Universally Designed Tactile Maps:
Carroll Center for the Blind Interactive Model Case Study

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"The best models are those which are most like the thing they represent."(Bentzen, 1983)

The process of orienting new students to a campus layout is often difficult. It is even more difficult when the student is blind or has a vision-impairment. Traditionally, schools for the blind have sought to support incoming students by providing a 'direct experience' tour of the campus with the help of an orientation and mobility specialist (Blades, Unger, Spencer, 1999). While this technique has proven effective, particularly for students attending large campuses, it does not support the goals of independence, self-sufficiency and self-fulfillment that are fundamental to this type of learning environment. Recently, some schools for the blind have sought to supplement the direct experience approach with the introduction of tactile maps. These maps are made available on a personal, portable scale and so reinforce institutional goals of autonomy. Although the potential offered by tactile maps is great, the actual product is often prepared very quickly, resulting in a crude mock-up of the campus that gives little meaningful information to the user. With the goal of finding a more inclusive method to meet this need for a more effective method of orientation, The IDeA Center and Touch Graphics, Inc. collaborated with the Carroll Center for the Blind in Newton, MA to design a prototype interactive model to aid navigation on their campus. Called the Carroll Center Touch Model, this new wayfinding device was developed by combining three dimensional rapid prototyping techniques and touch base sensing technologies into a simple, intuitive interactive tactile map. The map is based on haptics, and students learn to navigate the Carroll Center campus through a combination of touch and audio response. The interactive map is designed so that while exploring the map with their hands, the computer, sensing their touch, responds offering helpful audio descriptions and wayfinding information. Results of the use of this prototype have been positive, leading to the development of a market ready product suitable for a wide range of uses.

Model Development

<u>Site Documentation:</u>
The first step in creating the Carroll Center model was to document the site. Data was gathered through the use of photographs and a guided tour with an orientation and mobility (O&M) specialist working at the Carroll campus. In documenting the site particular attention was paid to the shape and material of each building, the main entrances to the campus, the connected pathways to and from each building, railings, pathway surface materials, parking areas, landmarks, landscape features, entrances to buildings, public transportation locations, sidewalks, and road conditions around the campus as well as to building type. Each building on the Carroll campus has a distinct shape and a designated function so that accurate representation would provide another layer of information to users. Additional buildings, not part of the school but on the site, were documented because they served as critical landmarks for the students. A detailed architectural drawing of the campus plan was provided by the Carroll Center outlining the site more thoroughly and providing a reference when digitizing the drawings for the computer aided design (CAD) environment. Finally, it was important to establish a benchmark against which all other buildings could be referenced to ensure accuracy when drawing buildings on the campus. It was determined that the most appropriate building

to use for this benchmark would be the Technology Center and so detailed measurements were taken of this building.

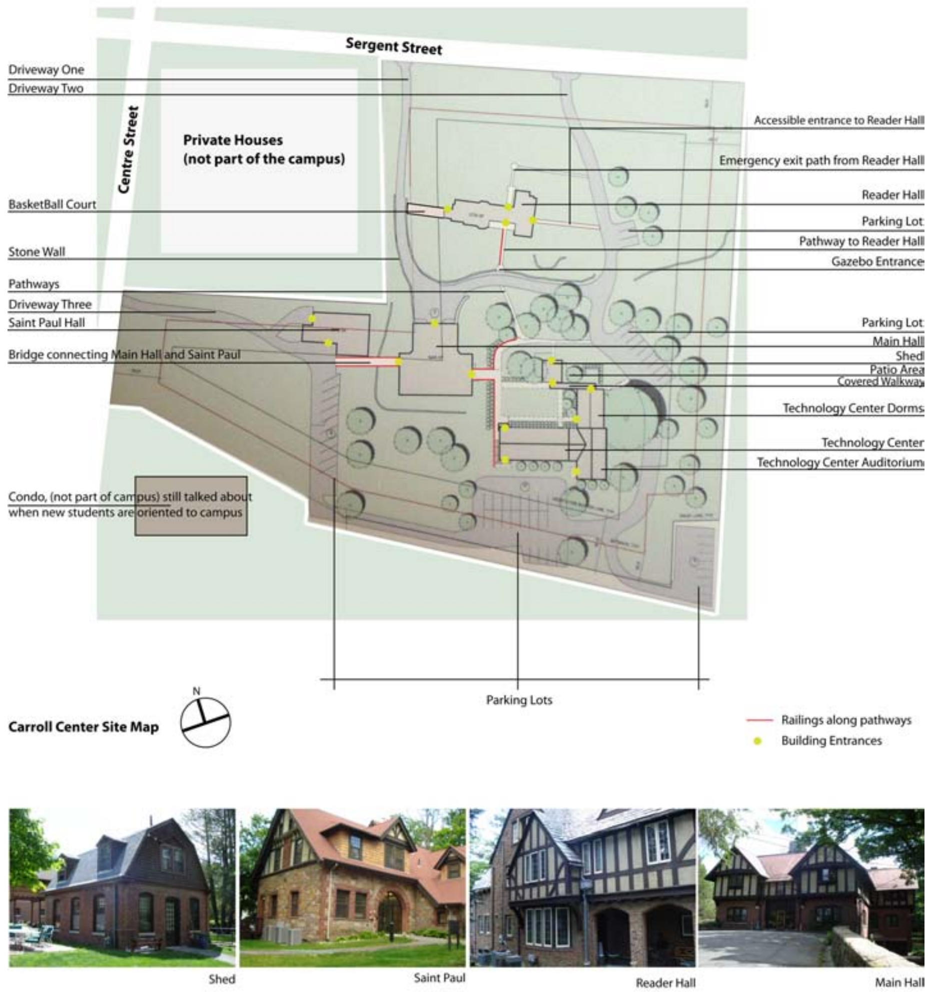
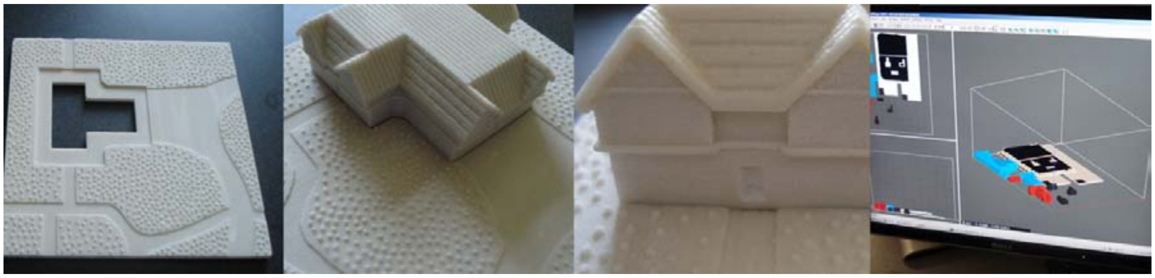


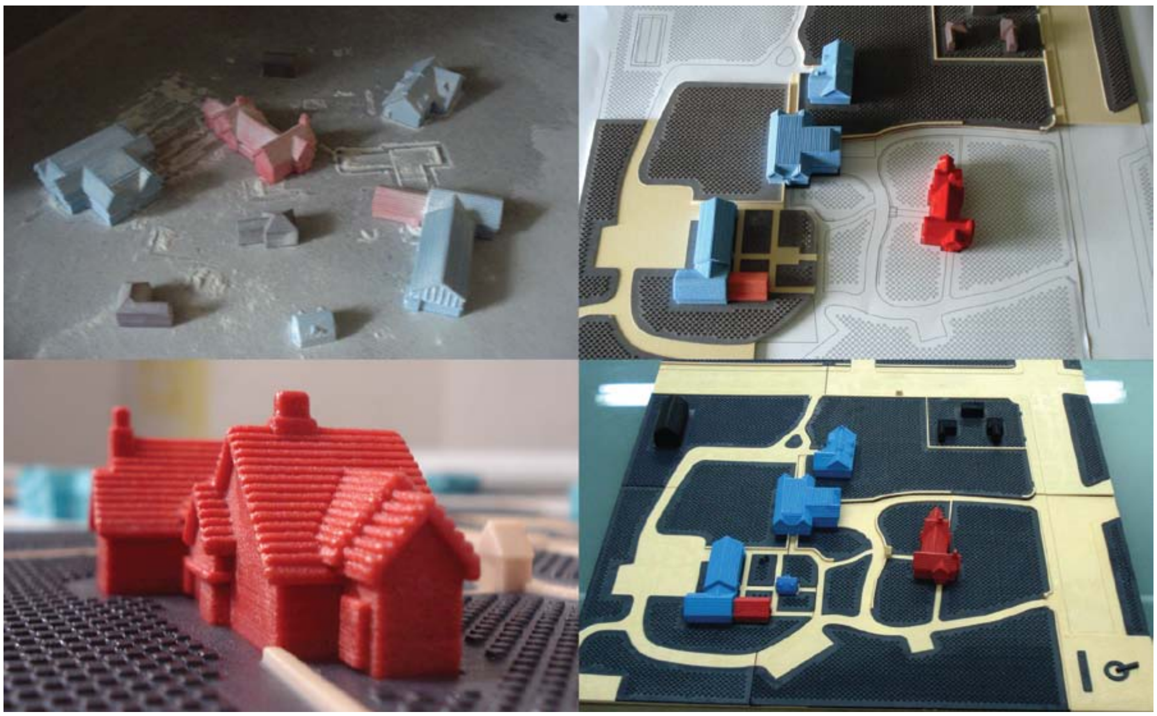
Figure 3: Carroll Center's site map

<u>2D Drawing and 3D Prototyping:</u>

The next step was to determine the actual size of the physical model. Before drawing or modeling in a virtual environment it is imperative that this model size be set. Taking into account the size of the campus, site features, various approaches to the model, user interaction with the model, the diversity of user types, and the location and orientation of the model, a 20in x 20in size was determined to be most appropriate. The size of the model allowed for the inclusion of the entire campus as well as roads and sidewalks around the campus. With proper site documentation, a 2D drawing in CAD was produced. At the start, a 4in x 4in section was selected to perform some initial prototyping studies of building and landscape textures, pathway size and depth, parking lot depths and railing conditions. Using recommendations from previous studies and past experience, testing prototypes were printed using a less expensive 3D printer (ZPrinter 450). The Zprinter provided an efficient way to produce small-scale samples so that multiple variables could be tested. With this type of testing it was possible to make real judgments on what would and wouldn't work in the full-scale model.



Initial material testing



Prototype model with printed with color

<u>3D Printing:</u>

The final model was printed from a Dimension 3D printer. Dimension 3D Printers generate durable models in acrylonitrile-butadiene-styrene (ABS) plastic, the most commonly used plastic in manufacturing today. Building the model out of a durable material was essential because it would be touched on a regular basis. The material properties of ABS are well suited to this type of prototype as it can withstand rigorous testing and will not warp, shrink or absorb moisture. ABS can also be drilled, tapped, sanded and painted. After the entire model was printed, elements that were to respond to the users touch were indentified and were painted with conductive paints. Those elements that were non-responsive were painted with non-conductive colored paints. To provide contrast and feature identification, black was selected as the base color for the landscape and private houses, while the roads and sidewalks were painted white. The buildings were divided into two colors; red was used for the dormitories, while blue was used for all other buildings. Providing proper color contrast on the model allowed sighted individuals and low vision individuals to easily read and use the model/map. Once all elements had been painted, a protective clear coat finish was applied in order to prevent wear. Finally, to accommodate for any breakage that might occur over time, flexibility of elements was built into the design so that sections and parts of the model can easily be unscrewed from below, removed and replaced.

Functioning model in use at the Carroll Center for the Blind

<u>Electronics:</u>

Once the physical aspects of the model were completed, the next step was to incorporate the electrical component. This component of the model is designed to obtain information observing changes in capacitance on a series of electrically conductive parts connected to a sensor device. It is not necessary for users to come in direct contact with the electrode for their touch to register. The clear coat and outer layer of paint create a barrier between the conductive paint, the metal electrodes and the individual's hand. The model is low voltage and so there is no risk of an electrical shock to the user. Each audio enabled feature on the model is connected to a separate channel and multichannel sensor developed by Touch Graphics, Inc. Because environmental variables can have an effect on the sensitivity of the audio enabled objects, the multichannel sensor allows them to be tuned individually. This was important because the conditions in the lab differed from the conditions on site at the Carroll Center and so some adjustments were necessary when the model was installed.

<u>Interaction:</u>

Most of the features on the Carroll Center Model are touch sensitive. When a user approaches the model, he or she can activate the model by touching it anywhere. If the user touches a part that is audio enabled, a recording describes the feature that has been touched. The audio-enabled features on the model are controlled by three buttons; a round main button, and two triangular directional buttons. If the user presses the main button, he or she will hear a recorded introduction to the Carroll Center explaining how the model is to be used as well as how to access such options as a campus overview and an alphabetical index of destinations (with audio coaching to find places on the model). The audio model is adjustable for individual preferences and hearing capabilities through volume control and pace of voice control. Users can further personalize their experience by adjusting the level of touch sensitivity of the features.

Usability Study

Methods:

After nearly six months of production and testing, the model was taken to the Carroll Center for the Blind for final installation. A brief usability study was conducted on site to evaluate the effectiveness of the prototype. A total of five participants who were either legally blind or visually impaired took part in the study. Each participant was interviewed about their orientation experience at the school and was asked whether they had previously navigated the Carroll Center's campus. Participants then received a 10-minute training session on the use of the model followed by 15 minutes where they could explore the model on their own. After the exploration period, participants were then asked to explain their process of orientating themselves using the model and were asked to find a physical location based on what they had learned from the model. If the participant already knew the location, they were asked to find another location with which they were not familiar. Each participant then attempted to walk from the location of the model to the assigned destination. If the participant could not find the location, they were asked to refer to the model a second time for as long as necessary and then asked to repeat the task. Finally, each participant completed a survey that assessed their experience with the talking model including the performance of audio information, quality of material texture (i.e. grass, roof, pathways, and railings), understanding the difference between street and sidewalk levels, and finding the location of key features such as door entries.

Results:

The general consensus from participants was that the interactive map was easy to use and that it enhanced their knowledge of the campus whether or not they had prior familiarity. Participants found that the navigation buttons were easy to use once they had located them on the model. Most of the participants were able to identify distinct textures on the model and were able to identify the differences between landscape, roads and pathways. Students were able to locate various buildings and learned different routes between buildings. According to the Carroll Center O&M specialist, the interactive tactile map is a positive addition to their campus wayfinding system and will improve orientation sessions in the future. The only negative feedback from the study was that the audio was sometimes unclear and hard to comprehend. Suggestions for improvement included a request for a more human audio voice.

Conclusion:

The Carroll Center Interactive Model originated as an experimental prototype to meet the orientation needs of blind and low vision students on school campuses and ended with a market ready product with the potential for widespread use. After a series of intensive studies involving material use, texture conditions, object placement, and technology refinement, Touch Graphics Inc. and the IDeA Center were able to refine the prototype to become a fully functional customizable product. Through the use of Touch Graphics' in-house rapid prototyping machines and on-site manufacturing system, the final model is streamlined and cost-efficient. The installation of the touch base interactive model proved to be a significant help to the students at the Carroll Center and the availability of the model to others in similar institutions will only enhance the knowledge of their surroundings and further the goal of creating inclusive wayfinding solutions.

Reference

Bentzen, B.L. (1983). “Orientation Aids.” Foundations of Orientation and Mobility, American Foundation for the Blind, 291-354.

Blades, M., Ungar, S. and Spencer, C. (1999), Map Use by Adults with Visual Impairments. The Professional Geographer, Vol. 51: 539–553.