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***Abstract*—Bed rest is a common treatment for physical injuries, but it can make using standard keyboards and mice challenging for patients. Improper posture and discomfort during computer use can delay recovery and cause new injuries. We aim to design ergonomic peripherals that are comfortable for individuals who are bedridden or reclined. To achieve the goal, we conducted a task analysis to identify a problem, ran interviews for user insights, brainstormed solutions, and created several prototypes ending in a physical electrical prototype with Unity integration. As a result, our prototype controller was created using the modified design choices made by our participants in keeping the design ergonomic. A major takeaway we found was that certain controllers will satisfy certain functions and that you'll need to compromise on some features when creating a controller.**

I. Introduction

BEDREST is a common treatment for many physical injuries like fractures, damaged ligaments and broken bones. It is prescribed because it minimizes physical strain on the body, allows the body to conserve energy and reduces stress on muscles and joints. Individuals on bed rest often find it difficult to use a keyboard and mouse at a desk due to limited mobility. Moreover, Individuals may struggle to maintain proper posture, which can cause delays in their recovery.

Current keyboards and mice are designed around use at a desk, where the user can sit upright with proper posture. However, most individuals on bed rest are either fully or partly reclined in bed, which makes it difficult to use a keyboard and mouse comfortably[2]. Furthermore, the awkward use angle can cause Individuals on bed rest additional strain on the wrists, arms, neck, and back. This can even cause muscle fatigue, and potential long-term issues, like repetitive strain injuries[1].

In this report, we will be trying to design a set of peripherals that allow individuals who are bedridden or unable to sit in a chair to use a keyboard and mouse without discomfort. We will focus on making sure that the design is comfortable enough so that users can interact with them without stressing their bodies while lying down or in a reclined position.

If this problem is not solved, individuals who already have health problems may experience worsening conditions due to the physical strain caused by using uncomfortable peripherals. Moreover, the use of non-ergonomic devices can also result in new injuries[1], like carpal tunnel syndrome, tendinitis, or other repetitive strain injuries.

II. Background review

A. Scientific papers

1) "Repetitive Strain Injury in Computer Keyboard Users: Pathomechanics and Treatment Principles in Individual and Group Intervention" by Katy Keller et al[1]: The keywords used to find this paper were: Repetitive Strain Injury, computer keyboard users, RSI, and Ergonomics. 1,850 results were found and after reading the abstracts of the top 5 results, this one was selected because it focuses on a multi-disciplinary treatment, of Repetitive Strain Injury rather than a single approach. The problem this resource is trying to address is the increasing amount of Repetitive Strain Injury in computer keyboard users which can lead to musculoskeletal and neurovascular problems. The main groups that will benefit from this are computer/keyboard users. This resource tries to address the problem by creating and testing a treatment which includes individual and group interventions. The treatment model is tested on 75 patients from keyboard-intensive occupations. They utilized technique retraining, ergonomic adjustments, and posture correction. They tested the results by doing a feedback survey at the end of their intervention sessions. The main thing I learned from this was that Repetitive Strain Injury treatment requires a multidisciplinary approach, moreover, I learned about what ergonomic improvements could be made to reduce the risk and occurrence of Repetitive Strain Injury.

2) "Game Accessibility: A Survey" by Bei Yuan, Eelke Folmer, and Frederick C. Harris Jr.[2]: The keywords used to find this paper were: video games disability, serious games and bed rest. 3,650 results were found and this one was selected because it covered several different disabilities and a variety of approaches to each disability. The problem this resource is trying to address is the lack of accessibility in video games for individuals with disabilities which mainly benefits individuals with disabilities. This resource tries to address the problem by doing a survey of accessible games and analyzing and categorizing accessibility strategies used. It uses this information to create a game interaction model which shows how different types of impairments affect the ability to play games. It defines specific low- and high-level strategies for making games accessible depending on the user's disability. They tested the accessibility strategies by evaluating existing games to see how well they incorporated accessibility strategies and the outcomes their implementation had. This paper's main takeaway for me was learning about how different types of disabilities require different strategies and solutions. There is always a trade-off between accessibility and functionality.

3) "A Console Interface for Game Accessibility to People with Motor Impairments" by L. Fanucci, F. Iacopetti [3]: I found this paper using research rabbit's similar work feature. The keywords of this paper are game accessibility; motor impairments; cognitive impairments; and assistive technology. The problem this resource is trying to address is the barrier to entry that modern game controllers present to individuals who have upper limb and mild cognitive impairments. This resource tries to address the problem by proposing an interface that utilizes external switch sensors so that users are not limited to small buttons/joysticks that require fine motor skills to use. The new interface was tested with impaired users playing an autonomous game, a cooperative game with another disabled mate, a cooperative game with an able-bodied mate using the joypad and an autonomous or cooperative game against a mate using the second joypad. They received positive results from the testing. The main takeaway I got from this paper was gaining insight into several devices that enable users to play games, as well as understanding the shortcomings and limitations of each device.

B. Commercial devices/Solutions

1) VR: One of the major preexisting solutions to playing games while bedridden is virtual reality (VR)[4]. A VR headset is a unique device because it functions as both a display and an input device[5]. The ability to place the user's display anywhere around them allows unparalleled comfort since the user can lay flat on the bed and still see the screen. However, the device has limitations: it often requires significant physical movement to play most VR games which can be problematic for our users, and it has a more limited game selection compared to PC and console platforms.

2) Controllers: The current golden standard of playing games while bedridden seems to be using a controller. Game controllers are popular for their compact design, wireless convenience, and ergonomic features, allowing players to enjoy a wide variety of games with minimal movement of the elbow and shoulder joints[6]. However, they do have limitations, they are hard to use if you do not have fine motor control and they are not well-suited for certain PC game genres, like real-time strategy (RTS)[7] or grand strategy games.

III. Results

The task analysis process narrowed our focus to a specific, heavyweight use case that influenced our design decisions. This analysis served as a foundational element during interviews, allowing participants to understand the problem we aimed to solve (see Appendix A for further information).

The interviews were conducted in a short period to respect the design thinking process and to keep each session short and sweet. This approach maximized our time with each participant while gathering as much data as possible. Additionally, each participant received a pitch about our controller, its real-world applications, and design choices (see Appendix B for further information).

The brainstorming and idea validation processes served different purposes. The brainstorming process allowed us to discover applicable ideas, while the idea validation process categorized those ideas into valid, absurd, and promising concepts. This categorization later drove our design choices, components list, and considerations for real-world applicability (see Appendix C for further information).

The system architecture creates a general overview of how a user can interact with our device, feedback mechanisms, and a glimpse of potential circuitry. Due to our device being split into two components, the system architecture was designed to accommodate this structure (see Appendix D for further information).

The schematics and components list were drawn up using Tinkercad, a program for electronics simulation. Once we created our controller virtually, we compiled a list of components used in its construction. Additionally, the schematic features commenting which specifies what components perform which functions. Notably, while potentiometers were used in the schematic, they were later replaced with a joystick in the physical implementation of our controller (see Appendix E for further information).

The code used for making the controller function virtually was also developed in Tinkercad. The program showcases initialized variables, inputs and outputs, and the ability to print inputs into the console (see Appendix F for further information).

IV. Conclusion

In conclusion, we used a structured approach, including task analysis, focused interviews, brainstorming and idea validation, to inform our design decisions. The task analysis helped us identify a heavyweight use case, guiding our conversations with participants about the problem we aimed to solve. By keeping interviews concise, we gathered valuable feedback while ensuring participants understood the controller's intended real-world applications.

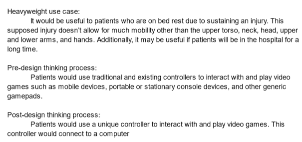
The brainstorming and idea validation processes allowed us to explore various ideas and categorize them, which influenced our design and component choices. Our system architecture provided an overview of user interactions and circuitry, accommodating the division of the device into two components.

Using Tinkercad, we developed the schematic and a components list, which laid the foundation for our prototype. Additionally, the code for the virtual controller added functionality to our design that was easily transferable to the physical prototype.

Ultimately, our prototype was shaped by the ergonomic modifications suggested by participants. The takeaway was the need to balance certain functions, as compromises on some features are often necessary when designing controllers. This insight will guide future improvements to ensure our controller meets user needs effectively.

Appendix A
Task Analysis

The task analysis was used to narrow our use cases to a specific and heavyweight use case that drove our design decisions. The task analysis was later used to inform the interviewees about the problem we were aiming to solve.


Heavyweight use case:
It would be useful to patients who are on bed rest due to sustaining an injury. This supposed injury doesn't allow for much mobility other than the upper torso, neck, head, upper and lower arms, and hands. Additionally, it may be useful if patients will be in the hospital for a long time.

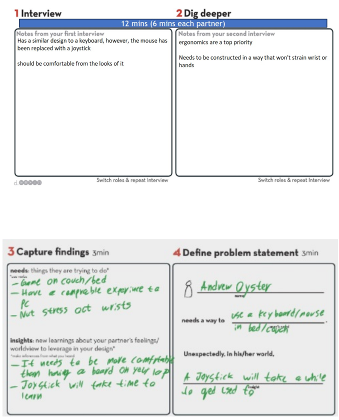
Pre-design thinking process:
Patients would use traditional and existing controllers to interact with and play video games such as mobile devices, portable or stationary console devices, and other generic gamepads.

Post-design thinking process:
Patients would use a unique controller to interact with and play video games. This controller would connect to a computer

Fig. 1. Task analysis session

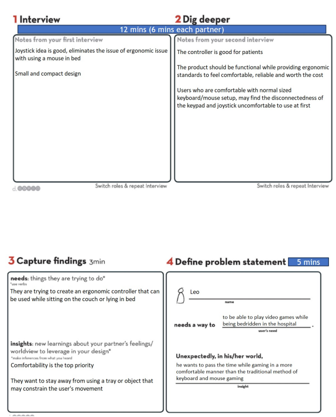
Appendix B
Interviews

These interviews were each done in a short period to respect the design thinking process and to keep each interview short and sweet. This way, we were able to maximize the time we had with our interviewee while gathering as much data as possible. Each interviewee had been given a pitch about our controller, its real-world applications, and design choices.


1 Interview
2 Dig deeper
12 mins (6 mins each partner)
Notes from your first interview
Has a similar design to a keyboard, however, the mouse has been replaced with a joystick
should be comfortable from the looks of it
Notes from your second interview
ergonomics are a top priority
Needs to be constructed in a way that won't strain wrist or hands
Switch roles & repeat Interview
Switch roles & repeat Interview

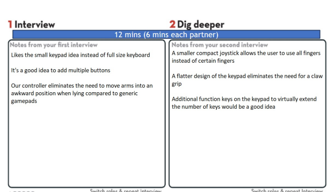
3 Capture findings 3min
needs: things they are trying to do*
*use verbs
- Game on couch/bed
- Have a comprable experince to pc
- Not stress out wrists
insights: new learnings about your partner's feelings/ worldview to leverage in your design*
*make inferences from what you heard
- It needs to be more comfortable than having a board on your lap
- Joystick will take time to learn
4 Define problem statement 3min
Andrew Oyster
name
needs a way to use a keyboard/mouse in bed/couch
user's need
Unexpectedly, in his/her world,
A Joystick will take a while to get used to
insight

Fig. 2. Interview one using the design thinking template


1 Interview
2 Dig deeper
12 mins (6 mins each partner)
Notes from your first interview
Joystick idea is good, eliminates the issue of ergonomic issue with using a mouse in bed
Small and compact design
Notes from your second interview
The controller is good for patients
The product should be functional while providing ergonomic standards to feel comfortable, reliable and worth the cost
Users who are comfortable with normal sized keyboard/mouse setup, may find the disconnectedness of the keypad and joystick uncomfortable to use at first
Switch roles & repeat Interview
Switch roles & repeat Interview

3 Capture findings 3min
needs: things they are trying to do*
*use verbs
They are trying to create an ergonomic controller that can be used while sitting on the couch or lying in bed
insights: new learnings about your partner's feelings/ worldview to leverage in your design*
*make inferences from what you heard
Comfortability is the top priority
They want to stay away from using a tray or object that may constrain the user's movement
4 Define problem statement 5 mins
Leo
name
needs a way to to be able to play video games while being bedridden in the hospital.
user's need
Unexpectedly, in his/her world,
he wants to pass the time while gaming in a more comfortable manner than the traditional method of keyboard and mouse gaming
insight

Fig. 3. Interview two using the design thinking template


1 Interview
2 Dig deeper
12 mins (6 mins each partner)
Notes from your first interview
Likes the small keypad idea instead of full size keyboard
It's a good idea to add multiple buttons
Our controller eliminates the need to move arms into an awkward position when lying compared to generic gamepads
Notes from your second interview
A smaller compact joystick allows the user to use all fingers instead of certain fingers
A flatter design of the keypad eliminates the need for a claw grip
Additional function keys on the keypad to virtually extend the number of keys would be a good idea
Switch roles & repeat Interview
Switch roles & repeat Interview

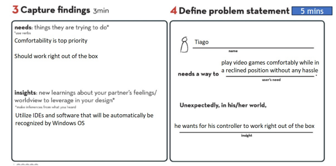
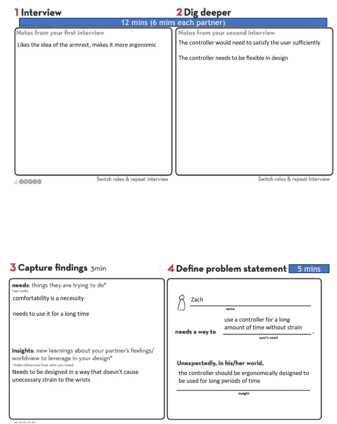
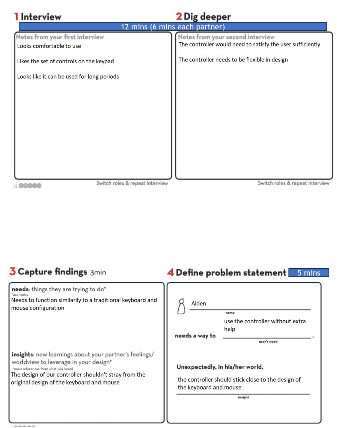

3 Capture findings 3min
needs: things they are trying to do*
*use verbs
Comfortability is top priority
Should work right out of the box
insights: new learnings about your partner's feelings/ worldview to leverage in your design*
*make inferences from what you heard
Utilize IDEs and software that will be automatically be recognized by Windows OS
4 Define problem statement 5 mins
Tiago
name
needs a way to play video games comfortably while in a reclined position without any hassle.
user's need
Unexpectedly, in his/her world,
he wants for his controller to work right out of the box
insight

Fig. 4. Interview three using the design thinking template


1 Interview
2 Dig deeper
12 mins (6 mins each partner)
Notes from your first interview
Likes the idea of the armrest, makes it more ergonomic
Notes from your second interview
The controller would need to satisfy the user sufficiently
The controller needs to be flexible in design
Switch roles & repeat Interview
Switch roles & repeat Interview

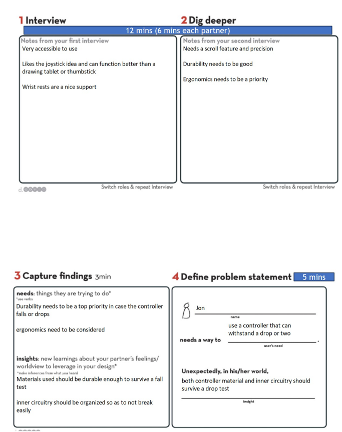
3 Capture findings 3min
needs: things they are trying to do*
*use verbs
comfortability is a necessity
needs to use it for a long time
insights: new learnings about your partner's feelings/ worldview to leverage in your design*
*make inferences from what you heard
Needs to be designed in a way that doesn't cause unecessary strain to the wrists
4 Define problem statement 5 mins
Zach
name
needs a way to use a controller for a long amount of time without strain.
user's need
Unexpectedly, in his/her world,
the controller should be ergonomically designed to be used for long periods of time
insight

Fig. 5. Interview four using the design thinking template


1 Interview
2 Dig deeper
12 mins (6 mins each partner)
Notes from your first interview
Looks comfortable to use
Likes the set of controls on the keypad
Looks like it can be used for long periods
Notes from your second interview
The controller would need to satisfy the user sufficiently
The controller needs to be flexible in design
Switch roles & repeat Interview
Switch roles & repeat Interview

3 Capture findings 3min
needs: things they are trying to do*
*use verbs
Needs to function similarily to a traditional keyboard and mouse configuration
insights: new learnings about your partner's feelings/ worldview to leverage in your design*
*make inferences from what you heard
The design of our controller shouldn't stray from the original design of the keyboard and mouse
4 Define problem statement 5 mins
Aiden
name
needs a way to use the controller without extra help.
user's need
Unexpectedly, in his/her world,
the controller should stick close to the design of the keyboard and mouse
insight

Fig. 6. Interview five using the design thinking template


1 Interview
2 Dig deeper
12 mins (6 mins each partner)
Notes from your first interview
Very accessible to use
Likes the joystick idea and can function better than a drawing tablet or thumbstick
Wrist rests are a nice support
Notes from your second interview
Needs a scroll feature and precision
Durability needs to be good
Ergonomics needs to be a priority
Switch roles & repeat Interview
Switch roles & repeat Interview

3 Capture findings 3min
needs: things they are trying to do*
*use verbs
Durability needs to be a top priority in case the controller falls or drops
ergonomics need to be considered
insights: new learnings about your partner's feelings/ worldview to leverage in your design*
*make inferences from what you heard
Materials used should be durable enough to survive a fall test
inner circuitry should be organized so as to not break easily
4 Define problem statement 5 mins
Jon
name
needs a way to use a controller that can withstand a drop or two.
user's need
Unexpectedly, in his/her world,
both controller material and inner circuitry should survive a drop test
insight

Fig. 7. Interview six using the design thinking template

Appendix C
Brainstorming and Idea Validation

The brainstorming and idea validation process served different purposes. The brainstorming process allowed us to discover any applicable idea, while the idea validation process took those ideas and categorized them into valid, absurd and promising ideas. This process later drove our design choices, components list, and real-world applicability.

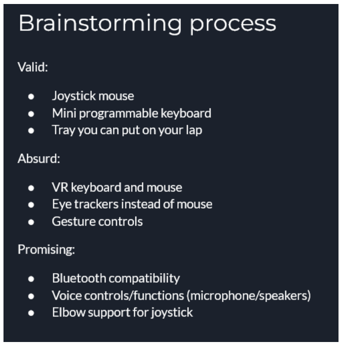


Fig. 8. The brainstorming and idea validation process

Appendix D
System Architecture

The system architecture creates a general overview of how a user can interact with our device, feedback to the user, and a glimpse of potential circuitry. Due to our device being split into two devices, the system architecture was made to accommodate its structure.

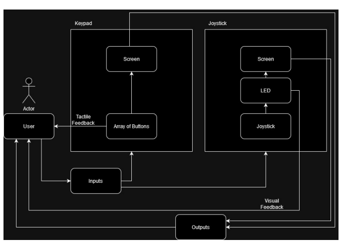


Fig. 9. The system architecture of our controller

Appendix E
Electronic Schematics and Components

The schematics and components list were drawn up from Tinkercad, a program used for electronics simulation. Once we created our controller virtually, the list of components used in its construction was created. Additionally, the schematic features comments that specify which components do what. Note that the potentiometers used in the schematic were replaced with a joystick in the physical implementation of our controller.

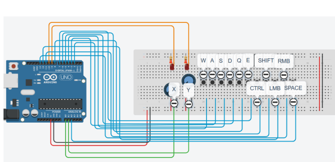
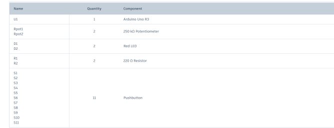


Fig. 10. The Electronic Schematics of our controller in Tinkercad

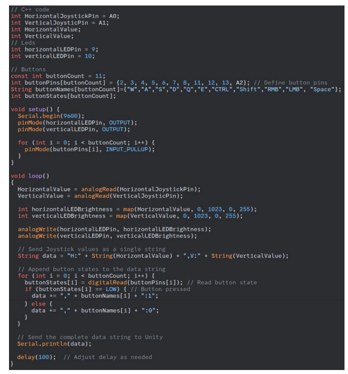


Name	Quantity	Component
U1	1	Arduino Uno R3
Rpot1 Rpot2	2	250 kΩ Potentiometer
D1 D2	2	Red LED
R1 R2	2	220 Ω Resistor
S1 S2 S3 S4 S5 S6 S7 S8 S9 S10 S11	11	Pushbutton

Fig. 11. The list of components of our controller in Tinkercad

Appendix F
Code

This is the code used for making the controller function virtually. The program used to run the simulated version of our controller was Tinkercad. Additionally, the image shows initialized variables, inputs and outputs, and the ability to print inputs into the console.



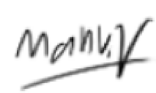
```
// C++ code
int HorizontalJoystickPin = A0;
int VerticalJoysticPin = A1;
int HorizontalValue;
int VerticalValue;
// Leds
int horizontalLEDPin = 9;
int verticalLEDPin = 10;

// Buttons
const int buttonCount = 11;
int buttonPins[buttonCount] = {2, 3, 4, 5, 6, 7, 8, 11, 12, 13, A2}; // Define button pins
String buttonNames[buttonCount]={"W","A","S","D","Q","E","CTRL","Shift","RMB","LMB", "Space"};
int buttonStates[buttonCount];

void setup() {
  Serial.begin(9600);
  pinMode(horizontalLEDPin, OUTPUT);
  pinMode(verticalLEDPin, OUTPUT);

  for (int i = 0; i < buttonCount; i++) {
    pinMode(buttonPins[i], INPUT_PULLUP);
  }
}

void loop()
{
  HorizontalValue = analogRead(HorizontalJoystickPin);
  VerticalValue = analogRead(VerticalJoysticPin);

  int horizontalLEDBrightness = map(HorizontalValue, 0, 1023, 0, 255);
  int verticalLEDBrightness = map(VerticalValue, 0, 1023, 0, 255);

  analogWrite(horizontalLEDPin, horizontalLEDBrightness);
  analogWrite(verticalLEDPin, verticalLEDBrightness);

  // Send Joystick values as a single string
  String data = "H:" + String(HorizontalValue) + ",V:" + String(VerticalValue);

  // Append button states to the data string
  for (int i = 0; i < buttonCount; i++) {
    buttonStates[i] = digitalRead(buttonPins[i]); // Read button state
    if (buttonStates[i] == LOW) { // Button pressed
      data += "," + buttonNames[i] + ":1";
    } else {
      data += "," + buttonNames[i] + ":0";
    }
  }

  // Send the complete data string to Unity
  Serial.println(data);

  delay(100);  // Adjust delay as needed
}
```

Fig. 12. The code used to make our controller function

Appendix G
Contributions

A. *Manvir punglia - 100828507*

Wrote Introduction, Background review, did 1 interview, made digital and physical electrical prototype, set up unity integration



B. *Saad Khan - 100829159*

Wrote made paper prototype and diagram,

References

[1] Keller, K., Corbett, J., & Nichols, D. (1998). Repetitive strain injury in computer keyboard users: Pathomechanics and treatment principles in individual and group intervention. *Journal of Hand Therapy*, *11*(1), 9–26. https://doi.org/10.1016/S0894-1130(98)80056-2

[2] Yuan, B., Folmer, E., & Harris, F. C. (2011). Game accessibility: a survey. *Universal Access in the Information Society, 10*(1), 81-100. https://doi.org/10.1007/s10209-010-0189-5

[3] Fanucci, L., Iacopetti, F., & Roncella, R. (2011). A console interface for game accessibility to people with motor impairments. *IEEE*, *10*, 206–210. https://doi.org/10.1109/icce-berlin.2011.6031883
[4] *Lying Down Mode*. (2023, April 22). Reddit.com. https://www.reddit.com/r/OculusQuest/comments/12v13ua/comment/jh95cel/
[5] *Meta Quest 3*. (2024). Meta.com. https://www.meta.com/ca/quest/quest-3/
[6] *DualSense Wireless Controller — PS5*. (n.d.). [Video]. PlayStation. https://www.playstation.com/en-ca/accessories/dualsense-wireless-controller/
[7] Atolm. (2024, February 17). *I wish more RTS and strategy games in general had controller support. [Online forum post]*. ResetEra. https://www.resetera.com/threads/i-wish-more-rts-and-strategy-games-in-general-had-controller-support.817983/