired users at Malaysian Association for the Blind (MAB) to use the audio-tactile map for wayfinding?	To understand visually impaired user motivation in using the audio-tactile map at the Malaysian Association for the Blind (MAB) for wayfinding.	Interview	Visually impaired users’ motivation in using the audio-tactile map for wayfinding at the Malaysian Association for the Blind (MAB).

Planning is the first phase of this research. Planning is a critical phase since it allows for the identification of topics relevant to this study's objective, such as the topic, problem statement, project background, etc. Additionally, it can affect all steps, which is why this step must be highlighted to ensure the success of this research study. Thus, the preliminary interview was conducted with Mdm. Sumitha from the MAB to define and gather more information on the research background, research questions, problem statement, objective, research scope, and target literature.

The second phase of this research is data collection, which is mainly concerned with the user test and an interview. Firstly, an early interview will be conducted to gather the participants' backgrounds. From the interview question in Section A: Demographic Information, nine questions will be asked to the participants. Next, the user test on the audio-tactile map using Nielsen Usability Model will be conducted to see their efficiency, learnability, satisfaction,

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errors, and memorability. For this, the participants among visually impaired users from the MAB, will be divided into three groups, Group B1: participants with total blindness; Group B2: participants with severe visual impairment, and Group B3: participants with moderate visual impairment, will be observed. A few data will be recorded, such as time and location accuracy. After the user test, the interview was conducted individually to understand their motivation in using the audio-tactile for wayfinding at the MAB. There are six open-ended questions in Section B that were asked during the interview session. Once the interview is done, the data will be analyzed using the Thematic Analysis that uses an Affinity Diagram.

Results

User Test for the Usability
From the observation during the user test, researchers have described the five attributes such as learnability, memorability, efficiency, errors, and satisfaction based on the Nielsen Usability Model, as below:

Learnability and Memorability
The participants should be able to easily learn how to use the audio-tactile map when performing the tasks. Researchers observed that there is a variation in the participants' performance in using the audio-tactile map. Also, from the observation, there were four participants (P1, P4, P5, and P6) who learned and memorized every location on the audio-tactile map. In contrast, two participants (P2 and P3) did not really memorize all those locations on the audio-tactile map.

Efficiency
Most of the participants were able to use the audio-tactile map and find the assigned locations when performing the tasks. Although some of them have taken more time to perform the tasks than the others, they might have been able to follow. Researchers also observed that tactile symbols such as the audio button on the audio-tactile map and instructions from the audio had affected the participants' performance. Aside from that, two participants (P1 and P3) expressed difficulty and confusion when using the audio-tactile map. However, the use of the audio-tactile map in helping all six participants with wayfinding around MAB's ground floor was efficient when all the eight assigned locations were accurate.

Errors
The observation showed a meagre error rate in using the audio-tactile map for wayfinding at the MAB. Only two participants (P2 and P3) showed minor errors while analyzing the shape of tactile symbols in the audio-tactile map. In comparison, four participants (P1, P4, P5, and P6) had no error while using the audio-tactile map to assist them in wayfinding.

Satisfaction
Five of the participants (P2, P3, P4, P5, and P6) explained and showed their satisfaction in using the audio-tactile map to help them in wayfinding at the MAB.
"I was satisfied because it has helped me with the wayfinding at the MAB." (P2)
"I am very satisfied with the audio-tactile map because the instruction given is very clear." (P3)
"Very satisfied because of the clear information and wayfinding instructions at the MAB." (P4)

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"Just satisfied. Because easy for me to reach the destination that I want to go to at the MAB." (P5)
"Very satisfied because of all the locations at the MAB's ground floor stated on the map." (P6)
In contrast, only one participant (P1) mentioned that she was not satisfied with the usability of the audio-tactile map to assist her in wayfinding at the MAB.
"Not satisfied because there is confusion between the audio button with the tactile symbol." (P1)

Overall, the usability of the audio-tactile map can be described as easy to learn, can be memorized, very efficient, has low errors rate, and meets users' satisfaction.

Thematic Analysis using Affinity Diagram
Thematic Analysis involves grouping the themes or commonalities discovered in the original codes. After researchers had arranged an array of codes and keywords, the data were classified into themes with which they were familiar. Researchers have discovered the necessary initial codes for the third phase. Then the sub-themes are categorized into single themes as shown below in Table 3.

Table 3: Categorization of Codes into Sub-Theme and Single Theme

Codes	Sub-Theme	Theme
1. Movement		
2. Wayfinding		
3. Easy	Emotion	
4. Fast		
1. Useful		Motivation
2. Information	Interest	
3. Satisfaction		
1. Audio		
2. Braille		
3. Symbol	Function	Features
4. Surface		
5. Language		

After the codes and themes had been restructured many times, the themes were reconsidered by selecting the theme that was closest to the topic of the codes. One of the themes was therefore, rebranded as a new theme. As indicated in Table 4 below, the other theme remained and appeared to create a cohesive pattern.

Table 4: Reviewing The Theme

Previous Theme	New Theme
1. Motivation	User Motivation
2. Features	Audio-tactile Map Features

Using all of the available data, researchers have crafted an overarching story. Each theme and its corresponding story were studied to determine whether any of the themes had sub-themes. Table 5 below depicts the Final Affinity Diagram.

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Table 5: Final Affinity Diagram

User Motivation	Audio-tactile Map Features
1. Participants are motivated to use the audio-tactile map for them to move anywhere in MAB without others' help. 2. Participants were using the audio-tactile map for helping them with wayfinding at the MAB. 3. By using the audio-tactile map, it is easy to find the location at the MAB. 4. The audio-tactile map is fast compared to other wayfinding tools when looking for the location at the MAB. 5. The audio-tactile map is very useful in helping them with wayfinding at the MAB. 6. The audio-tactile map provided clear and accurate information about the MAB's ground floor. 7. Participants were very satisfied because it really helped them in wayfinding at the MAB's ground floor	1. Audio 2. Braille 3. Symbol 4. Surface 5. Language

Conclusions

A user test and an interview have been conducted physically by researchers with visually impaired users at the MAB to fulfil both objectives of this research study. Essentially, this research study has described the usability of the audio-tactile map and understands users' motivation in using the map for wayfinding at the MAB. In conclusion, the research study has fulfilled both objectives stated earlier.

Objective 1: To describe the usability of the audio-tactile map that helps visually impaired users in wayfinding at the Malaysian Association for the Blind (MAB).

From the analysis and findings in this research study, the objective for this has been fulfilled. Researchers were able to describe the usability of the audio-tactile map that helps visually impaired users at MAB in wayfinding. The audio-tactile map was described as easy to learn and memorize, very efficient, low error rate, and most of the visually impaired users were satisfied with using it.

Objective 2: To understand visually impaired users' motivation in using the audio-tactile map at the Malaysian Association for the Blind (MAB) for wayfinding.

The objective to understand visually impaired users' motivation in using the audio-tactile map at the MAB also has been fulfilled. From the analysis and findings using the Thematic Analysis, the answers from the interview session have shown most participants are motivated to use the audio-tactile map because the features were easy to use in wayfinding at the MAB. Those features like audio and tactile in the map really helped them to find every location on the MAB's ground floor, as it provides complete information and instructions.

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