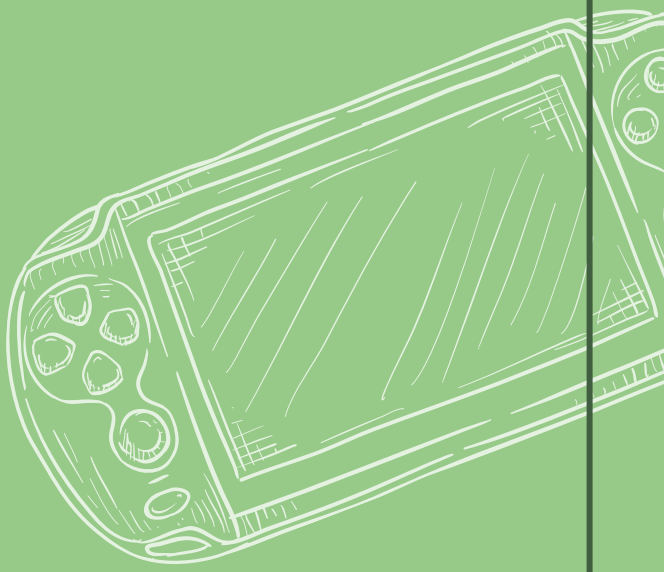
2025

DNB311 INDUSTRIAL DESIGN CAPSTONE

RESEARCH REPORT

Inclusive design: a study on how research and customisation could play a role in the future of gaming for physically impaired users.



QUEENSLAND UNIVERSITY OF TECHNOLOGY

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ACKNOWLEDGEMENTS

Authenticity Statement: This is to certify that to the best of my knowledge; the content of this report is my own work. This report has not been submitted for any subject or for other purposes. I certify that the intellectual content of this report is the product of my own work and that all the assistance received in preparing this report and sources have been acknowledged.

AI Use Statement: I have utilised AI in this report. Atlas.ti was used to assist in various ways throughout Part Two Analysis and Findings. The ways it was used include assistance in transcribing audio, and coding qualitative responses in interviews and surveys.

Acknowledgment of Country: The Queensland University of Technology (QUT) and I acknowledges the Turrbal and Yugara people, as the First Nations owners of the lands where QUT now stands. We pay respects to their Elders, lores, customs and creation spirits. We recognise that these lands have always been places of teaching, research and learning and that sovereignty was never seeded. QUT acknowledges the important role Aboriginal and Torres Strait Islander people play within the QUT community.

Name: Ella Hore
Date: 7th of September, 2025

EXECUTIVE SUMMARY

This research project aimed to bridge a significant gap in the gaming industry: the lack of accessible hardware for individuals with physical upper limb disabilities (ULDs). While gaming has evolved into a global phenomenon, most gaming hardware is still designed for an "average" user, overlooking the diverse and specific ergonomic needs of gamers with physical ULDs. This study employed a comprehensive approach, leveraging secondary research such as a literature review and product benchmarking, as well as primary research methods, including a large-scale survey and interviews with experts and end-users. The research investigated the functional impacts and limitations experienced by people with physical ULD's relating to their interaction with video games. Through a statistical and thematic analysis, the primary research findings revealed that gamers with physical ULD's frequently face a combination of challenges, including fatigue from repetitive movements, difficulty with complex button combinations, and more common functional limitations such as limited hand mobility, reduced grip strength and coordination deficits. The findings also highlighted a strong desire among this community for greater customisation and flexibility in their gaming setups. The quantitative and qualitative data consistently concludes that innovation in gaming hardware should shift from a one-size-fits-all approach to developing flexible, intuitive systems that can be easily personalised from user to user. Opportunities arose from the research study, proposing design considerations and implications for future hardware development.

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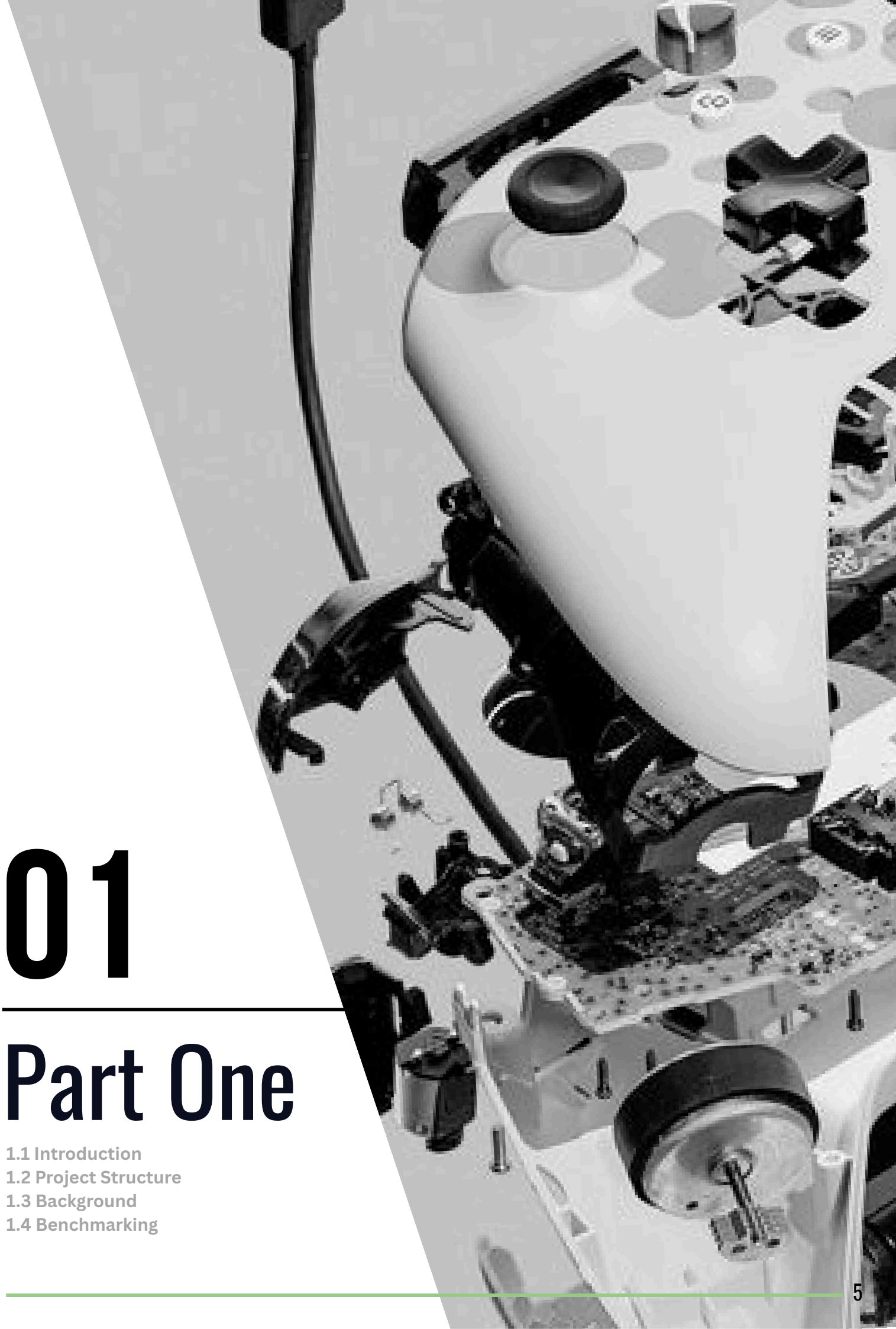

01

Part One

1.1 Introduction
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PART ONE

1.1 INTRODUCTION

WHY ACCESSIBLE GAMING?

Games are no longer a niche activity but a global industry worth over $200 billion annually, embedded in everyday in many cultures across the globe (Chadha, 2024). The evolution of gaming hardware dates back to the 50's, where video games were considered as entertainment media. Today, video games are positioned as not only a means of entertainment, but an important source of education, social connection and rehabilitation. Australian Research Council Centre of Excellence for the Digital Child's chief investigator Daniel Johnson believes “gaming will continue to become an increasingly integral part of family life” (Johnson, 2025).

For people with Motor Neuron Disease (MND), such as 56 year-old Australian Rob Taylor, gaming is a way to “disappear from reality and become the avatar that doesn't have a disability” (Taylor, 2025).

The **aim of this project** is to better understand the diverse physical and ergonomic needs of individuals with physical ULD’s and investigate how emerging technologies and industrial design can be applied to gaming hardware to enable more equitable participation in gaming. A physical disability can be referred to a condition limiting an individual’ s physical functioning (Maggiorini et al., 2017). More specifically people with physical disabilities affecting their upper limbs often suffer mobility and dexterity limitations which can have manifold consequences on the gamer’s daily interaction with video games.

Unlike digital tools, which can often be adapted quickly through software adjustments, physical products require more complex design solutions to accommodate diverse bodies, abilities, and ways of interaction. Professor Johnson said while games were becoming more accessible for people with disability, but there was there was still more that could be done: “there's no reason you can't adapt it to the different needs of people playing” (Johnson, 2025). Therefore, this report will explore three key objectives:

1. *To investigate the accessibility challenges and ergonomic needs faced by gamers with physical upper limb disabilities.*
2. *To benchmark existing adaptive and mainstream gaming hardware in order to identify limitations, gaps, and opportunities for improvement.*
3. *To examine how emerging technologies and design strategies can enable more adaptable and personalised gaming experiences for users of all abilities.*

Figure 1: Key Objectives of the research report

1.2 PROJECT STRUCTURE

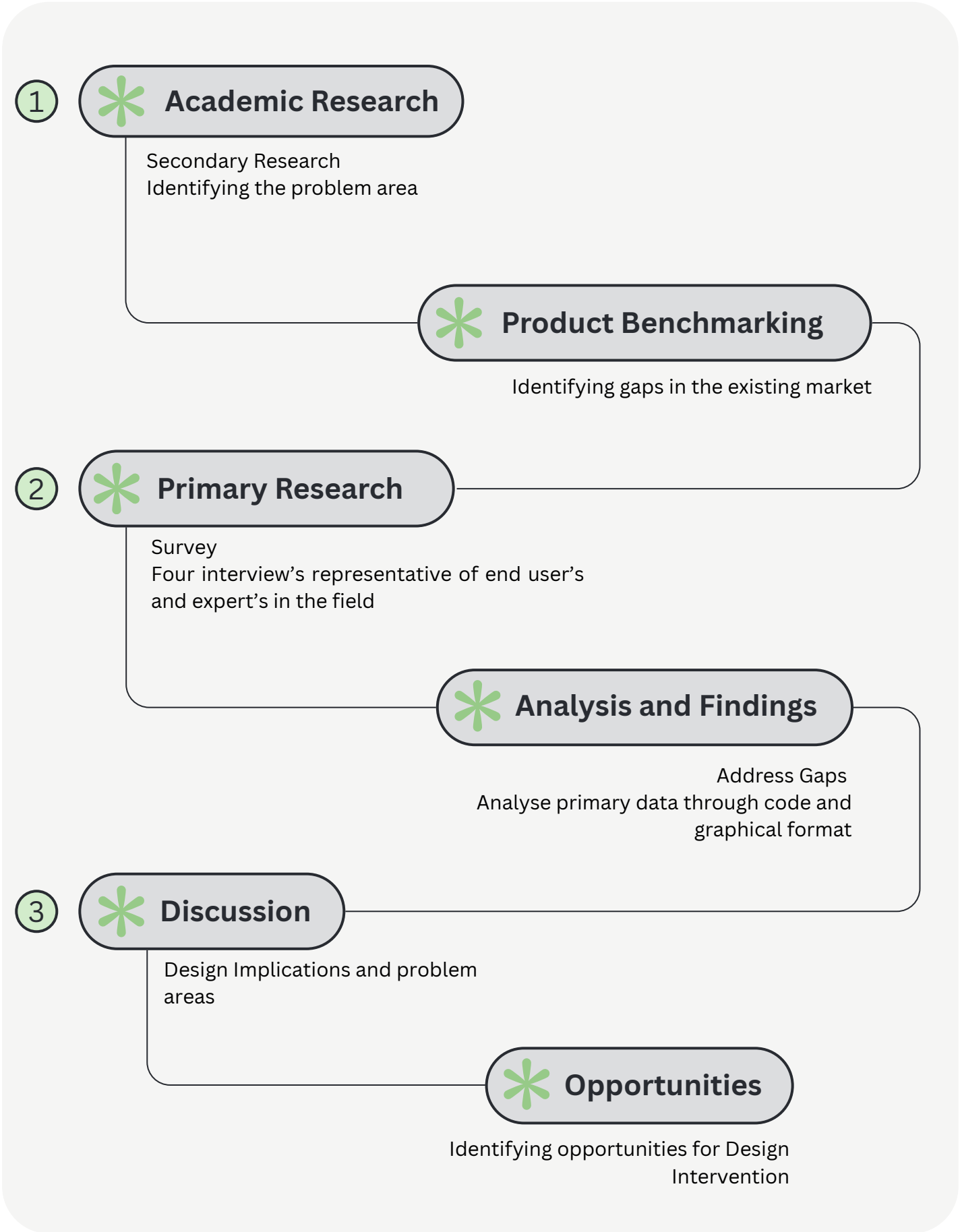

Figure 2: Project Structure Diagram

1.3 BACKGROUND

Accessible gaming has emerged as a critical area of study within inclusive design ever since the introduction of 3D games in the 1990's, new areas of exploration opened up. MND Queensland's director of care services, Alicia Edwards, said “many people with the condition found gaming to be a pastime for leisure and social connection” (Edwards, 2025). The effects of video gaming are widely discussed among scientists. Recent studies using MRI/fMRI technique for brain imaging have demonstrated that there is a link between neural correlates of video gaming (particularly 3D adventure games) and cognitive function. Further, such studies showed effects on the structure of hippocampus, dorsolateral prefrontal cortex, cerebellum, and ventral striatum activity. In simpler terms, the hippocampus showed improvement in short term memory and scene recognition, whereas the dorsolateral prefrontal cortex and cerebellum are storage information manipulation and problem-solving processes (Brilliant et al, 2019).

It’s necessary to understand the diverse range of conditions that fall under ‘physical ULDs,’ all of which impact physical function rather than cognitive ability (Poltawski et al., 2016). Physical ULD’s can arise from: musculoskeletal conditions, such as paresis, pain, loss of sensation, spasticity in different parts of the upper limb, or from neurological injuries affecting the network of nerves in the shoulder and arm (e.g. the brachial plexus). **Functionally**, physical ULD’s can significantly impair fine motor control, such as grasping, writing, and holding everyday objects, as well as gross motor functions including reaching and lifting. These impairments often limit independence in essential activities of daily living, restrict educational participation, and contribute to fatigue and secondary physical strain (Klingels et al., 2012).Physical ULD’s can be grouped into three primary categories of causes, congenital conditions, acquired injuries and progressive diseases (figure 3) (Melgio et al., 2024).

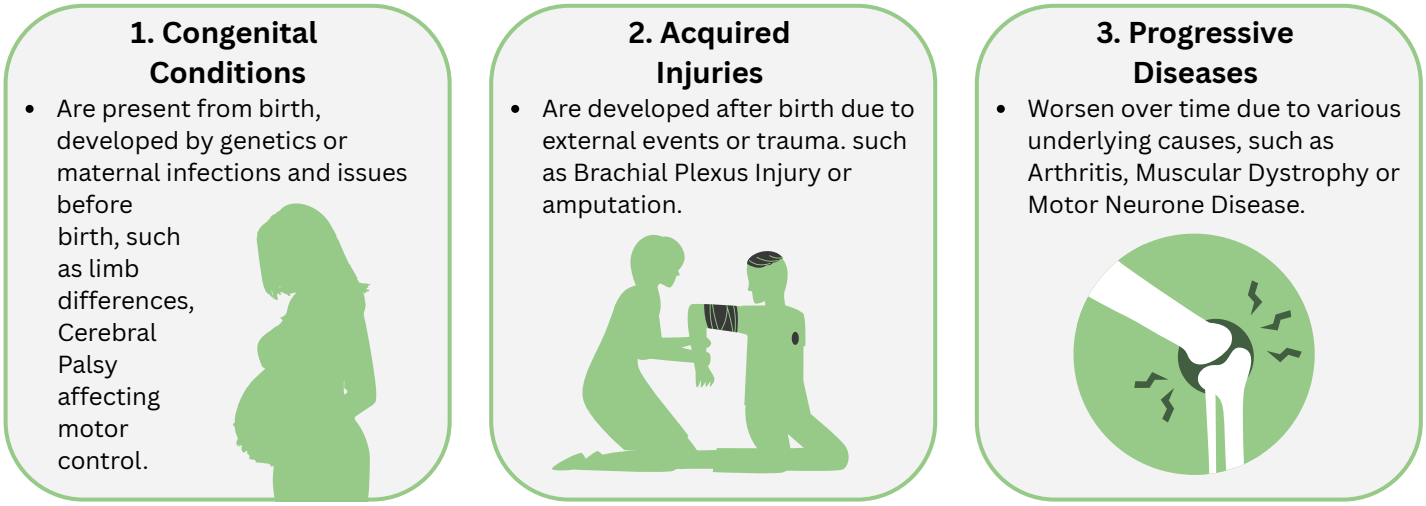

Figure 3: Causes of ULD’s (O’Flaherty, D., & Ali, K., 2024).

Importantly, this research project will focus on disabilities that only affect the user physically, and not cognitively or intellectually. In other words, cognition remains intact but the user’s physical function is failing, where the brain is capable of engaging in gaming experiences, but the body presents barriers to input and interact with the hardware (Uitti et al., 1995). This can range from common physical conditions such as Arthritis and Carpal Tunnel Syndrome to some congenital upper limb abnormalities and syndromes that are exceptionally rare such as Dysplasia in the hands. Further, physical ULD’s alone can affect the persons **psychosocial** well-being, contributing to emotional stress for both individuals and caregivers. Children and adolescents may experience frustration, reduced confidence, and social exclusion when unable to participate fully in peer activities. (Sakzewski et al., 2015).

1.4 BENCHMARKING

The best designs are rarely created in isolation, the quality of a new product is typically judged by how it compares to what already exists. The process of Benchmarking involves systematically evaluating existing products within the same market to identify cost, current market trends, quality drivers, lack of functionality and unwanted functionality (Per et al., 2001). With the vast range of gaming hardware available for 3D video games, this section narrows its focus to devices specifically marketed as “accessible” or “adaptive.” The aim is to build a clearer understanding of the current market landscape and the products designed to support players with disabilities. The following benchmarking outlines both the methodology and findings used to evaluate key products within the accessible gaming hardware space.

	Product	Category	Modularity	Platform Compatibility	Connectivity	Portability / Flexibility	Accessibility	Price / Value	Overall Score
	**ByoWave Proteus**	Handheld controllers	4	5	5	5	3	1	23/30
	**Grier QuadPad Button Set**	Buttons and Switches	2	2	2	1	2	3	14/30
	**Nintendo Hori Flex Controller**	Adaptive Hub	5	2	2	3	3	1	16/30
	**Logitech Adaptive Gaming Kit**	Buttons and Switches	5	3	3	2	5	5	23/30
	**PlayStation 5 Access Controller**	Adaptive Controllers	3	1	5	5	3	5	22/30
	**Razer Naga V2 Pro**	One handed gaming Mouse	3	3	4	2	1	1	14/30
	**Thrustmaster eSwap X Pro/X2**	Handheld controllers	3	3	4	5	2	3	20/30
	**Xbox Adaptive Controller**	Adaptive Hub	4	5	5	2	5	5	26/30
	**Xbox Adaptive Joystick**	Joysticks	2	5	2	2	1	3	15/30

Table 1: Accessible Gaming Hardware on the current market scored (Refer to Appendix X for a full analysis and benchmarking criteria information)

Table 1 compares a range of existing adaptive and mainstream gaming devices against benchmarking criteria including modularity, platform compatibility, connectivity, portability, accessibility, and price/value. Visualised in Figure 4 is a radar graph highlighting both the strengths of current products and the significant opportunities that remain within the accessible gaming hardware market. The Xbox Adaptive Controller (26/30) scored the highest overall, excelling in platform compatibility and connectivity as it acts a hub for third party buttons and peripherals, such as the Logitech Adaptive Gaming Kit which also scored relatively high (23/30). However, both of these products have limited portability and require rigorous set up and programming of buttons. Similarly, the PS5 Access Controller (22/30) provided remapping and accessibility features but lacked broader platform support being a Playstation only product.

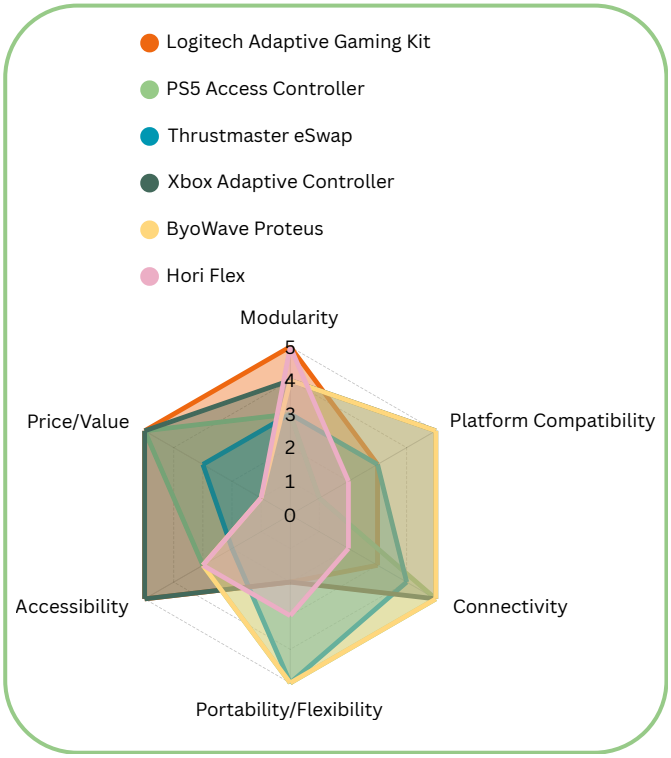

Figure 4: Radar Graph benchmarking the highest scoring products identified in Table 1

The ByoWave Proteus (23/30) stood out as an innovative concept with snap-together modular design, but its high price and novel design make it less viable for widespread adoption. In contrast, smaller devices such as the Grier QuadPad (14/30) or Razer Naga (14/30) one handed Mouse cater to niche needs, such as one handed players, but fail to address the broader spectrum of disabilities, overall offering limited flexibility. These products highlight the fragmented nature of the market, where devices either target specific impairments or offer modularity without addressing affordability, aesthetics, or portability. The radar graph (Figure 4) reinforces this imbalance: no product achieves high scores across all categories, with each excelling in certain areas while compromising in others.

MARKET SUMMARY

This highlights several key gaps and opportunities: the need for greater affordability, lightweight portable solutions, and mass-customisable designs that respond to varied ergonomic needs such as hand size, grip strength, and range of motion.

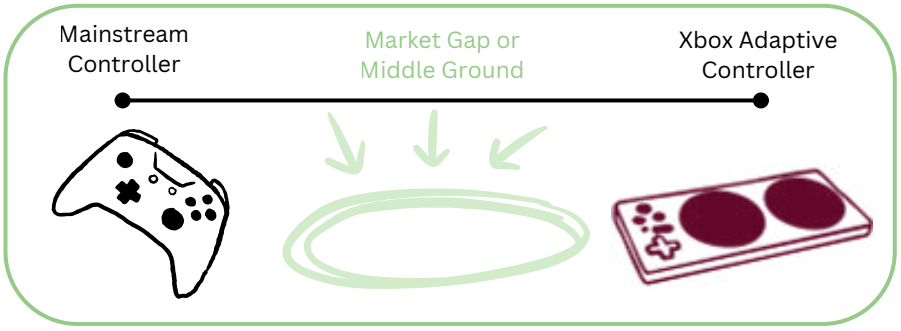

Figure 5: Market Gap

Current gaming hardware exists on a spectrum, ranging from mainstream, mass-market controllers designed for the average consumer, to adaptive and inclusive controllers specifically tailored to support players with diverse physical needs. The gap between these categories highlights the limitations of one-size-fits-all design and the need for more modular, customisable systems. People with physical ULD's often possess a greater degree of fine motor control and cognitive function, and therefore find elaborate systems such as the Xbox Adaptive Controller and Logitech Adaptive Buttons, excessive in supporting their specific needs.

02

Part Two

PART TWO

2.1 PRIMARY RESEARCH OVERVIEW

Involving stakeholders and defining research and development activities can be very beneficial early in process. Many of the best ideas for new products and services such as LEGO sets, Local Motors' cars, and telecommunication applications have originated from stakeholders having a say in setting the research and development agenda (Grill, 2021). Conducting primary research is necessary to discover new perspectives and experiences of both experts in the field and possible end users.

2.2 METHODOLOGY

When executing primary research, often the discussion about triangulation methods and the validity of this research arises. 'Method triangulation' refers to the process where multiple methods of data collection is employed involving both quantitive and qualitative research. This ensures both numerical data is obtained to to identify patterns and make predictions as well as non-numerical data and written responses that allow for an in-depth understanding of experiences (Farr, 1987). This study implemented by utilising two different methods of data collection. These two qualitative research methods were: four semi-structured interviews with both field experts and end users, and a survey that generated 120 responses.

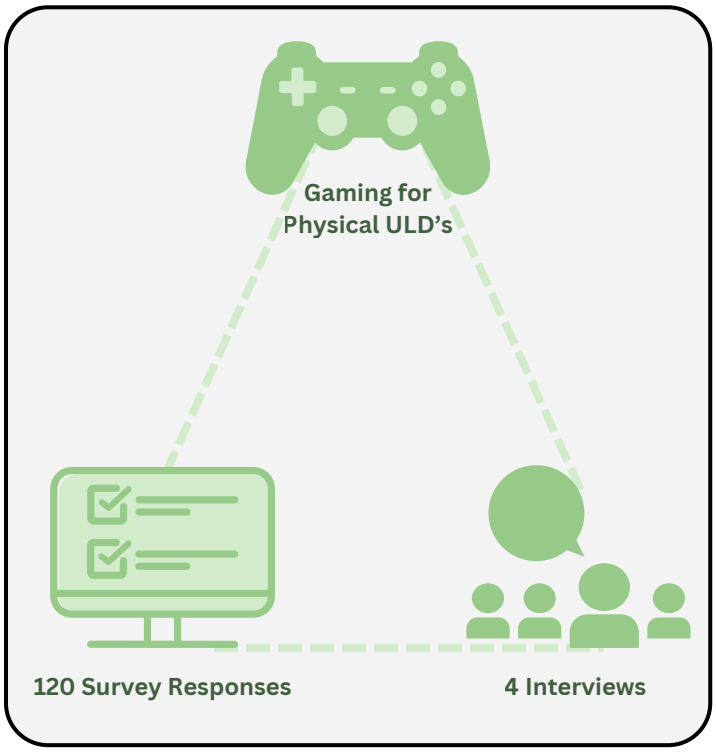

Figure 6: Triangulation Methods of Data Collection

Further, 'Triangulation of data analysis techniques'. allows for a more comprehensive understanding of phenomena. By executing multiple analysis techniques the reliability of the results is increased. This research strategy is a favourable way to test validity through the convergence of output information from various sources (Lauri, 2011). For example, the results from a thematic analysis of data, are congruent with the results found by analysing the same interview transcripts using correspondence analysis for example, it is logical to argue that the analysis and interpretation of the data is valid. "The possibility of using different techniques in collecting as well as in analysing data is one of the strengths of the theory" (Farr, 1987). Triangulation strengthens a study by combining multiple methods of data collection as well as multiple methods of data analysis.

RESEARCH DESIGN

1 Survey

- Survey was designed using google forms ensuring participant confidentiality
- Distributed directly to participants, shared on Facebook groups, Discord groups, posted on multiple Instagram accounts, and promoted through campus advertising.

1 Interviews

- Interview Questions were developed
- Four interviewees were recruited
- Each interview was conducted in a semi-structured manner over audio and video call, which was selected to balance flexibility with structure
- Interviews were transcribed

1 Data Analysis

- Qualitative and Quantitative data was analysed and combined to compare results
- For Qualitative results thematic coding was utilised
- for Quantitative results statistical analysis was applied

Figure 7: Research Design

2.3 METHODS SURVEY DESIGN

Survey research uses quantitative research strategies such as numerically rated items as well as qualitative research strategies such as open-ended questions (Singleton & Straits, 2009). By engaging a larger number of participants, surveys allow researchers to gather broader insights and answers to more pertinent questions. Although this study is focusing on user's specifically with physical ULD's, it was important to gain a more holistic understanding of the diverse needs and preferences (such as hardware design, ergonomics and aesthetics) of a broad demographic of gamers, including both novice and expert players.

Whilst creating the survey, it was important to understand the 'Leverage-saliency theory', first proposed by Robert M. Groves and his colleagues in 2000. It seeks to explain the factors influencing an individual's decision to either cooperate or decline participation in a survey request (Seifert, 2008). The theory, in summary, demonstrates that a person's interest (personal connection, perceived importance and/or subject matter) in a survey's topic plays a big role in their likelihood to participate. The survey employed engagement strategies such as conversational language, context-appropriate humour, and concise interactive questions to encourage participation. By considering these hidden motivators and driving factors, the overall survey participation was wide-reaching to a sample size of 120 respondents.

The survey consisted of both **quantitative** and **qualitative question types** to capture measurable trends and nuanced insights. Question formats included binary yes/no items, Likert scale ratings to assess levels of preference, multiple-choice questions, and 'select all that apply' questions to capture a broader range of responses. Optional short-response questions were also included, providing participants the opportunity to elaborate on their experiences in their own words.

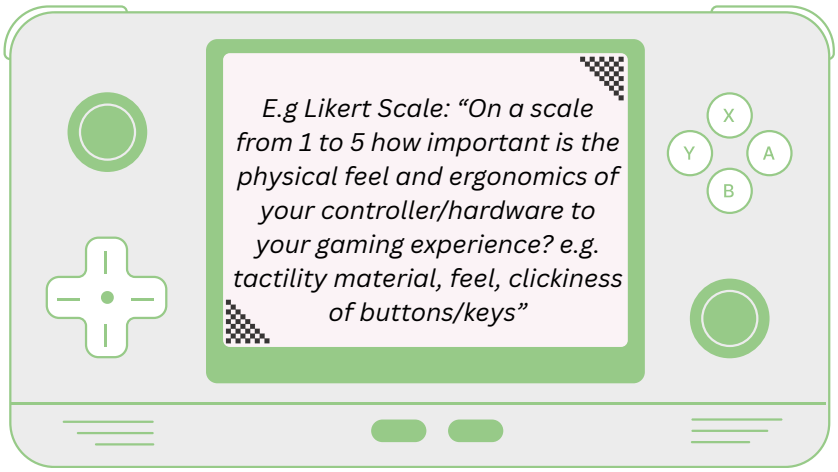

Figure 8: Example Likert Scale Survey Question

This combination allowed for both breadth of data collection and the ability to identify key themes in greater detail. It was essential that respondents were experienced gamers, as their knowledge and expertise provided critical insights to inform the inclusive design process. This requirement was communicated at the start of the survey and reinforced through questions designed to confirm that respondents were regular gamers.

There are several **limitations** that must be discussed. As participants were recruited via social media, Discord, and personal networks, the sample was skew toward younger population, which cannot represent the full diversity of gamers such as older users and less online communities. Due to the self-selection bias, respondents chose to take part voluntarily, meaning participants likely had a stronger interest in gaming or accessibility than the average, more casual gamer. This may limit generalisability.

2.4 METHODS INTERVIEW DESIGN

Each interview took a semi-structured approach in order to gather both comparable data from predetermined questions (Appendix F) and in-depth insights by asking spontaneous follow-up questions. This approach is ideal for understanding participants' experiences, beliefs, and attitudes, uncovering new themes, and adapting the conversation to emergent topics or sensitive issues in a way that pure structured or unstructured interviews cannot (Siedlecki, Sandra L, 2022).

Interview 1: Gamer with Physical ULD (Nerve Damage)
Length: ~ 40 minutes
Format: Recorded Mobile call
Type: Semi-Structured

Interview 2: Medical Professional
Length: ~ 30 minutes
Format: Recorded Mobile call
Type: Semi-Structured

Interview 3: Medical Professional
Length: ~ 20 minutes
Format: Recorded Mobile call
Type: Semi-Structured

Interview 4: Expert in NDIS Assessments
Length: ~ 15 minutes
Format: Recorded Mobile call
Type: Semi-Structured

Figure 9: Summary of Interviews

Two of the the **industry experts** were experienced Occupational Therapists who engage with clients that have both physical ULD's and neurological disabilities and the final industry expert was an experienced NDIS engagement partner with prior experience as a physiotherapist.

It was deemed important to engage with multiple experts of their fields in order to gain diverse perspectives on a range of conditions and disabilities. The main topics of conversation within these interviews were: understanding differences in conditions and individual needs surrounding limb differences, motor dexterity, reach, and fatigue as well as pain points that arise with current gaming systems, toys and the importance of adaptability for a wide range of users.

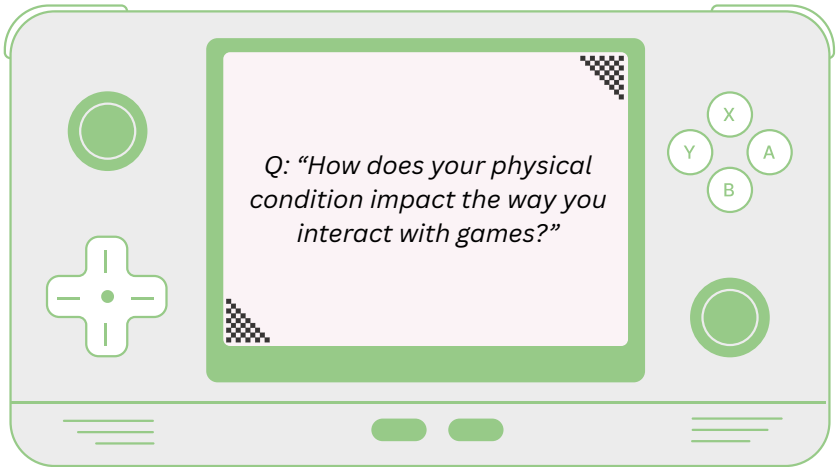

Figure 10: Example Interview Question

An interview was conducted with a end user who is permanently physically disabled in his upper limb experiencing intense pain in both arms as a result of from nerve damage. His enthusiasm ad experience with a range of video games from console to PC, provided extremely valuable information about lived experiences, frustrations and opportunities for design. The main topics of conversation within this interview were about his Xbox adaptive gaming setup, habits, workarounds, future hardware needs and pain mitigation surrounding his physical disability.

2.5 ANALYSIS & FINDINGS SURVEY

Quantitive and qualitative data collected from the interviews and surveys will be interpreted through a statistical analysis and thematic codes analysis to better understand the information gathered and the key research findings of the results. It's important to mention that during the survey a short response question was added halfway through (after 50 participants had already responded), making there an *original survey* and an *adapted survey*. Nevertheless, this is a normal process well documented through research studies, where component of the (research) design may need to be modified throughout the study in response to new developments or to changes (Maxwell, 2013).

A) Original Survey (18 questions: 16 multiple choice selection and 1 optional short-response)
B) Adapted Survey, with an additional short-response question (19 questions: 16 multiple choice and 2 optional short-response)

STATISTICAL ANALYSIS

The survey yielded 120 responses from gamers with diverse experiences and hardware preferences. Across platforms, PC was the most widely used, though several PC respondents explicitly wrote that they preferred Xbox controllers and third party xbox controllers such as 8bitDo's controllers over PlayStation controllers (such as the DualShock 4, PS5 DualSense). This suggests that controller design appeal often extends beyond platform loyalty, with comfort and usability driving preference more than brand identity.

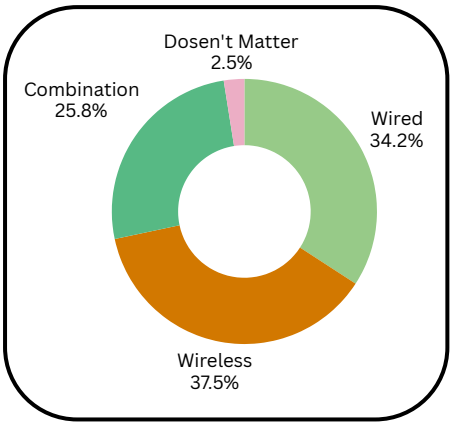

Figure 11: Wired vs Wireless Controller/System

A consistent theme across responses was dissatisfaction with the "one-size-fits-all" approach of most mainstream controllers, with 74.2% of gamers seeking a highly customisable experience (figure 19). Some players expressed interest in hardware that is a combination (25.8%) of wired and wireless systems, however the widespread response in figure 11, suggests that developing a versatile eco-system offering either wired or wireless connections would cater the individual preferences of all gamers, pointing to a desire for greater flexibility and reduced physical encumbrance. Further, ergonomics emerged as a central point of difference with respondents rating it highly on a 1-to-5 Likert scale alongside aesthetics and branded products (figure 12).

70.8% of gamers reported that they would be interested in the ability to change the physical shape and size of their controller to better suit their hands (figure 21). Further, 78.3% of respondents reported interest in controller with swappable buttons and thumb sticks to change their feel or placement (figure 23). This was further informed with responses such as "*Across the board I enjoy having the option to customise, even if I end up going with close to the default"* and "*I want to change Buttons to match Position of X and other symbols."*

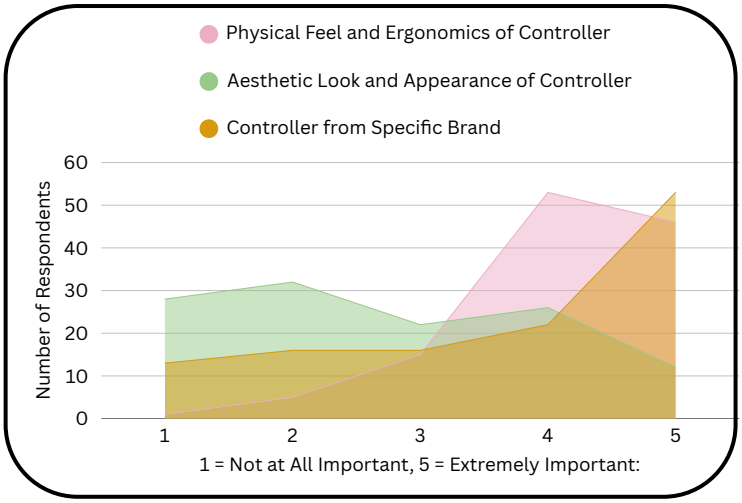

Figure 12: Controller Preferences rated through a Likert Scale

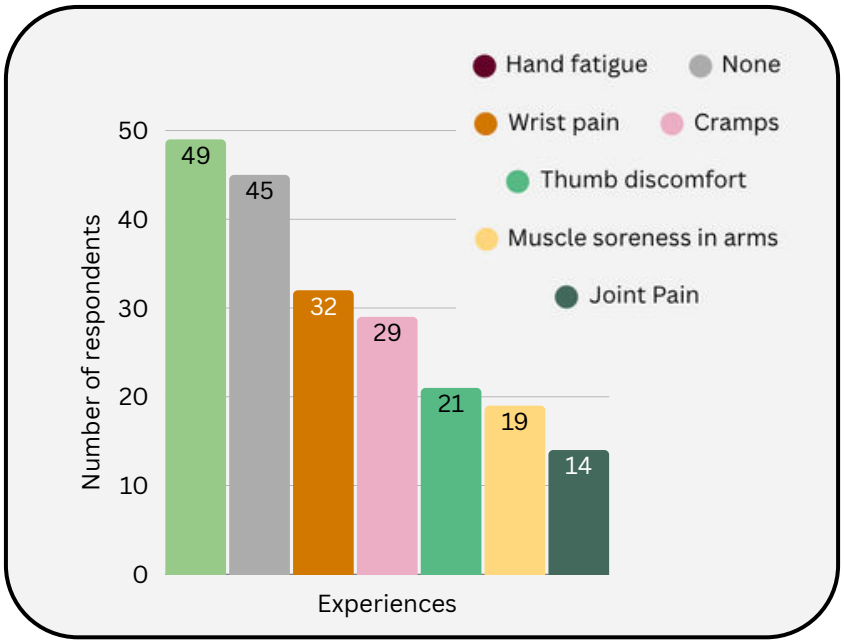

Figure 13: Gamers experience with pains and fatigue

A critical finding is the high prevalence of physical discomfort among participants, with 60% reporting that they has experienced issues such as hand cramps, wrist pain, thumb discomfort, and general fatigue after long gaming sessions (Figure 13). These problems were particularly pronounced among participants gaming for more than 21–30 hours per week (figure 14). The prevalence of these reports indicates a gap in hardware design, where devices are not adequately addressing prolonged use or the physical strain of repetitive inputs.

THEMATIC ANALYSIS

Thematic analysis was executed using Atlas.ti to group quotes and find underlying meanings within them in order to identify the more prevalent themes within the responses.

Participants reported a wide spectrum of personal preferences and challenges that were categorised into two groups (Figure 25). Issues such as **hand size** mismatches, **controller size** and need for **lightweight** design, suggested that many mainstream devices fail to account for anthropometric diversity. *"Steam controller seems to be 'too fat'"* and *"I open my brand new controller to remove the weights inside to make my controller as light as possible."* Highlighted 14 times was **adaptability** often mentioning concerns about controller durability, versatility, addressing specific needs, customisable buttons etc. Further, some users explicitly connected **adaptability** to **ergonomics** seeking a (Dualsense) controller split in half because *"Hands aren't symmetrical and neither is the way we use them"*, underscoring the need for more personalised design approaches.

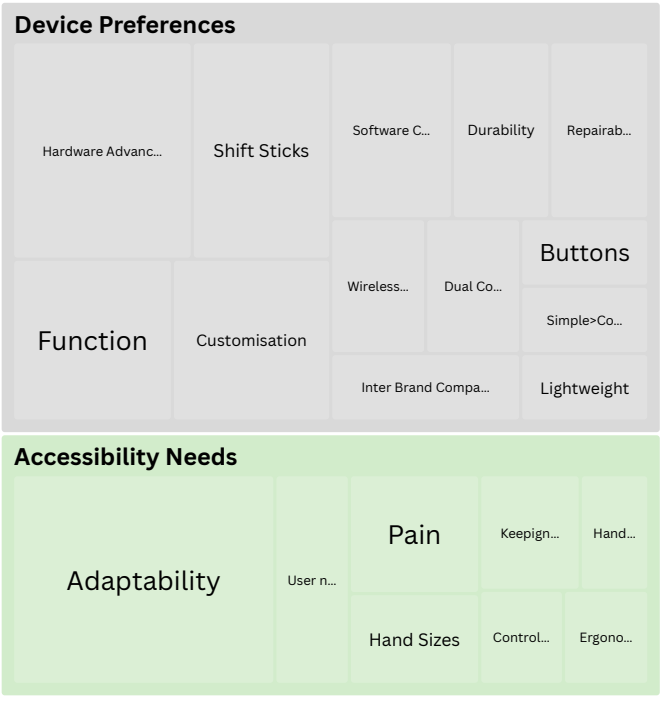

Figure 25: Treemap of Thematic Analysis of short-response survey answers (Group-Subgroup-Count (size of rectangle). See Appendix D for a more detailed coding classification.

2.6 ANALYSIS & FINDINGS INTERVIEWS

Although identifying recurring themes and the noting the importance of these recurrences, in general qualitative research focuses on describing participants' experience as accurately as possible, rather than using numbers to describe the phenomena of interest (Sandelowski, 1997). Thematic analysis coding was conducted using Atlas.ti which grouped quotes into sub categories. Manual refinement was then done to cull and combine groups for more thorough analysis. Please refer to page 20 throughout this section, where figure 26 demonstrates the frequency of thematic codes.

Image 1+2: Interviewee 1 (Gamer with physical ULD) creates an alternative setup to video game using feet with the Xbox Adaptive Controller and Logitech Adaptive Gaming Kit Buttons

THEMATIC ANALYSIS OF EMERGING THEMES

Workarounds and Alternatives (19)

A dominant theme within the *Current Systems and Devices* theme was the reliance on improvised solutions to compensate for inaccessible devices. Many gamers described using feet for inputs or mixing buttons, with thumb sticks and other peripherals (Image 2). While these workarounds allow participation they reveal the absence of inclusive hardware designed with such needs in mind, highlighting the systemic exclusion.

The hardest game I've played is League....my right foot is doing buttons and my left foot just has the mouse. And then for some of the buttons that you use much less often, I'll just get my hands, because if im not pressing things a lot its fine..”
-Gamer with Physical ULD

Frustrations and Issues (16)

Current systems were described as frustrating due to missing functions (e.g attachable thumb sticks), cluttered wiring (2) (Image 1), and limited portability related to setup issues (10). This is echoed by Interviewee 1, who described frustrations when purchasing the Logitech Gaming Kit. He wanted only the smaller trigger buttons but was forced to buy entire sets, resulting in waste as the larger buttons were discarded. This not only increases cost but also highlights the lack of customisation options for users who want to tailor their setup before purchase.

“It allows third parties. It's just it's just bloody hard to find one that will actually work...That is a that is a gaping hole, thumbsticks that you can attach the adaptive controller.“

“I just have the Logitech I just have a bunch...(the) throttles are useless. The the little small buttons, the tiny buttons. They are gold.“

-Gamer with Physical ULD

Adapting to Advancing Technology (31)

Software posed as many barriers in compatibility with hardware (12). Configuring buttons to game inputs, endless software updates and remapping of buttons was a recurring issue, for different video games inadvertently excludes disabled users. Further newer ports and connectivity of third party hardware was a frustration from end users.

"As the technology advances you want the tools of the trade so to speak to to keep up with that as well."
-NDIS Engagement Partner

Physical Limitations (34) + Ergonomic Needs (14)

Participants noted that due to the wide range of physical limitations and diverse abilities, there would be ergonomic concerns surrounding cramped button layouts and small inputs directly impacting usability. Several participants, such as the Occupational therapists had experimented with gaming, such as the Wii as a rehabilitation method. They reported difficulties with clients pressing the buttons but comfortability using arm movements (such as swinging motions). while some noted that deeper pressure or larger control spacing improved accessibility.

"I would consider controller adoptions for each deficit. Whether it's coordination, poor grip strength like something quite small, shoulder and their elbow function, can't reach forward to use a controller, the sensitivity and vibrational feedback that would vary from patient to patient or they might need their hands strapped into a controller."
-Occupational Therapist

RESEARCH SUMMARY

By interviewing both experts in the field and end users, a second triangulation method was executed. This convergence of information provided from end users and industry experts surfaced insightful answers to what end users are looking for versus what is actually feasible within the industry and for a broader spectrum of user's with physical ULD's.

PACKED CIRCLES REPRESENT THEMATIC CODES

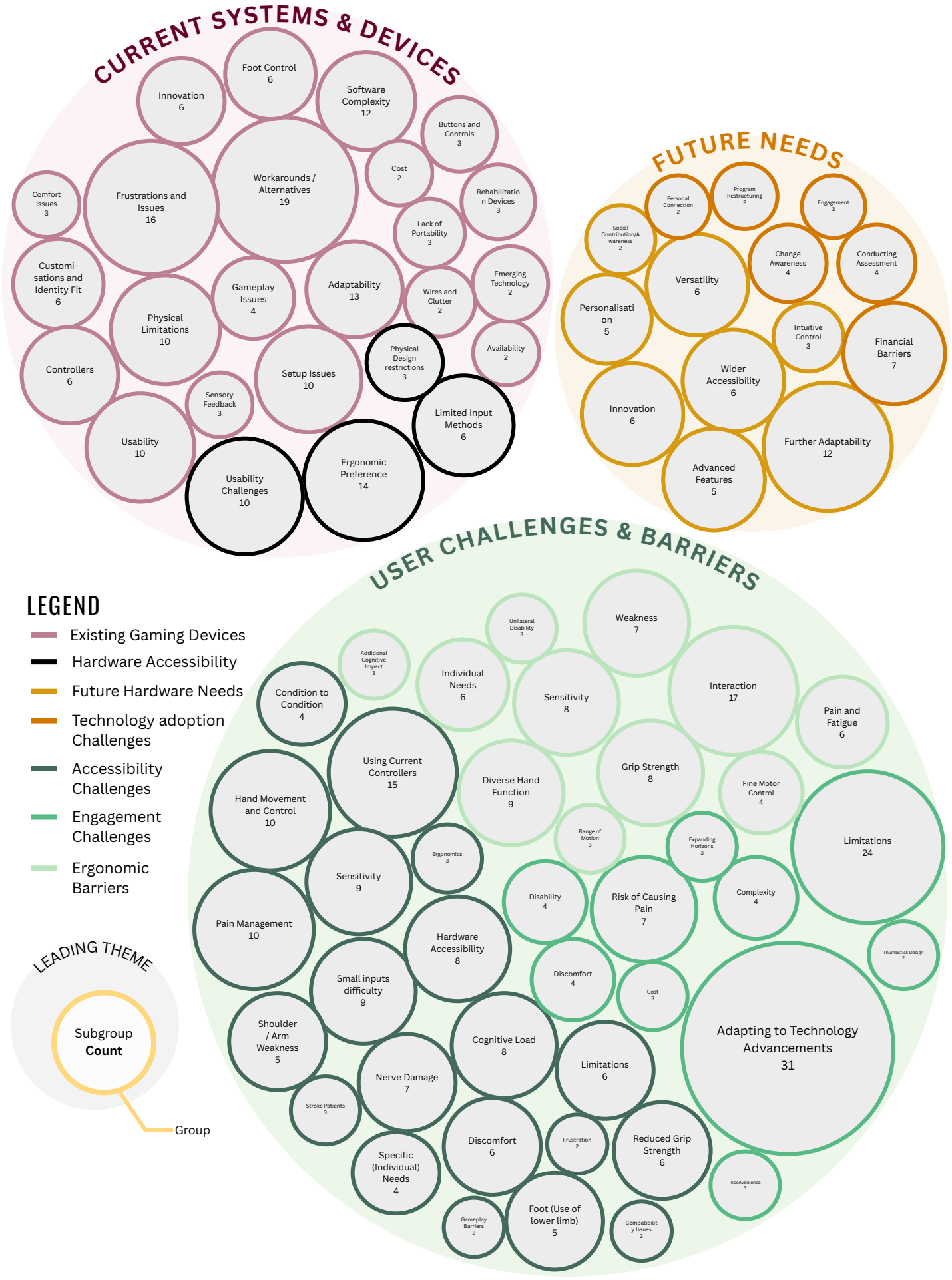

Figure 26: Codes Represented by Frequency

03

Part Three

PART THREE

3.1 DISCUSSION

The overall research analysis and findings provided a nuanced examination of secondary literature and the adaptive gaming market which revealed a significant gap in accessibility solutions, particularly for individuals with physical upper limb disabilities (ULD's) that fall outside the traditional target demographic of high-end, purpose-built assistive technologies. It's evident that industry has in fact made progress, but still remains incomplete. Both the benchmarking and qualitative findings through primary research found that the top two accessible gaming devices on the market (PlayStation 5 Access Controller and the Xbox Adaptive Controller paired with the Logitech Buttons) represent a monumental step forward in providing comprehensive, modular solutions for gamers with severe motor impairments. However, they may be over engineered for individuals with less severe, yet still debilitating, physical limitations.

1. **The first key finding is that mild/less severe physical ULDs are systematically overlooked in mainstream design.**
   Controllers are typically designed around assumptions of normative hand size, dexterity, and grip strength (Chae et al., 2002), which was further reinforced by survey participants complaints about "small controllers" and recurring hand pains and fatigues. As seen in figure 5, these gamers are left in a "middle ground" of accessibility. Their disabilities are too significant to allow for comfortable and competitive use of standard commercial controllers, yet not severe enough to warrant the investment and learning curve required by the leading adaptive devices which are often designed with cognitive disability in mind.

2. **The second contributor is ergonomics and comfort, where both primary and secondary research align.**
   Literature shows historical neglect of diversity in gaming, with examples such as the Nintendo Power Glove disadvantaging left-handed players (Tollefsen et al., 2004). While one handed gamers already face major disadvantages with standard controllers (Brown et al., 2015), interviewee 1 noted that he experiences significantly more pain in his right hand limiting his gaming abilities. 60% of participants in this study also reported pain, fatigue, and long-term strain from poorly designed hardware. Primary research revealed that user's rate ergonomics over aesthetics in controller design (figure 12), suggesting that ergonomics are not an accessory concern but central to accessibility.

3. **The third finding is the market gap between adaptability and usability.**
   Current users echoed similar frustrations with cluttered setups, complex software, and rigid hardware ecosystems. Interviews further illustrated how gamers compensate through *"placing (my) controller on a pillow for comfort"* and workarounds, such as operating buttons with their feet, underscoring the inadequacy of existing devices for nuanced needs. The demand for modular, customisable, and ergonomic solutions remains unmet by both mainstream and adaptive controllers.

3.2 DESIGN IMPLICATIONS

After discussing the findings of this study, there are few direct implications for the design of future gaming hardware, particularly in bridging the gap between mainstream devices and highly specialised adaptive controllers. This section identifies design opportunities shifting away from one-size-fits-all or overly specialised products toward systems that can flexibly support diverse user needs.

OPPORTUNITIES

Intuitive Modular Systems

A central opportunity lies in the users ability to swap, reposition, or resize components such as buttons, thumb sticks, and throttles within the development of modular controllers. Participants valued adaptability but feared fragility and complexity. This suggests a need robust modular systems that can be reconfigured without tools, wires, or excessive setup, offering improved usability empowering users without compromise.

Ergonomically Adaptive Systems

Controllers or gaming systems that support a variety of ergonomic needs and input methods (such as head titling, hands, fingers, thumbs, arms and even feet) present opportunities to directly address ergonomic diversity. Similarly, utilising customisation prior to purchase would allow for users to customise their controller shape, weight, button layout, which for example, could allow for asymmetrical designs helping users with unilateral impairments.

Integration of Inclusive Haptics

Several industry experts highlighted differences in tactile sensitivity amongst clients, as well as the survey data which revealed user interest in haptic technology (figure 20). There is an opportunity to design adaptive haptic systems where vibration strength, resistance, or sensory feedback can be calibrated to the user's needs. Such systems could serve both accessibility and immersive gameplay.

Mass Customisation through Digital Fabrication

Building upon customisation at the ergonomic and haptic level, additional emerging technologies such as parametric modelling and 3D printing present the opportunity to mass-produce personalised hardware. A controller ecosystem that allows users to generate custom-fit shells, grips, or even as Interviewee 1 highlighted, a custom foot joystick for purely movement (*"if you have only one hand available....in that case you would actually have one of your feet do (move) a joystick"*). Beyond function, this also supports identity-driven customisation, enabling users to design aesthetics such as colour, materials, or lighting to reflect personal style.

Portability and Everyday Usability

Portability amongst existing adaptive setups were often described as cumbersome, wired, and difficult to move. There is an opportunity to design portable, streamlined systems that can transition between spaces such as at home, work or school and/or platforms, removing barriers to consistent use.

3.4 CONCLUSION

The lack of holistic solutions discussed throughout this research report surface persistent gaps in the accessibility of gaming hardware, highlighting clear opportunities for innovation. Findings from interviews, surveys, and benchmarking demonstrate that while existing adaptive devices have advanced inclusion, they often fail to capture the full spectrum of physical diversity among gamers. The value of research lies not only in identifying problems but also in uncovering opportunities. For industrial designers, this research process demonstrates how deep user research and co-design are central to creating meaningful, equitable products that respond to both individual and collective needs. This makes achieving true inclusivity in tangible learning objects a demanding but critical task for designers.

APPENDICES

A. ABBREVIATIONS & KEY WORDS

The List below describes the significance of abbreviations and acronyms used throughout this report.

Abbreviation	Meaning
ULD	Upper Limb Disability
MND	Motor Neuron Disease
MRI	Magnetic Resonance Imaging

B. BENCHMARKING CRITERIA

The benchmarking criteria was described to be used for scoring products in table 1, and for a more descriptive benchmarking table on the following page (26).

Target Users: Identifies the primary audience or user group each device is designed to support, such as gamers with specific physical disabilities or ergonomic needs.

Modularity: Refers to the device's ability to be adapted, reconfigured, or customised through interchangeable parts or layouts.

Charging: Notes the power source or charging method used for the device, where applicable.

Accessibility: Highlights key accessibility features, such as large buttons, remapping options, ergonomic shapes, or compatibility with external switches.

Platform Compatibility: Outlines which gaming platforms (e.g., Xbox, PlayStation, PC, Nintendo Switch) the device can be used with.

Connectivity: Describes how the device connects to hardware, such as wired (USB, 3.5mm jack) or wireless (Bluetooth, USB dongle).

Portability / Flexibility: Assesses the ease of transport, assembly, and setup across different environments (e.g., wheelchair mount, living room, desk).

Price (AUD): Provides the retail cost in Australian dollars for comparison between devices.

B. BENCHMARKING TABLE

	Product	Category	Description	Target Users	Modularity	Platform Compatibility	Connectivity	Charging	Portability/ Flexibility	Accessibility	Price (AUD)
	**ByoWave Proteus**	Handheld controllers	Magnetic blocks with different controls that snap together creating customised shapes and controller layouts.	Users seeking customisable layouts and better ergonomic comfort	High	Xbox, PC, Steam Deck	Wireless Connection via USB Dongle	Battery in Power Cubes charged via USB-C	Moderate - Assembly required	Ergonomic variations, multi grip support	$551
	**Grier QuadPad Button Set**	Buttons and Switches	Compact module of 4 coloured large arcade style buttons with 4 output cables designed to connect to adaptive hubs.	Users needing larger buttons	Low	Xbox Adaptive Controller, PS5 Access Coontroller	Wired (3.5mm headphone jacks)	-	-	Reachable large buttons.	$46.68
	**Nintendo Hori Flex Controller**	Adaptive Hub	Adaptive Hub for Switch and PC. Port-based customisation supports external buttons, joysticks and input devices.	Users with profound disability seeking flexible setups. Remapping ability	Medium	Nintendo Switch, PC	Wired (USB Cable)	-	-	Itself N/A. Needs third party connections.	$450
	**Logitech Adaptive Gaming Kit**	Buttons and Switches	12 large and small buttons, triggers and pressure pads stick to the velcro board for flexible arrangement. Designed for Xbox Adaptive Controller.	Users needing varied button sizes for their setup. Remapping ability	High	Xbox Adaptive Controller and PS5 Access	Wired (3.5mm headphone jacks)	-	-	Button, joystick sizes and options. Co-designed with accessibility experts.	$160
	**PlayStation 5 Access Controller**	Adaptive Controllers	Circular single module. Ability to personalise control layouts, configuring buttons, adjusting the control stick, and connecting external adaptive devices like 3D printed joysticks or switches.	Users with profound disability seeking flexible setups. Remapping ability	Medium	PS5	Wireless (paired using USB then Bluetooth)	Battery Charged via USB-C	Battery Charged via USB-C	Customisable interface	$139
	**Razer Naga V2 Pro**	One handed gaming Mouse	A 12-button thumb grid, ergonomic palm claw, macros. Allows for one handed pro/experienced gaming	Users with one hand. Wanting high-level gaming option for MMO	Medium	PC	Wireless (Bluetooth)/Wired (USB-C)	Battery Charged via USB-C	Battery Charged via USB-C	Interchangeable thumb panels/interfaces	#319
	**Thrustmaster eSwap X Pro/X2**	Handheld controllers	Competitive controller with swappable modules for customisation. Ergonomic and functional (software) adaptability.	Users seeking customisable layouts/buttons. Advanced software customisability	Medium	Xbox, PS5	Wired (USB)	-	-	Competitive gamers, diverse control preferences	$250
	**Xbox Adaptive Controller**	Adaptive Hub	Adaptive hub designed in compatibility with Logitech Adaptive gaming kit. 19 Input jacks, programmable buttons, large dials.	Users with profound disability seeking flexible setups. Remapping ability	Medium	Xbox, PC	Wireless (Bluetooth)	Battery Charged via USB-C	Battery Charged via USB-C	Itself N/A. Needs third party connections - but these are programmable.	$129.99
	**Xbox Adaptive Joystick**	Joysticks	Small wired joystick for single hand use providing precision. Interchangeable thumb stick and mounting options.	Users with limited mobility needing one hand use	Low	Xbox Adaptive Controller, Xbox, PC	Wired (USB-C)	-	-	Interchangeable toppers, 3D print compatibility	$44.95

C. QUANTITATIVE SURVEY QUESTIONS

Survey questions with answer type and purpose. Yellow highlight identifies the optional short response questions.

Question	Answer Type	Purpose
Do you consent to participating in this short survey?	Yes/No (Consent)	To obtain participant consent before collecting data.
What is your age?	Multiple choice (Age ranges)	To understand the age demographics of respondents.
What is your gender?	Multiple choice (Male, Female, Other, Prefer not to say)	To identify gender distribution among participants.
What is your primary gaming platform?	Multiple choice (e.g., PC, PlayStation, Xbox, Switch, Mobile)	To determine the main gaming platforms used.
Controller players and users... what controller do you have and like the most?	Open-ended	To gather qualitative insights on preferred controllers.
Are you satisfied with the current controllers on the market?	Likert scale (Yes/No or satisfaction rating)	To measure satisfaction with existing controllers.
How many hours per week do you typically spend gaming?	Numeric / Multiple choice (ranges)	To understand gaming frequency and intensity.
Which of the following game genres do you play most often? (Select all that apply)	Multiple choice (Checkbox, multi-select)	To identify preferred gaming genres.
Do you prefer using a wired or wireless controller/system (such as mouse, keyboard, headset, etc)?	Multiple choice (Wired/Wireless/No preference)	To understand hardware connectivity preferences.
How important is the physical feel and ergonomics of your controller/hardware?	Likert scale (Not important → Very important)	To assess the value placed on ergonomics/tactility.
How important is the aesthetic look and appearance of your controller/hardware?	Likert scale (Not important → Very important)	To measure the influence of aesthetics on user preference.
How important is it for you to have a controller from a specific brand (e.g., Sony, Microsoft, Nintendo)?	Likert scale (Not important → Very important)	To assess brand loyalty in controller selection.
In an ideal world, would you prefer a gaming system that offers a 'one-size-fits-all' experience or one that is highly customisable?	Multiple choice (One-size-fits-all / Customisable)	To capture preferences for standardisation vs. personalisation.
Do you think advanced haptic feedback would improve your gaming experience?	Yes/No	To measure interest in enhanced haptic technologies.
Do you experience any pains or fatigue in your hands or muscles when gaming?	Multiple choice (Checkbox: wrist pain, finger fatigue, etc.)	To identify common ergonomic/health issues.
Would you be interested in a controller that lets you change its physical shape or size to better fit your hands?	Yes/No	To gauge demand for adaptive/ergonomic hardware.
Have you ever used or considered using a custom-made controller or keyboard?	Yes/No	To determine awareness and adoption of custom controllers.
Would you be interested in a controller where you could easily swap out buttons or thumbsticks?	Yes/No	To measure interest in modular controller design.
Optional: Comments about issues you have with current gaming hardware?	Open-ended (Text)	To capture additional qualitative insights and feedback.

C. QUANTITATIVE SURVEY DATA GRAPHICS

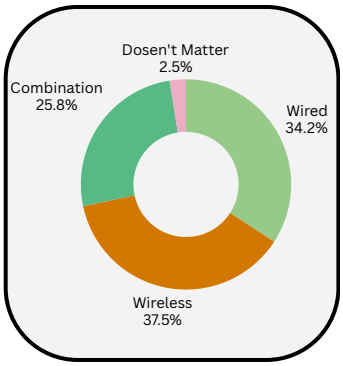

Figure 11: Wired vs Wireless Controller/System

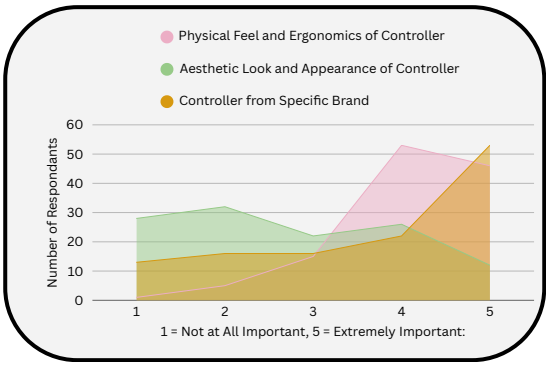

Figure 12: Controller Preferences rated through a Likert Scale

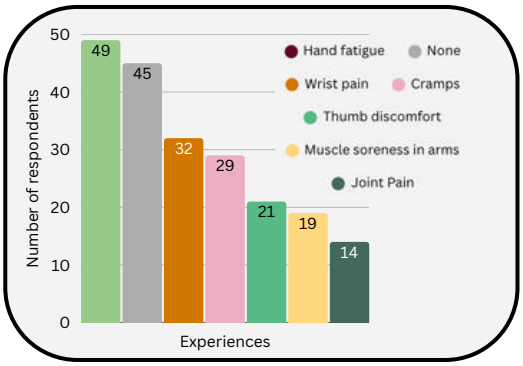

Figure 13: Gamers experience with pains and fatigue

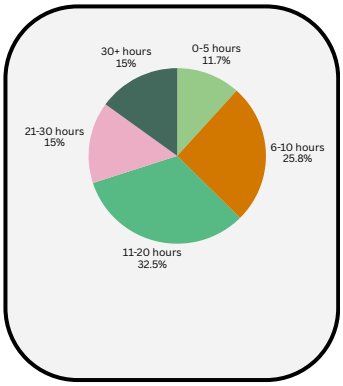

Figure 14: Hours a week spent gaming

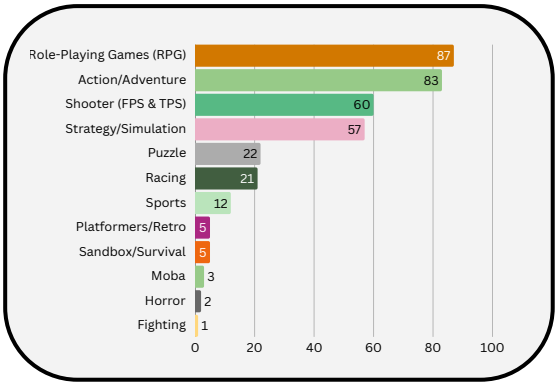

Figure 15: Genre of Game Played Most Often

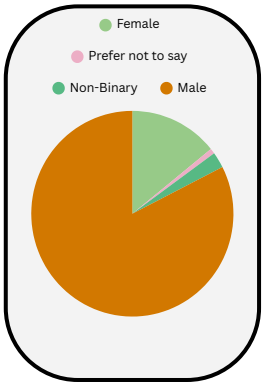

Figure 16: Gender of Participants

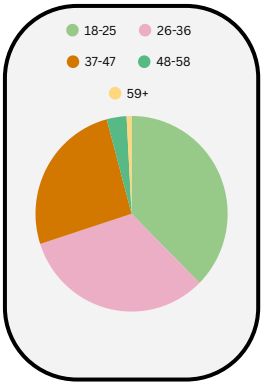

Figure 17: Age of Participants

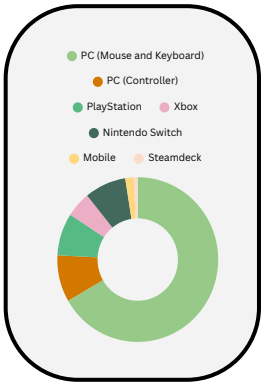

Figure 18: Primary Gaming Platform

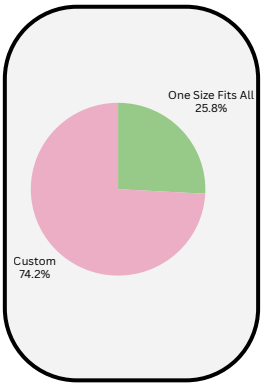

Figure 19: One Size fit's all versus Highly Customisable experience

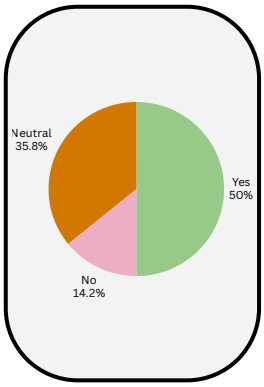

Figure 20: Interest in Haptic Technology to improve the gaming experience

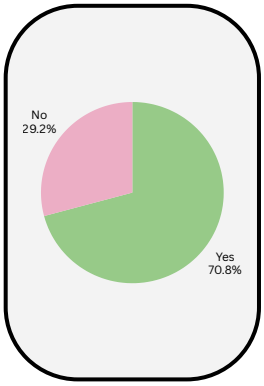

Figure 21: Percentage of Gamers interested in a controller that allows you to change the physical shape and size

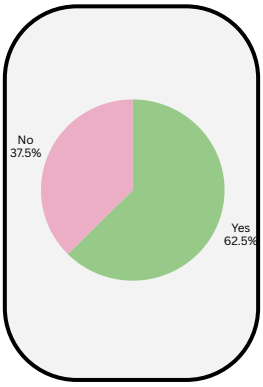

Figure 22: Percentage of Gamer's that have used custom-made controllers

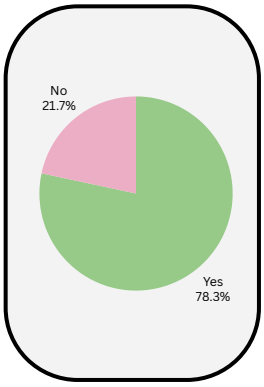

Figure 23: Percentage of Gamer's interested in a controller that allows for swappable buttons and thumb sticks

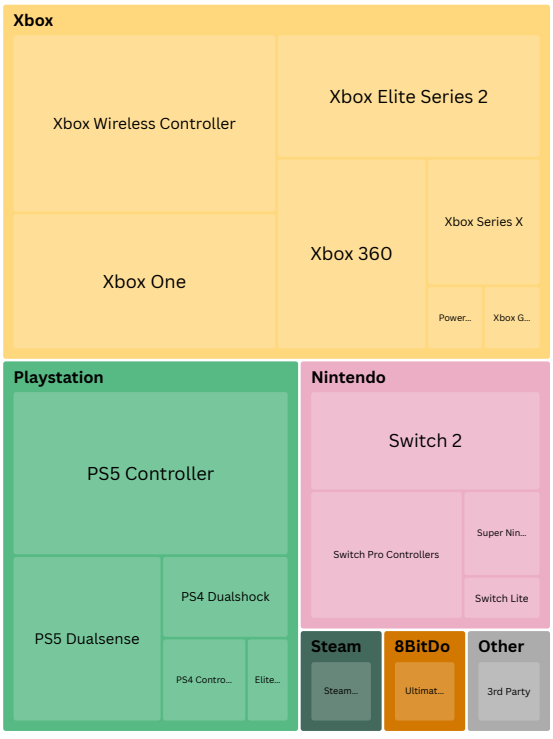

Figure 24: Controller Preference

D. QUALITATIVE SURVEY DATA THEMATIC CODES

Group	Subgroup	Highlight Count	Example Quote
Accessibility Needs	Hand Sizes	3	"Steam controller seems to be 'too fat' and I have large hands. Sony really got something going with the dual shock design and future iterations."
	User needs	4	"Changing Buttons to match Position of X and other symbols"
	Hand fatigue	2	"Love the steam deck but hands go numb after holding out for like half an hour."
	Pain	4	"I injured my left wrist and now experience a lot of discomfort, numbness, and pain in the hand and wrist of that arm."
	Keepign up with changes	3	"As I get older, I find some of the new mechanics in a game too much to keep up with."
	Controller Size	2	"Controllers are deisgned for baby hands there needs to be one for big man hands"
	Ergonomics	2	"Hands aren't symmetrical and neither is the way we use them."
	Adaptability	14	"Having a controller that changes sizes or where you can swap out buttons sounds nice in theory but I'd be concerned that it's just more to break."
Device Preferences	Function	6	"Style before function. The switch is a huge offender on this front. They made it work but the ergonomics of the joycons still suck."
	Customisation	6	"Across the board I enjoy having the option to customise, even if I end up going with close to the default"
	Durability	4	"I worry about issues like the rigidity of the frame, and how it'll hold up long term. I should add that on second to customisability I greatly prefer technology that is either robust or repairable."
	Buttons	2	"It would be cool if the controller industry embraced extra buttons as well."
	Repairability	4	"Stick drift and longevity of the controller. Easy part replacement would be amazing, and highly marketable."
	Simple>Complex	2	"The simpler the controller the better. I would hate to deal with something that can transform too much"
	Wireless Features	3	"On the other hand if it is wireless would be awesome to have an option to make it make sounds to find it if one needs to, like if it fell between the cushions."
	Software Compatibility	5	"The speed of sending the signal to the PC is important as well. Best of luck with your project!"
	Dual Controller	3	"Imagine if we could split a DualSense controller in half, so we could move our arms freely while holding each half separately in our right and left hands."
	Hardware Advancements	9	"Many peripherals charge a lot due to features and design, but the quality of the components and overall feel of the product is usually significantly lacking."
	Inter Brand Compatibility	3	"Gaming hardware are a pain in the ass, and force players to stick to one brand if we dont want multiples softwares running."
	Lightweight	2	"I open my brand new controller to remove the weights inside to make my controller as light as possible."
	Shift Sticks	7	"The shift key sucks placement wise. And nintendos lack of any decent controller entirely kills the switch for me"

E. QUALITATIVE INTERVIEW DATA THEMATIC CODES

Leading Theme	Group	Subgroup	Highlight Count	Example Quote
Current Systems & Devices	Existing Gaming Devices	Workarounds/Alternatives	19	"I think the hardest game I've played is League of Legends. That's pretty difficult...my right foot is doing buttons
		Frustrations and Issues	16	"a gaping hole that does not that does not easily exist. It is thumbsticks you can attach the adaptive controller."
		Adaptability	13	"The way I do it, is my right foot is doing buttons and my left foot just has the mouse. And then for some of the buttons
		Software Complexity	12	"If there is a controller and it has controller support, it tries to force the controller buttons. So I need to I needed to download
		Physical Limitations	10	"I physically can't click it with my moving foot. But I just can't do fast-paced gaming at all, it's just not that good."
		Setup Issues	10	"The annoying things about it is that thumbsticks are completely nowhere to be found and yeah so many wires. So many
		Usability	10	"I was just gonna say it actually annoys my other friends so much, because the way feet work is it's kind of better to have to
		Controllers	6	"I know that the buttons that you connect to it are just the same Logitech buttons, so I feel like it would end up being pretty
		Customisations and Identity Fit	6	"I can change the button however I want. I think I found a pretty good to do it. And I just I have the same button layout on both
		Foot Control (Workaround)	6	"I accidentally click it. You're mainly using the ball with your foot. You put the mouse in the ball of your foot and then you just
		Innovation	6	"It takes a few months of brain training because instead of like doing it, pressing A, you have to think of a box moving foward."
		Gameplay Issues	4	"Playing zombies, like Call of Duty, I still use the thumbsticks of the controller, but everything except for the thumbsticks, I
		Buttons and Controls	3	"Yeah, throttles are useless. The the little small buttons, the tiny buttons. They are gold. They are so perfect."
		Comfort Issues	3	"I wouldn't play a switch because yeah, holding the device is annoying. When I'm playing first person shooters, I will use the
		Lack of Portability	3	"I actually have another one (Logitech kit) coming in the mail, just everything so that I don't have to move it ever when I want to
		Rehabilitation Devices	3	"playing connect four and having to pick up the checkers with that hand or putting pegs on a clothesline using tweezers to
		Sensory Feedback	3	"Sensitivity and vibrational feedback would vary from patient to patient, but typically a lot of our patients struggle with light touch
		Availability	2	"It allows third parties. It's just it's just bloody hard to find one that will actually work."
		Cost	2	"Logitech doesn't sell one. And so I think there's some that are like really expensive, just ridiculous."
		Emerging Technologies	2	"So I just anytime I want to do anything with them (arms), I use voice recognition."
		Wires and Clutter	2	"I think I literally have like 16 wires, I've velroed them all together, but uh my desk is full of wires."
	Hardware Accessibility	Ergonomic Preference	14	"I don't use it (voice recognition) for gaming. I I feel like my mouse and my left foot is just better."
		Usability Challenges	10	"Any game that uses WASD movement.I just would have a lot of trouble with. Yeah, because the mouse can do vision, but
		Limited Input Methods	6	"I think thumbsticks, feet thumbsticks there's plenty of games where it would be useful."
		Physical Design restrictions	3	"If it's a game like League of Legends or BG 3 when you're looking down from above, you don't even bother with any of that."

E. QUALITATIVE INTERVIEW DATA THEMATIC CODES

Future Needs	Future Hardware Needs	Adaptability	12	"Thumbsticks that you could use instead of a controller....I can see that being useful in some games in some sometimes like for a game like Star Wars."
		Innovation	6	"as the technology advances you want the tools of the trade so to speak to to keep up with that as well."
		Versatility	6	"Yeah, my setups just in my room. It pretty much never moves. Making it portable would be nice."
		Wider Accessibility	6	"my mouse is not the shape of a foot. That would be nice."
		Advanced Features	5	"She just has a brain waves scanner on and she just plays games with that....somehow the tilt of her head is the movement."
		Personalisation	5	"a streamlined item or a piece of equipment, there is still so much that goes into personalising that per person."
		Intuitive Control	3	"You just code different thoughts into different actions or one ability."
		Social Contribution/Awarenes ss	2	"the concept of developing products that then you can see the benefits out of."
	Technology Adoption Challenges	Financial Barriers	7	"I know it was quite an expensive set because I was thinking about getting one for the hospital, but I think it was like $200,000."
		Change Awareness	4	"feeling annoying as somebody that's working within it, because what people don't see is the benefits that people that people get out of it."
		Conducting Assessments	4	"assessments for driving functional assessments for NDIS aged care assessments, equipment, home mods, return to work, all that sort of stuff."
		Engagement	3	"Wii sometimes like I've used the Wii at work. But that's more for your kind of bigger arm movements rather than your fine motor control."
		Personal Connection	2	"yeah, we're seeing it every day and what a person might need."
		Program Restructuring	2	"it's, it's crazy just how much it is changing and how much we're having to adapt."
User Challenges & Barriers	Accessibility Challenges	Using Current Controllers	15	"different adaptions. Like controller adoptions for the hand cause each person has different deficits in the hand. You'd probably need to make different controllers for different people based on
		Hand Movement and Control	10	"mild coordination loss or their hand, they might not be able to grasp correctly or oppose their fingers or something like that."
		Pain Management	10	"Finds ways to avoid getting pain as they can still use their arm and hands."
		Sensitivity	9	"Sensitivity and vibrational feedback would vary from patient to patient, but typically a lot of our patients struggle with light touch sensation."
		Small inputs difficulty	9	"Standard sort of like Xbox or PlayStation controller where you've got quite small, intricate buttons close together that probably wouldn't work for someone that's had a stroke or has MND."
		Cognitive Load	8	"From a cognitive point of view, will they be able to understand the instructions and the requirements."
		Hardware Accessibility	8	"I think thumbsticks, feet thumbsticks there's plenty of games where it would be useful."
		Nerve Damage	7	"nerve damage, it presents similarly to like a Gillian Barret. Which they might come in with severe weakness in both arms. which can make things really difficult when you're working with both upper
		Discomfort	6	"stroke clients or clients with high spasticity where they've got tight tone and tight muscles that may cause some discomfort or pain."
		Limitations	6	"Ohh, my arms...I don't like touching anything else. I don't use anything else on there. That's pretty specific to me."
		Reduced Grip Strength	6	"people can't even grasp, so they might not be able to grasp a cup or something like that."
		Foot (Use of lower limb)	5	"The side of the foot wiht the pinky, that's the one that spam clicks."

E. QUALITATIVE INTERVIEW DATA THEMATIC CODES

Leading Theme	Group	Subgroup	Highlight Cou	Example Quote
User Challenges & Barriers	Accessibility Challenges	Shoulder/Arm Weakness	5	"a lot of pain, primarily at the shoulder, because if they have really poor shoulder muscles and there's a risk of the shoulder subluxing."
		Condition to Condition	4	"depend on what condition you target because you might get someone with motor neuron where their cognition is fine, but their body is failing."
		Specific (Individual) Needs	4	"If they have a really dense upper limb with no sensation to begin with. They might not be able to feel anything in the whole arm."
		Ergonomics	3	"More larger spread out controls ...even if they sort of are off target, a little bit, still gonna ....hit the button as such."
		Stroke Patients	3	"someone post a stroke where both their cognition and their upper lung function is not great."
		Frustration	2	"I want to play Xbox in like a different room....because that's shits annoying."
		Gameplay Barriers	2	"I just can't do fast-paced gaming at all, it's just not that good."
		Compatibility Issues	2	"It allows third parties. It's just it's just bloody hard to find one that will actually work."
	Engagement Challenges	Adapting to Technology Advancements	31	"can be annoying when the game does support controller because sometimes it tries to do the controller buttons. So I have to download it. I need to download another driver."
		Limitations	24	"So, like, just pressing occasionally, like the just the things with long cool down."
		Risk of Causing Pain	7	"My rights are a little bit worse. So if I do have to press anything with my buttons, I'm usually pressing them with my left hand."
		Complexity	4	"Like Understand the instructions and the requirements like I guess primarily it would be used with the younger population."
		Disability	4	"depend on what condition you target because you might get someone with motor neuron where their cognition is fine, but their body is failing."
		Discomfort	4	"I refused to do basically everything in my arms."
		Cost	3	"it was quite an expensive set because I was thinking about getting one for the hospital, but I think it was like $200,000."
		Expanding Horizons	3	"WASD with head tilting, that would be awesome and would open up a lot of games to me, but I haven't really branched out to try and sort that out."
		Inconvenience	3	"have so many wise so many wires. I have Velcro them together but yeah my desk is full of wires."
		Thumbstick Design	2	"that does not easily exist. It is thumbsticks you can attach the adaptive controller."

E. QUALITATIVE INTERVIEW DATA THEMATIC CODES

Leading Theme	Group	Subgroup	High light Cou	Example Quote
User Challenges & Barriers	Ergonomic Barriers	Interaction	17	"typically a lot of our patients struggle with light touch sensation. But that deeper pressure they can feel usually quite well."
		Diverse Hand Function	9	"Parkinson's patients, they get a lot of tremor through their hand as well. But typically if they're they're grasping on something quite strong, that trend will stop."
		Grip Strength	8	"they might not be able to grasp correctly or oppose their fingers or something like that, so it will definitely range."
		Sensitivity	8	"But if it's kind of that deeper pressure, theyy can normally feel it quite well."
		Weakness	7	"Severe weakness in both arms.... can make things really difficult when you're working with both upper limbs."
		Individual Needs	6	"probably need to make different controllers for different people based on their deficits."
		Pain and Fatigue	6	"Complex Regional Pain Syndrome (CRPS)....it's more pain focused medical condition."
		Fine Motor Control	4	"But we have to consider all all the joints. So you've got the shoulder, the elbow, the wrist, the fingers, the thumb. They all operate differently and they can all be affected differently."
		Additional Cognitive Impact	3	"They're impacted physically, but then also the cognitive impact also has a role in playing with their limitations as well."
		Range of Motion	3	"really poor shoulder muscles and you can't, we can't flex their shoulder past 90°."
		Unilateral Disability	3	"Depending on what side of the brain, say it was on the left side of the brain... it will primarily affect the right side of the body and vice versa. So only one upper limb is usually affected. There are a few outliers where you might get both."

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