



DECO2300/7230 Digital Prototyping

Interactive Prototype 2

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Practical Session & Tutor's Name: Week 9

Friday 10 am-12 pm - **Sanya Ahmad**

Statement of Originality

I certify that all images & audio used in the creation of this prototype are my original work. References for all external sources can be found on page 2 of this document.

[RBFPSController]:[Trajectory Predictor],[Bolt-Scripts];retrievedfrom[Unity Assets Store]([https://assetstore.unity.com/packages/tools/physics/trajectory-predictor-55752]) , Last Accessed [20/08/2023]

[Orbiter] :[Trajectory Predictor],[Bolt-Scripts];retrievedfrom[Unity Assets Store]([https://assetstore.unity.com/packages/tools/physics/trajectory-predictor-55752]) , Last Accessed [20/08/2023]

[MouseOrbiter]:[Trajectory Predictor],[Bolt-Scripts];retrievedfrom[Unity Assets Store]([https://assetstore.unity.com/packages/tools/physics/trajectory-predictor-55752]) , Last Accessed [20/08/2023]

[LauncherFPS]:[Trajectory Predictor],[Bolt-Scripts];retrievedfrom[Unity Assets Store]([https://assetstore.unity.com/packages/tools/physics/trajectory-predictor-55752]) , Last Accessed [20/08/2023]

[Launcher2D]:[Trajectory Predictor],[Bolt-Scripts];retrievedfrom[Unity Assets Store]([https://assetstore.unity.com/packages/tools/physics/trajectory-predictor-55752]) , Last Accessed [20/08/2023]

[LauchDelayDestory]:[Trajectory Predictor],[Bolt-Scripts];retrievedfrom[Unity Assets Store]([https://assetstore.unity.com/packages/tools/physics/trajectory-predictor-55752]) , Last Accessed [20/08/2023]

[HitSound]:[Youtube],[M Murad Iqbal - Tech Nuggets - Javangelist];retrievedfrom[Youtube]([https://www.youtube.com/watch?v=yE0JdtVTnVk&t=72s]) , Last Accessed [20/08/2023]

[Golf environments setting(Hole A, B, C, Hole Open, Hole Around, open, block, that's the castle, obstacle Diamond)]: [Mini-

Golf(Assets)],[swapnilrane24];retrievedfrom[Github]([https://assetstore.unity.com/packages/tools/physics/trajectory-predictor-55752]), Last Accessed [20/08/2023]

Audio Used:Success: success sound by swapnilrane24 (2020) in GitHub. Negative_beeps-6008:Negative_beeps by Pixabay (2023) in Pixabay.

Arduino Code: The code of mouse movement is modified from the library example of Circuit Playground Express, and the LED display retrieved from Adafruit NeoPixel Library: ,Member Function Documentation

(https://adafruit.github.io/Adafruit_NeoPixel/html/class_adafruit___neo_pixel.html#ab8763ccc6f9a090df1f753905fd5561e) Last accessed 17/9/23.

The Concept

This concept incorporates interactive content and practice exercises to assist beginners in improving their golf swing's accuracy and direction in virtual environments. This prototype is a virtual training tool for beginner golfers, integrating a Circuit Playground Express board to display directional feedback based on the user's swing, helping them adjust their technique.

The Purpose of this testing round:

The Unity of Golf will stay the same as prototype 1 shows that most participants can understand and solve the idea and problems. Subsequently, this round of testing is intended to evaluate:

- A. User Feedback on LED Lights' Colour Displays:** How viability and efficiency of the Circuit Playground Express board as an instructional feedback tool for golf swing corrections.
- B.** After prototype 1 received feedback regarding text descriptions on prediction sentence display style, whether prototype 2 could improve user's golf swing skills after changes.
- C. User Experience:** The overall usability, intuitiveness, and satisfaction derived from using the prototype.

A. To understand which mode of LED lights' colour display communicates the user's swing directions, I will implement different LED lights' colour variants to signal the direction of swing:

1. User Intuitiveness: How straightforward can users understand and interpret feedback from the LED light's colour displays? (If and how quickly beginners can adjust their swings based on feedback from the board.)
2. Effectiveness: Does the LED light's colour feedback lead to measurable improvements in the user's golf swing technique?

As a tangible interface designed to provide users with real-time feedback, certain decisions were critical to the development of our prototype:

B & C:

To understand the improvements and user experience of prototype 2, the questionnaire and an open-ended feedback form for users will be filled in after the testing session.

Inclusions:

1. Multiple LED lights' colours Feedback Variants: Given the uncertainty of the most effective display mode, I incorporated several, which would allow for direct comparison during testing.
2. Simple, Intuitive Colour Codes: Using universally recognised colour cues (red for left, green for right, up for yellow, down for white) ensures a lower learning curve for users.
3. Immediate Feedback Mechanism: The prototype was designed to provide instant feedback upon a swing, emphasising the real-time learning aspect.
4. Same mouse movement sensitive control: To only test the LED light's colour display impacts on the user, ensure the user swing feedback sent to the unity is at the same speed.

Exclusions:

1. Complicated Patterns: I omitted complex LED light colour patterns or sequences to prevent overwhelming or confusing users.
2. Advanced analytics: I omitted the advanced analytics, such as swing speed or angle, which could distract from the core functionality I aim to test.

Hypotheses:

H1: Using the entire LED lights' colour display on the Circuit Playground Express board will result in over 80% of users accurately correlating colour with swing direction after a brief introduction.

H2: Immediate LED lights' entire colour display feedback from the prototype, enabling at least 70% of users to adjust and improve their swing skills after 3 attempts.



H3: Over 80% of participants agreed with the prediction text and thought that it is helpful for them to adjust the directions when they hit the ball to the object.

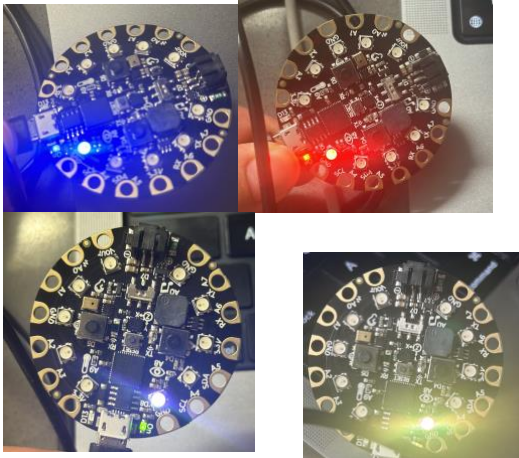
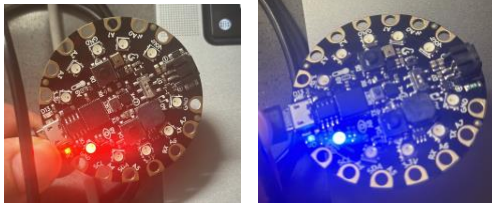

The Form of the Prototype:

Our prototype consists of a Circuit Playground Express board connected to a computer that runs the virtual training tool software.



Image 1: User test with Circuit Playground Express board and unity, A circular board filled with LED lights and motion sensors that capture and interpret the golfer's swing. The board changes the LED lights' colours based on the direction of the swing.

Components	Description	Image
LED lights' colour Feedback Mechanism - Variant A1	Variant A1's feedback system for showing swing direction.	<div></div> <p>Image 3,4,5,6: LEDs split in half: blue for the "left" swing, red for the "right" swing, yellow for the “up” swing and white for the “down” swing.</p>
LED lights' colour Feedback Mechanism - Variant A2	Variant A2's feedback system for showing swing direction.	<div></div> <p>Image 3,4: LEDs split in half: blue for the "left" swing, red for the "right" swing.</p>

<p>LED lights' colour Feedback Mechanism - Variant B1</p>	<p>Variant B1's feedback system for showing swing direction.</p>	 <p>Image 7,8,9,10: Single LED colour change: blue for the "left" swing, red for the "right" swing, yellow for the "up" swing and white for the "down" swing.</p>
<p>LED lights' colour Feedback Mechanism - Variant B2</p>	<p>Variant B2's feedback system for showing swing direction.</p>	 <p>Image 7,8: Single LED colour change: blue for the "left" swing, red for the "right" swing.</p>
<p>How users interact with the device and receive feedback</p>	<p>How users interact with the device and receive feedback</p>	 <p>Image 11,12: Users perform a swing, and the board detects the movement. Depending on the direction, LEDs lights' up accordingly. The board of the right button click to perform the launch the ball function.</p>

Task for the user:

Task 1: Familiarise themselves with the LED lights' colour feedback colours and their corresponding swing directions.

Task 2: Engage in 4 simulations of the user hitting the ball into 3 holes in various directions in 4 diverse LED lights' colour displays.

Task 3: Prompt the stand-up position during the testing session to simulate the golf swing environment.

Task 4: Filled the questionnaire after the testing session to get the general user experience of the prototype.

Feedback Collection:

At the end of the testing session, users were provided with:

1. A quantitative online questionnaire where they rated aspects like the intuitiveness of LED lights' colour feedback, clarity of swing direction indication, and overall user experience on a scale of 1 to 5.
2. An open-ended feedback form where they could provide qualitative insights and suggestions or report any issues they faced [3].
3. Conduct interviews with users by testing (H3) whether they have noticed the prediction object's text display to help them find the right direction to hit the balls recorded on the Excel sheet (Yes/No).

Evaluation Method:

The evaluation method utilised **A/B testing**, where users were needed to test 4 times with variants A1A2, B1 and B2 LED lights' colour display. The metrics tracked were swing direction accuracy, user-reported satisfaction, average time consuming on task 2, and the number of users successfully hitting the ball into 3 holes in various directions.

Evaluation Outcomes & Reflection:

The results of the tests indicate Variant B2 has the lowest success rate for hitting the balls from three different directions; thus, this will be the reference object for the following data analysis in LED lights' colour display feedback on the user swing of the Arduino board.

Results Outcome [2]:

1. Variant A-1 vs. Variant B2: 80% more accuracy in swing direction, 80% less time-consuming on task 2.
2. Variant A-2 vs. Variant B2: 80% more accuracy in swing direction, 76% less time-consuming on task 2.
3. Variant B-1 vs. Variant B2: 50% accuracy in swing direction, 18% less time-consuming on task 2.

Feedback Outcome [1]:

1. Overall prototype: 90% of participants agree that my prototype is understandable, over 90% agree it is in working condition, and 90 % agree that it is easy to handle [1].
2. Effective idea: 90% of participants thought it may solve the problem, 90% of participants thought it could be effective, over 90% of participants users can come up with my idea with swings behaviour thought that hitting the ball is easy, 90% of users found the colour feedback when they swing the directions are easy to understand, and over 90% of users found that is interesting enough as the golf beginner player [1], which supports hypothesis H2.
3. Text on the display of club predictions: over 90% of participants state that text descriptions of club predictions are helpful for them to find the right direction and, along with colour feedback that helps them to remember to adjust the swing direction, supports hypothesis H3.

Reflection:

1. Variant A-1 provided the most accurate feedback for users, indicating that the all-LED lights' colour representation was the most intuitive.
2. Users commented that the individual LED lights' colour feedback in Variant A-2 and B-2 needed to be more subtle, leading to slight confusion.
3. Some users mentioned wanting a feedback mechanism for swing strength, not just direction.

4. Open-end Feedback recommended customised LED lights' colour responses and having a tutorial for beginners.

Conclusion:

The data strongly suggests that the entire LED lights' colour display on the Circuit Playground Express board improves users' ability to correlate colour with swing direction after a brief introduction. This conclusion supports hypothesis H1 and indicates the prototype's potential effectiveness in real-world applications, and the feedback outcome supports hypotheses H2 and H3.

Changes in Response to Evaluation:

Considering the results, the next iteration of our concept will fully incorporate the LED lights' colour display as a core feature. However, it might be beneficial to:

1. Explore more intuitive colour schemes or patterns to improve accuracy further.
2. Introduce an audio cue alongside the visual feedback to cater to diverse users.

Prototype Sufficiency:

The current prototype effectively demonstrated the potential advantages of the LED lights' colour display for correlating swing direction. Although the results are promising, future tests should consider turning on half of the LED lights when the user swings the express board up and down rather than turning on all LED lights when the user swings the express board up and down.

Testing Plan:

Prototype 3: Instruction video Tutorial

Description and Aspects to Test: Considering the user's desire for the tutorial, a built-in video tutorial will be introduced to guide beginners through the usage and understanding of text prediction and LED light colour feedback.

Testing Focus (User experience):

- User satisfaction video tutorial.
- Effectiveness of the video tutorial: Is it clear and comprehensive? Do beginners feel more confident after going through it?

- Confirm that all usability issues identified in earlier prototypes have been effectively addressed. The user interface should be highly intuitive, with minimal barriers to accessing content.

To see if feedback improves or hinders the learning curve for users.

Miro Link

https://miro.com/app/board/uXjVMYwNGPQ=?share_link_id=670176182865

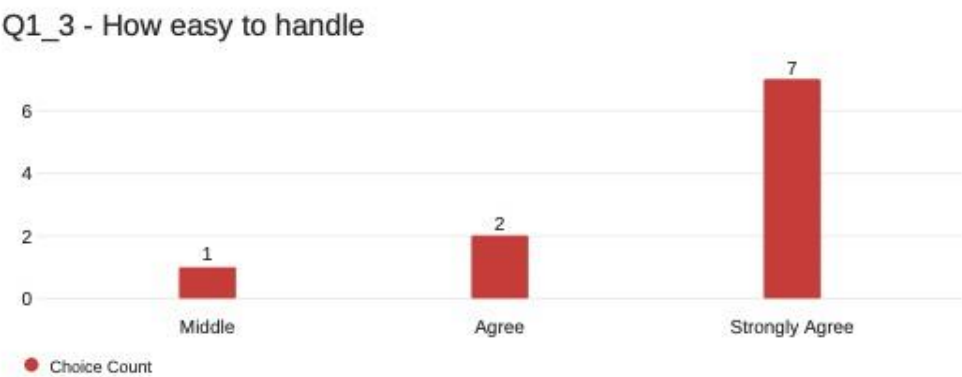
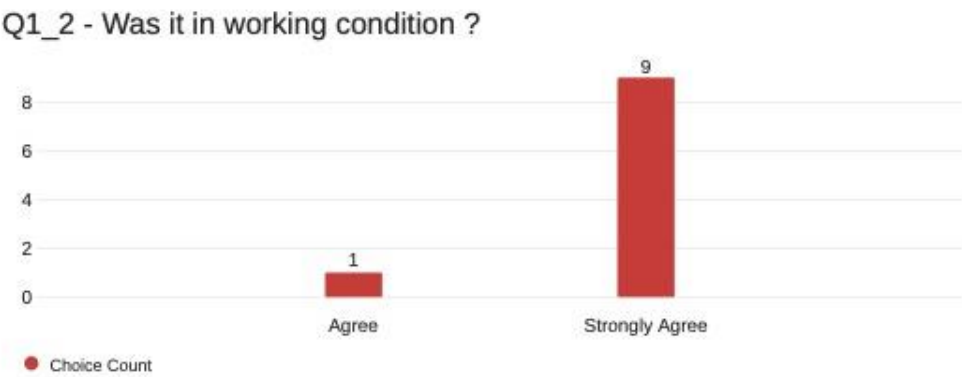
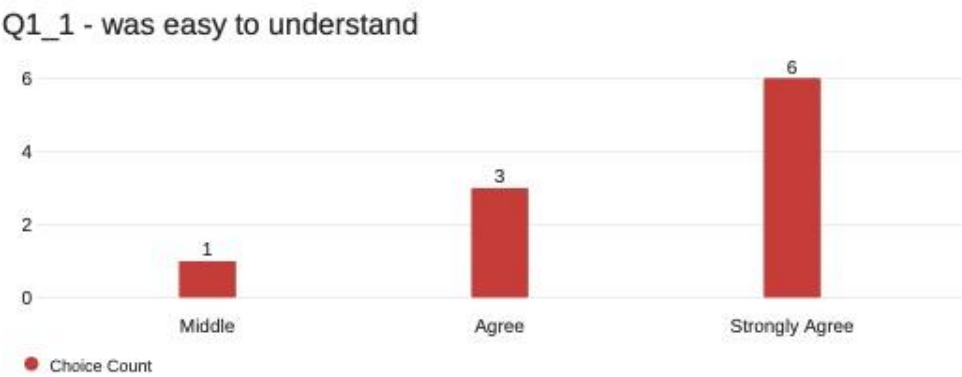
Video Link

https://www.canva.com/design/DAFvd9S16ao/BXdlG0rwnHqolRJQvPqpXA/view?utm_content=DAFvd9S16ao&utm_campaign=designshare&utm_medium=link&utm_source=recording_view

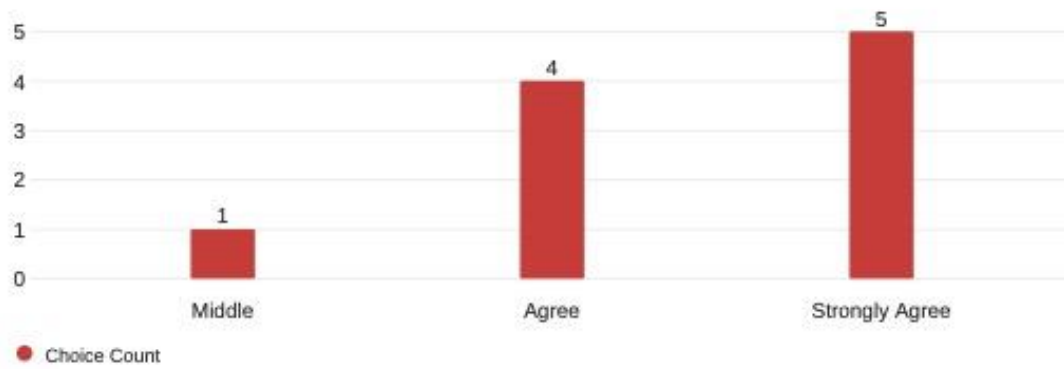
Appendix:

[1] The report of the participant's questionnaire.

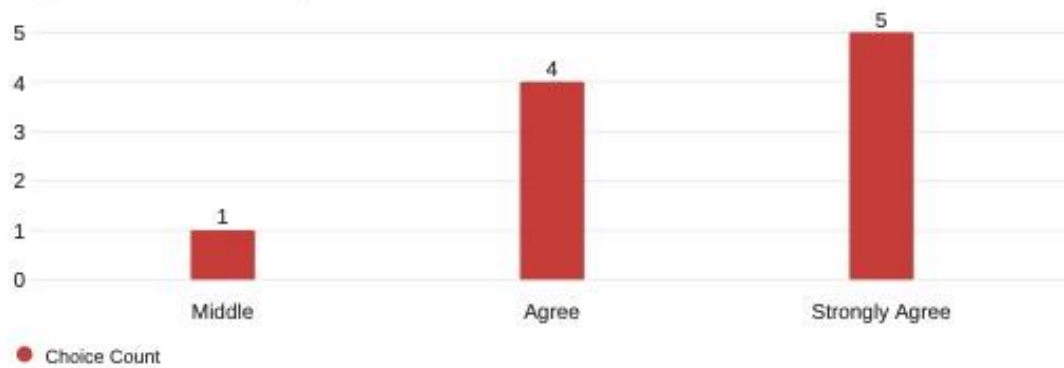
1



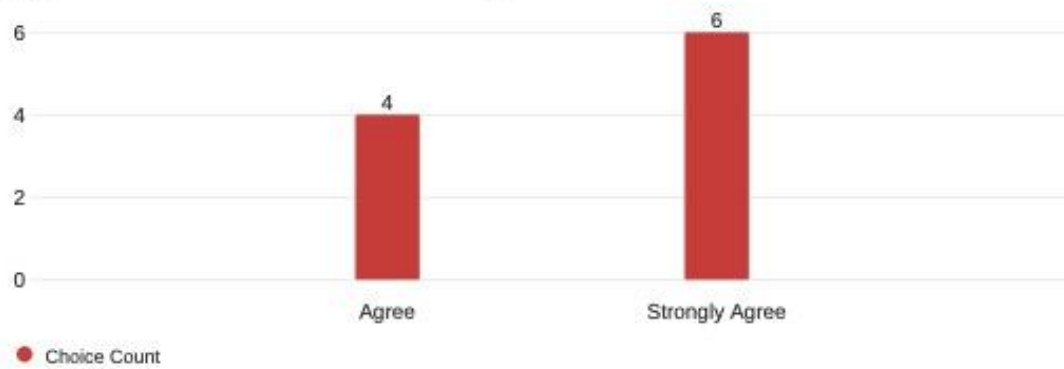
Q2_1 - it may solve the problem



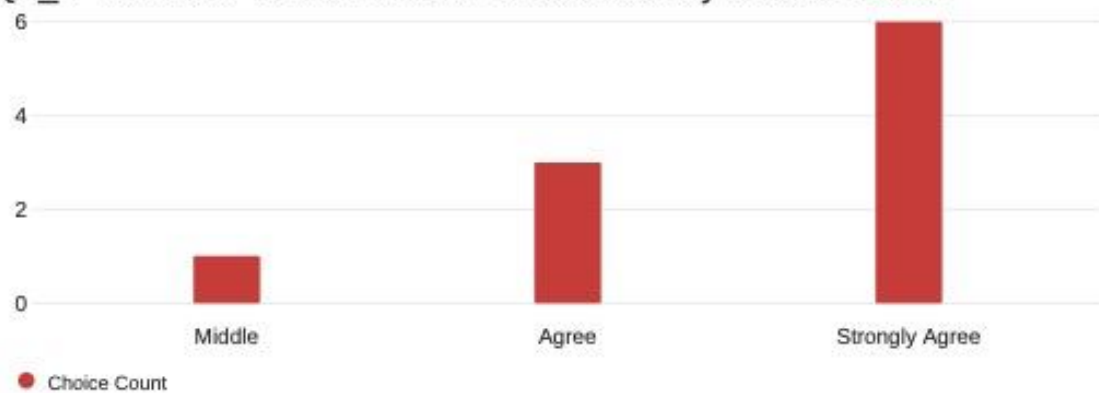
Q2_2 - it can be really effective



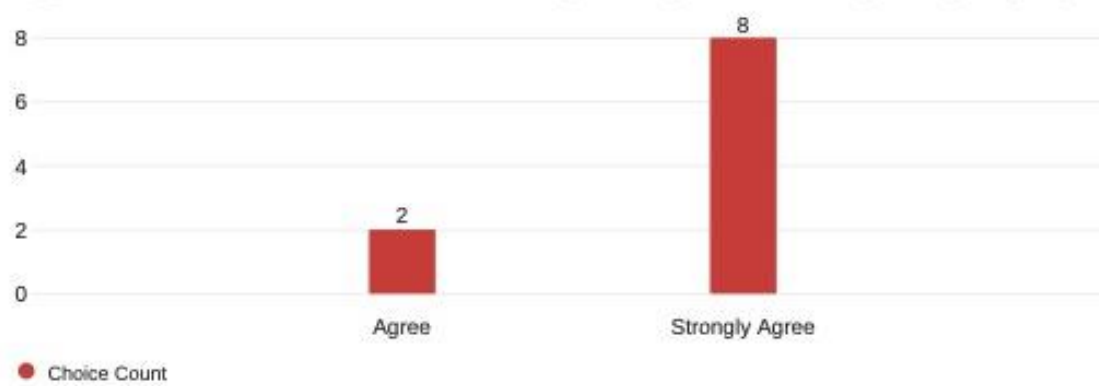
Q2_3 - can user hit the balls easily



Q2_4 - can user found the color feedback easy to understand



Q2_5 - can user found that interesting enough as the beginner golf player



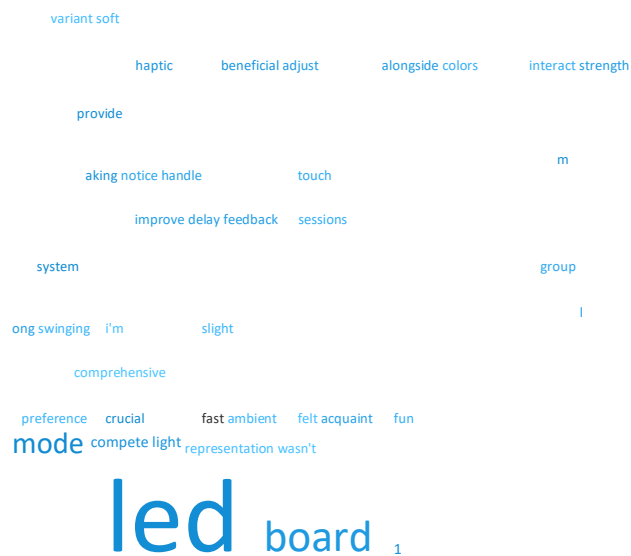
[2] Excel sheet records results outcome

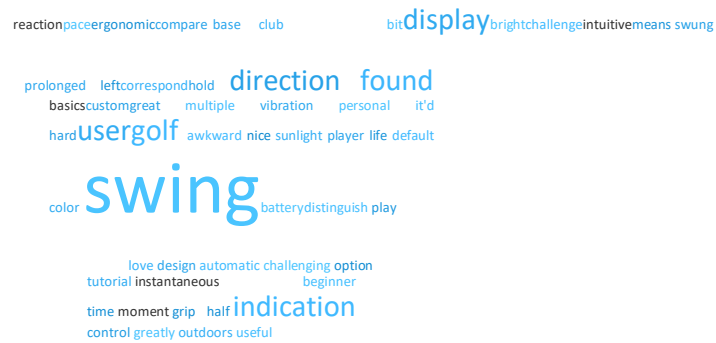
Task	Determine whether it is useful to help them find the right hole to hit the ball by examining the forecasting description sentence		Task 2	Find the right direction to hit ball to the hole		Find the right direction to hit ball to the hole		Find the right direction to hit ball to the hole		Find the right direction to hit ball to the hole		Find the right direction to hit ball to the hole	
	Variant A: This sentence describes the user's swing forecasting of hitting an object which helps the user hit the ball.	Variant B: This sentence describes the user's swing forecasting of hitting an object which does not help the user hit the ball.		Variant A-1: Using the half of LEDs' color blue for a "left" swing, half of the LEDs's red for a "right" swing, all of LEDs yellow for an "up" and all of the LEDs' White for an "down" will allow users to easily understand and interpret their swing direction.	Variant A-2: Using the one LED color blue for a "left" swing, red for a "right" swing, Yellow for an "up", and White for a "down" will allow users to understand and interpret their swing direction easily.	Variant B: Only use one simple LED to display when the user swings the board.	Variant B-1: Using the LEDs' color turn on blue for a "left" swing, half of them turn on red for a "right" swing, and no display when the user swings up and down will be more intuitive for users	Variant B-2: Using the single LEDs' colour turn on blue for a "left" swing, half of them turn on red for a "right" swing, and no display when the user swings up and down will be more intuitive for users					
1	Yes	Yes		Yes	Yes		Yes	Yes		Yes			
2	Yes	Yes		Yes	Yes		Yes	No		No			
3	Yes	Yes		Yes	Yes		Yes	No		No			
4	Yes	Yes		Yes	Yes		Yes	No		Yes			
5	Yes	Yes		Yes	Yes		Yes	No		No			
6	Yes	Yes		Yes	Yes		Yes	Yes		No			
7	Yes	Yes		Yes	Yes		Yes	No		No			
8	Yes	Yes		Yes	Yes		Yes	Yes		No			
9	Yes	Yes		Yes	Yes		Yes	No		No			
10	Yes	Yes		Yes	Yes		Yes	No		No			
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													
Total (Yes / Total No)	10	0	10	0	0	10	0	10	0	5	5	2	
												accuracy 0.8	

Task 2	Find the right direction to hit ball to the hole		Find the right direction to hit ball to the hole		Find the right direction to hit ball to the hole		Find the right direction to hit ball to the hole		Find the right direction to hit ball to the hole	
	Variant A: All of the LEDs have been used to display the lights.	Variant A-1: Using the half of LEDs' color blue for a "left" swing, half of the LEDs's red for a "right" swing, all of LEDs yellow for an "up" and all of the LEDs' White for an "down" will allow users to easily understand and interpret their swing direction.	Variant A-2: Using the one LED color blue for a "left" swing, red for a "right" swing, Yellow for an "up", and White for a "down" will allow users to understand and interpret their swing direction easily.	Variant B: Only use one simple LED to display when the user swings the board.	Variant B-1: Using the LEDs' color turn on blue for a "left" swing, half of them turn on red for a "right" swing, and no display when the user swings up and down will be more intuitive for users	Variant B-2: Using the single LEDs' colour turn on blue for a "left" swing, half of them turn on red for a "right" swing, and no display when the user swings up and down will be more intuitive for users				
1		0.3		0.2		0.45		0.39	all agree	
2		0.3		0.25		0.5		1		
3		0.2		0.3		1.45		1		
4		0.2		0.15		0.17		1		
5		0.2		0.15		1		1.2		
6		0.3		0.2		1.3		1.4		
7		0.3		0.3		1.3		1		
8		0.24		0.6		1.5		1		
9		0.32		0.5		1.3		2		
10		0.2		0.3		1.3		2.5		
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
Time Average	#DIV/0!	0.256	0.295	#DIV/0!	1.027	1.245	80%			

[3] The open-ended feedback from the user's questionnaire.

Q1 - Are there any suggestions or feedback you would like to provide?





Q1 - Is there any suggestions or feedbacks you would like to provide ?

Is there any suggestions or feedbacks you would like to provide ?

For beginners like me, an interactive tutorial mode using the LEDs could help get acquainted with the basics of golf swings and what each LED feedback means.

While the default feedback colors are great, having an option to customize the colors to our preferences might be a nice personal touch.

I wasn't sure how to use this kind of golf board; if a tutorial video shows it before, that would be great.

I think it'd be fun to have a two-player or group mode where multiple users can compare swings or compete in challenges, with each user having their color on the LED display.

The board felt a bit awkward to handle after prolonged use. A more ergonomic design or a grip might help users like me hold onto it for longer sessions.

Alongside the LED indications, a vibration or some other haptic feedback to correspond with the swing's direction might provide a more comprehensive feedback system.

While playing outdoors, I sometimes thought it may be challenging to see the LED feedback due to sunlight. A brightness control or an automatic adjustment based on ambient light would be beneficial.

I noticed a slight delay from the time I swung the club to when the LED displayed the feedback. Making this instantaneous would greatly help improve my reaction time.

I loved how the board indicated the direction of my swing. However, in golf, the strength of the swing is just as crucial. Can there be a way for the board indicate if I'm swinging too hard or too softly?

While I found the LED feedback to be intuitive in general, especially with the half-LED representation in Variant A1, distinguishing between certain feedback like 'up' and 'down' took me a moment, especially during fast-paced swings.