Addressing Dexterity Challenges in the Classroom

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Augmenting Human Dexterity – Spring 2021
Term Project Report

Abstract

We hypothesized that a modular device will empower students to perform better in the classroom as measured by the competition rate using said device across a subset of tasks. Holding the environment and tasks constant across test subjects, we will ask children to complete 3 tasks. Within our control group, students are asked to complete the task using a predefined tool that they have had previous exposure with. For our treatment group, students are given the choice between 3 tools to accomplish the task. Completion rates across test and treatment groups will be compared. We expect to find the competition rate of tasks for most children to be higher when given the autonomy to pick which tool they will use to complete the task. This would successfully help us understand factors that have an impact on school performance. Subsequent research might explore the attachments that are most critical to a modular device.

I. Introduction

According to the Center for Disease Control and Prevention, "cerebral palsy (CP) is the most common motor disability in childhood," with estimates as high as 4 in 1000 children are affected.[1] While symptoms and severity can vary, common forms of cerebral palsy might result strong or weak muscle tone which affect grasp, can result in tremors, or affect general mobility.[1] While children with cerebral palsy are able to attend school, the disability can have impacts on overall school performance. Our team recognizes that school can be such a pivotal point in a child's life because it is here that they first develop a relationship with learning. A study by Jones, Rodger, Ziviani foud Boydnd that , anwhen compared to non-disabled peers, children with physical disabilities are twice as likely to drop out of school.[2] To that end, our research aimed to understand dexterity challenges students with cerebral palsy encounter within the classroom and identify opportunities to improve learning outcomes for those students. Our goal is to design dynamic, modular solutions for children with cerebral palsy to use day-to-day that empower students to modify the solution to fit their context of use.

A. Background

The first part of our research highlights work that shows for a solution to be adopted, the product must be grounded in the needs of the target population. Schenker, Coster, and Parush's work on children with cerebral palsy shows that reduced dexterity has a measurable negative effect on classroom participation and performance.[3] Diving into more of the why, work by Berrin et al. shows that pain or fatigue can affect confidence and motivation within the classroom.[4] In the context of our solution space, this means that products that reduce pain or increase classroom confidence can be keys to improving classroom performance. Further research by Tieman et al. highlights that overcoming reduced dexterity requires a contextual understanding of cognitive and behavioral capabilities and the setting of the desired task.[5] For our solution, this means we need to take into account current limitations of the environment in order to promote successful adoption. Finally, we referenced work by Huang, Sugden, and Beverdige that shows parents and teachers play a large role in the adoption of a device but often perspectives from adults can differ from the willingness of the child.[6] While we did not identify a gap in this research, these insights are critical in helping us understand the key stakeholders and factors that will ultimately influence whether the product is adopted.

Recognizing the importance environment plays in adoption, we next looked to understand how the success of products is defined. Specifically, we wanted to understand how assessments are used to measure activity levels, as this is likely to influence our research design. The research highlights that there are many different measures used to capture activity levels among children. While a number of these evaluations depend on the context, some studies have developed completion norms across age, gender, and ethnicity, such as work on the 9-hole peg test studies by Wang et al.[7] Palisano, Rosenbaum, Walter, Russell, Wood, and Galuppi developed a gross motor classification system that outlines the expected mobility a child by age range that can be applied to children with cerebral palsy.[8] These frameworks are helpful as we think about tools to measure baseline performance. That said, we were unable to find research that applies these frameworks to measure performance of assistive devices for children with cerebral palsy. While this highlights a gap in how to assess the efficacy of our own work, we plan to use this research to inform how we measure baseline activities for our study.

Finally, we looked at types of assistive devices used to augment human dexterity for children with cerebral palsy. A survey on assistive devices by Davies, Mudge, Amertunga, and Stott highlight the use of pointers, speech-recognition software, keyboard modifications, and screen interface options as the top solutions for computer use.[9] Resource guides such as those found on mycerebralpalsychild.org highlight common types of assistive devices for children with cerebral palsy, ranging from mobility devices like wheelchairs and braces to communication devices like hearing aids and voice controlled devices.[10] While these devices can have a tremendous impact on a child's life, most were static in nature and developed with a single context in mind.

In recent years, there has been a trend towards electronic-based solutions which includes revolutionary research by Meyer-Heim and Hedel on robot-assisted rehabilitation and virtual reality systems [11] and Herbs et al. on robot-assisted movement therapy. [12] These robotic solutions can be dynamic, however they are focused on rehabilitation and less on day-to-day use in the classroom. Unlike the research on environment and success measurements, the research on the latest assistive devices highlighted a clear gap: a lack of solutions for children with cerebral palsy that would allow the user to switch tools or components based on the current environment. Given that the environment plays such a critical role in the ultimate product adoption by the user, we wanted to explore this gap by looking at modular designs to help this target population.

B. Overview

From prior art we know that environment plays a critical role in adoption and yet most devices are grounded in one context, thus it follows that school performance outcomes might be improved from devices that are adaptable to the task at hand. We hypothesize that a modular device will empower students to perform better in the classroom as measured by the competition rate using said device across a subset of tasks. A preliminary interview with physical and occupational therapists who work with school children with dexterity challenges discussed in Section III, support the notion that for adoption to be successful, assistive devices need to be suited for the student's abilities and context. In Section IV, we present the design of a modular device that includes 4 different attachments and will enable us to study performance of school children with dexterity challenges. If our hypothesis holds true, it could change how engineers think about incorporating multiple contexts in the design of assistive devices, as discussed in Section IV. Section V discusses how these results would benefit students, school districts and the general public.

II. Preliminary Results

Our design process included an in-depth interview to better understand the needs of children with dextrous challenges. We interviewed occupational and physical therapists who work for a large urban school district. They are responsible for assessing the needs of children with physical or mental disabilities and coming up with solutions to improve their ability to attain an education. They each oversee roughly 70 children with a range of medical conditions, and have extensive knowledge of the availability and use of assistive devices. We used the method of contextual inquiry to explore the nature of dextrous challenges in children, their impact on performance and participation in the classroom and what mitigating strategies are used to remove educational barriers. Contextual inquiry attempts to reconstruct relevant scenarios for need-knowers through an expert-apprentice model. This uncovers needs and pain points in the current setting, often through unprompted remarks. Our interview provided valuable insight into the problem space and uncovered a core set of needs for the proposed device.

We first discussed the nature of dextrous challenges school-aged children face. The most common conditions related to reduced hand dexterity were cerebral palsy and autism. A novel insight gained from this interview that was not identified in our background research was the link between cognitive and physical abilities. For example, if a child is cognitively incapable of reading, they cannot write. The non-trivial implication of this insight is that the device needs to be embedded in the proper contextual ability of the end user; the physical goal of the device must also be a reasonable intellectual goal for the child user. Our interviewees noted this was in contrast to many device designs, which attempt to achieve the highest number or complexity of end goals possible. Our interviewees also expanded our understanding of how dexterity challenges appear in children. A student may have acceptable manipulation of their hand but have what is called "low tone" which means low muscle strength. Conversely, a student may have "high tone" with exceptional muscle strength but be subject to involuntary closures or poor finger manipulation. These challenges often result in very disparate needs for the user. Challenges also change over time; there are a number of conditions that result in dexterity challenges that may get more or less severe as the child ages, which causes change in their resulting needs.

Our interview next covered how these challenges impact classroom performance and participation. We had previously identified pain and fatigue as the most relevant symptoms of dexterity challenges as it pertains to school performance. While pain was not considered to be a common factor, our interviewees mentioned physical and mental fatigue as a highly limiting factor for performance among our target population. The insight that mental fatigue from frustration or concentration on a task is just as limiting as physical fatigue guided our hierarchical needs chart to include ease of use and instant usability. We confirmed our initial finding that dexterity challenges can cause increases in time for task completion, often leading to reduced performance and participation. Additionally, our interview uncovered a social impact of dexterity challenges. A student with severe dexterity challenges may be unable to communicate or participate in activities at the same pace as the rest of the classroom, leading to social isolation. Interventions such as individual helpers and complicated or intimidating devices may increase social isolation.

Our interviewees had extensive experience using and modifying assistive devices to improve a child's ability to obtain an education. They had used a variety of solutions including iPads, sticks, foot switches, picture boards, stability chairs and eye-tracking devices. This portion of the interview uncovered a wealth of needs for a device to be successful. We learned that teachers would be unlikely to implement the use of the device if it is too complicated or disruptive. The school district purchases and reuses devices so a successful device must be extremely durable and useful for a variety of users. Any level of maintenance or susceptibility to tampering will likely result in the device not being usable for extended periods of time. Devices that are classified as medical become exponentially more expensive. Heavy devices will increase fatigue and frustrate users. Students appear to prefer simple functional devices over flashy complicated ones. While the classroom is our main focus, students may also use the device in their homes, communities, stores, or churches. A student's medical needs may change over time and require a different or altered device. We organized and distilled these needs into the prioritized hierarchical needs shown below.

NEEDS

- The device enables independent completion of school-related tasks
- The device is durable and low maintenance
- The device is comfortable and easy to use
- The device is affordable
- The device is well-suited for the student's abilities and context

III. Methods

The overall concept of our prototype is to design a modular device for children with cerebral palsy to use day-to-day that enables them to modify the solution to fit their context of use. The figure below depicts the device and several attachments. Additional images and contextual use information are located in Appendix A. The prototype contains a universal adapter and various attachments. Although the adapter itself is rigid, it does have hinges to increase flexibility which allow better fit with the user's arm and necessary articulation. The larger rear section of the adapter is the battery pack while the front end contains attachment integration ports. This will be paired with different attachments for different use cases. The potential attachment may include a simplified mechanical hand, a hook, a laser, and a stylus holder to operate a tablet. The adapter can be attached to either side of the arm for different use cases. For example, it may be more convenient to attach the adapter on the palm side of the hand when using the pencil holder or the simplified mechanical hand. These devices only require limited hand dexterity to operate and interchange attachments without assistance from others. They slide into place and are removed by pushing back to release. While the goal is to allow for independent user attachment changes, students have support from faculty and staff available.

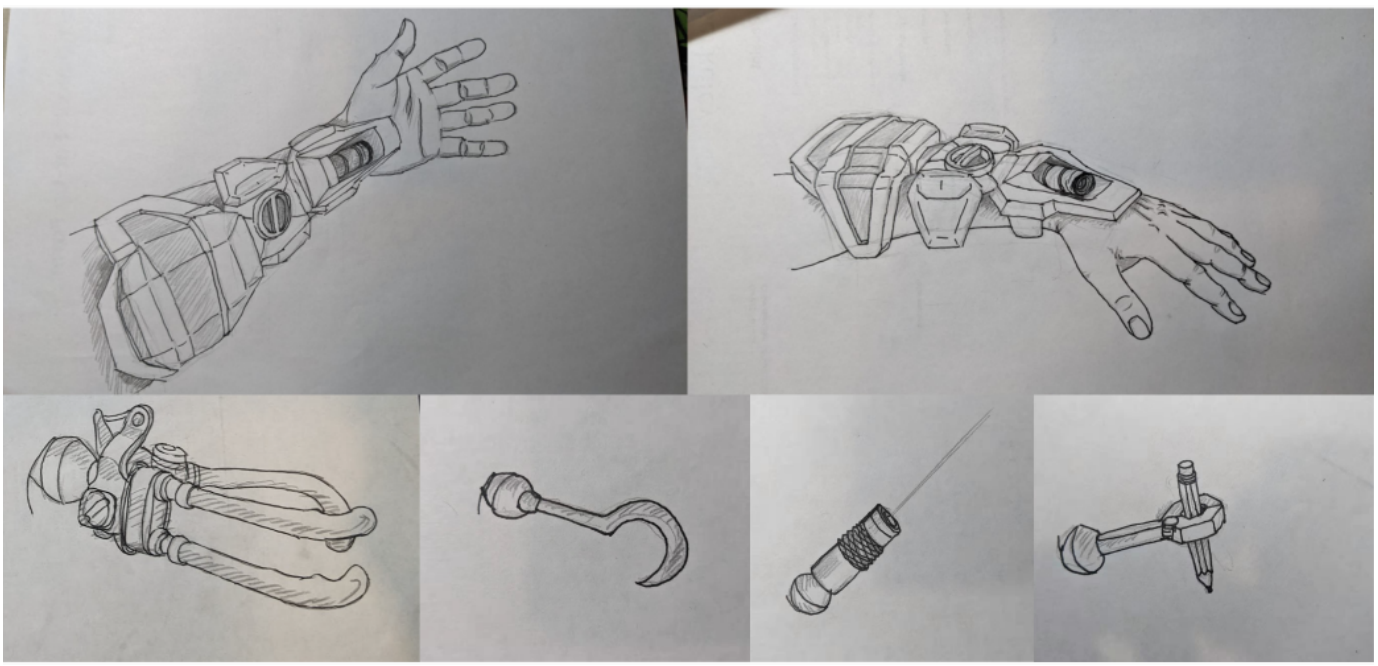


Fig. 1. Our Final design

We will attempt to evaluate the efficacy of the proposed device through a scientific study. At a fundamental level, we believe that our device will enable higher levels of educational attainment by reducing physical barriers to classroom activity participation. While educational attainment is a difficult result to quantify and study, we are able to examine and measure classroom activity participation. Thus, we propose a study that tracks completion percentage for various common classroom activities such as worksheets and assignments. The study will contain one control group and one intervention group who will receive the device. The target group will be sixth grade students with dexterity challenges. Teachers or in-classroom staff will note whether or not a student completes a given activity, data typically already collected by teachers for grading purposes. Completion of an activity, for the purposes of this study, will consist of a clear attempt to answer or complete more than three quarters of the given activity. Data collection will occur for one school year, or approximately 9 months. This will allow students adequate time to learn how the device works and how each attachment might benefit them individually.

The study will be conducted in partnership with a chosen school district. The initial sample size will contain 100 students in each of the control and experimental groups. Parents of the students will be approached the prior school year to explain the study and obtain permission for observation. Students will be monitored starting at the beginning of their sixth grade academic year. All students will have been evaluated by the occupational therapy office of the school district as having some form of moderate to severe hand dexterity challenges. This classification, while not precisely quantifiable, will be left to the expertise of the occupational therapists. At the beginning of the school year, students will be provided with the device and be given a short introductory training session with an occupational therapist to ensure proper understanding of operation. After this introductory period, resources required to run the study will be minimal. Teachers will record completion of in-classroom activities and provide that data to the study researchers. Completion may be defined differently by different teachers, so for the purposes of this study an activity will be considered complete if the student makes a clear attempt to finish at least three quarters of the activity.

The expected outcome of this study is increased completion of classroom activities amongst students who are given the device. The ability to choose the right tool for a given task will reduce physical barriers to task completion and enable students to more easily participate in these activities. We expect that students with the device will not attain higher completion rates immediately after receiving the device, but will learn to use the device rapidly within 2 weeks of initial use. Quick adoption of the device is crucial to success, as our background research and interview revealed that students may quickly become frustrated if device use is not easy to learn. Potential avenues of further research for this topic include a broader study group such as younger or older students, students with a wider range of dexterity challenges or associated cognitive disabilities. Evaluating whether or not this device assists students in educational attainment would require a longitudinal study that tracked student grade performance or graduation rate among users and non-users of the device.

IV. Intellectual Merit

This project has potential to be of interest to the academic research community. Many augmentative interventions, while well-intentioned, are prescriptive devices that stem from colonial notions of disability and aim to “save” the user. To our knowledge, this is the first study on an augmentative device that allows the user to make critical design decisions via tool selection. Positive results from this study would suggest that devices may be more useful when the end user has the ability to customize and shape their device to their needs in a specific scenario. This would fundamentally alter the role of designers, engineers and researchers in the field of assistive devices. Device design would have to adapt to better include user choice and embrace adaptability. This would include recognition of user needs and scenario constraints as being dynamic, rather than static, forces during design and implementation.

V. Broader Impact

This project has potential impact on the broader public. As the end-user, school-age children with dexterity challenges would directly benefit from a device that enables better completion of regular classroom tasks. Benefits may include better access to education, higher social and academic integration and reduced cognitive load during activities. Public school districts, as the key purchaser of this device, would benefit from students who are better able to participate in the classroom. This includes reduced human resources required to assist students, reduced spending on devices when reused, and better integration of students into mainstream classrooms. The broader public would benefit from a society better able to obtain an education and reduced public spending on devices and assistance. In addition, if successful this device could be used for a wide range of use cases common to the public such as repetitive stress activities, sports or leisure hobbies.

REFERENCES

[1] N. C. on Birth Defects, C. f. D. C. Developmental Disabilities, and Prevention. (2020) Data and Statistics for Cerebral Palsy kernel description. [Online]. Available: https://www.cdc.gov/ncbddd/cp/data.html

[2] F. Jones, S. Rodger, J. Ziviani, and R. Boyd, "Transition to secondary school for students with cerebral palsy and implications for quality of life: A systematic review," *Journal of Occupational Therapy, Schools, & Early Intervention*, vol. 2, no. 2, pp. 133–147, 2009.

[3] R. Scehenker, W. J. Coster, and S. Parush, "Neuroimpairments, activity performance, and participation in children with cerebral palsy mainstreamed in elementary schools," *Developmental Medicine & Child Neurology*, vol. 47, no. 12, pp. 808–814, 2005. [Online]. Available: https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1469-8749.2005.tb01085.x

[4] S. J. Berrin, V. L. Malcarne, J. W. Varni, T. M. Burwinkle, S. A. Sherman, K. Artavia, and H. G. Chambers, "Pain, Fatigue, and School Functioning in Children with Cerebral Palsy: A Path-Analytic Model," *Journal of Pediatric Psychology*, vol. 32, no. 3, pp. 330–337, 07 2006. [Online]. Available: https://doi.org/10.1093/jpepsy/jsl017

[5] B. L. Tieman, R. J. Palisano, E. J. Gracely, and P. L. Rosenbaum, "Gross Motor Capability and Performance of Mobility in Children With Cerebral Palsy: A Comparison Across Home, School, and Outdoors/Community Settings," *Physical Therapy*, vol. 84, no. 5, pp. 419–429, 05 2004. [Online]. Available: https://doi.org/10.1093/ptj/84.5.419

[6] I.-C. Huang, D. Sugden, and S. Beveridge, "Assistive devices and cerebral palsy: the use of assistive devices at school by children with cerebral palsy," *Child: care, health and development*, vol. 35, no. 5, pp. 698–708, 2009.

[7] Y.-C. Wang, R. W. Bohannon, J. Kapellusch, A. Garg, and R. C. Gershon, "Dexterity as measured with the 9-hole peg test (9-hpt) across the age span," *Journal of Hand Therapy*, vol. 28, no. 1, pp. 53–60, 2015.

[8] R. Palisano, P. Rosenbaum, S. Walter, D. Russell, E. Wood, and B. Galuppi, "Development and reliability of a system to classify gross motor function in children with cerebral palsy," *Developmental Medicine & Child Neurology*, vol. 39, no. 4, pp. 214–223, 1997.

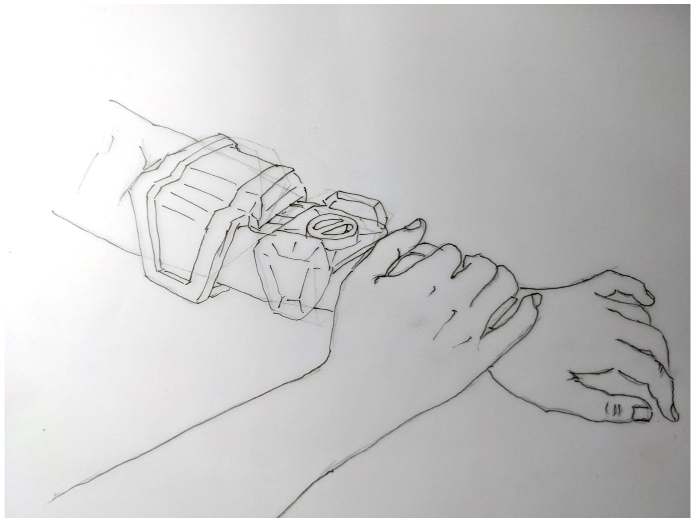
[9] T. C. Davies, S. Mudge, S. Ameratunga, and N. S. Stott, "Enabling self-directed computer use for individuals with cerebral palsy: a systematic review of assistive devices and technologies," *Developmental Medicine & Child Neurology*, vol. 52, no. 6, pp. 510–516, 2010.

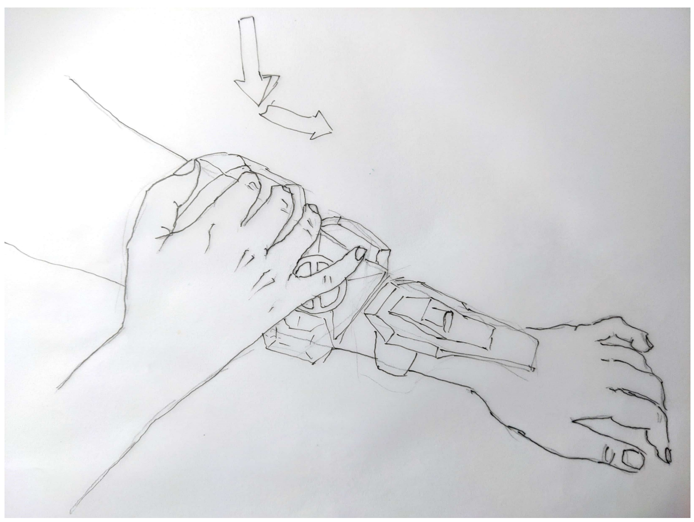
[10] MyCerebralPalsyChild.org. (2021) Assistive Devices for Kids with Cerebral Palsy kernel description. [Online]. Available: https://www.mycerebralpalsychild.org/treatment/assistive-devices/

[11] A. Meyer-Heim and H. J. van Hedel, "Robot-assisted and computer-enhanced therapies for children with cerebral palsy: current state and clinical implementation," in *Seminars in pediatric neurology*, vol. 20, no. 2. Elsevier, 2013, pp. 139–145.

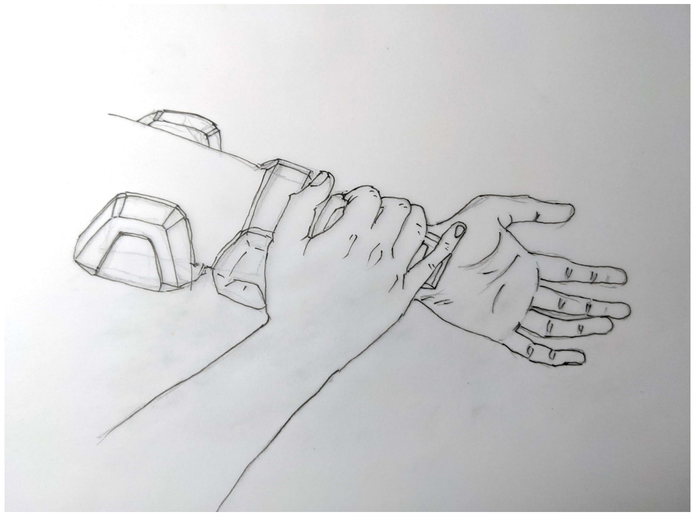
[12] H. I. Krebs, B. Ladenheim, C. Hippolyte, L. Monterroso, and J. Mast, "Robot-assisted task-specific training in cerebral palsy," *Developmental Medicine & Child Neurology*, vol. 51, pp. 140–145, 2009.

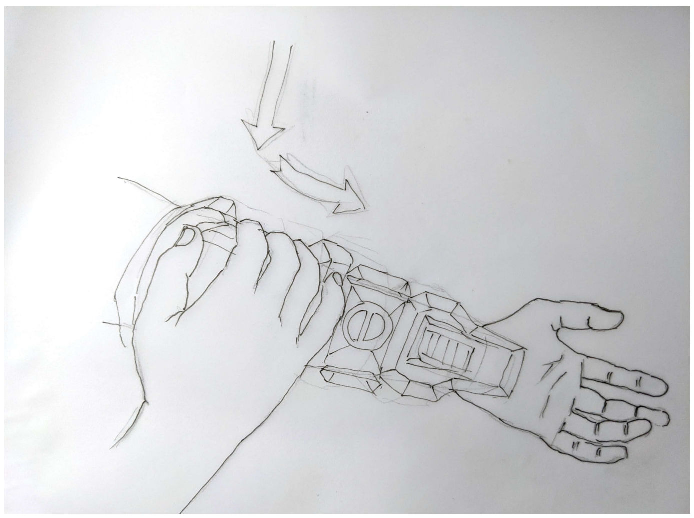
Appendix A
Investigational Device Details



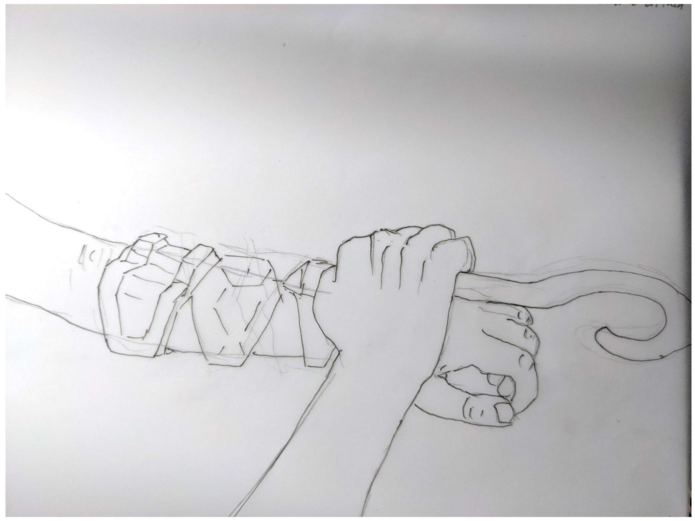


a): In most cases the user will find it handy to attach the universal adapter on the back side of the arm for more strength and dexterity. Those two drawings show how to put the universal adapter on the user's arm and attach the battery pack. Each module of this adapter has an adjustable latch similar to the dive watch belt. This only requires limited hand strength and dexterity to put it on and fasten. To attach the adapter, the user needs to place the adapter on the front of their forearm to fasten the adjustable latch. Once the adapter is in place, the user can attach the battery pack by first placing the battery on the arm and slide in to fit the slot of the adapter. After that the user can then choose the type of attachment he/she wants to use in each use case.

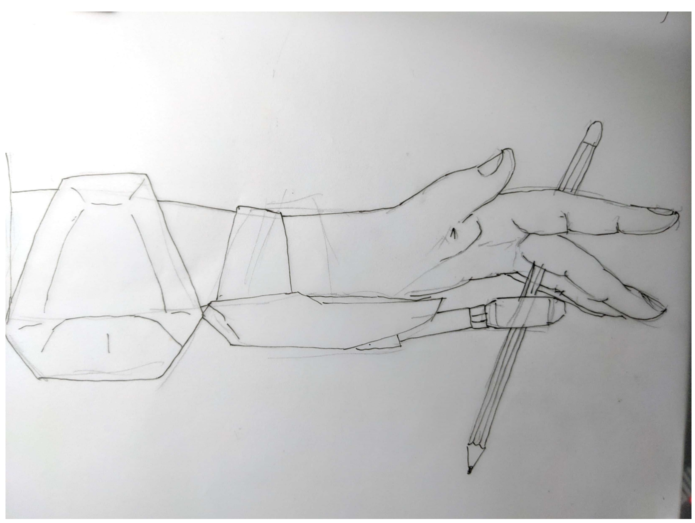




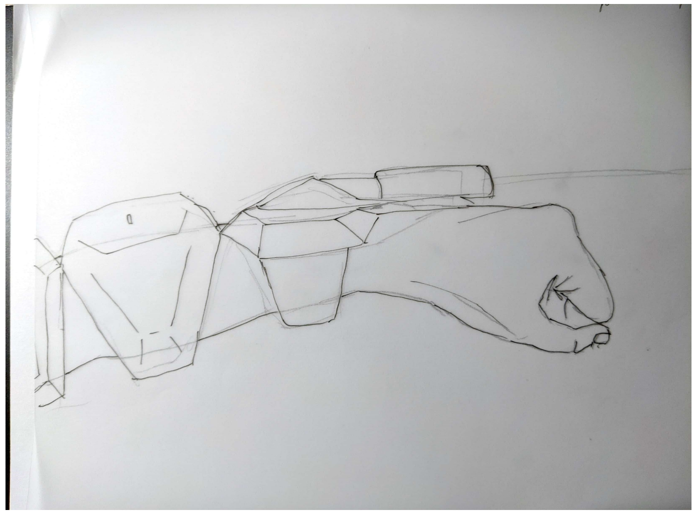
b): In other cases where the user might find it more useful to attach the universal adapter on the palm side of the arm to manipulate certain attachments. Those two drawings show how to switch/attach the universal adapter on the palm side of the arm. The use can loosen up the adjustable latch on the belt and put it on the wrist/arm. Then he/she just needs to tighten the latch to secure the position of the universal adapter. Last but not least, attach the battery pack in the same manner as previously.

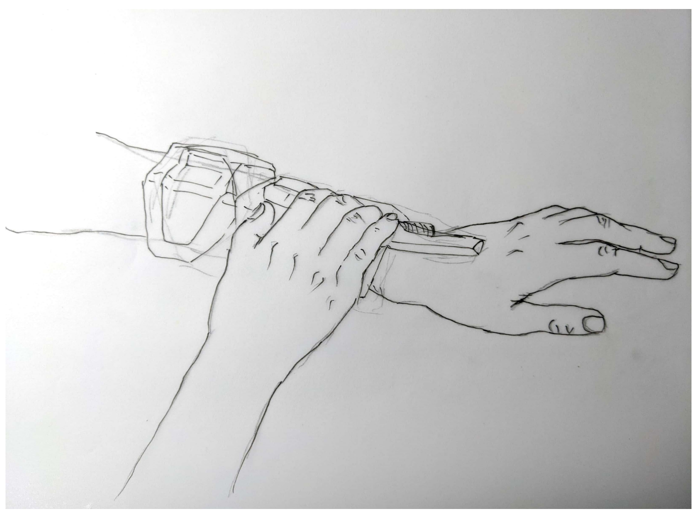


c): This demonstrates how to put on attachments (in this case a hook). The universal adapter has a mating port that the hook can fit in. The user simply needs to align the hook with the port to attach. The universal adapter will provide 1 degree of freedom(rotation)



d): The user can attach various attachments to fit different use cases. Examples like using a laser pointer and a mechanical pen holder to write/operate iPad. The universal adapter will provide electric power to the attachment if needed.





e): When the user wants to detach the attachment, simply press the button on the middle of the universal adapter. The adapter will release the attachment automatically.

APPENDIX B
REQUEST FOR INTERVIEW SCRIPT

Input your script for initial contact with the prospective interviewee. Also include two followups, if the person says yes, or if they say no.

Initial Script
Dear X,

I hope you are doing well. We are reaching out as 3 graduate students at UC Berkeley taking a class on augmenting human dexterity. As part of our class, we are hoping to understand the experience of X, in order to support the creation of an assistive product for our class project.

We would love to schedule a 1-1.5 hour long interview with you to learn more about X within the next 2 weeks. We are interested in your thoughts specifically because X.

We would like to clarify a few points about our request. Because this is an activity for a class project, we would like to clarify that there is no direct benefit or compensation for participating in this interview. That said, we are happy to share our end-of-semester project report with you and would really appreciate your time. Our intention is that this would be a private interview that would not be published with your permission.

Please let us know if you are both interested and available in participating.

Best,
Signature

If they decline:
Thank you for your time, we understand completely. Please let us know if you change your mind or wish to share any further thoughts.

If they agree and want to know more:
Thank you for your response. In answer to your questions, X.

If possible, we would prefer to conduct this interview via Zoom. Would that work for you? Alternatively, we could use another platform or a phone call.

Moreover, please let us know your availability to conduct the interview.

APPENDIX C
COLLECTING AND ANALYZING INTERVIEW DATA

This is work from P2. For the preliminary results distilled from the interview, please see Section VI: Preliminary Results.

A. *Part 0: Reading Preparation*

a): On page 79, the author proposed a list of helpful questions. How would you rework these types questions to fit with your own interviewee and topic? (If your interviewee is not yet confirmed, assume your "top-choice"). Product experience is a useful line of questioning, once you are familiar with existing technologies (i.e. through background research!). In the context of this class, what are the limitations of this type of questioning, that is only in reference to an existing technology, and what types of questions can you ask that are not limited in this way?

Response: These questions are vague, and could be tailored to ask directly about children and learning in the classroom. Our interviewee will be very familiar with these devices, but does not use them directly, so can only comment on their own observations. For example, questions might look like:
- What types of products do you see used in the classroom by your patients?
- When/why do children turn to these products?
- What's the biggest complaint you hear from your patients about these products?

The limitation in asking directly about products is that you might end up overly focused on a single product or end up creating an incrementally better product as opposed to one that addresses the needs of the user. To avoid this limitation, questions can be asked about needs or pain points rather than existing solutions. This allows interviewers to have a better understanding of the problem space, without the reference bias of current products.

b): What is the purpose of capturing wording verbatim, rather than simply summarizing the responses throughout the interview? In what other ways is video recording and automatic transcript generation (e.g. the "Zoom" phenomenon) so valuable?

Response: Any time the interviewer synthesizes or summarizes a response, they may add their own biases or interpretations so it is important to retain a reference of the verbatim source material. Automatic transcript generation and video recording allow the interviewer to focus solely on the interview without being distracted by the notetaking. Video interviews also allow "face to face" conversations with users who may be in other countries or states. Finally, video interviews enable interviewers to capture facial responses to questions. These types of observations are more difficult to capture in standard note collection and may offer more insight into the user's candid thoughts about a task/product/situation.

c): Summarize, on whole, why is it important to follow the guidelines outlined on page 82-83 while first analyzing the data, and what is the primary outcome of such an exercise. Why is this not the final "Step" in the analysis process?

Response: The guidelines help frame the analysis of the problem space identified by the interviewees. The guidelines can turn raw information from an interview into useful insights. Guidelines also help the team maintain consistency in the phrasing of their outputs, which allows for easier analysis and comparison afterwards. The primary outcome of such an exercise is a list of customer needs as it relates to potential new products.

This is not the final step because you may need to reconcile conflicting needs that the team has identified at a later point. It is also important to accomplish this step early in the process, as prioritizing needs cannot be done without understanding what the needs are.

d): Describe how your team will adjust this exercise to perform it remotely, while still achieving the same step-by-step procedure suggested by the author.

Response: Note taking and creation of user needs can be conducted through Google Docs to allow for simultaneous editing. Utilize tools such as Zoom and Mural for discussions and activities.

B. Part 1: Interview Preparation

Part 1a: Beginning of Interview

- Facilitate introductions and role of each participant on the call (e.g. note take vs. interviewer)
- Secure permission to record the conversation
- Remind interviewees of duration of interview and that they're free to end it at any time
- Provide purpose of the interview: To better understand the nature of dexterity challenges children face, what solutions currently exist and what needs aren't being met
- Offer the chance for them to ask any clarifying questions before we begin

Part 1b: Questions

- Tell us about your job duties
- What conditions can cause dexterity challenges in students? Which ones are most/least common
- What types of dexterity challenges have you seen in your role? nature/characteristics of challenges eg loss of finger function, shaking, low strength etc
- How do/might these challenges affect a student's performance or participation in the classroom?
- How do/might these challenges affect a student's performance or participation in a remote learning setting?
- What types of assistive devices do students use?
- What types of tasks are students trying to accomplish with these products? When/how do they use these products?
- Does a student typically have one device to accomplish one task, or are there devices that accomplish multiple tasks?
- How do students acquire these tools? Are these products provided to the students or do they have to purchase their own?
- What do you like about these products?
- What are some complaints you hear from parents about these products?
- What are some complaints you hear from students about these products?
- What factors are important when considering whether a child will want to use an assistive device?
- What types of factors would you look at to determine whether these tools are successful?
- Where do current solutions fall short? What latent needs/factors that have not been addressed by any of the current solutions?
- Is there anything we didn't cover that would be helpful for us to know in the context of this project?
- Do you have any other connections that we can reach out

Part 1c: Conclusion

- Thank participant for their time today
- Remind participant interview will be kept confidential
- Invite participant to reach out with any further thoughts or insights if they arise
- Ask participant if it would be ok to reach out for any follow-up questions
- Ask if there are any final questions on their end?

Part 1d: Roles

- Primary Interviewer: Ian
- Secondary Interviewer/Timekeeper: Dunja
- Note taker: Xiaolin

C. *Part 2: Conduct the interview*

Nothing to report for this section.

D. Part 3:Interpret the interview results(analyze)

User Needs Chart

Customer:	Interviewees	Interviewers	Ian Miller, Dunja Panic, Xiaolin Wang
Address:	Zoom	Date	9, March, 2021
Telephone:	N/A	Currently users:	Children from 3-22 with hand motor issues
Willing to follow up?	Yes	Type of users:	Students

Question/Prompt	Customer Statement	Interpreted Need
Common causes of dexterity issues	Cognitive function determines motor function and dexterity	The device accomplishes tasks that are reasonable for the cognition of the user
	CP and autism are the most common causes of dexterity issues	The device would have the largest market if it was friendly towards CP/autism students
What types of dexterity challenges have you seen?	Hard for kids to hold things so they get less practice than other kids	The device is easy to hold and allows for repetitive use
	Kids with CP do not have fine motor skills and can't operate an iPad	The device does not require fine motor skills and makes it easier to use an electronic device
	High muscle tone students have involuntary grasp reflex	The device is strong enough to be crushed or is not located in the palm
	Low muscle tone students have squishy hands	The device is strong The device does not require high grip strength
How do these challenges affect performance/participation in the classroom?	It depends on their stamina and frustration	The device is easy to use and is not fatiguing
	We can look for alternatives (using a foot, pointing at pictures, etc)	The device does not have to use hands for input
	We can use switches they operate with their hand or head	The device is capable of inputs using various parts of the body

	Need to think about the audience that they're communicating with - they have to understand them	The device is able to effectively interact with non-users
What types of assistive devices do students use?	iPads sticks pictures pointers switches cork boards	The device could be electronic, mechanical, or physical
	Chairs and wheelchairs with lateral support so they just have to think about their hands	The device does not require increased workload/control of any other part of the body
	If we can establish a method of communicating a consistent yes, we can ask yes no questions and get a lot of communication	The device is very capable of getting a consistent yes
Are the devices task specific, or usable for a wide variety of things?	iSome devices very specific: shaking spoon. Others more general	The device is capable of accomplishing several tasks
How do students acquire these devices?	We pay for them	The device presents good value for the cost
	We look at the cost and see if its a good investment. Need to be able to reuse/adjust/use for another student	The device is adaptable and durable enough to be used by several different users
What are some complaints you hear about these devices from parents	Some parents want to try everything	?
	Most parents don't care to know the specifics	The device is easy for parents/caregivers to implement and maintain
	A big portion of the district is SE disadvantaged	The device is not expensive
Complaints from students?	Teachers priorities for student may not always align	The device reduces caregiver burden on teacher
	Our first priority is education. Parents may prioritize other things	The device improves the user's ability to obtain an education
What factors do you consider when selecting a device?	Pain is rarely an issue. Fatigue is an issue.	The device does not cause fatigue
	Dystrophy students don't lose function until 8 or 9 and we transition them to electronics	The device does not have to be helpful to the user for years
What determines if a tool is successful?	If you cant fix something, find an alternative	The device is capable of accomplishing alternative tasks
	Must be picked up and used quickly otherwise they get frustrated	The device is easy to learn how to use

	If its too complicated for the teacher to implement they wont use it	The device is easy for the teacher to support
	Cost	The device is low cost
	Weight	The device is low weight if it is held by the user
	Durability	The device is durable enough to survive drops/spills/etc
	Maintenance	The device does not require a lot of maintenance
	Ultimate goal is to continue improving their education	The device improves the users ability to obtain an education
Are there temporary dexterity challenges	We have to continually monitor students to see how their needs change over time	The device is adaptable as the user's medical needs change
Where do current solutions fall short?	Price for medical devices can be cost prohibitive, whereas educational devices are more affordable	The device is affordable for families
	Low tech solutions have a shorter learning curve	The device is easy to use
What are suggested improvements?	Would love voice to text where you don't have to go back and type to fix what you said	The device includes the ability to make edits without the use of hands
	Want cheap, light, durable objects that are easy to replace	The device is tamper-proof
	Want clamp that holds an object firmly to a wheelchair, doesn't turn when you bump it, and requires no disassembly to go to the bathroom	The device achieves its main objective without disrupting an individual's current environment

Hierarchical List of Primary and Secondary Customer Needs

1.0	**The device provides comfort and ease of use**	3.0	**The device is durable and low maintenance**
1.1	The device does not cause fatigue.	3.1	The device is adaptable and durable enough to be used by several different users
1.2	The device is easy to use and is not fatiguing	3.2	The device does not require a lot of maintenance
1.3	The device is low weight if it is held by the user	3.3	The device is easy for parents/caregivers to implement and maintain
1.4	The device is easy to hold and allows for repetitive use	3.4	The device is strong enough to be crushed or is not located in the palm
1.5	The device does not require fine motor skills and makes it easier to use an electronic device	3.5	The device is tamper-proof
1.6	The device does not require high grip strength	4.0	**The device is adaptable to the user's context and environment**
1.7	The device does not require increased workload/control of any other part of the body	4.1	The device achieves its main objective without disrupting an individual's current environment
2.0	**The device is easy to learn**	4.2	The device accomplishes tasks that are reasonable for the cognition of the user
2.1	The device is easy to learn how to use	4.3	The device is able to effectively interact with non-users
2.2	The device is easy for the teacher to support	4.4	The device is adaptable as the user's medical needs change
5.0	**The device is affordable**	7.0	The device improves the users ability to obtain an education
5.1	The device presents good value for the cost	8.0	The device is electronic, mechanical, or physical
5.2	The device is not expensive	9.0	The device would have the largest market if it was friendly towards CP/autism students
5.3	The device is affordable for families		
6.0	**The device is very capable of getting a consistent yes**		

E. Part 4:Perform a remote brainstorming session with your team(diverge)

Fig. 2. Ideas generated during brainstorming session

F. Part 5:Select an idea for continued study/development for the rest of the semester(converge)

Part 5A:

Criteria	Weight	Voice text editing capabilities	Clamp that holds objects firmly	Object that helps loosen grip and/or reduce shaking	Mechanical arm that writes what is said by user	Sensors that detect hand release to deploy mesh net for dropped items	Supernumerary finger to help provide stability for grasping objects	Visual to voice converter	Eye tracker to type keyword	Additional arm to assist heavy object lifting	Modular device that is customizaable
Applicability to Class	2	1	3	3	3	2	4	1	1	4	4
Scalability	1	3	2	2	2	3	3	2	3	3	3
Team Interest	1	2	3	2	3	2	3	2	2	4	3
Feasibility in 4-6 Weeks	3	2	3	2	1	3	3	1	2	1	3
Meets Customer Needs	3	4	3	2	3	3	2	3	3	3	3
Total Score	10	25	29	22	23	27	29	18	22	27	32

Fig. 3. Criteria with Rankings for Ideas

Criteria	Weight	Psycho-frame to control prostehtic arm/leg	Prosethtic hand controlled by buttons	Devices that reinforce grasping/pinching	Magnetic/ rubber band stylus and wristband to operate ipad	Button board - press one large button to change scenario, other buttons have common items/needs	Tray/catcher to prevent dropping things	Bands that stabilize hand as it operates	Headband to control electronics	Pencil that is vertically attached to clipboard
Applicability to Class	2	3	4	4	3	2	2	3	1	2
Scalability	1	2	3	4	4	2	3	2	3	3
Team Interest	1	2	3	3	2	3	2	1	2	2
Feasibility in 4-6 Weeks	3	3	2	3	4	3	3	3	2	3
Meets Customer Needs	3	3	3	3	2	3	2	2	3	3
Total Score	10	28	29	33	30	27	24	24	22	27

Fig. 4. Criteria with Rankings for Ideas, continued

Part 5b:

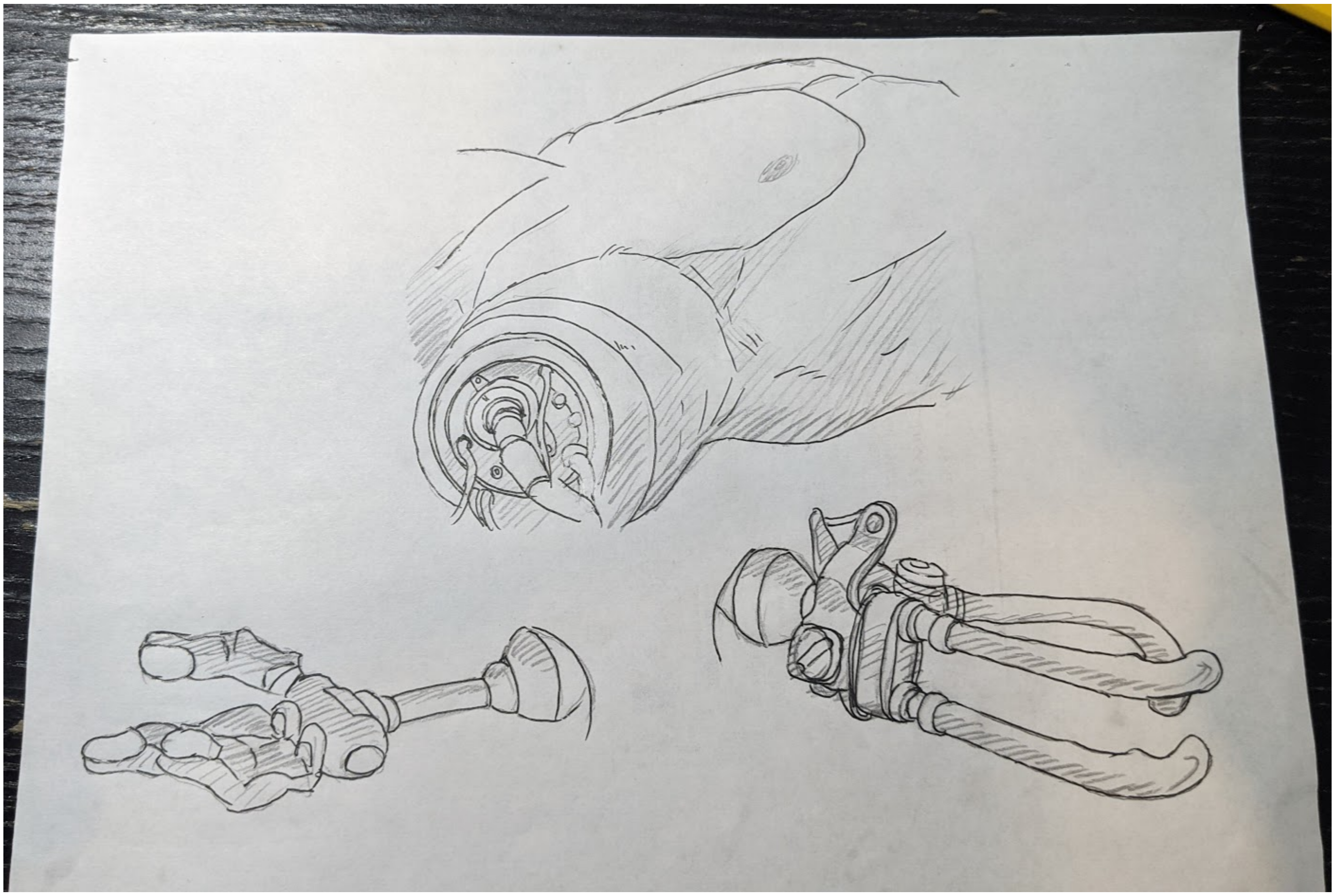


Fig. 5. Our Final Concept

This idea is a modular device that is customizable. With a standardized connecting port from the limb, the user can swap out different types of prosthetic hand for specific tasks. Examples of prosthetic hand could be hooks used to lift heavy objects, high articulation hand that perform delicate tasks, simplified hand(¡5 fingers) for regular grasping, and devices that fit magnetic/ rubber band stylus and wristband to operate ipad. We hope this design can enable prosthetics to have unlimited possibilities to help people with disabilities.