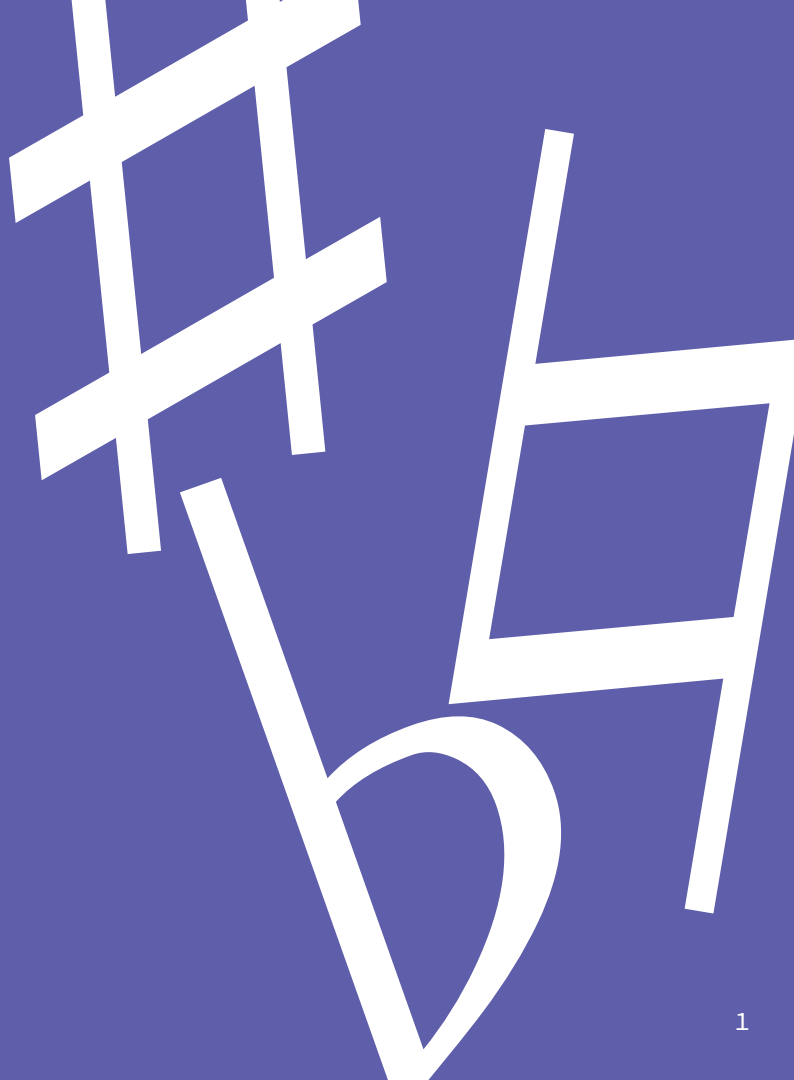


Fall 2023

Identifying and Addressing Mismatches in Private Instrument Lessons for Blind Adults: A Codesign case study

Dani Leinwander

Georgia Institute of Technology - College of Design - Music Technology - CCML (Computational & Cognitive Musicology Lab)

Advisor

Claire Arthur

Computational & Cognitive Musicology Lab (CCML)

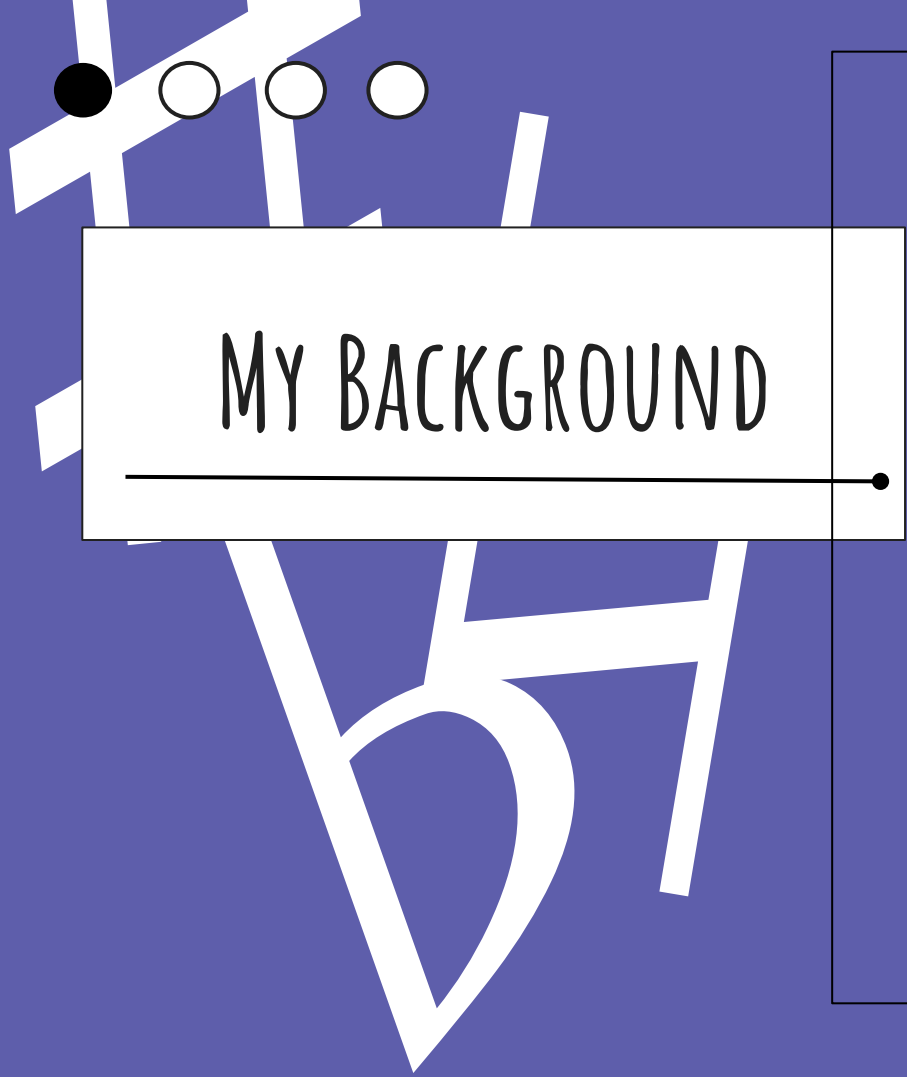
Codesigner

Alonso Zubillaga

Special thanks to:

Abigale Stangl

MultiSense Design Research Studio



My Background

Music composition, violin performance, engineering

Teaching, gigging and event planning

Devoted to accessibility from day one

- What makes an educational experience or an event accessible?

My Goals

I see the impact music has on people and their quality of life

General life goal:

To find ways to facilitate access to music for anyone and everyone

Project goal:

To teach my friend (who is blind) flute!

@zubiflow

Alonso Zubillaga

Flow Artist

Massage

Dance

Poi (light and fire)

♭ ♯ ♮

Legally Blind

Goal to learn flute

also to learn about
Western music theory

Holmes' Three Skills of Successful Inclusive Designers

1. Identify ability biases and mismatched interactions between people and world.
2. Create a diversity of ways to participate in an experience.
3. Design for interdependence and bring complementary skills together.

For accessibility, it is absolutely necessary to consider codesign as a critical part of the entire development process, not just as an afterthought or retrofit.

Holmes, K. (2020). *Mismatch: How Inclusion Shapes Design*. MIT Press.

What is a mismatch?

From the social model of disability

Mismatch between

- Assumed abilities of product users
- What users can actually do

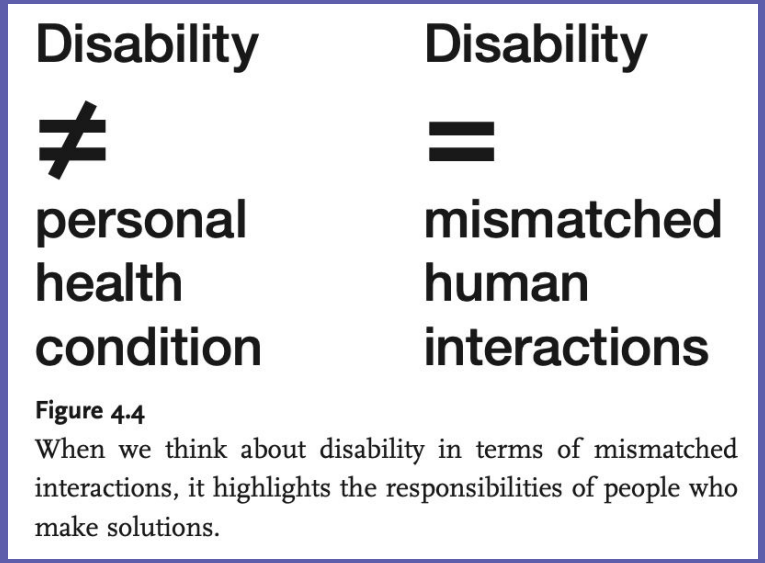


Figure 4.4
When we think about disability in terms of mismatched interactions, it highlights the responsibilities of people who make solutions.

A way to identify and communicate why a particular design or product is inaccessible.

Holmes, K. (2020). *Mismatch: How Inclusion Shapes Design*. MIT Press.

Mismatch example

Betsy Farber

OXO Tools

Needed a potato peeler that wouldn't hurt her hands (arthritis)

Metal potato peeler

Assumes non-painful grip strength

OXO potato peeler

Non-slip soft grip

Developed by Sam Farber

Bennett, Cynthia L., Burren Peil, and Daniela K. Rosner. "Biographical prototypes: Reimagining recognition and disability in design." *Proceedings of the 2019 on Designing Interactive Systems Conference*. 2019.

Mismatch example

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OXO potato peeler prototype

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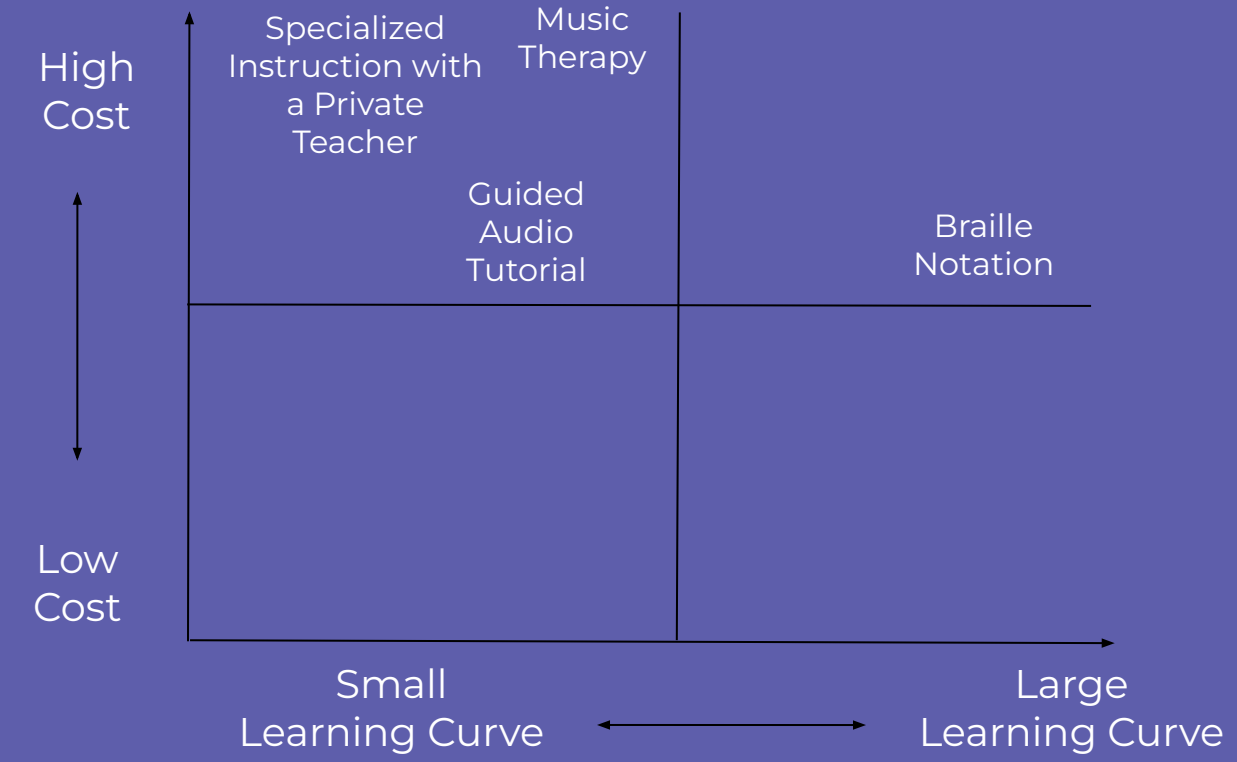
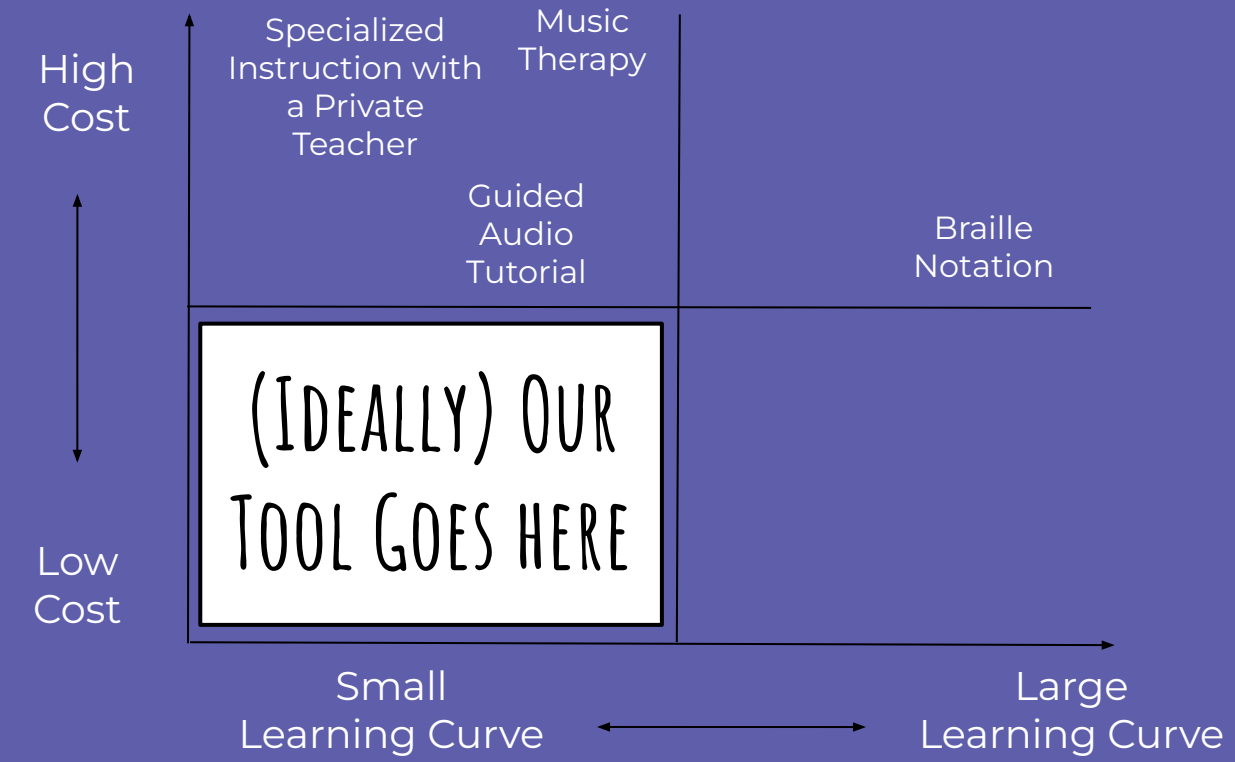
Existing Technologies Positioning Matrix



"We Avoid PDFs": Improving Notation Access for Blind and Visually Impaired Musicians (2023 William Payne & Amy Hurst)

"Why are there so many steps?": Improving Access to Blind and Low Vision Music Learning through Personal Adaptations and Future Design Ideas (2023 Leon Lu et al)

Existing Technologies Positioning Matrix



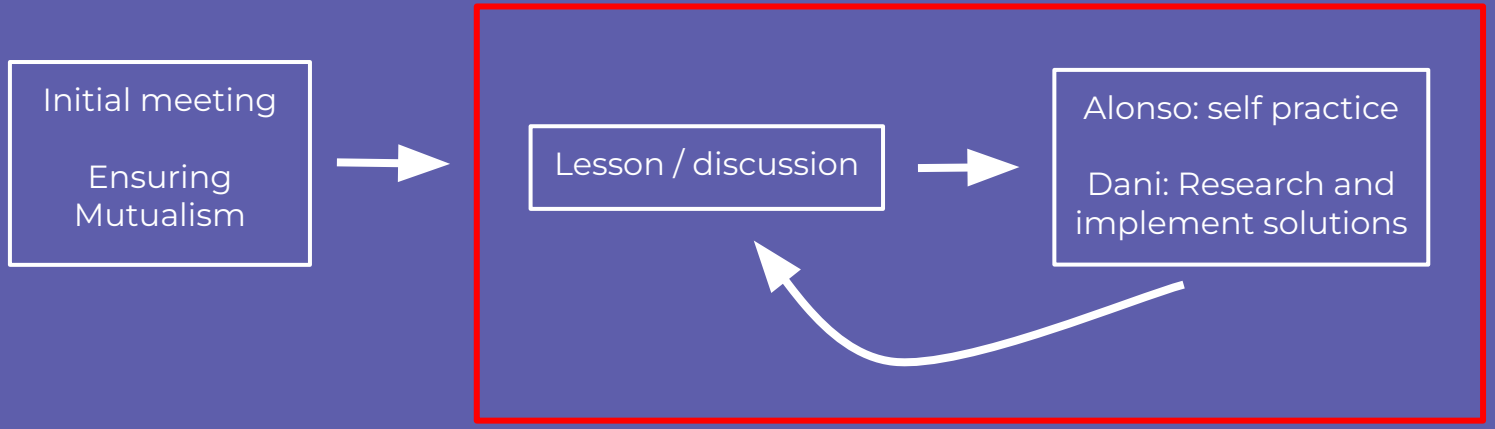
Why do we need to use codesign?

Ensure Mutualism ✅

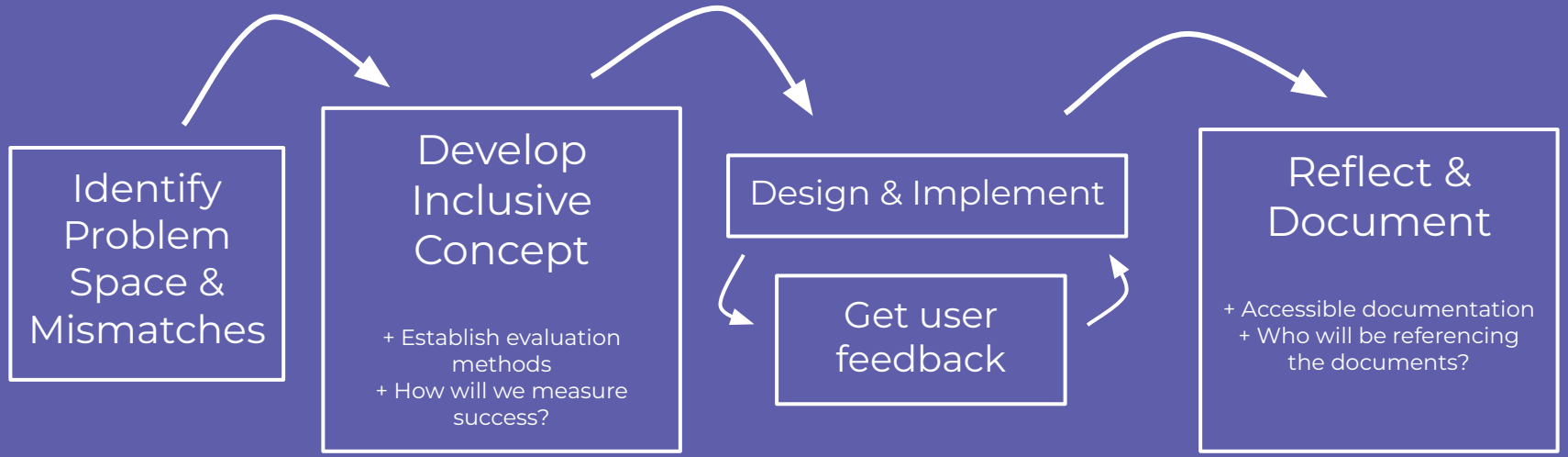
It takes time and is hard to do!

What the process has looked like

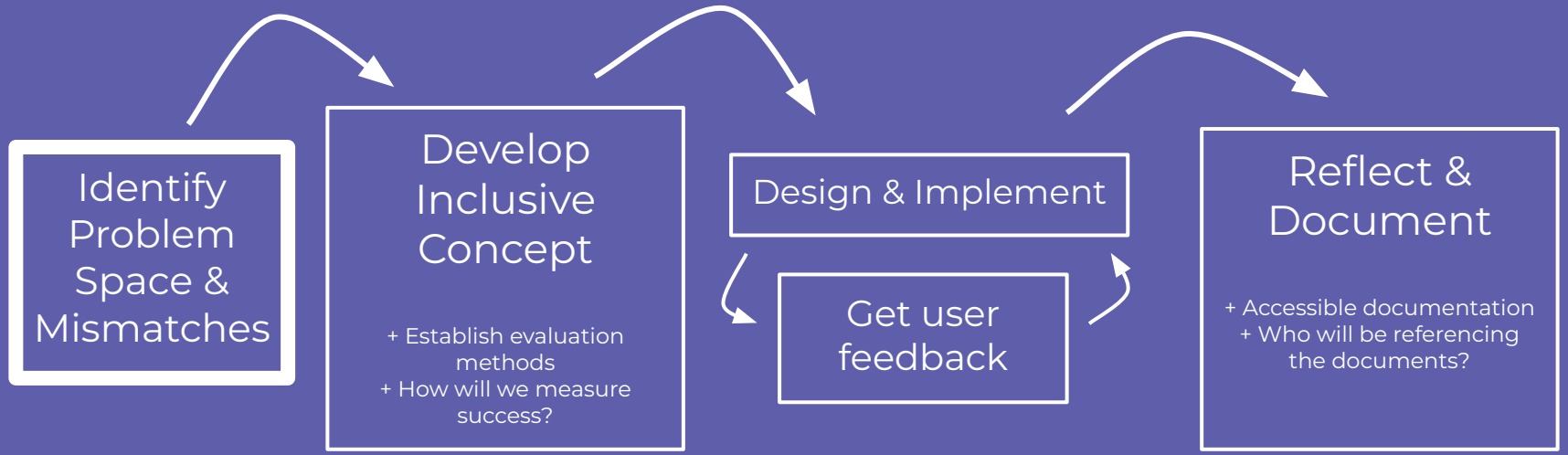
What the process has looked like



Our devised Codesign Framework



First need to Identify Mismatches



Identified Mismatches

1
Sheet music
(assumes sight)

2
Fingering Charts
(assumes sight)

3
Visual Cues
(assumes sight)

Identified Mismatches

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Sheet music
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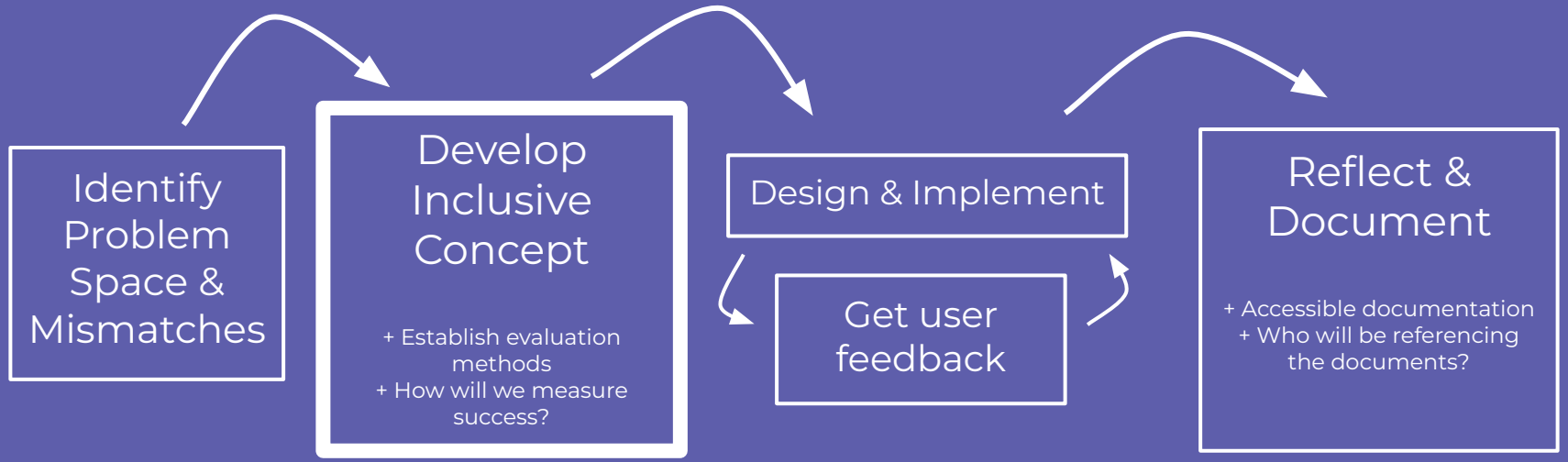
Developing an Inclusive Concept



The General Idea

What we want is an aural alternative to visual music references

One that preserves some sort of parsing flexibility

Aural Learning App

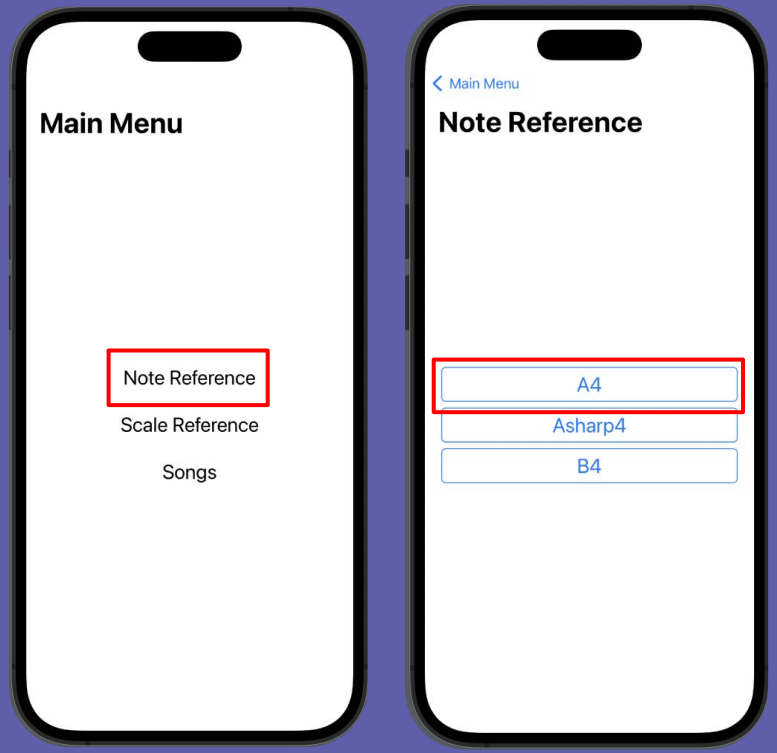
Accessed by students using iOS Voice Over

Note & Scale References

- Aural clips stitched together from premade clips:
  - note names
  - fingerings
  - sounding pitches

Made using SwiftUI

Coming next: implement user input so can be dynamically generated based on individual needs



Prototypical Flute Fingering Chart

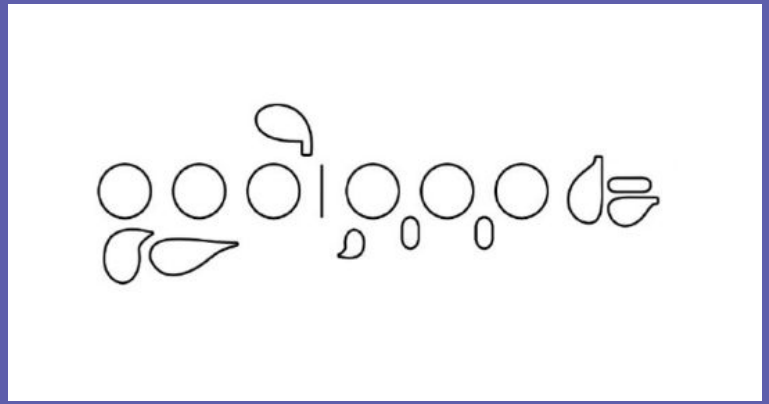
The Woodwind Fingering guide

How do we find a useful way of aurally communicating fingering information without inducing cognitive overload?

Note	Written	Fingering		Description
D_5		T -23|123		Basic.
$D\sharp_5$ $E\flat_5$		T -23|123$_{Eb}$		Basic.
E_5 $F\flat_5$		T 123|12-$_{Eb}$		Basic.
$E\sharp_5$ F_5		T 123|1--$_{Eb}$		Basic.
$F\sharp_5$ $G\flat_5$		T 123|--3$_{Eb}$		Basic.
		T 123|-2-$_{Eb}$		Trill fingering with E_5.
G_5		T 123|---$_{Eb}$		Basic.
$G\sharp_5$ $A\flat_5$		T 123$^{G\sharp}$|---$_{Eb}$		Basic.
A_5		T 12-|---$_{Eb}$		Basic.
$A\sharp_5$ $B\flat_5$		T 1--|1--$_{Eb}$		Basic.
		Bb 1--|---$_{Eb}$		Basic, use in passages without B_4 or B_5.
		T 1--|$_{Bb}$---$_{Eb}$		Trill fingering with B_5.

Fingering Codes

Storytelling
as a way to communicate
flute fingerings

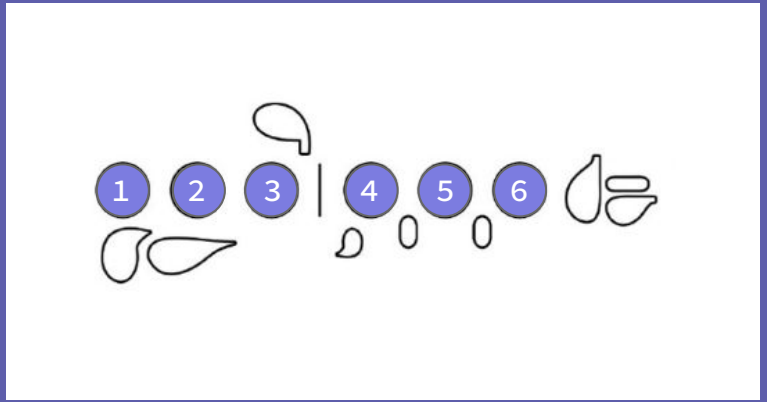


Fingering Codes

Storytelling
as a way to communicate flute fingerings

+ Home Keys

Trevor Wye's home keys
Link

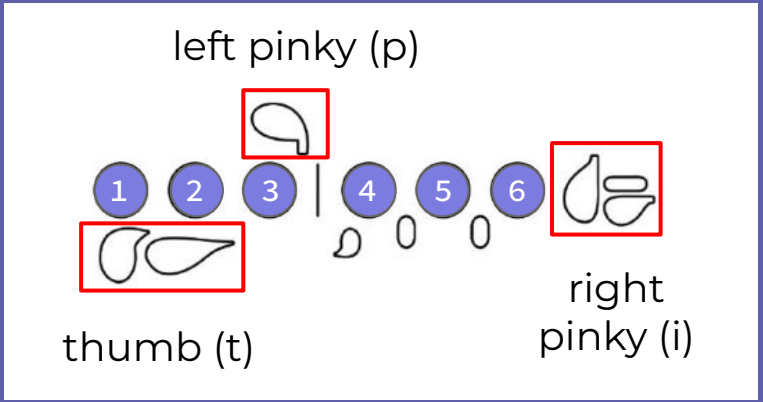


Fingering Codes

Storytelling
as a way to communicate
flute fingerings

We added...
+ Away Keys

away keys



Fingering Codes

Storytelling
as a way to communicate
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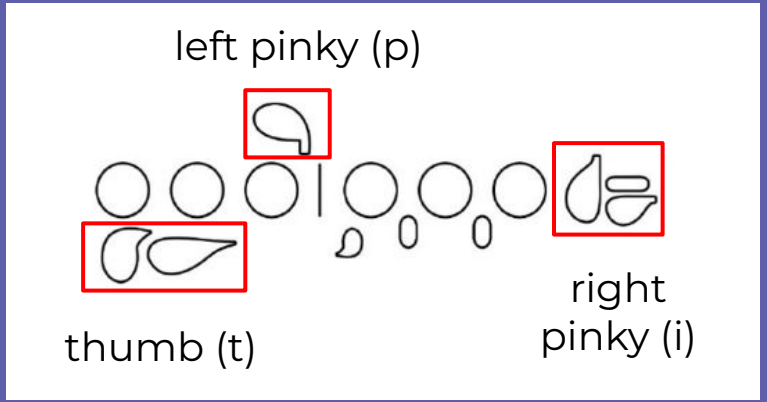
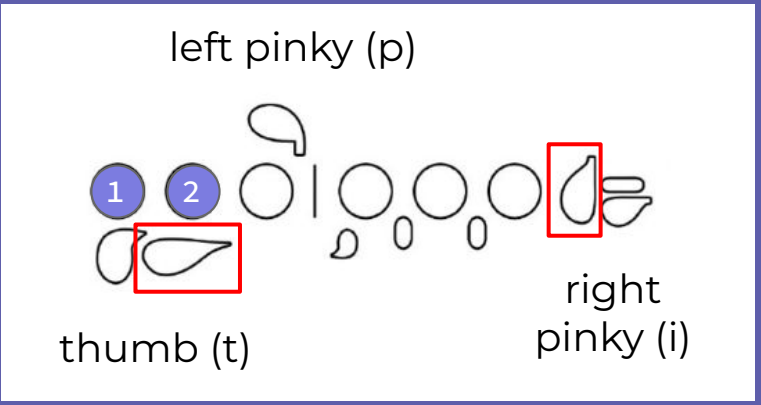
We added...
+ Away Keys

away keys



Fingering Codes

								n = none
audio file name = unique name						n = none		p = pinky on d sharp key
						t = thumb	n = none	s = pinky on c sharp key
					0 = none	h = thumb b key	p = pinky on g# key	c = pinky on both cs and next key
					(n = none?)			b = pinky on both cs and c and b key
unique ID	unique name	pitch (sharps)	alt pitch (flats)	octave #	homekeys (0,1,2,3,4,5,6)	thumb (n,t,h)	left pinky (n,p)	right pinky (n,i,cs,c,b)
1	B3	B	n	3	123456	t	n	b
2	C4	C	n	4	123456	t	n	c
3	Csharp4	Csharp	Dflat	4	123456	t	n	s
4	D4	D	n	4	123456	t	n	n
5	Dsharp4	Dsharp	Eflat	4	123456	t	n	i
6	E4	E	n	4	12345	t	n	i
7	F4	F	n	4	1234	t	n	i
8	Fsharp4	Fsharp	Gflat	4	1236	t	n	i
9	G4	G	n	4	123	t	n	i
10	Gsharp4	Gsharp	Aflat	4	123	t	p	i
11	A4	A	n	4	12	t	n	i
12	Asharp4	Asharp	Bflat	4	14	t	n	i
13	B4	B	n	4	1	t	n	i
14	C5	C	n	5	1	n	n	i
15	Csharp5	Csharp	Dflat	5	0	n	n	i
16	D5	D	n	5	23456	t	n	n
17	Dsharp5	Dsharp	Eflat	5	123456	t	n	i
18	E5	E	n	5	12345	t	n	i
19	F5	F	n	5	1234	t	n	i
20	Fsharp5	Fsharp	Gflat	5	1236	t	n	i
21	G5	G	n	5	123	t	n	i
22	Gsharp5	Gsharp	Aflat	5	123	t	p	i
23	A5	A	n	5	12	t	n	i
24	Asharp5	Asharp	Bflat	5	14	t	n	i
25	B5	B	n	5	1	t	n	i
26	C6	C	n	6	1	n	n	i

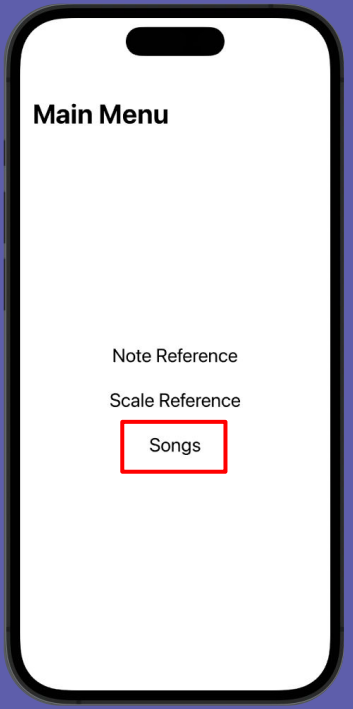


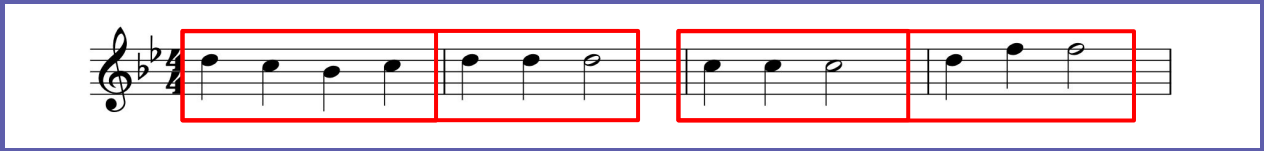
11 A4 A n 4 12 t n i

Melody Segmentation

1
Transition difficulty informed symbolic melody segmentation

2
Presentation of output audio files in iOS for best non-visual organization that provides parsing flexibility





Measuring Transition & Note Difficulty

Inspiration from Sébastien's

performance difficulty criterion

Performance difficulty criterion	Definition	MusicXML implementation	Instruments
Playing speed	The required fingers velocity to play the piece. Depends on the tempo and the shortest significant note value (i.e. a piece presenting a high tempo may contain only long values, and conversely, a piece with a low tempo may contain groups of short notes thus increasing the required fingers agility for the players)	<note><type> elements Tempo attribute in <sound> element	All
Fingering	Fingering: choice of finger and hand position on various instruments. Different notations exist according to the instrument. (ex: in piano: 1 = thumb, 2 = index finger, 3 = middle finger, etc.) Cost functions are used on intervals to extract the general fingering difficulty level See [8][8][9] for more detail.	<fingering> element within each <note> element 	All, requires adaptations in constraints and costs functions (some instruments do not use thumbs)
Hand Displacement	Ratio of hands displacements greater than an octave (12 semitones). Depends on the duration of the interval: if the duration exceeds 2 beats (i.e. 2 quarters in 4/4, 2 eights in 6/8), the displacements is not considered as difficult. The difficulty degree of the displacement evolves with its size (in pitch), its duration and its fingering	Combined <note> elements where <pitch> gap > 12 and <duration> gap < 2 beats 	All, requires adaptations depending on the instrument morphology
Polyphony	Chords ratio (aggregate of musical pitches simultaneously attacked) Polyphonic difficulties may increase with the number of notes played at the same time and their fingerings. Simultaneous voices (in a Fugue for instance) constitute special cases of polyphonic difficulties to treat.	<chord> element 	All (except for monophonic instruments, such as the flute)
Harmony	Ratio of differences from the piece main tonality. Characterized by the amount of accidental alterations.	<alter> and <accidental> elements 	All
Irregular Rhythm	Ratio of irregular polyrhythms (simultaneous sounding of two or more independent rhythms). Example: synchronizing a triplets over duplets	<time-modification> element 	All (except for monophonic instruments)
Length	The number of pages of the score. May also be measured in bars number to avoid dependency to the page layout.	new-page attributes or <measure> elements	All

Table 1. Performance difficulty criteria in piano practice

Sébastien, Véronique, et al. "Score analyzer: Automatically determining scores difficulty level for instrumental e-learning." *13th International Society for Music Information Retrieval Conference (ISMIR 2012)*. 2012.

Altering performance difficulty criterion for flute...

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Length	The number of pages of the score. May also be measured in bars number to avoid dependency to the page layout.	new-page attributes or <measure> elements	All

Let's add...

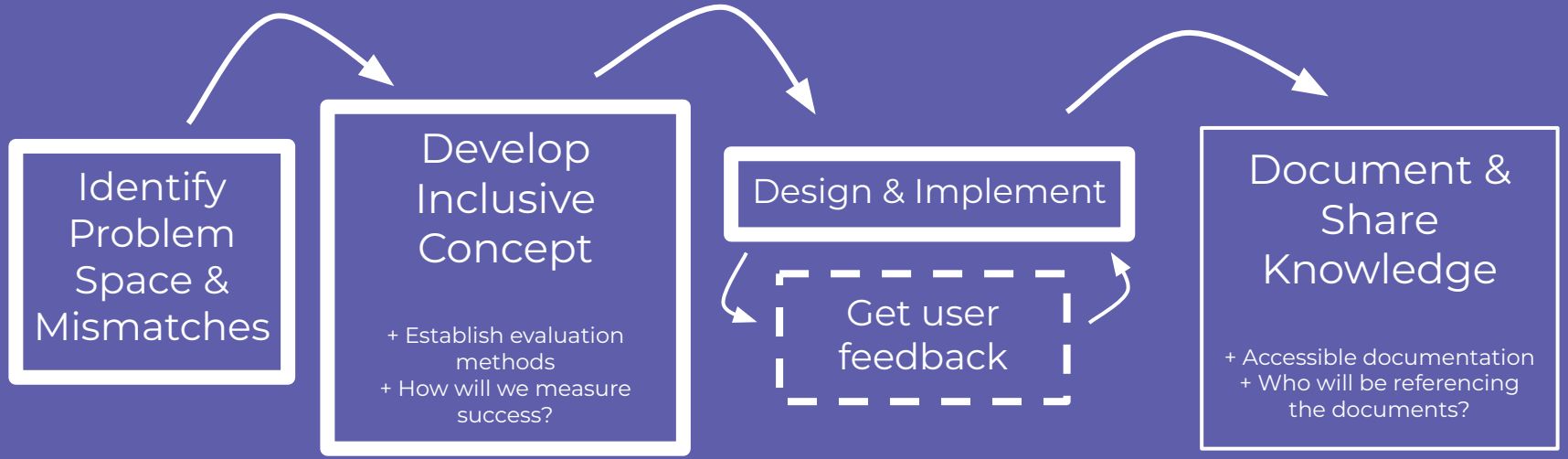
- Octave / Air speed

Sébastien, Véronique, et al. "Score analyzer: Automatically determining scores difficulty level for instrumental e-learning." *13th International Society for Music Information Retrieval Conference (ISMIR 2012)*. 2012.

Research Question - Melody Segmentation

How can performance difficulty criterion inform a rule-based music segmentation algorithm to segment melodies in the best way for Alonso's flute learning?

We are here now



Ultimate Impact

Maybe this project is a way to articulate this process for other music teachers and their students to go through on their own.

Maybe it's not possible to have a one size fits all solution.

3. Design for interdependence and bring complementary skills together.

Timeline

	November	December	January	February	March	April
App & Note Reference	Basic Generative Framework for note and scale learning (almost there)	Design & implement user input of generative parameters	Complete Initial Design Recommendation	Finish baseline implementation (iOS, SwiftUI)	Adjusting input parameters, getting feedback, rinse and repeat	End interviews and reflections Document Findings
Melody Segment-ation	Finalize data structure for performance criterion symbolic data representation + How do we represent this data for our algorithm to process?	Gather and/or curate MIDI (or MusicXML?) data for input	Devise baseline rule based system for giving difficulty score for each transition + How will we use the performance difficulty criterion to give a difficulty score? + How to use that score to inform segmentation?	Complete design recommendation Implement Algorithm	Adjusting input parameters, getting feedback, rinse and repeat	

Design — Implement — Document

Citations

Bennett, C. L., Peil, B., & Rosner, D. K. (2019). Biographical Prototypes: Reimagining Recognition and Disability in Design. *Proceedings of the 2019 on Designing Interactive Systems Conference*, 35–47. https://doi.org/10.1145/3322276.3322376

Frid, E. (2019). Accessible Digital Musical Instruments—A Review of Musical Interfaces in Inclusive Music Practice. *Multimodal Technologies and Interaction*, *3*(3), Article 3. https://doi.org/10.3390/mti3030057

Fyans, A. C., Marquez-Borbon, A., Stapleton, P., & Gurevich, M. (2012). *Ecological Considerations For Participatory Design Of Dmis*. https://doi.org/10.5281/ZENODO.1178257

Holmes, K. (2020). *Mismatch: How Inclusion Shapes Design*. MIT Press.

Kulik, J. A., Kulik, C.-L. C., & Cohen, P. A. (1979). Research on audio-tutorial instruction: A meta-analysis of comparative studies. *Research in Higher Education*, *11*(4), 321–341. https://doi.org/10.1007/BF00975623

Lu, L., Cochrane, K. A., Kang, J., & Girouard, A. (2023). "Why are there so many steps?": Improving Access to Blind and Low Vision Music Learning through Personal Adaptations and Future Design Ideas. *ACM Transactions on Accessible Computing*, *16*(3), 22:1-22:20. https://doi.org/10.1145/3615663

Mankoff, J., Hayes, G. R., & Kasnitz, D. (2010). Disability studies as a source of critical inquiry for the field of assistive technology. *Proceedings of the 12th International ACM SIGACCESS Conference on Computers and Accessibility*, 3–10. https://doi.org/10.1145/1878803.1878807

Payne, W. C., Xu, A. Y., Ahmed, F., Ye, L., & Hurst, A. (2020). How Blind and Visually Impaired Composers, Producers, and Songwriters Leverage and Adapt Music Technology. *Proceedings of the 22nd International ACM SIGACCESS Conference on Computers and Accessibility*, 1–12. https://doi.org/10.1145/3373625.3417002

Payne, W., & Hurst, A. (2023). "We Avoid PDFs": Improving Notation Access for Blind and Visually Impaired Musicians. In I. Sserwanga, A. Goulding, H. Moulaison-Sandy, J. T. Du, A. L. Soares, V. Hessami, & R. D. Frank (Eds.), *Information for a Better World: Normality, Virtuality, Physicality, Inclusivity* (pp. 581–597). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-28032-0_44

Quintero, C. (2022). A review: Accessible technology through participatory design. *Disability and Rehabilitation: Assistive Technology*, *17*(4), 369–375. https://doi.org/10.1080/17483107.2020.1785564

Saha, A., McHugh, T. B., & Piper, A. M. (2023). Tutoria11y: Enhancing Accessible Interactive Tutorial Creation by Blind Audio Producers. *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*, 1–14. https://doi.org/10.1145/3544548.3580698

Sharif, A., McCall, A. L., & Bolante, K. R. (2022). Should I Say "Disabled People" or "People with Disabilities"? Language Preferences of Disabled People Between Identity- and Person-First Language. *The 24th International ACM SIGACCESS Conference on Computers and Accessibility*, 1–18. https://doi.org/10.1145/3517428.3544813

Storytelling to Sensemaking: A Systematic Framework for Designing Auditory Description Display for Interactives | Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems. (n.d.). Retrieved October 24, 2023, from https://dl.acm.org/doi/abs/10.1145/3313831.3376460

Tigwell, G. W. (2021). Nuanced Perspectives Toward Disability Simulations from Digital Designers, Blind, Low Vision, and Color Blind People. *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, 1–15. https://doi.org/10.1145/3411764.3445620

Thank you for hearing me today

and as Alonso would say, “Hear you later!”