CAREER: Bridging the Digital Accessibility Gap in STEM Using Multisensory Haptic Platforms

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Motivation

Make digital information accessible using multimodal feedback on touchscreens and peripherals.

Hands-On Learning

- "Hands-on" touch is important for active learning across all learners.
- **Haptics (touch) and audio** are useful in interpreting **graphs** [1], **maps** [2], and for **panning and zooming** on touchscreens [3][4].

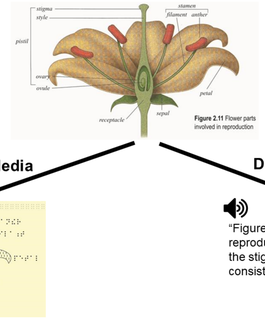


Image from BANA Guidelines (2018) http://www.brailleauthority.org/tg/web-manual/u3parts-of-flower.html

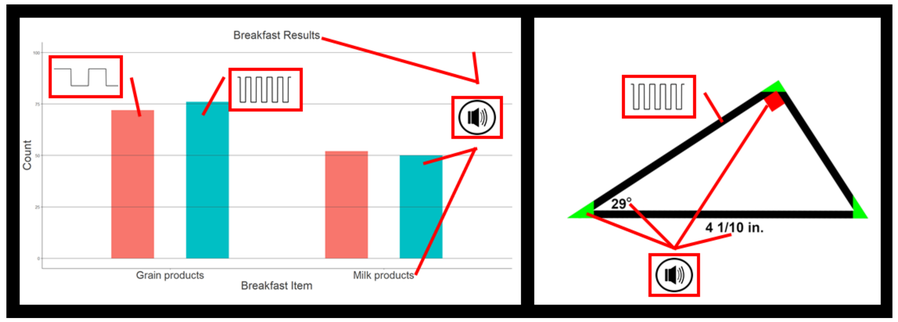
Guidelines for Touchscreen Graphs

- ❖ Optimal vibrotactile line width for information extraction is 4 mm.
- ❖ Gap between vibrotactile lines should be 4 mm at minimum.
- ❖ Borders around lines encourages finer tracing.
- ❖ Indicate significant points with a different vibration or with audio.
- ❖ Design to allow multitouch on screen, even if just used for reference.
- ❖ Minimize signal distractions and clutter during tasks.

❖ **Full guidelines**: Gorlewicz et al (2020. ACM TACCESS 13(3), 1-30. [5]

Evaluating Nonvisual, Multimodal, Touchscreen Graphs

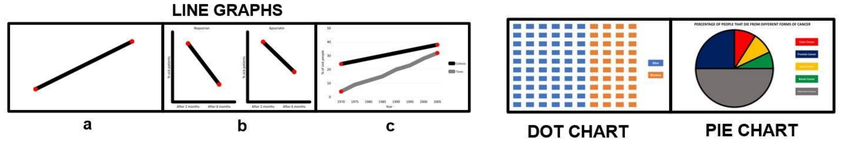
How do multimodal graphs compare to traditional, tactile graphics?



- Twenty learners with visual impairments (3 schools for the blind) explored bar charts and geometry figures in print as well as on a touchscreen.
- Participants were evaluated on tasks of information orientation and extraction as well as attitudes toward the graphics.
- Learners with VI **successfully access and orient** to graphical content on a touchscreen using haptics and audio, **preferring it** over traditional print media [6].
  - ❖ **Information orientation** significantly better on multimodal graphs than in print.
  - ❖ Multimodal graph **information extraction** was at the same level as print.
  - ❖ **Attitudes** significantly more favorable for multimodal graphs than print graphs.

Exploration Strategies and Cognitive Processing for VI Using Multimodal Graphs

What strategies and skills are most advantageous to exploring multimodal graphs on a touchscreen?

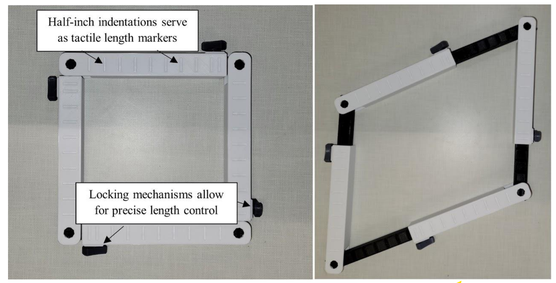


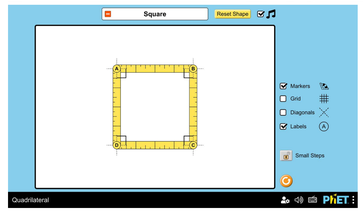
- Eighteen sighted learners and 2 learners with VI explored graphs (line, pie, bar, and dot) on a touchscreen and were evaluated on graph literacy and strategy measures.
  - ❖ High **cognitive processing speed & spatial memory** associated with high literacy
  - ❖ Successful literacy associated with using **multiple strategies together**
  - ❖ **Systematically** locate key features (axis, lines, labels, legends, etc.)
  - ❖ **Goal-oriented** scanning movements (horizontal, vertical, zig-zag)
  - ❖ Deploying **reference points** with fingers ("anchoring")

Beyond the Screen

Tangible Manipulatives

- Rooted in embodied design philosophy that particularly benefit learners with diverse ability.





PhET INTERACTIVE SIMULATIONS

edH

Tangible Manipulative Quadrilateral (TMQ)

- The four-sided quadrilateral was chosen as the first prototype due to its ability to take on many different forms.
- Initial findings are promising [7].
  - ❖ Learners 1.4 times more successful in identifying shapes when using the TMQ.
  - ❖ Learners recreated shapes from explicit parameters with 94% accuracy with the TMQ.

Acknowledgements

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References

[1] Klatzky, Giudice, Bennett, & Loomis, 2014
[2] Poppinga, Magnusson, Pielot, & Rassmus-Gröhn, 2011
[3] Palani & Giudice, 2017
[4] Palani, Giudice, & Giudice, 2016
[5] Gorlewicz et al., 2020
[6] Tennison et al., 2023 (To Be Published)
[7] Lambert et al., 2022