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ENHANCING THE BLIND PATH AT A LARGE PUBLIC UNIVERSITY BY USING BLUETOOTH TECHNOLOGY

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ABSTRACT

The present study is geared toward documenting, imperially evaluating, and improving the usefulness of the newly constructed tactile paving path at King Abdulaziz University (KAU), Jeddah, Saudi Arabia. KAU is one of the oldest and largest government funded universities in Saudi; with more than 80,000 enrolled students, among them 200 students with vision impairments, the majority of them are blind. KAU has installed tactile paving to provide independence and freedom of movement around its campus for the visually impairedstudents. After using the path for few months, the Center for Students with Special Needs (CSSN) has realized a good level of students' satisfaction using the path, thus would like to further enhance the effectiveness of the path, by adding Bluetooth technology, so users can hear voice guidance during their commute around campus. This research was aimed at empirically evaluating the effectiveness of adding Bluetooth technology to the tactile path. This research discusses the practical implication and lessons learned from adding Bluetooth technology to aid visually impaired students to move safely and independently around campus.

KEYWORDS: Accessible Built Environment, Ergonomics, Tactile Paving, Human Factors, Visually Impaired.

1. INTRODUCTION

According to the World Health Organization (WHO), Disability is a complex, multidimensional, dynamic, and contested term. It can be defined as "an umbrella term, covering impairments, activity limitations, and participation restrictions. Impairment is a problem in body function or structure; an activity limitation is a difficulty encountered by an individual in executing a task or action; while a participation restriction is a problem experienced by an individual in involvement in life situations." (WHO, 2019). The American with Disability Act (ADA) defines disability as "physical or mental impairment that substantially limits one or more major life activities" (ADA. (2019).

Over the years, many models have been developed trying to explain disabilities and its interaction with society; which include (Bickenbach et al. 1999):

- Moral Model: A very old model, which defines disability as a consequence of persons' bad deeds.
- Charity Model: Also, an outdated model, which states that people with disabilities are often treated as objects of charity and pity.
- Medical Model: People with disabilities were considered as sick and needing to be fixed, cured, and cared for with medical intervention and rehabilitation.
- Social Model: disability-related problems result from an inaccessible social structure, as contrasting to the disability itself.

The Convention of the Right of Persons with Disabilities (CRPD) was ratified by 177 countries around the globe; based on the Social Model of Disability, and calls for inclusion and equality of people with disabilities in every aspect of life (Convention on the Rights of Persons with Disabilities, 2019).

People with disabilities may also be categorized into four major classifications: physical disabilities; hearing disabilities; visual disabilities; and cognitive disabilities (Crow, 2008). According to (Bourne et al., 2017) it was estimated that 36 million people were blind worldwide, and 216 million people had moderate to severe visual impairments, in 2015 around the globe.

Visually impaired people use white canes and create a mental map for the environment and places around them (Center on Technology and Disability, 2018). Visually impaired people might benefit greatly from using tactile paving; which are tiles that are mounted in or slightly above the pavement, in their built environments as depicted in Figure 1. Tactile paving was introduced in Japan in 1967, and adapted in different ways by many nations afterwards (Tactile paving, 2019).

Figure 1: Tactile Paving.

Tactile paving blocks have two basic shapes: the long striped which means a clear way to move, and the cones or "truncated domes", which is used as decision points; going left or right for example. Tactile paving help visually impaired persons develop their mental maps for the surrounding environment, and provide extra measure of safety, as users will have a clear path to move (Yaagoubi et al., 2012).

KAU is an equal opportunity learning environment, and eager to provide an accessible campus for all. To facilitate movements around the campus for the 200 visually impaired students, the University has installed 3 km of tactile paving (see Figure 2) that covers the new academic square, and is planning to lie-down additional 10 km of the path in the future to cover the whole campus.

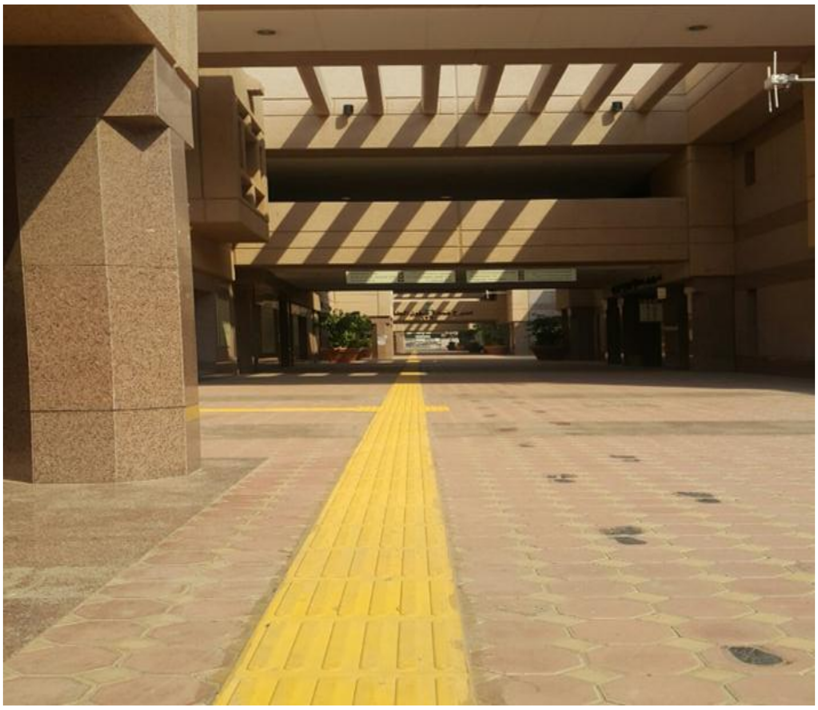

Figure (2): Tactile Paving at KAU Campus.

The University adopted the Japanese standard in installing the path, and realized much improved results in terms of comfort and independence in moving around campus for the visually impaired. The path is the first and longest of its kind in the Kingdom, and plans include to extend it to cover additional 10 km.

RESEARCH PROBLEM

The Center for Students with Special Needs (CSSN), responsible for improving services for students with disabilities, has realized a good level of student's satisfaction using the path, according to current international standards. However, CSSN is looking to enhance the path further; by adding available advances in technology. The cooperation between CSSN and many researchers at KAU has yielded a brilliant yet a cost-effective idea to enhance the path; by adding Bluetooth technology. The idea is to develop an application that can be used with any cell phone (Android or IOS) and install Bluetooth beacons at the path's decision points; so that students would hear messages about their whereabouts and directions for incoming building and/or facilities, see Figure 3.

Figure 3: Adding Bluetooth Beacons to the Tactile Path.

CSSN desired to test the effectiveness of adding Bluetooth technology to the tactile path before making the investment.

MATERIALS AND METHODS

Our goal was to examine the effectiveness of the Bluetooth technology on improving wayfinding using the blind path. We have designed an experiment that simulates using the path as if it was equipped with Bluetooth technology. We used two groups, 3 students in each, as control and experimental groups. Subjects were freshly admitted students who had never used the blind path. Subjects in both groups were given training on how to use the tactile paving. Moreover, they had the opportunity to develop their mental map of the task at hand, by interacting with a 3D model of the segment of the path, in order to be able to complete the task independently (see Figure 4).

Figure 4: Helping Subjects Creating their Mental Map of Segment.

Subjects in the control group were instructed to complete the segment using their white cane without any help. For the experimental group, subjects were given voice commands using a cell phone that simulated the operation of a voice guidance application (see Figure 5).

Figure 5: Navigating the Path with Voice Guidance.

The application, which will be developed later, would give instructions about:

- The whereabout of the person; like "you are in front of the restaurant"
- Distance to the upcoming place; "20 meter to decision point 9"

The manual voice commands were designed to exactly simulate the commands given by the Application envisioned by the CSSN officials. Subjects in both groups were returned to correct route if they were off by two decision points. Digital stopwatch was used to measure the time.

The first part of the experiment was to test the equality of the two groups; regarding their spatial abilities using small remote segment of the path. The second part was the actual experiment; where we tested the effectiveness of adding the Bluetooth technology, in which we selected another segment of the path (see Figure 6).

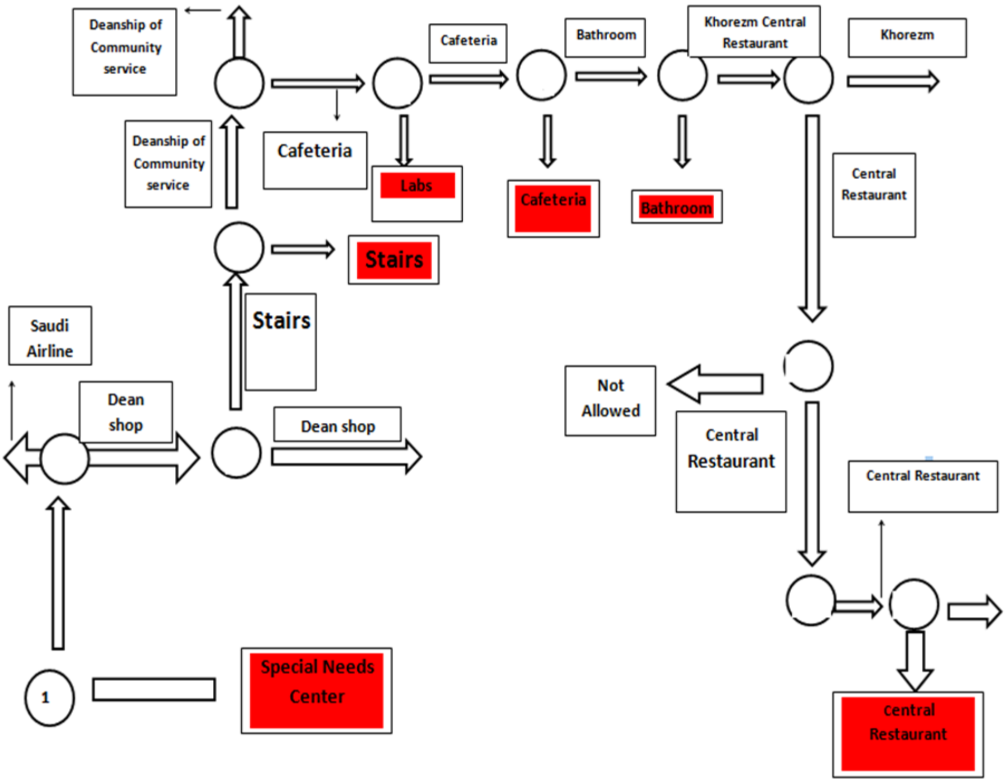

Figure 6: Segment of the Path Used for the Experiment.

RESULTS AND DISCUSSION

We have designed a two-phased experiment to test the effectiveness of adding Bluetooth technology to the blind path. Participants were six new students without any prior experience in using tactile paving. It should be noted that it was very difficult to find more subjects for the experiment with the conditions set.

Participant were randomly assigned to either the control group or the experimental group. In phase one, we have conducted a pre-test to ensure that the control and experimental groups have similar spatial abilities. The pre-test was conducted on a remote segment of the path, and the t-test showed that the means (minutes to complete the task) of the control (N=3, M=2.447, SD=0.542) and the experimental (N=3, M=2.217, SD=0.161) groups were not significantly different (t-value = 0.52, p-value = 0.631) in completing the task, at α level of 0.05. Hence, we concluded that the two groups have similar spatial abilities and proceeded with second and actual experiment.

Using the segment of the path shown in Figure 6, we have measured time to complete the task at phase two of experiment as shown in Table 1.

Table 1: Time to Complete the Task.

Subject	Control Group (Min.)	Experimental Group (Min.)
1	3.10	2.28
2	3.52	2.44
3	4.12	2.40

Once again, we have conducted an independent-samples t-test to figure out whether our intervention by adding voice commands were effective. Table 2 show the results of the statistical analysis.

Table 2: Testing the Means of Control vs. Experimental Groups

Mean (Control)	Mean (experimental)	t-value	p-value	Sig. at α (0.05)
3.58	2.37	2.7764	0.016	YES

The difference between the means was significant at α level of 0.05. Hence, we can infer that students leveraged with voice commands can move around the path faster than students that did not receive any sort of guidance.

It was clear that the average time to complete the selected segment was about 1.5 minutes more for the control group than the experimental group, which is more than 50%. This time saving is great help for blind students commuting throughout the day around the huge campus of KAU. The benefits of providing voice command was not only apparent in the time saving, but also in the accuracy of the navigation. In addition to the known security provided by the tactile paving for users, students with voice guidance made much fewer wrong turns than students without voice guidance. These fewer mistakes in completing the route may have further positive impact on the safety of students going around campus; as students will not move into unfamiliar places, and hence increased safety for path users.

CONCLUSION

Incorporating voice guidance for visually impaired students using the tactile paving at KAU has a strong impact on reducing the time required to move around campus. Moreover, it has a positive effect on the level of safety for persons using the path; as it greatly reduces erroneous turns, and hence avoiding unaccustomed places and obstacles.

Based on the result of this study, The Center for Students with Special Needs has recommended to proceed with the plan to install Bluetooth beacons on the path, and develop the mobile phone application. We have also provided the structure for the voice commands, as well as the places and format of the instruction. The Center follows the recommendation, and has installed the Bluetooth beacons and developed the application on a trial area of the path. Initial feedback from students and visitors using the path with voice guidance were encouraging.

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