Design Document 4 - Context and Exploration

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4.1 Design Context

4.1.1 Broader Context

Area	Description	Examples
Public health, safety, and welfare	How does your project affect the general well-being of various stakeholder groups? These groups may be direct users or may be indirectly affected (e.g., solution is implemented in their communities)	- This project may reduce stress for users - This project may provide a creative outlet for some - This project could provide a relatively healthy coping mechanism for some. - This project could increase general welfare for the population from the increased enjoyment from easily learning the kalimba
Global, cultural, and social	How well does your project reflect the values, practices, and aims of the cultural groups it affects? Groups may include but are not limited to specific communities, nations, professions, workplaces, and ethnic cultures.	- This project could potentially increase musical interaction for subgroups of people that would not otherwise want to put in the effort required to develop musical skill. - More children might start to interact music as they could easily learn to play familiar songs - More people might start replacing short bursts of screen time with Kalimba time. - This project might bring more recognition to Zimbabwe in Africa, where the kalimba is thought to have originated

Environmental	What environmental impact might your project have? This can include indirect effects, such as deforestation or unsustainable practices related to materials manufacture or procurement.	- Increase to the creation of non-renewable materials through the use of plastics/metals required for the project - Slight increase to indoor noise pollution by encouraging people to play the kalimba - Marginal increase to deforestation for material to create kalimbas
Economic	What economic impact might your project have? This can include the financial viability of your product within your team or company, cost to consumers, or broader economic effects on communities, markets, nations, and other groups.	- The product needs to be affordable for any user as the Kalimba itself is relatively cheap and the device we create shouldn't cost much more than the instrument itself. - This project could potentially open up a previously untapped market.

4.1.2 Prior Work/Solutions

Some similar products exist for different instruments such as the piano. Although these products exist for other instruments there would not be any competition since there have not been any devices made for the Kalimba as far as we know. Some cons could be that our device would require another attachment whereas the piano has the light-up function as a built-in feature. This could also be seen as a pro as well since the user could use the device with multiple different kalimbas. The user could also easily have one kalimba with the light-up device and one without.

For hardware, there exists light-up pianos that operate similarly to our light-up kalimba.

- Here is one example of this.
- and here is an example video of one in action coupled with software.

For software, there does not exist an exact copy of what we are going to be using, but there is a very good visual tool for learning online that we found called TabWhale. Instead of being web-based, our product will include a mobile application with the tutorial song library. Another source of inspiration on the software side is KalimbaTabs.

4.1.3 Technical Complexity

The design consists of multiple components/subsystems that each utilize distinct scientific, mathematical, or engineering principles –AND–

There is a large hardware and software component that each contain many subsystems and all connect to one another. For software, there will be the frontend subcomponent that will contain all of our

UI design, and be able to pull information from the backend. There will also be a backend subcomponent that will store our various songs in a database for the frontend to use.

For the hardware side of things, we are going to be dealing with components such as, a pickup to transfer vibrations to the software for note reading, LEDs to visually display to the user the next note(s) to play. There would also be the wiring for both of those, and we are going to try and make it so at the end, our device will connect to a phone through a single usb type c cable.

The problem scope contains multiple challenging requirements that match or exceed current solutions or industry standards.

At this current time, there does not exist a tool that will allow as much direct interactivity. Our tool will mount any kalimba and through a series of hardware mounts and software I/O, the user will be able to get instant feedback from the device to more rapidly contribute towards their learning.

The closest way someone is able to mimic what we are trying to do is to write down tabs and place those written notes near the top of the kalimba while attempting to play the tines in order. There is no tool currently available that gives the user immediate feedback while they play notes.

4.2 Design Exploration

4.2.1 Design Decisions

- The device that we create should be physically transferable between different kalimbas, so that someone can buy one device and attach it to any typical kalimba size.
- The device will also use a pickup to determine which notes the user has played. This sensor type was chosen to reduce the chance of outside interference that could occur while only using an audio sensor for note detection. Having both sensor types increases the accuracy of our detection system.
- The software will use some existing music library, for example musicXML, that will make it possible to read the notes from the sheet music in the app, we have not yet decided on what we will use there is still research we need to do to figure out which is best for our project

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4.2.2 Ideation

In order to decide between the following options, we brainstormed ideas together as a group. As mentioned in the following section, the pros/cons that we came up with ruled out many of our options.

- Design Decision: Recognizing that a specific note is played
- Five Potential Options:
    1. **Vibration**. We could directly pass the vibrational information from the hardware to the software. This could be done with a simple pickup.
    2. **Sound**. The software would be able to recognize the tune of the tine that was played via a mic and determine whether it was the correct note or not based on tunes set up in the database.
    3. **Tine Being Touched**. The hardware device would detect any time the user touches a tine to indicate a note being played. (i.e. a sensor physically attached to a tine)
    4. **Tine Movement/Proximity**. For this idea there would have been physical sensors next to each tine that would detect when a specific tine is plucked. (i.e. a sensor physically very close to a tine)

5. **Optically Detected Movement.** A camera would be set up to visually detect when the user has plucked each tine.

4.2.3 Decision-Making and Trade-Off

In order to identify our pros and cons for each of the options we brainstormed ideas at our meeting. The cons ruled out most of the options and we were easily able to pick the best option.

- **Vibration**
    - Pros: Sensors already exist for the Kalimba to transmit this, and we already have a pickup to test with. It would also be easy to transmit this information with an aux cord, and the power draw would be very small.
    - Cons: The pickup might not have the sensitivity to correctly identify notes played, especially if many are played at once. If the user is very percussive in their playing, they might introduce noise that messes with the program a lot.
- **Sound**
    - Pros: This would be fairly simple to program. Most modern devices have mics prebuilt in them that could be used.
    - Cons: If a key is out of tune and isn't in the database the software may not be able to recognize it as the correct note and the user would be stuck on that note. Also, any background noise in the user environment could mess with the note recognition, which is a big problem..
- **Tine Being Touched**
    - Pros: Straightforward to detect when any tine is played.
    - Cons: Overly sensitive to user input, would often mistake the user resting their fingers with a note being intentionally played. This would also potentially be more expensive as many sensors wouldt need to be used and powered. Could impact the vibration of the tines which would ruin the sound of the instrument.
- **Tine Movement/Proximity**
    - Pros: Straightforward to detect when any tine is played.
    - Cons: It could be difficult to differentiate between the plucking movement and other movements the user makes that is not meant to actually pluck the tines. It would be hard to tell when the tine stops producing sound depending on the location of the sensor. This would also potentially be more expensive as many sensors might need to be used and powered.
- **Optically Detected Movement**
    - Pros: Because it is using visual input, it would be able to take in lots of information about the tines being plucked.
    - Cons: This would require setting up an external camera, and the external camera would also have to connect to the rest of the system, it would also be hard to see which tine the user is touching since they are close together and it may look like the user is touching more than one, it could also think the user has played a tine if they are touching it even if they haven't actually played it. This would also be expensive in terms of power draw and equipment.