

Creating Engaging & Research-Supported User Experiences for **duolingo**

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UXSD Tools & Technologies



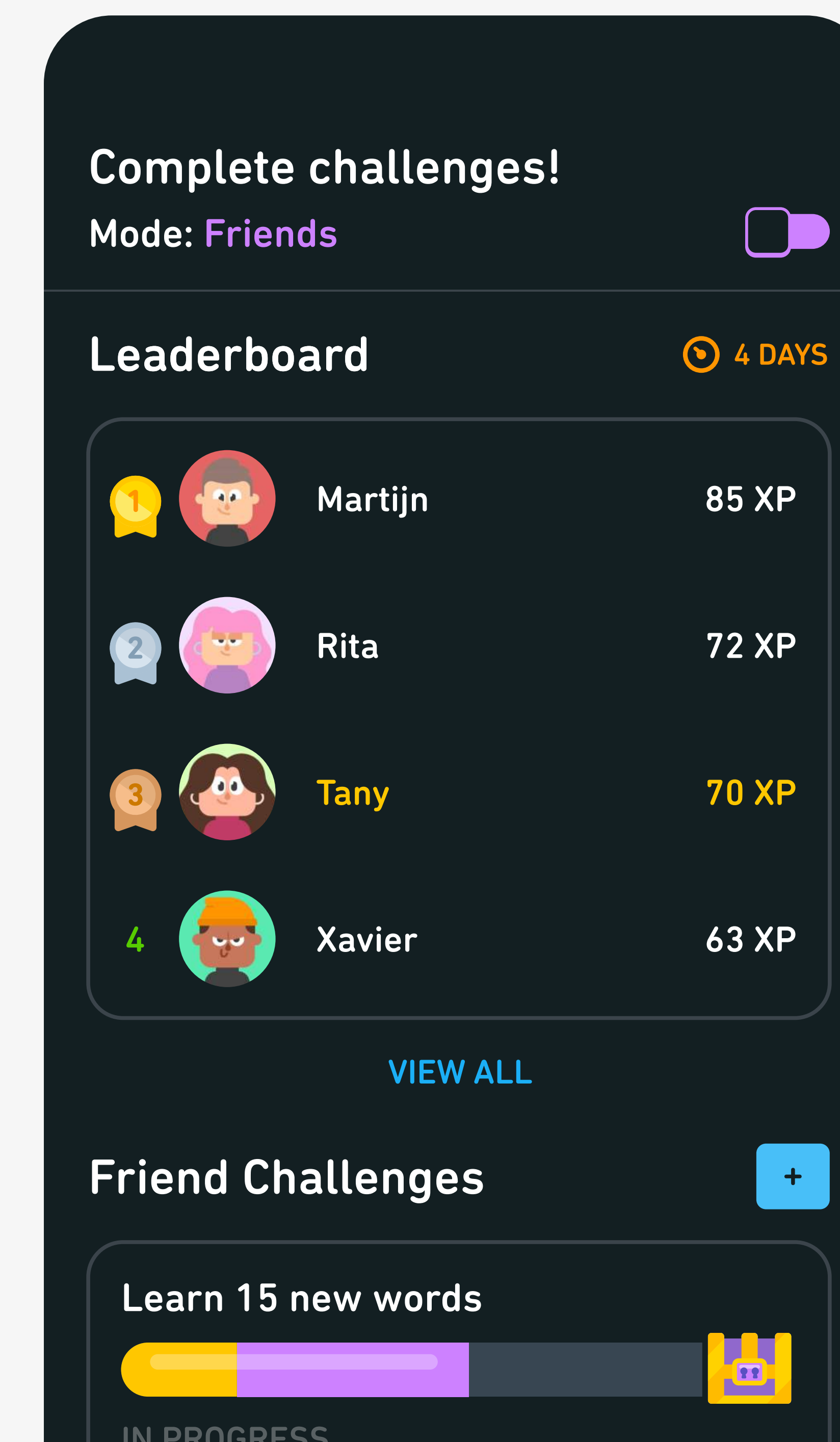
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Overview

For this project, I chose to tackle the challenge of analyzing and improving the user experience of mobile-assisted language learning (MALL) apps — specifically, examining the functionality of **Duolingo** and its features through the form of a case study. The app, which has been on the iOS and Android markets since 2012, is considered one of the top language-learning resources available for download. With its cheeky marketing, the infamous Duo owl, charming cast of characters and variety of languages, Duolingo is recognized as a go-to for people looking to pick up some new lingo.

This case study introduces two new conceptual features designed for implementation: **Duolingo Notes** and **Learning with Friends**. Each feature has been visually designed to match the current user interface of Duolingo, including iconography, illustrations, typefaces, colours and overall layout. Supplemented by research on MALL apps, and supported by data derived from user interviews and testing, the new features provide an intuitive and fresh approach to learning languages through engaging methods.

Let's get started! →



Academic & User Research →

MALL 101

Mobile-assisted language learning (MALL) is a teaching method for language studies that integrates mobile technology, such as phones, tablets and personal digital assistants (ex. Apple's Siri, Amazon's Alexa). In today's age of technology, MALL often takes the form of language learning apps found on app stores for download. Examples include:



DUOLINGO



ROSETTA STONE



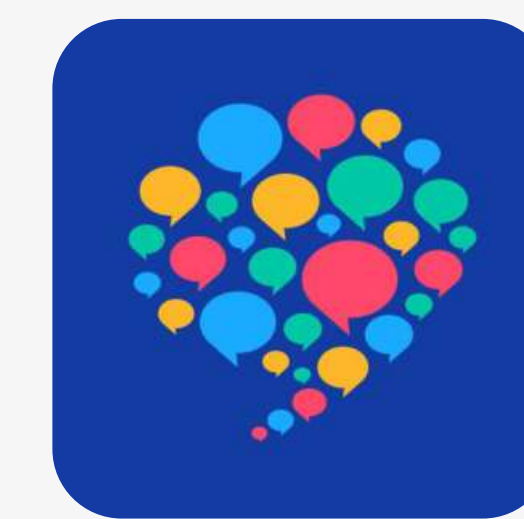
BUSUU



BABEL



MEMRISE



HELLOTALK



DROPS

While MALL apps allow users to learn at their own pace and brush up on skills without needing a classroom setting, linguistics researchers have noticed that designers are ignoring the basic fundamentals of language learning theory. In other words, users are interacting with underdeveloped apps that have limited teaching abilities, yet these apps are amongst the most-used digital tools for language learning. **Duolingo is no exception — the app strongly promotes itself as a service that adheres to international learning standards for its courses, but it exhibits signs of the exact issues that are highlighted by researchers.**



Common Issues with MALL Apps

In order to make informed and research-backed decisions for this project, I gathered information on common issues in MALL apps that are highlighted by linguistics and language-learning researchers:

There is a high emphasis on learning vocabulary in isolated contexts 📖

"In 84% of apps (42 out of 50), vocabulary was taught in isolation, while only 23 of 50 apps (53%) taught vocabulary in context."

(Heil et al., 2016)^[1]

Apps are not designed to adapt to the skill levels of learners 📈

Over 80% of MALL apps state that their content is prepared for all language levels; there is no evidence of how accurate this claim is.

(Bączkowska, 2021)^[2]

There is often little to no explanation for why mistakes were made 🚫

"Some apps offered simple textual correction... only 3 of 50 apps provided any explanation [for why mistakes were made]."

(Heil et al., 2016)^[1]

Gamification is overly used to motivate and engage users 🎮

Apps like Duolingo rely on gamified elements to retain user interest, such as gems, streaks, XP points, leaderboards and daily challenges.

(Loewen et al., 2019)^[3]

Speech detection software is still greatly underdeveloped 💬

"... If the user only imitates the intonation [of the word], it is evaluated as correct, despite that fact that, in reality, the answer was a total nonsense."

(Pikhart, 2020)^[4]

MALL apps undervalue the importance of speaking the language 🗣️

"... Participants scored lowest on the speaking (33%) and listening (37%) sections, which both required processing language in real time."

(Loewen et al., 2019)^[3]

User Interviews

To better address the topic of Duolingo's current user experience, I gathered feedback and opinions from a group of Duolingo users in the form of interviews. Four (4) participants agreed to be part of the study, providing information on their experiences and suggestions for improvement. The following is a summary of each participant's key data:

Participant 01



🇫🇷 • Beginner • 347 days ⚡

- **Usage:** Average twice daily, around bedtime.
- Mostly uses the review section in the practice hub.
- Prefers the branching style of lessons (old UI), instead of the current linear structure (new UI).
- Finds that the app doesn't provide good explanations for mistakes.
- Considers the speech detection feature to be very frustrating.
- **Would like to see an improved leaderboard system and improved help system.**

Participant 02



🇫🇷 🇪🇸 • Inter./Beg. • 941 days ⚡

- **Usage:** Average 15-20 minutes, max 30 minutes.
- Believes the app doesn't do a good job at catering to users at higher levels.
- Finds that the app doesn't provide good explanations for mistakes.
- Likes the idea of being able to learn words/phrases used by locals.
- Doesn't view gamification as an effective motivator.
- **Would like to be able to make notes on concepts in the app.**

Participant 03



🇫🇷 • Beginner • 98 days ⚡

- **Usage:** Minimum 1 lesson, does lessons based on hearts available.
- Enjoys the more social aspect of the app (friend streaks, completing challenges/quests).
- Finds that the app doesn't provide good explanations for mistakes.
- Believes that the heart system should only be on unit tests and not in regular lesson
- Enjoys the gamification aspect as a method of motivation.
- **Would like to see more ways to learn and interact with friends.**

Participant 04



🇫🇷 • Beginner • 0 days ⚡

- **Usage:** Tries to use it daily; had a 200-day streak previously.
- Was drawn to the app through the marketing and Duo owl memes.
- Finds that lessons are helpful in teaching vocabulary, but don't explain how to make use of the vocabulary in real-life contexts.
- Enjoys the gamification, but thinks it's "too easy to game the system" when earning XP.
- **Would like to see an improved XP and reward system.**
- **Would like to be able to make notes on concepts in the app.**

Key Takeaways from Research & Interviews

My research on MALL apps and language learning revealed the following key points:

- The app relies too much on **teaching vocabulary in isolated contexts** and doesn't provide any information on how to apply the words/phrases in real-life contexts.
- There is **little to no instruction** on grammar and the rules of the language, leading learners to develop their own understandings through trial/error.
- Duolingo's **high level of gamification** can be a strong motivator for consistency, however users feel that the levels should be **modified to supplement learning in a more subtle way** (ex. earning gems for learning a new skill vs. earning gems solely to be #1 on a XP leaderboard).

Based on the data collected from the user interviews, I noticed that many of the suggestions for improvements were leaning towards themes such as **allowing users to be more in control of their learning journeys** and **interacting more with friends**. Prior to the interviews, I already had the idea to potentially design a note-taking system for Duolingo; to confirm whether this would be a suitable solution, I included specific questions on individual learning styles for each interviewee. Not only did I learn more about the methods people use to better retain information, but also reaffirmed the theory that note-taking could be a beneficial addition.

The Original Problem Statement:

How can we design MALL apps that allow users to learn languages through methods that are supported by linguistics research and engaging for long-term learning? 

(This will be important for later!)

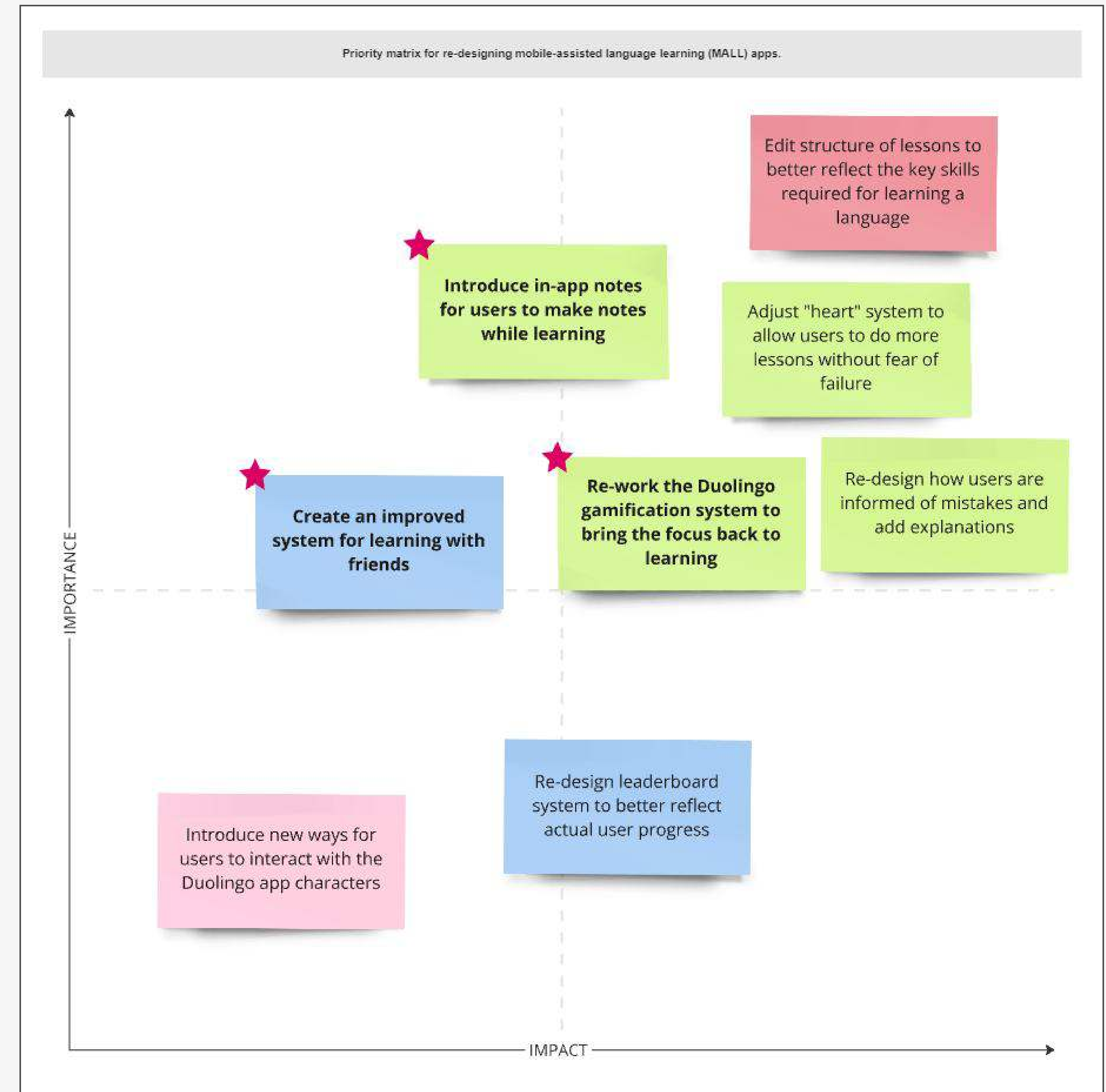
Priority Matrix →

Prioritizing Changes

Given the variety of issues noted by both Duolingo users and linguistics researchers, the next step was to identify and prioritize changes that could be made to the app's design.

Based on the first problem statement, the two key elements were "**supported by linguistics research**" and "**engaging for long-term use**". Changing the educational content on the app would require the assistance of a linguistics expert, which wouldn't be feasible for this project. However, it would be possible to develop engaging features outside of the lessons to provide an improved user experience.

★ **The top three (3) ideas selected to move onto the phase of prioritizing changes.**



RIGHT: Priority matrix designed using Miro.

Selected Changes & Plan

Through the priority matrix, the following three (3) changes were selected:

Introduce in-app notes for users to make notes while learning 📖 📝

Students are taught to make notes while studying and learning course material; why not bring that over to language learning?

Create an improved system for learning with friends 👤 👤

The current system is very limited when it comes to learning with friends, but part of what makes learning fun is doing it with others.

Re-work the Duolingo gamification system to bring the focus back to learning 🏆 💎

Duolingo is known for its XP points, gems and leagues - all of which are factors in retaining user engagement.

★ **Priority (to be completed for submission)**

★ **Secondary (to be done if time remains)**

In order to make these improvements, the concepted features would be designed through Figma and displayed as a merged prototype. The process would include making wireframe sketches, low-fidelity versions, high-fidelity designs, and integrating Duolingo's branding/visual UI guidelines for accuracy and consistency. Once each prototype is completed, user testers would then be invited to perform a test of the new features by completing a list of tasks, as outlined by the designer for evaluation.

The New Problem Statement:

How can we create engaging and research-supported user experiences for Duolingo?

WHY THE CHANGE?

While the original problem statement was a good starting point, I felt that it was too broad and the scope needed to be refined further. By addressing a smaller portion of the app, as opposed to trying to change everything, I could achieve a solution that focused on improving engagement through research-supported methods and was more feasible for a solo designer with my current timeline.

Personas →

Persona #1

Based on an interest to make in-app notes, as noted by users.



ABOUT

Already six years into her career as a consultant for a global analytics firm, Eileen's passport is full of stamps from regular business trips across Asia and North America. While her job doesn't give her much downtime, she likes to make the most out of her flights to prep — this includes going over itineraries, organizing her schedule for the week, catching up on missed work and most importantly, learning some local lingo. She likes the variety of languages that Duolingo offers and has found herself using phrases to ask questions, but visiting a new country every month means a lot of vocabulary to remember and not a lot of time to review.

GOALS

- To learn basic and commonly-used words/phrases in advance when visiting a foreign country.
- To find a way to retain information from lessons without losing progress to due to limited review time.
- To be able to comfortably embrace local culture and not feel like an outsider when travelling.
- To further her career as a consultant and climb her way up to corporate partner.

FRUSTRATIONS

- Doesn't have much time to review words/phrases, so she sometimes forgets what she learned.
- Likes to make notes to keep organized, but is already regularly travelling with a lot of paperwork for her job.
- She only uses her notes app for work-related matters.

AGE

30 years

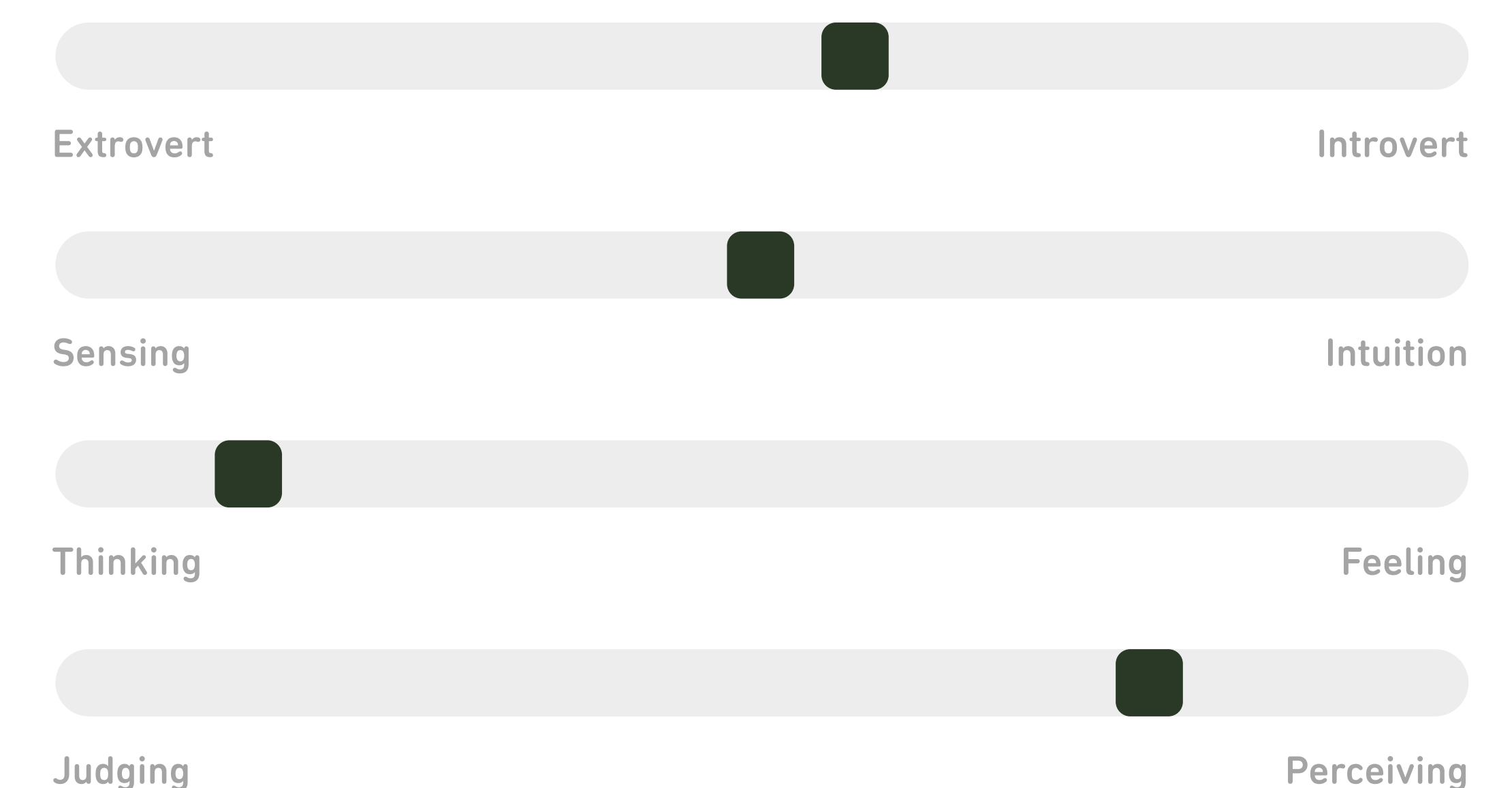
OCCUPATION

Consultant

STATUS

Single

PERSONALITY



Persona #2

Based on an interest for an expanded friend system, as noted by users.



ABOUT

Meet Rico, an international student from Latin America who is finishing his Bachelor's degree in marketing and design. After having taken a few years off to visit relatives back home before moving abroad, he finds himself juggling both a foreign language and a time difference. He uses Duolingo to practice his English along with his two siblings: his younger sister, who started learning it as a way to understand her favourite English songs; and his older brother, who also moved abroad and works in an English-speaking company. While Rico is constantly keeping in touch with his family, he wants to do more activities together with his siblings on Duolingo.

GOALS

- To keep learning and improving his English-speaking abilities through Duolingo.
- To find more ways to connect with his siblings and maintain their familial bond.
- To finish his degree and start his career within a design agency or B2B company.
- To stay motivated and mentally happy while studying abroad and being away from his family.

FRUSTRATIONS

- Feels that Duolingo provides very limited opportunities to interact with friends on the app.
- Still struggles with English grammar and pronunciation.
- Feels overwhelmed by the amount he has to learn, both in school and about living on his own.

AGE

23 years

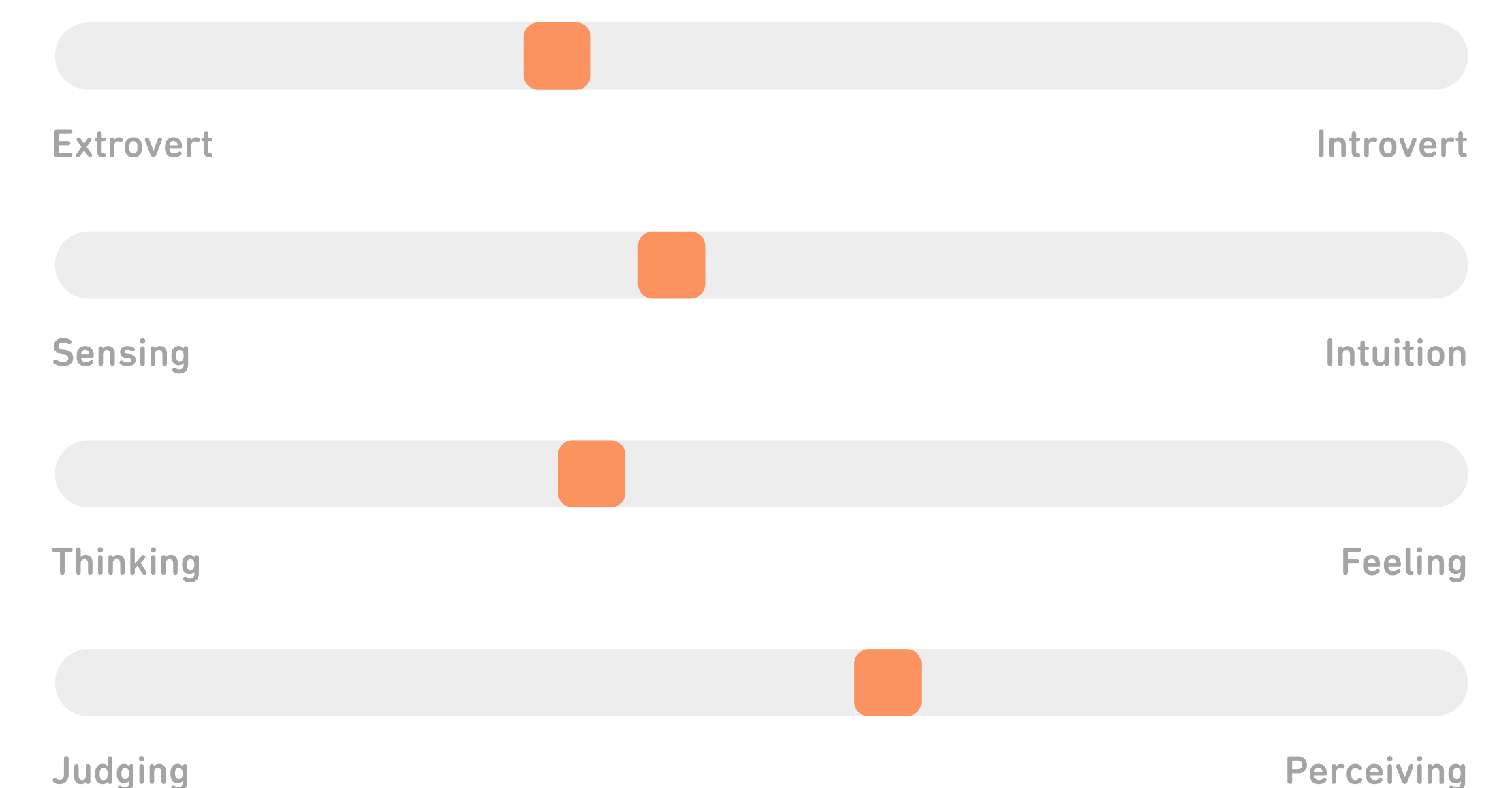
OCCUPATION

Student, 4th year

STATUS

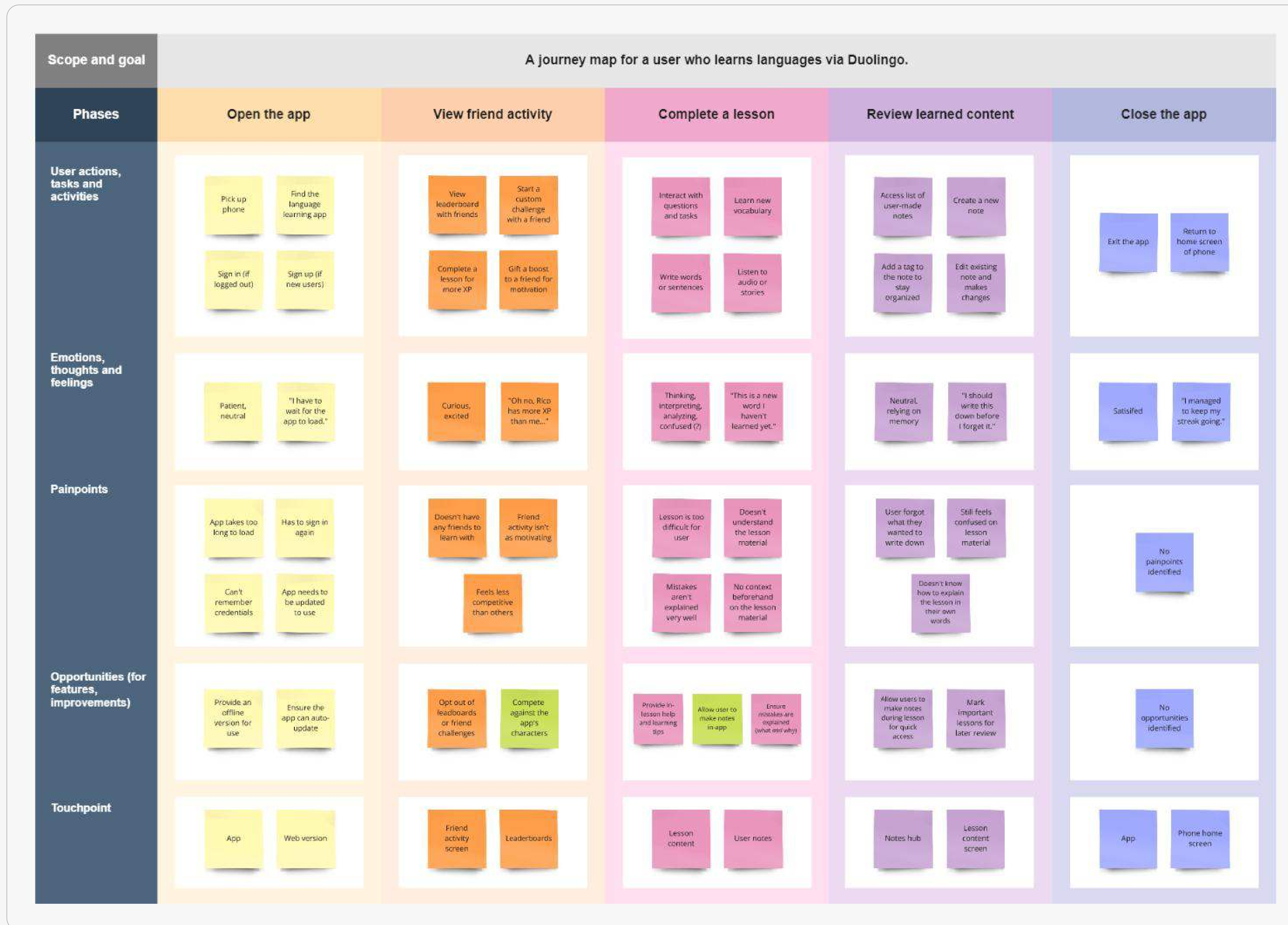
Single

PERSONALITY



User Journey Mapping →

User Journey Mapping



LEFT: User journey map for improvements to Duolingo, designed using Miro.

Moodboard & Visual User Interface (UI) →

Moodboard

Given the fact that I would be working directly with Duolingo's existing user interface (UI), the moodboard is **reflective of the app's current branding guidelines and standards for its content**. I wouldn't be deviating from the existing UI because the proposed features are designed for direct implementation — meaning that their appearance needs to match what has already been established by Duolingo.

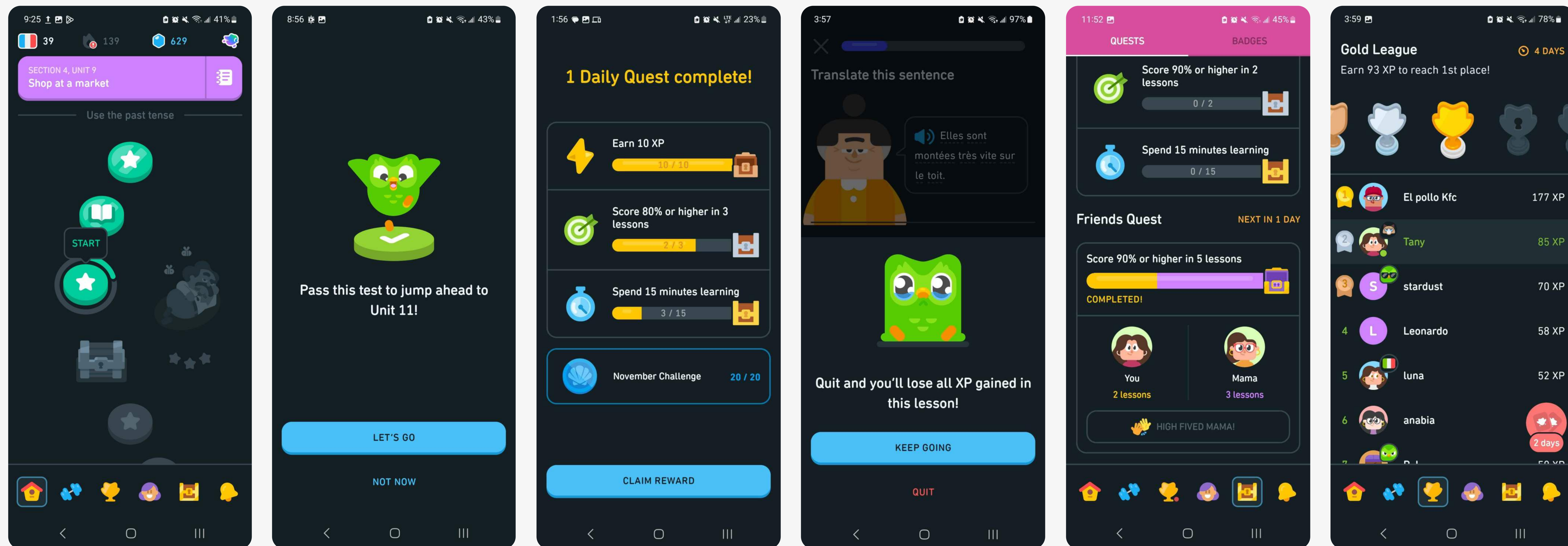
Duolingo is a **highly visual brand**, relying on bright colours, rounded typography and shapes, cartoon-like characters and a sense of approachability that makes learning fun. Its mission is to make language learning fun and effective for anyone who wants to learn, regardless of where they are.

The asset and branding guidelines for Duolingo can be found [here](#).



Visual User Interface (UI)

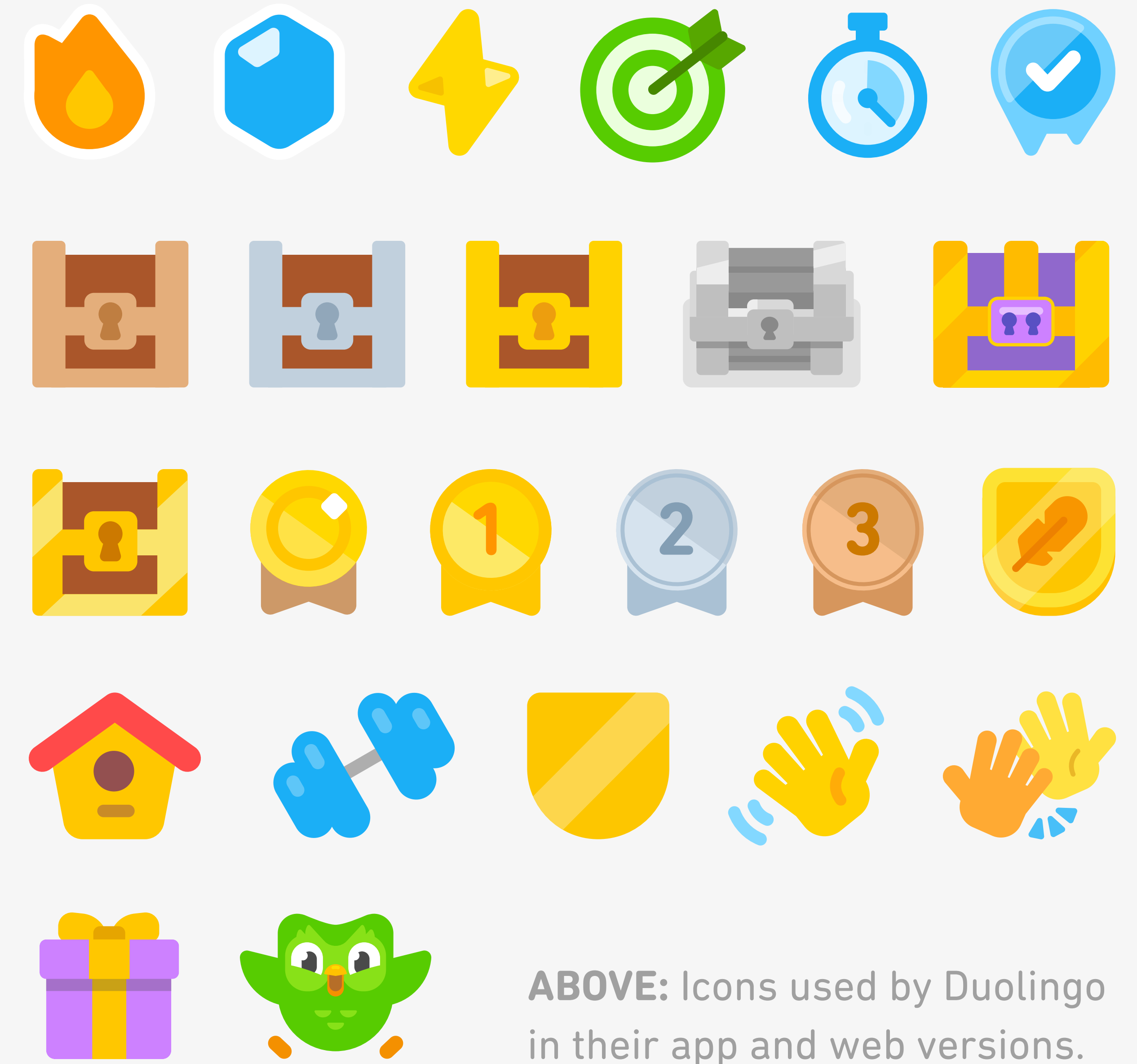
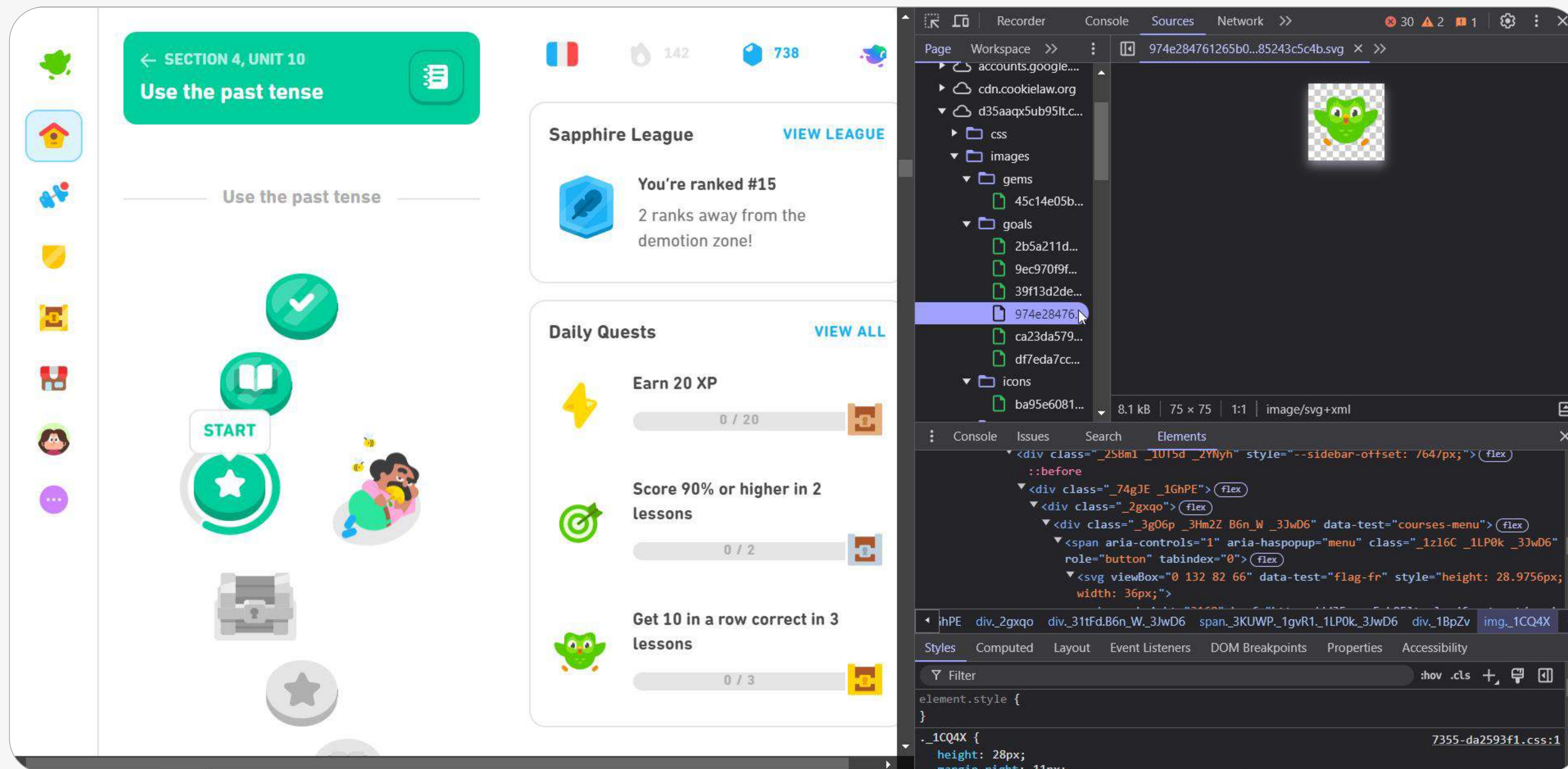
Re-creating the Duolingo user interface proved to be a challenge — not because it was a difficult interface to replicate, but rather that there were no existing component libraries that I could utilize. The only Figma community file that I could find contained an outdated interface and the screens themselves were not designed with the same level of detail as the Duolingo app, which meant that I had to rely on screenshots from the app to mimic the current UI and create my own components.



ABOVE: Screenshots from the Duolingo app for Android (taken on a Samsung Galaxy A53).

Using Duolingo for Web

Duolingo's web version, which is accessible via any web browser on mobile and desktop, proved to be a very useful resource when gathering components such as icons, colours and illustrations for use. Using the Developer Console (F12), I was able to find high-quality SVGs within the code structures that were native to the Duolingo UI. This way, I could save time by not having to re-create elements from scratch and could retain the original designs for use in my prototypes.



ABOVE: Icons used by Duolingo in their app and web versions.

ABOVE: Finding illustrations and icons using the Developer Console.

Colours

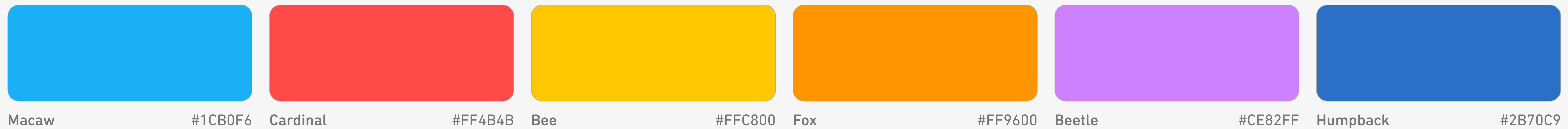
Duolingo uses a custom colour palette that is divided into core brand colours, secondary colours and neutrals. The core colours are based on the Duo owl, while other colours are based on animals.

Core Brand Colours



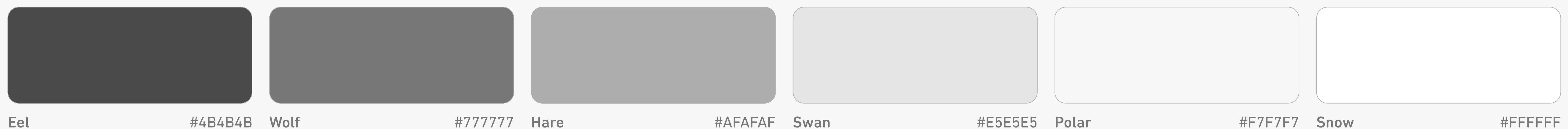
Feather Green #58CC02 Mask Green #89E219 Eel #4B4B4B Snow #FFFFFF

Secondary Colours



Macaw #1CB0F6 Cardinal #FF4B4B Bee #FFC800 Fox #FF9600 Beetle #CE82FF Humpback #2B70C9

Neutrals



Eel #4B4B4B Wolf #777777 Hare #AFAFAF Swan #E5E5E5 Polar #F7F7F7 Snow #FFFFFF

Typography

Duolingo makes use of two separate typefaces: **Feather Bold** and **DIN Next Rounded**.

Feather Bold

ABCDEFGHIJKLMNOPQRSTUVWXYZ

abcdefghijklmnopqrstuvwxyz

0123456789

-«+»!?.*\|/()£€\$¥¢+ - ± × ÷ = ≠ ≈ < > ≤

čďđĵğřǫřβηϑēīóķųỳ

Variants Used in Prototypes

- Headings: DIN Next Rounded Bold
- Page/Screen Titles: DIN Next Rounded Medium
- Body Copy: DIN Next Rounded Regular
- Buttons: DIN Next Rounded Medium

Duolingo Wordmark: Feather Bold

Substitute Font: Nunito (not used in prototypes)

DIN Next Rounded

DIN Next Rounded Light ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz 0123456789

DIN Next Rounded Regular ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz 0123456789

DIN Next Rounded Medium ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz 0123456789

DIN Next Rounded Bold ABCDEFGHIJKLMNOPQRSTUVWXYZ abcdefghijklmnopqrstuvwxyz 0123456789

Prototypes →

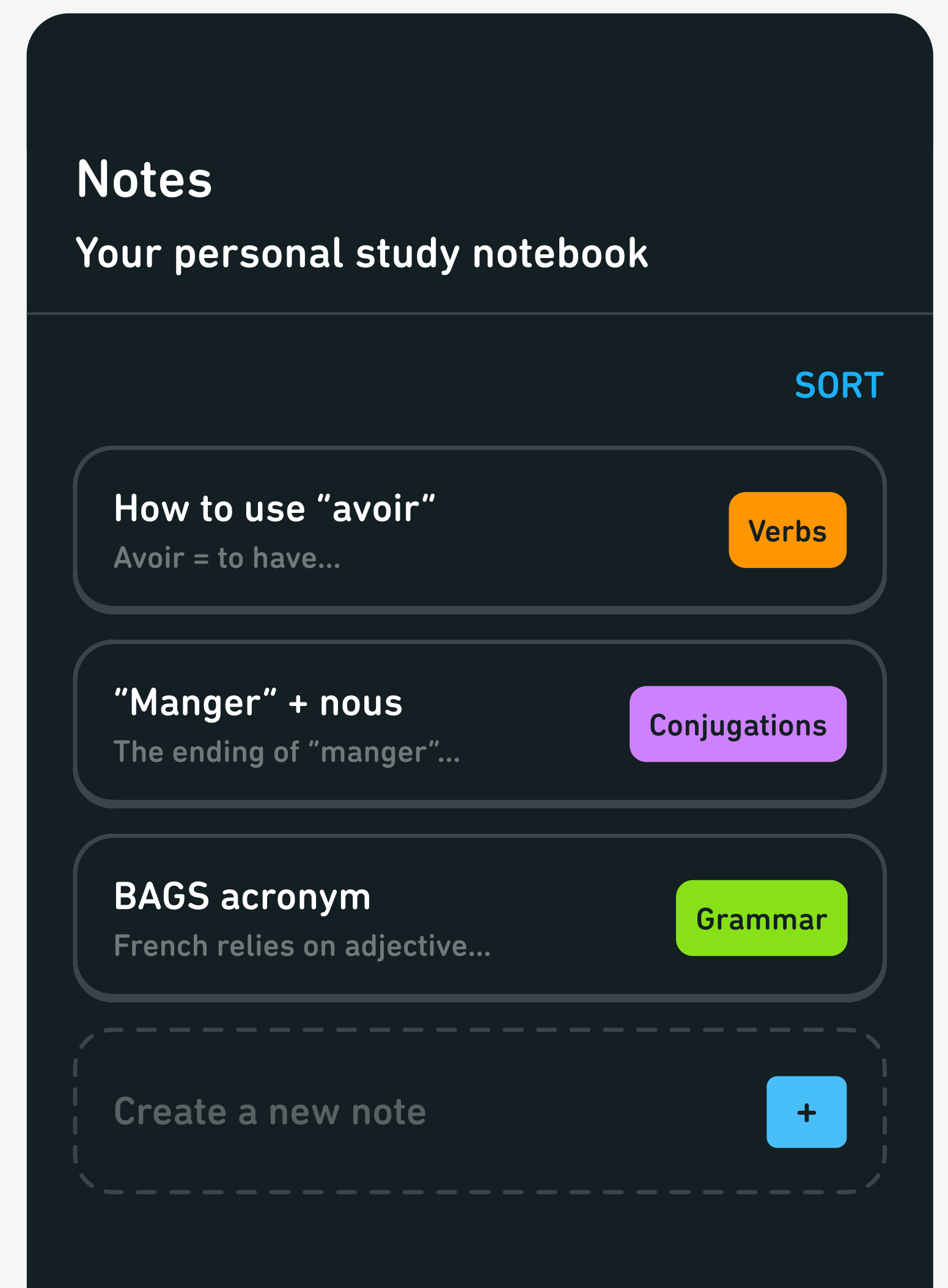
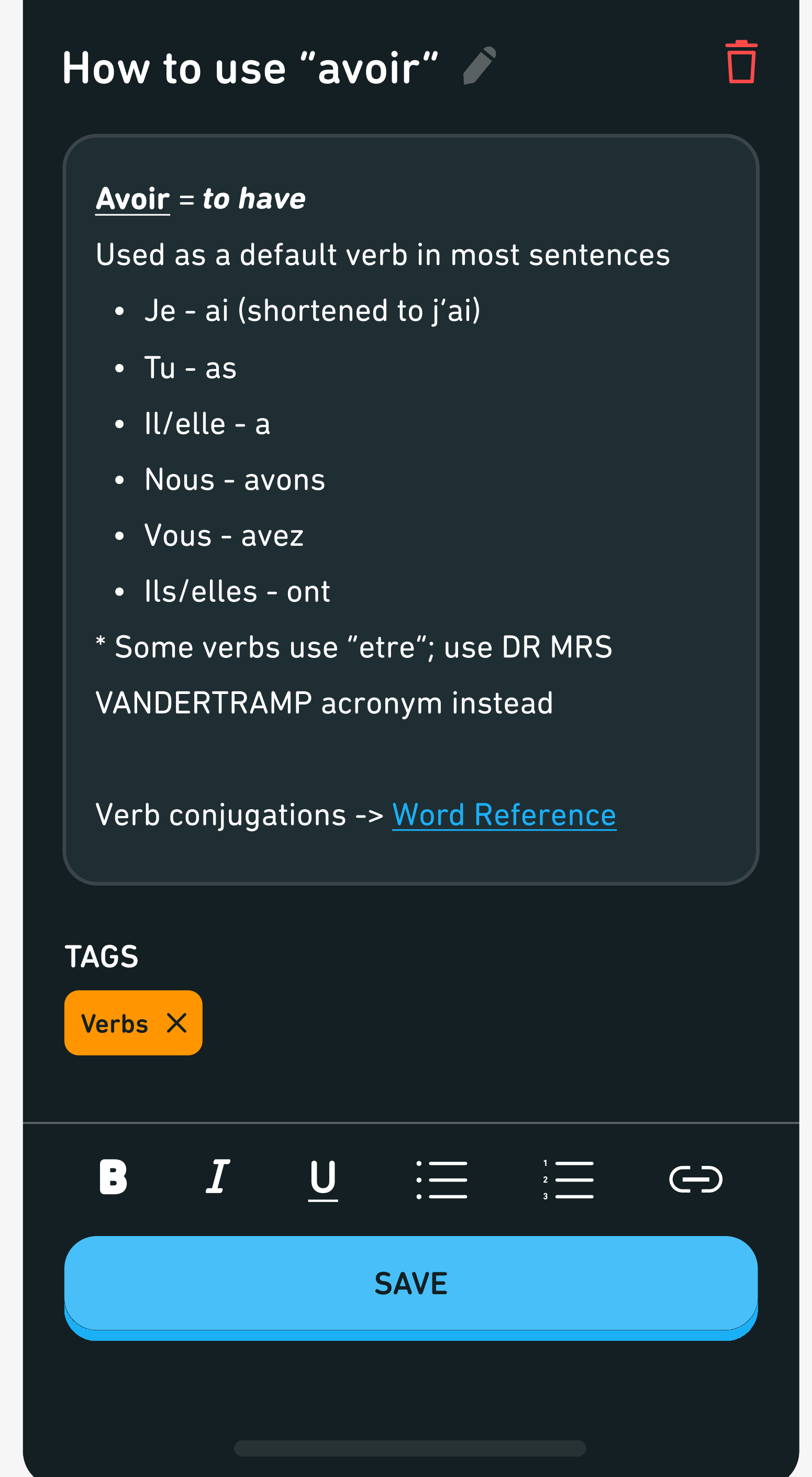
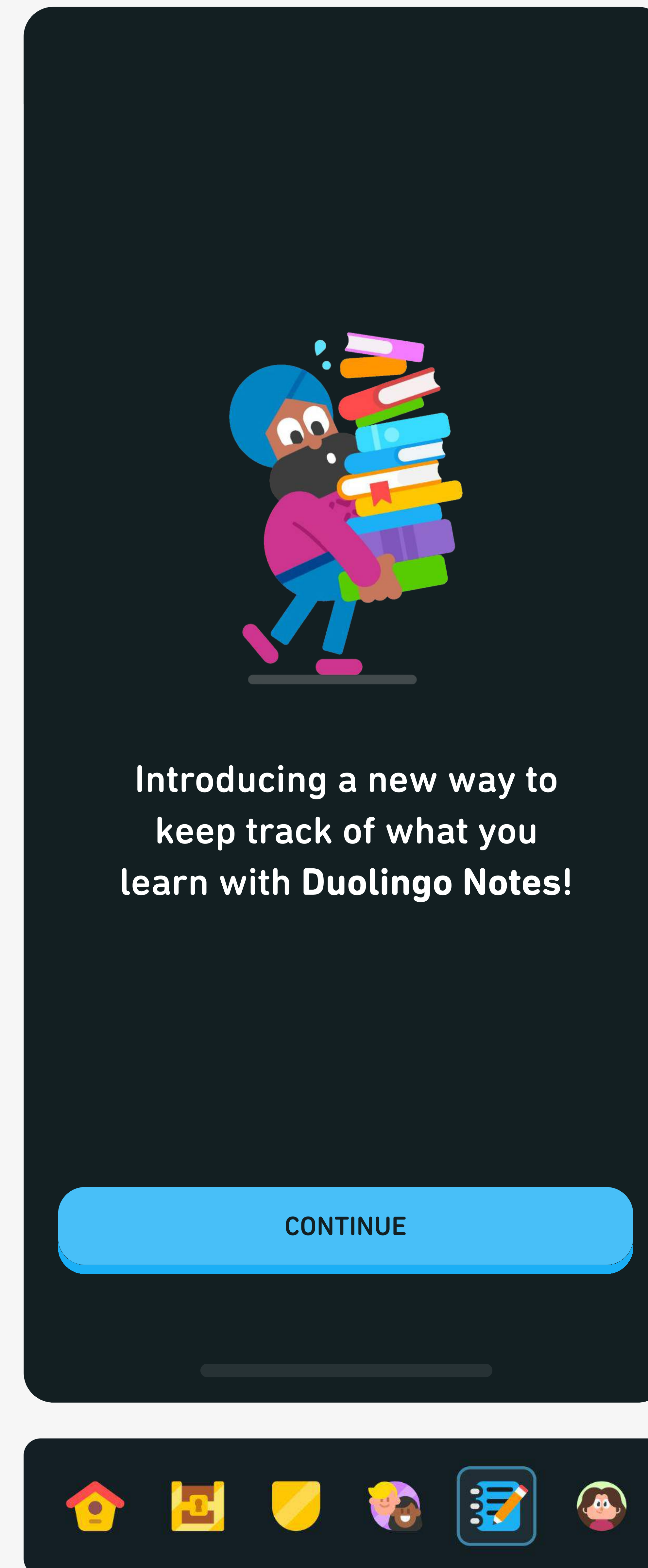
#1: Duolingo Notes

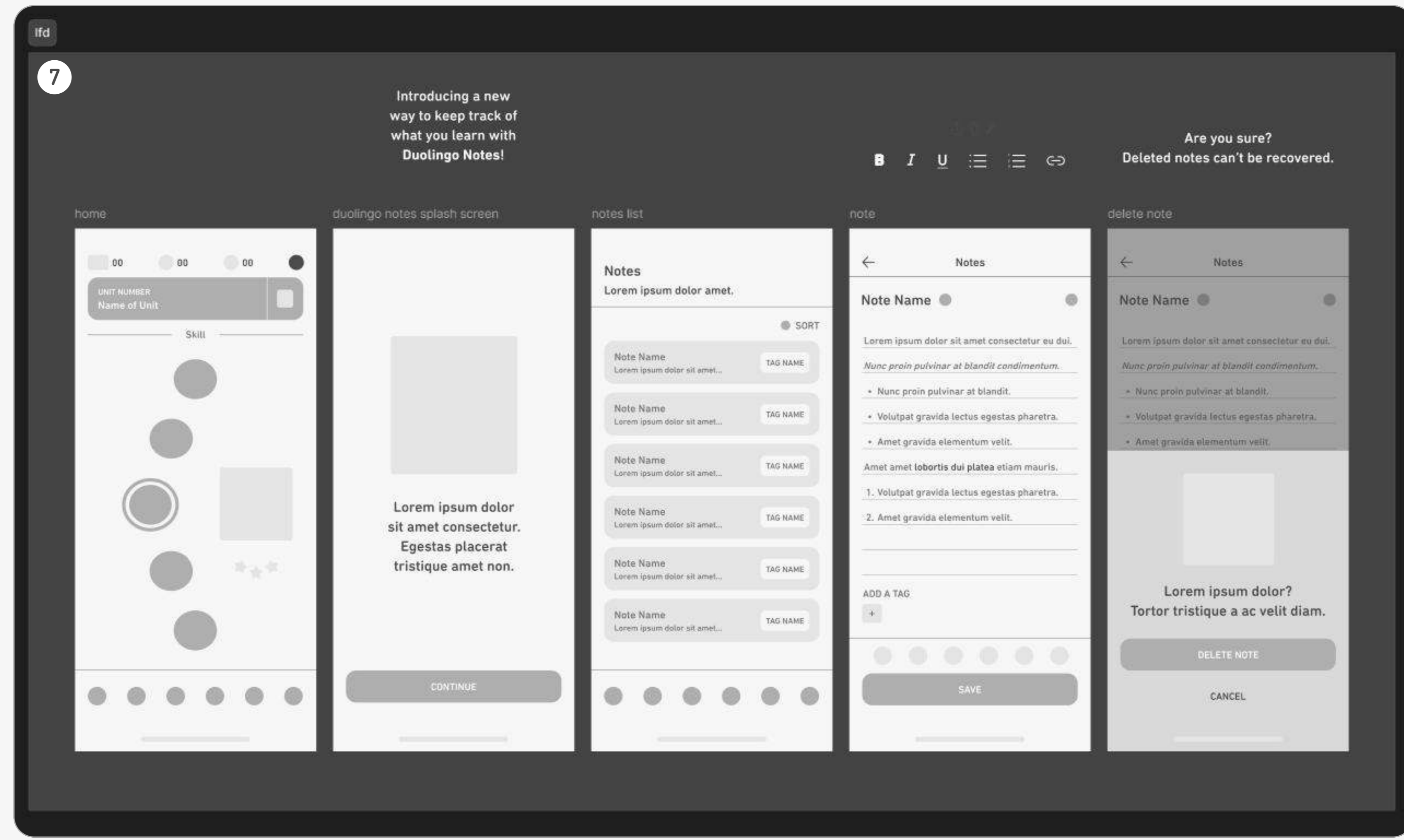
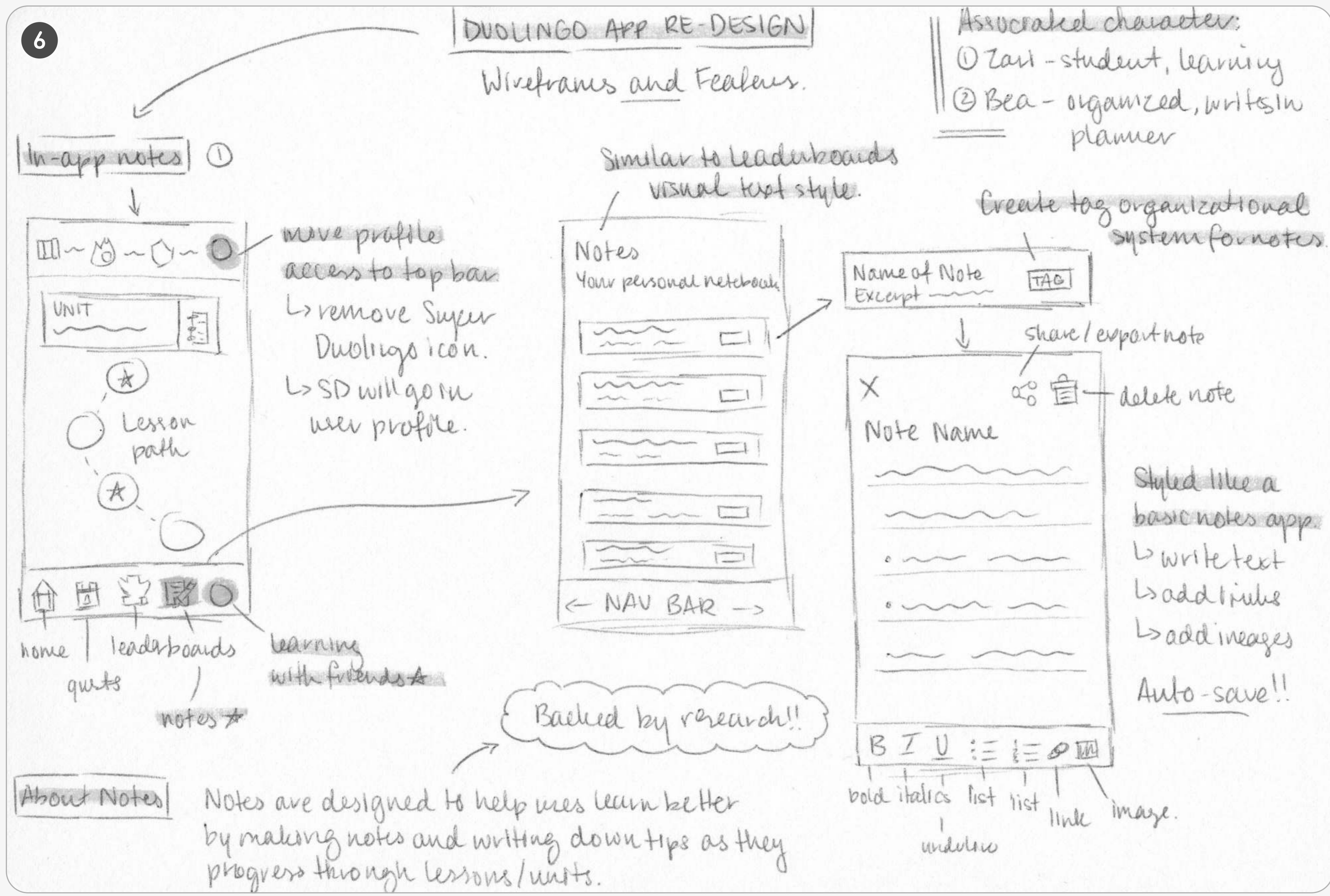
The integrated note-taking system, titled **Duolingo Notes**, is the first of two features that I chose to implement as a solution to my revised problem statement and research. The feature is based on the concept of students writing their own notes to assist with learning, as note-taking is encouraged by every educational system and comes in various methods (ex. Cornell notes).

Duolingo Notes uses the same visual style and interactions as a **basic notepad or notes app**, as found on many phones. Tags can be added to categorize notes, completely user-controlled and definable according to their needs. Not only does a note-taking system better help users retain learning material, but also re-introduces habits that were present during their education.



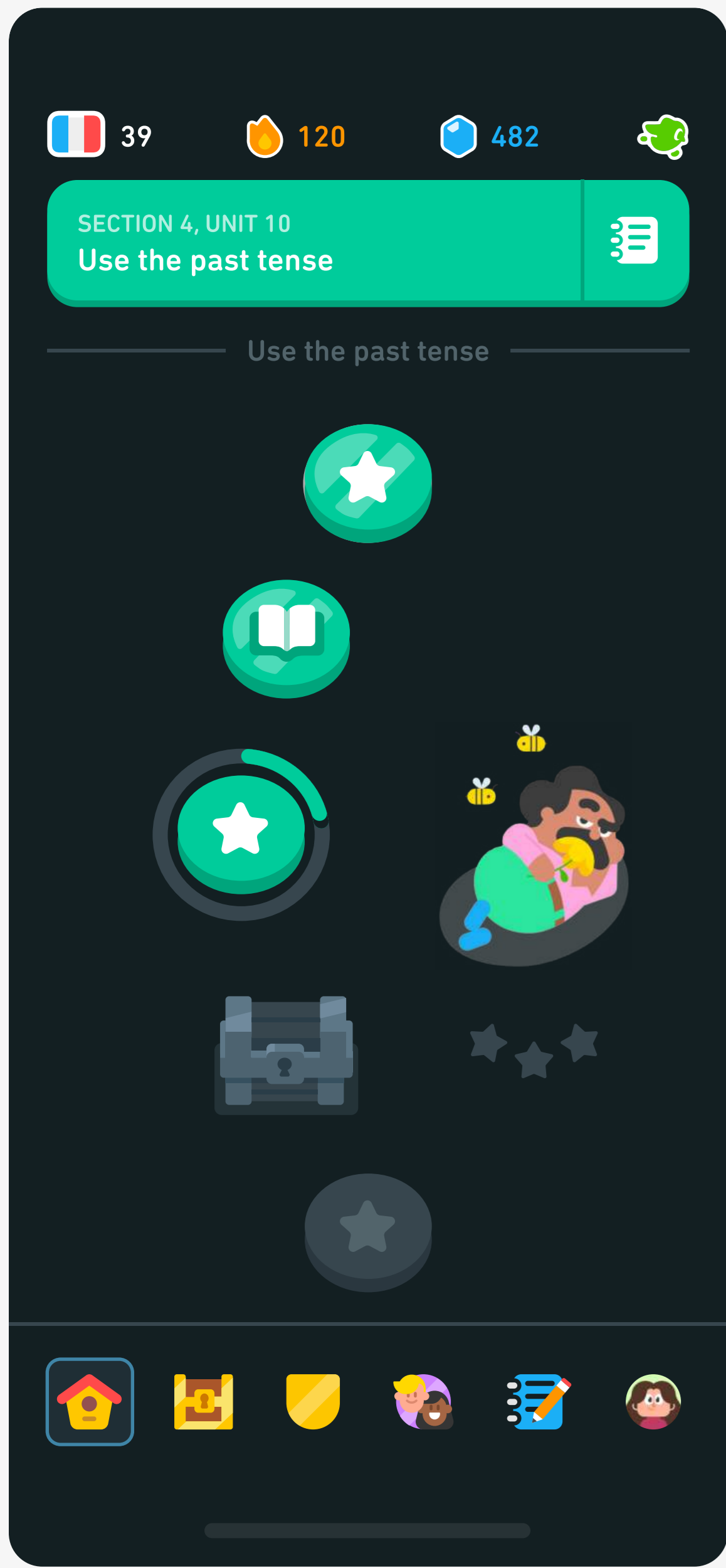
The Icon: Designed to simulate a notebook, which is used by students to make notes.



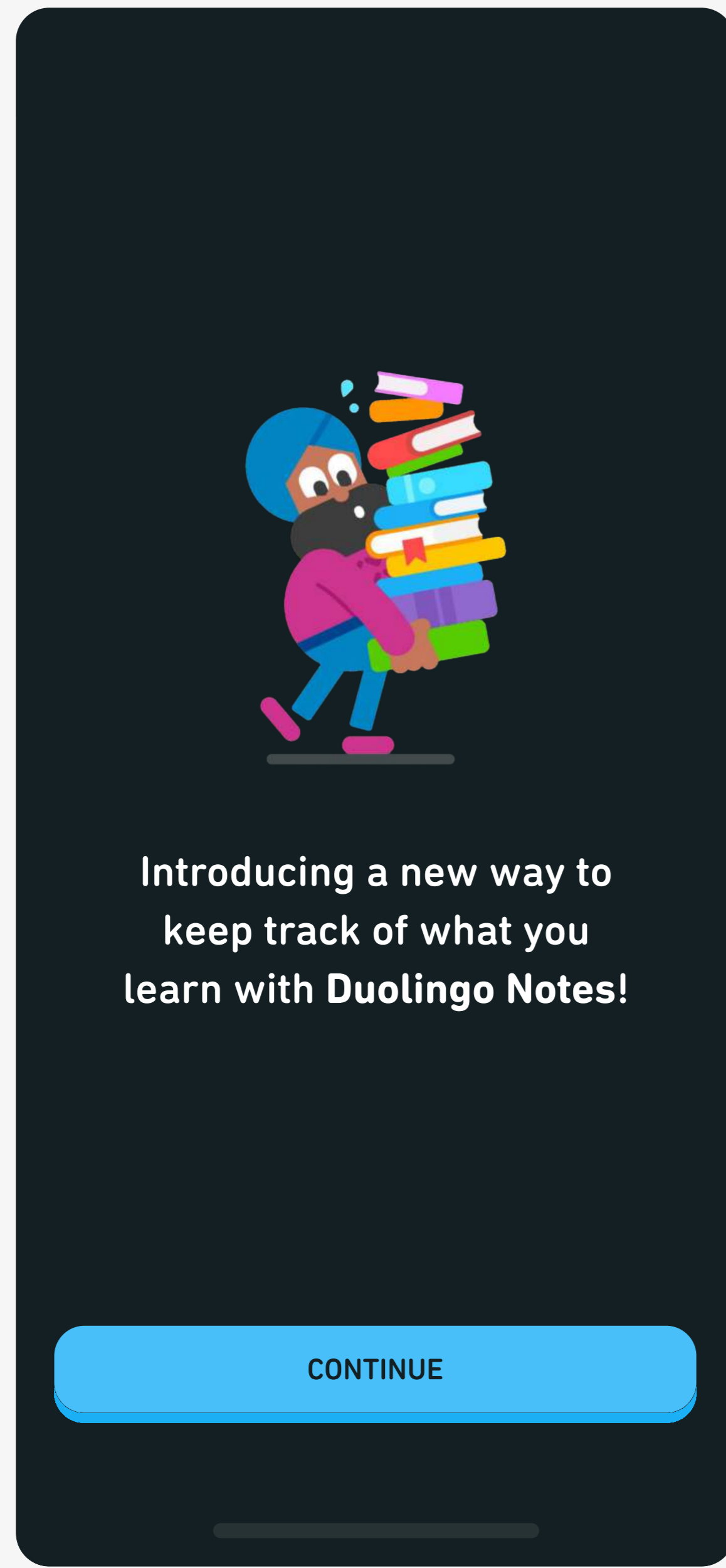


- 1 Page in Figma for Duolingo Notes, with reference screenshots, requirements, notes, wireframe sketches, low-fidelity versions, high-fidelity designs, and connected prototype.
- 2 Variations of colour combinations for the Duolingo Notes icon.
- 3 The Duolingo Notes icon on the app's navigation bar at the bottom of the screen.
- 4 The illustration for Duolingo Notes, featuring Vikram holding a stack of books. This is from the September 2022 monthly challenge titled "Vikram's Reading Marathon".
- 5 Logo variants for Duolingo Notes, designed in accordance with guidelines for sub-brands.
- 6 Initial brainstorming through wireframe sketches on pen/paper.
- 7 Low-fidelity versions with placeholder content.

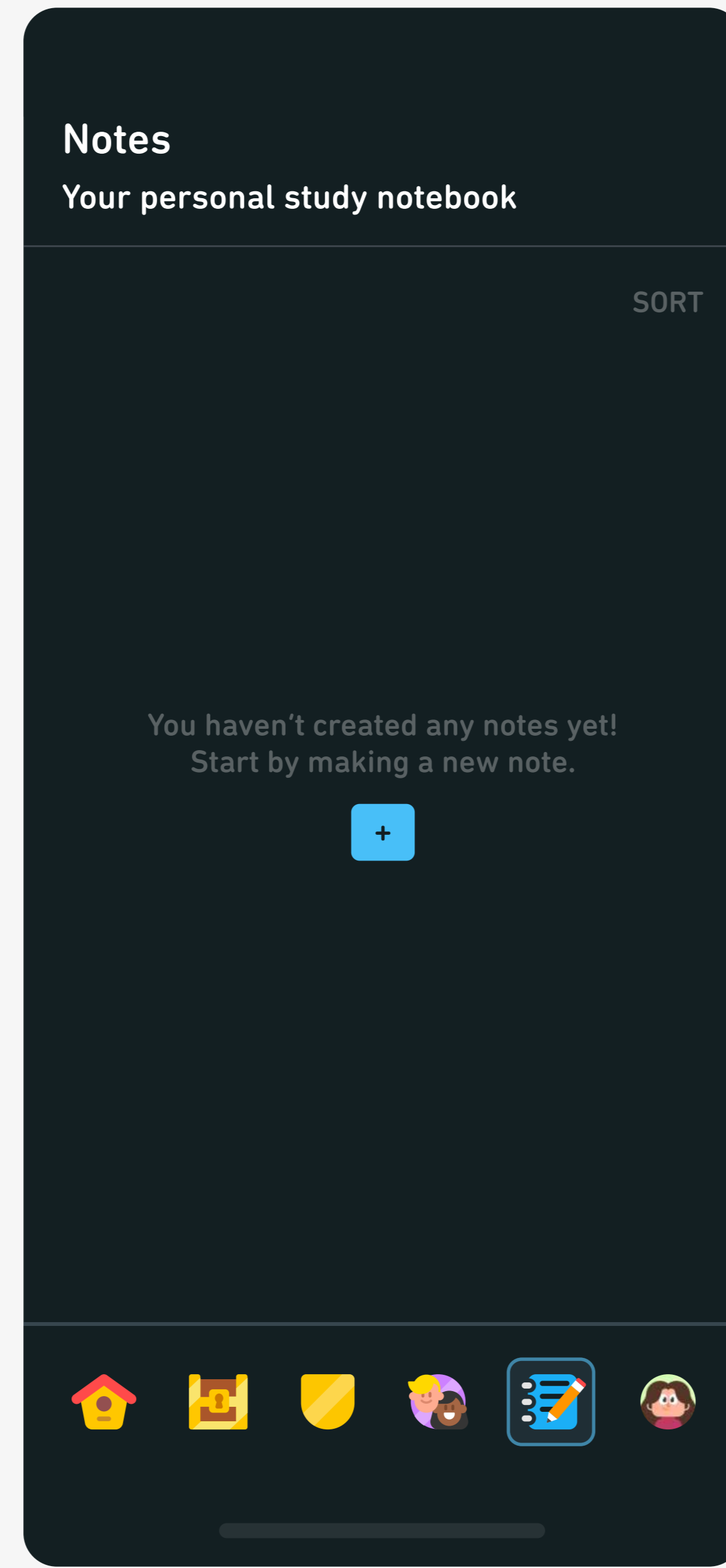
High-Fidelity Screens



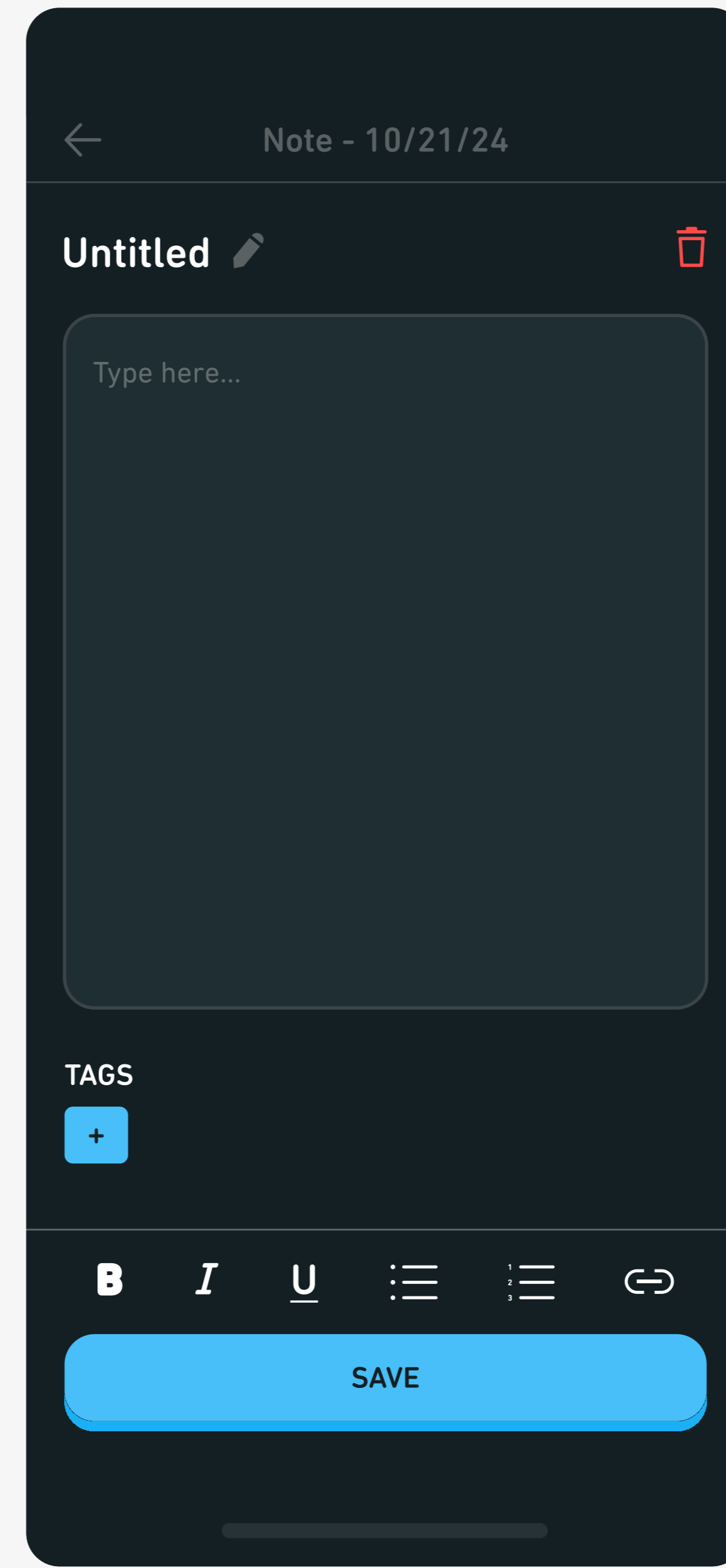
Home



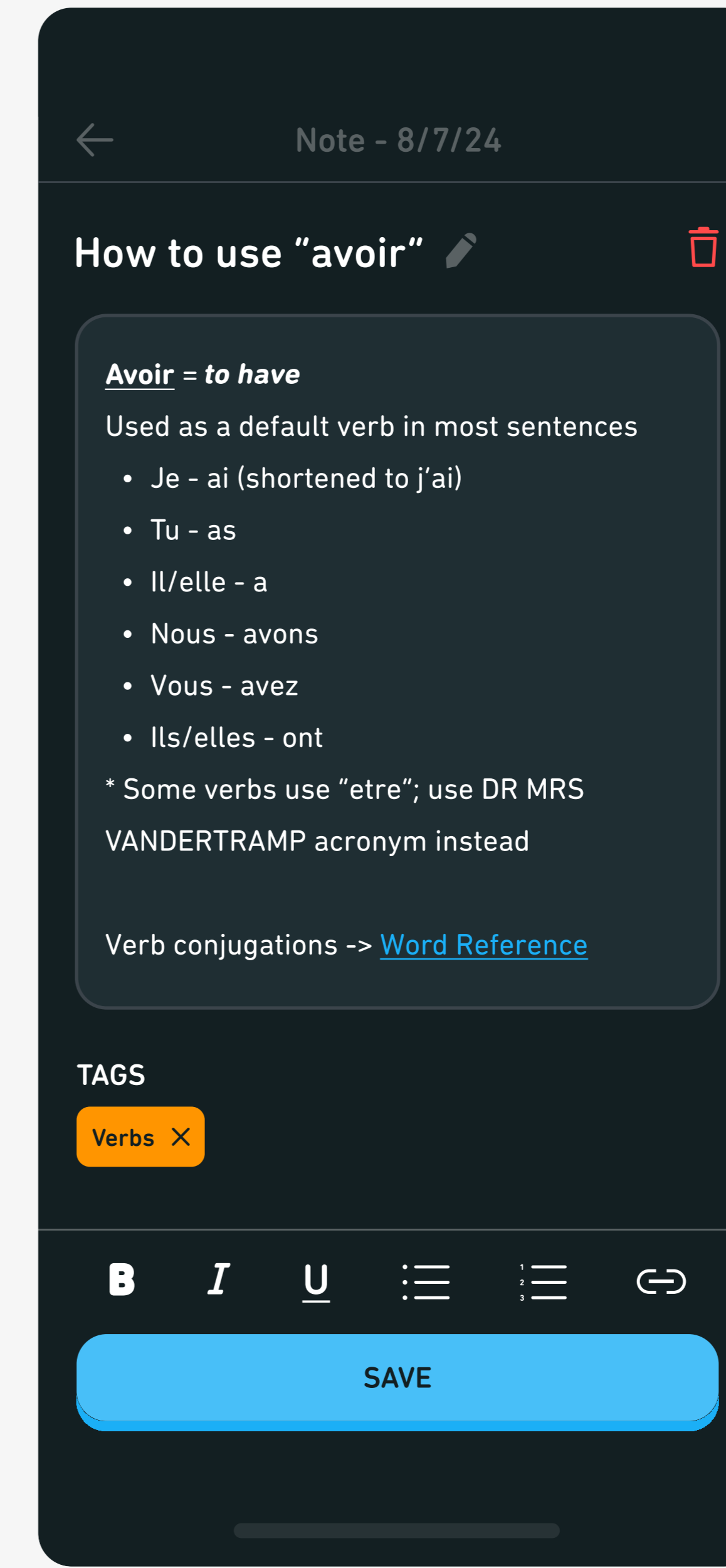
Duolingo Notes splash screen



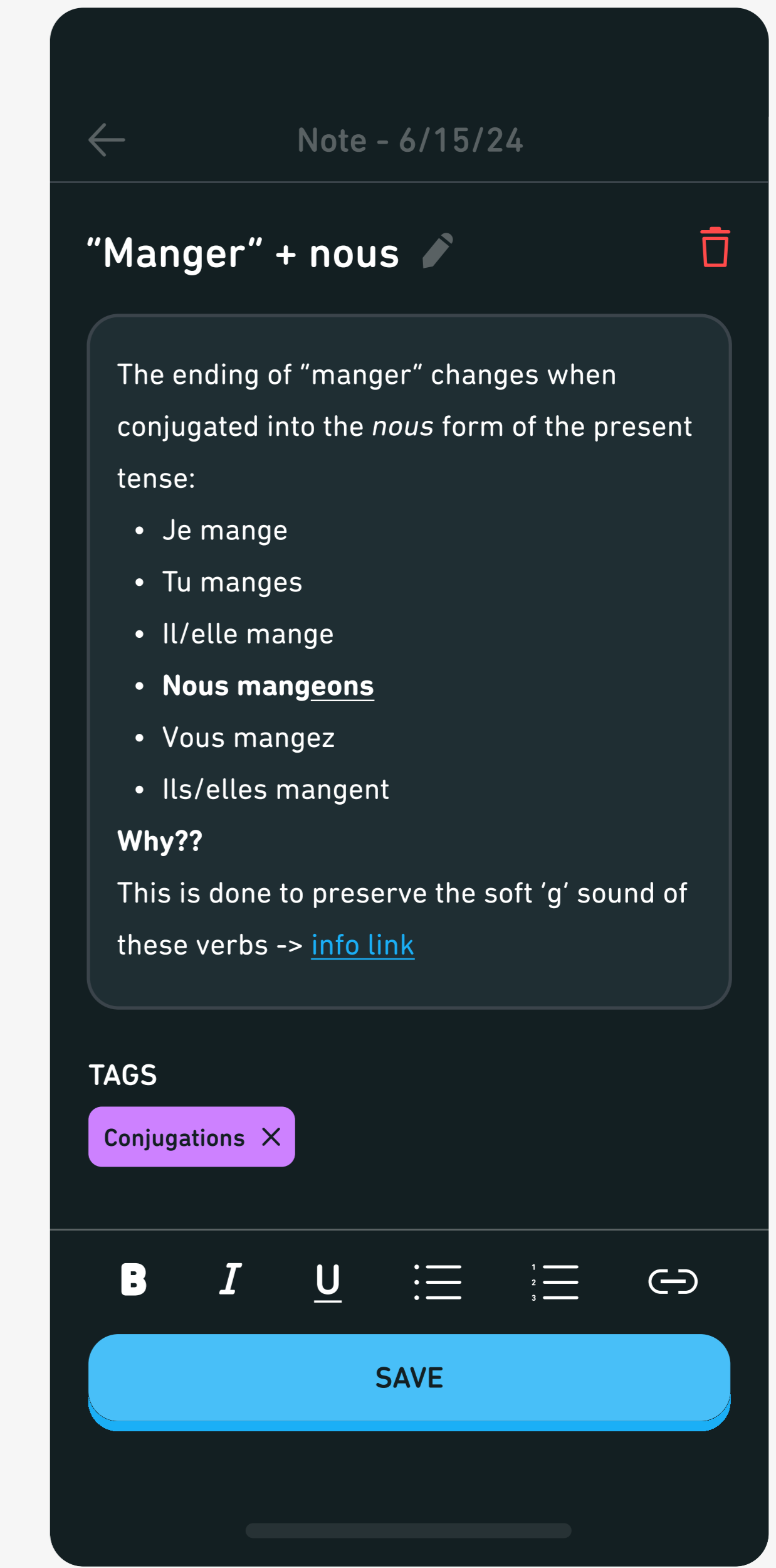
Notes hub



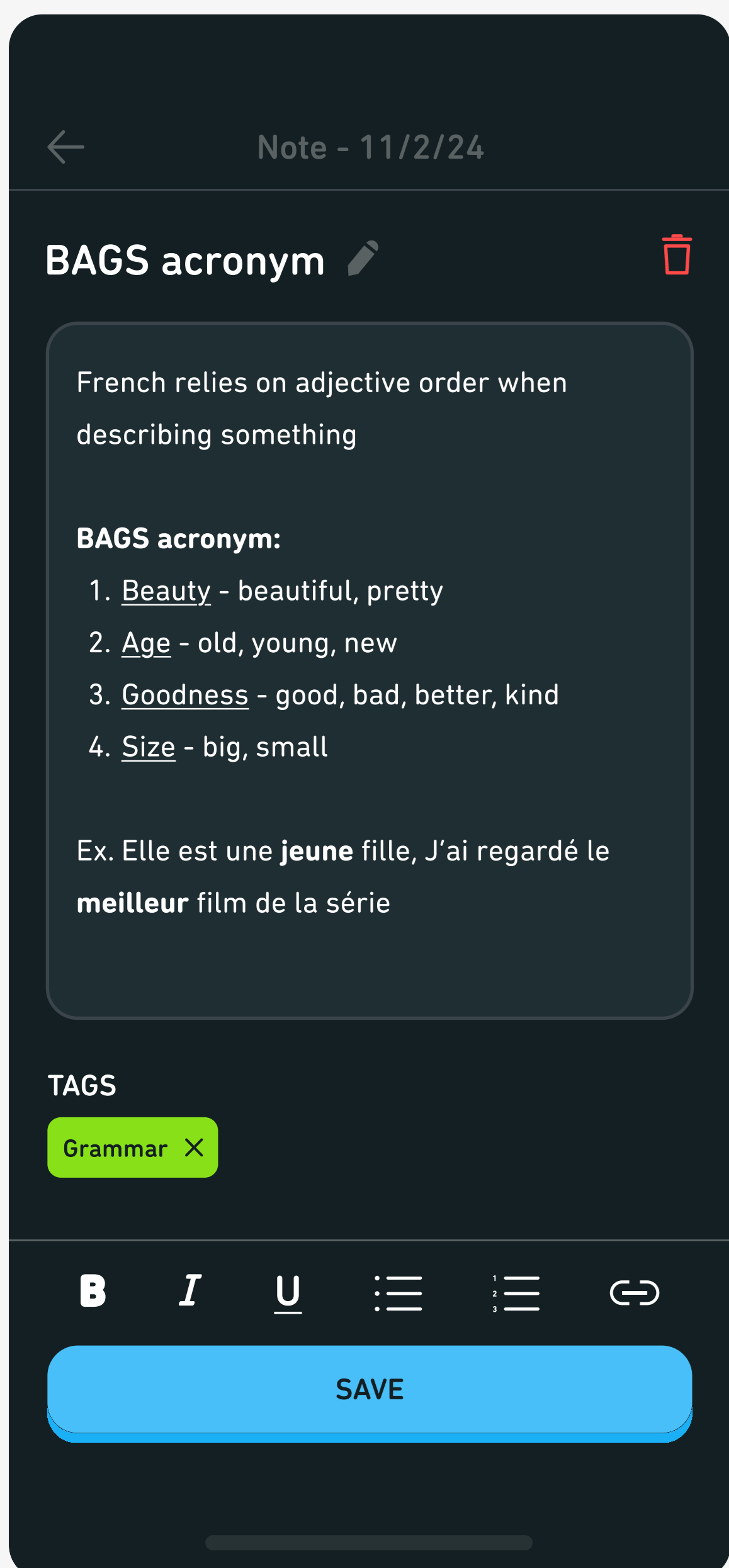
Create a new note



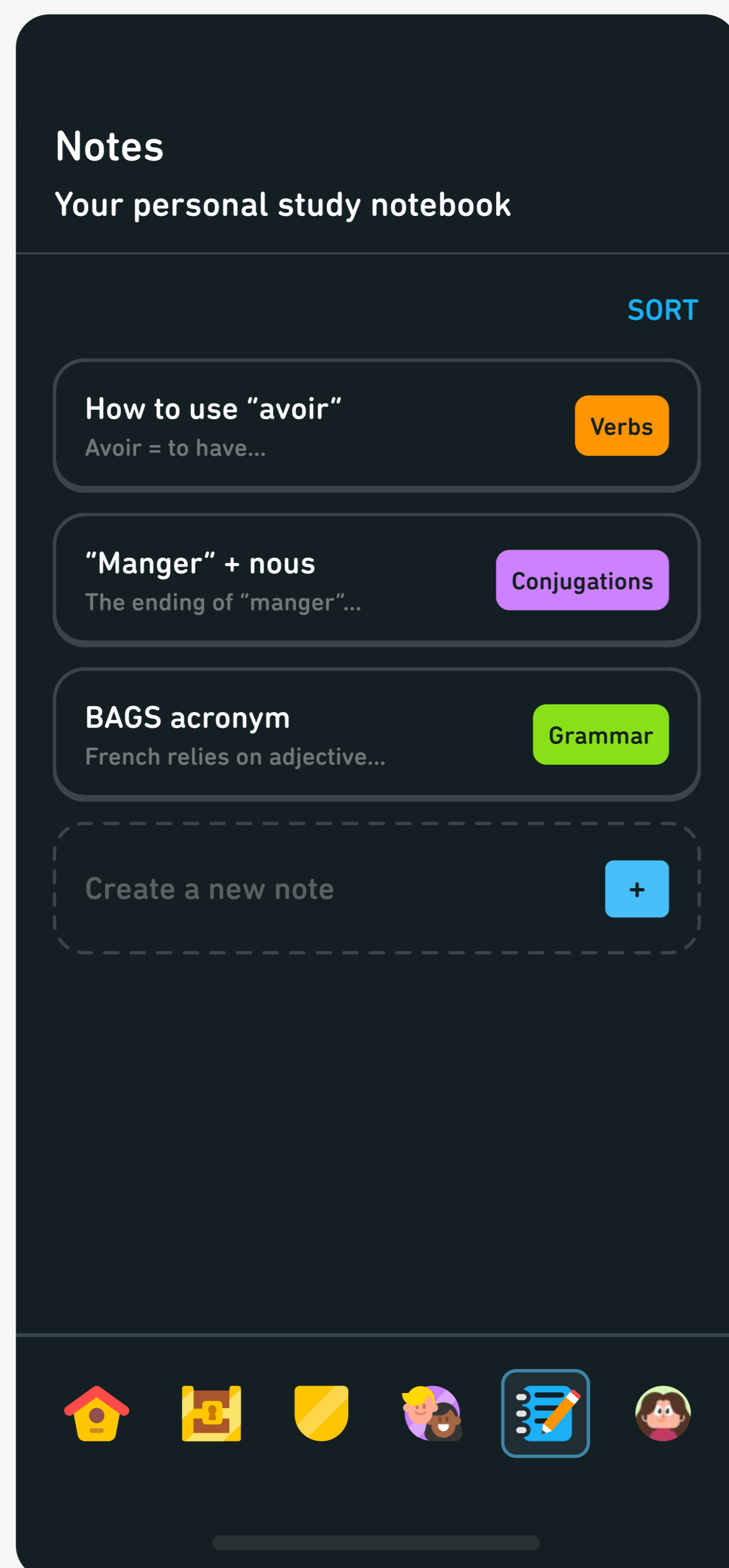
Filled note example #1



Filled note example #2

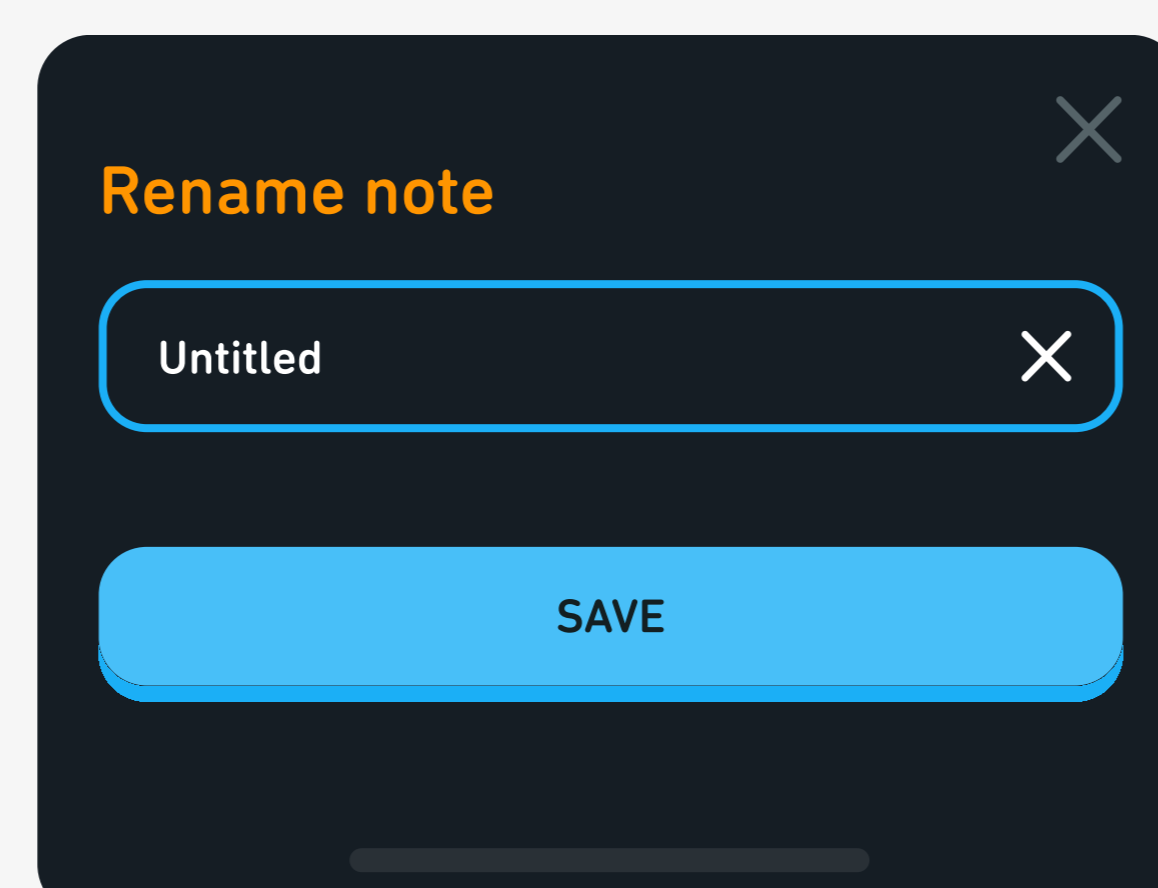


Filled note example #3

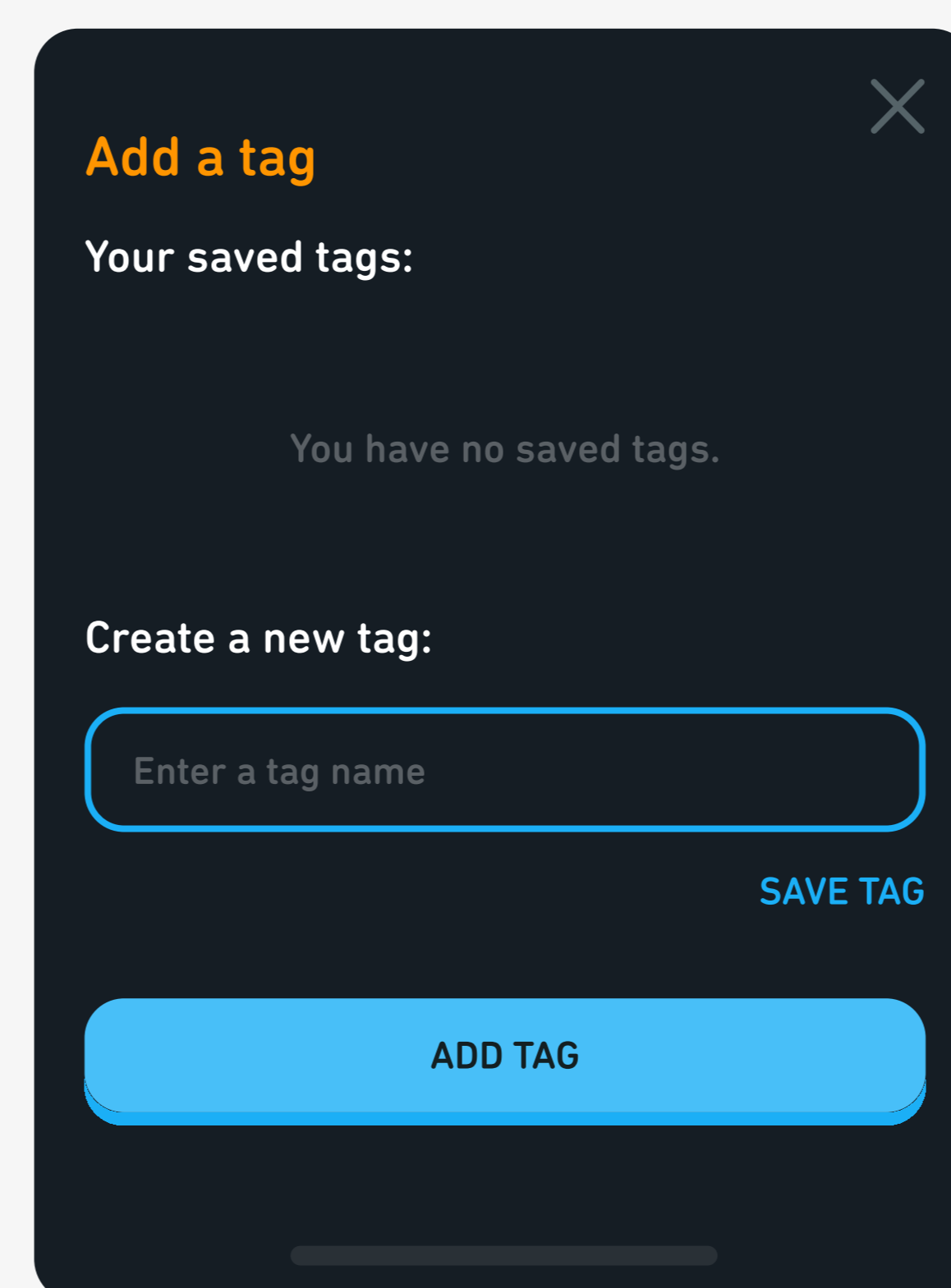


Notes hub with multiple notes

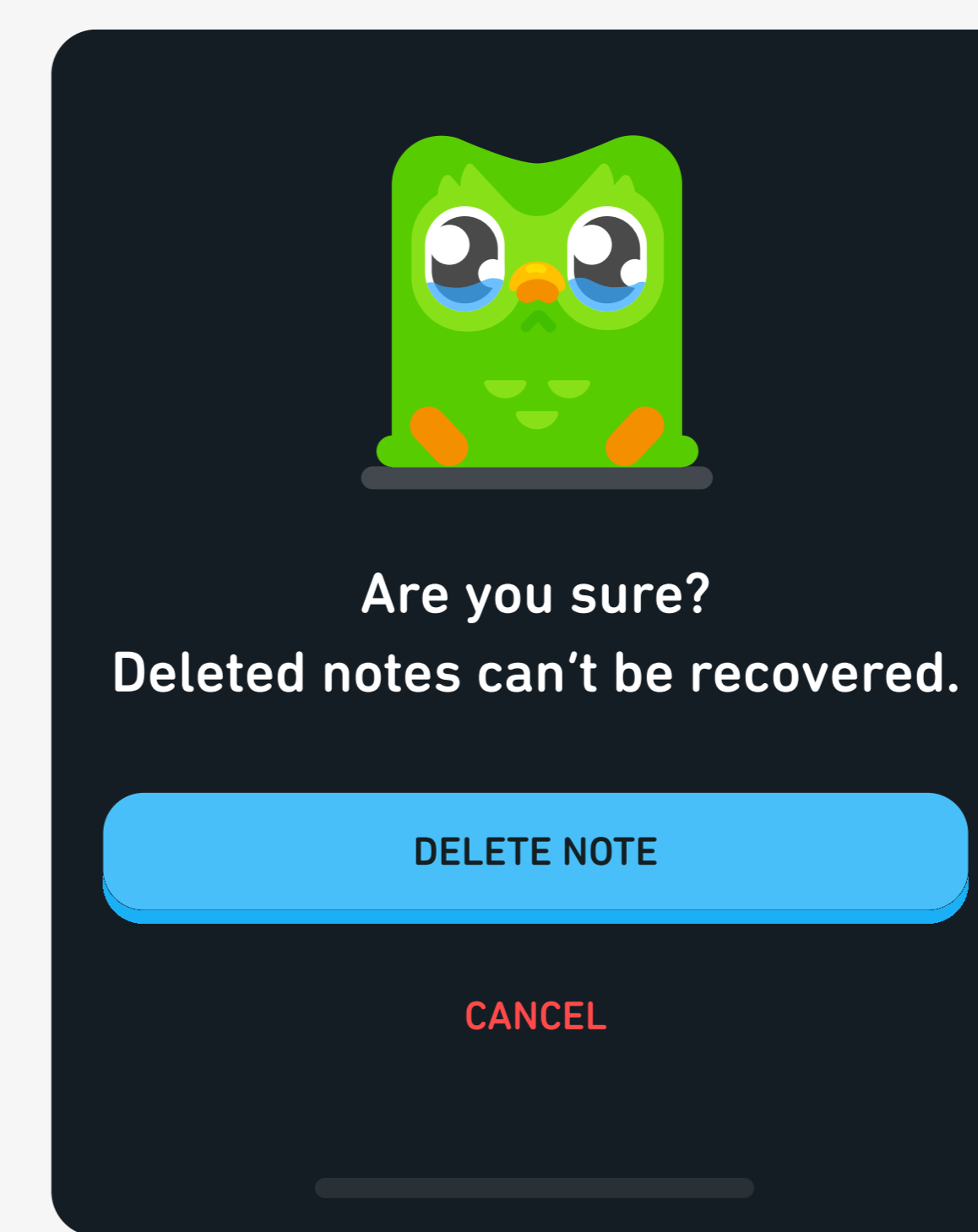
Pop-up Overlays



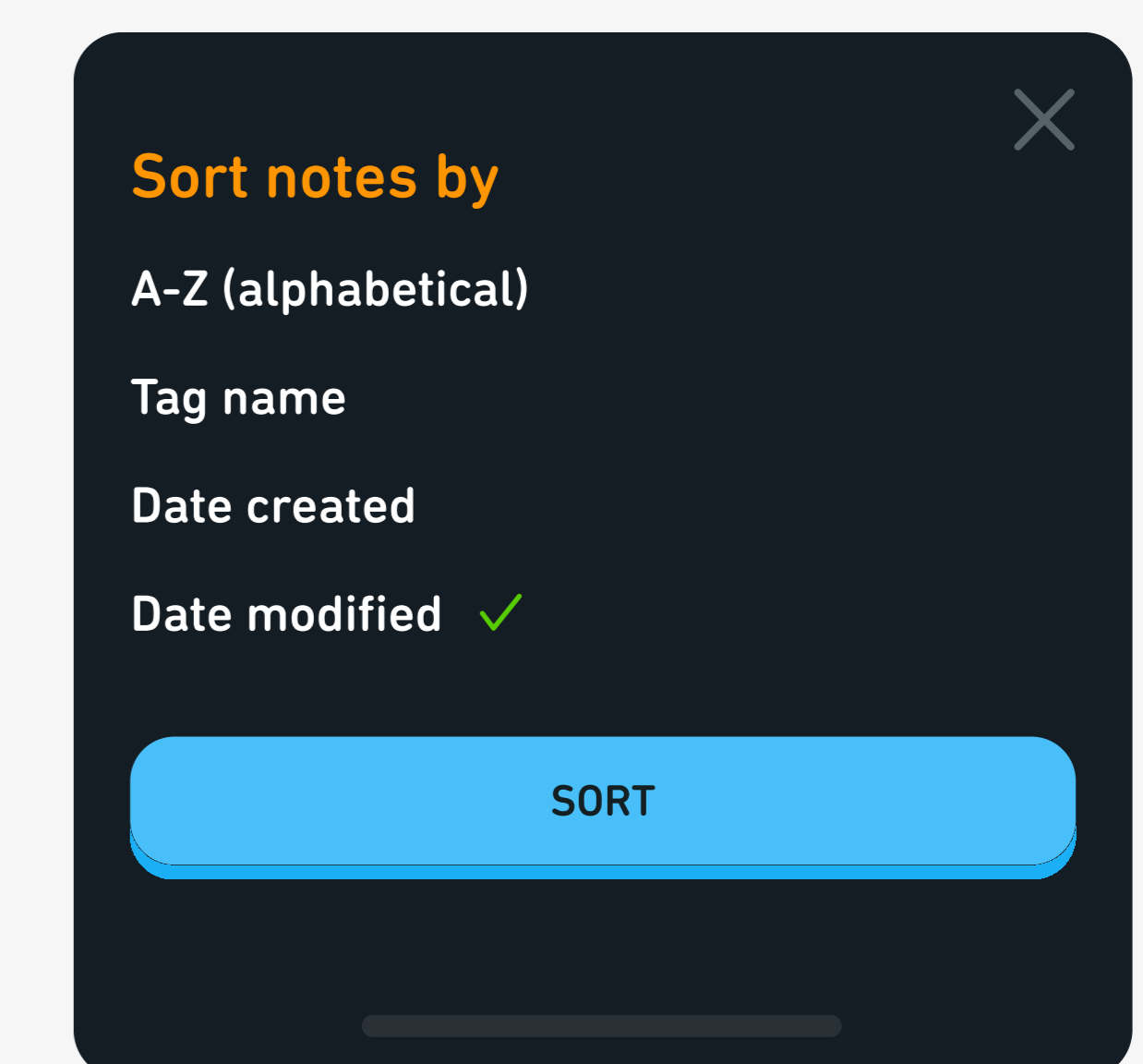
Rename note



Add a tag / access saved tags



Note deletion screen



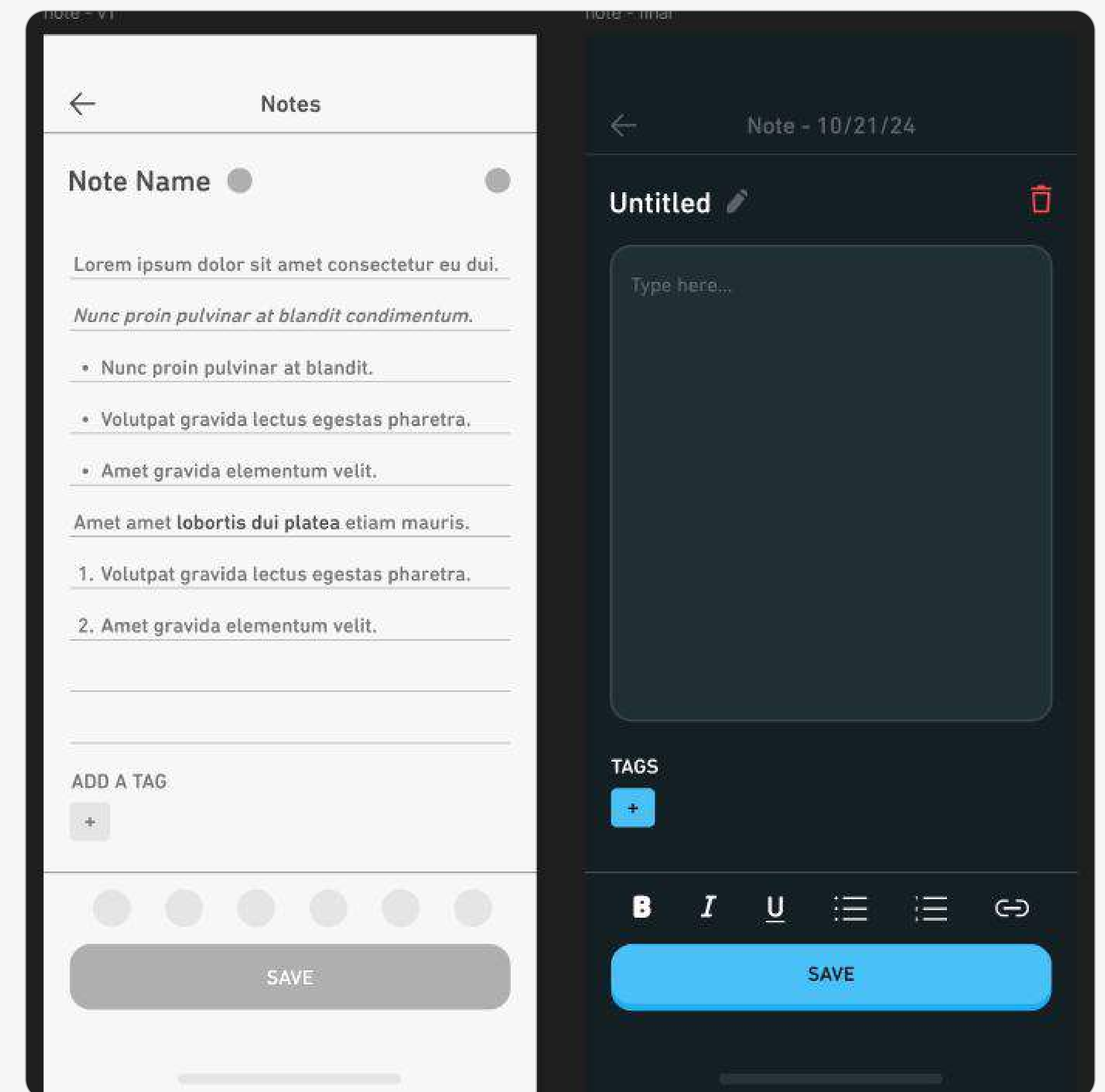
Sort list of notes

User Testing for Duolingo Notes

A total of four (4) testers interacted with the Figma prototype for the feature, each of whom were given their own checklist with tasks to complete. Some had already been involved with the project as interview participants and had prior knowledge of a potential note-taking feature, but had not been provide exact details of how it worked.

Testers experienced very few issues with navigating the prototype for Duolingo Notes, showcasing a relatively high level of understanding of where to find elements and completing the tasks with ease. **Overall, feedback for the feature was positive and testers liked the idea of a note-taking integration.** They enjoyed the ability to organize notes using tags and have a sorting system, which would reduce the time spent searching for a specific note.

When showcasing early versions for feedback, it was suggested that I change the text input section to a limitless text box (shown right), as opposed to providing lines. While the lines bear a closer resemblance to a notebook or journal, the text box is more similar to the way notes apps on mobile devices are designed.



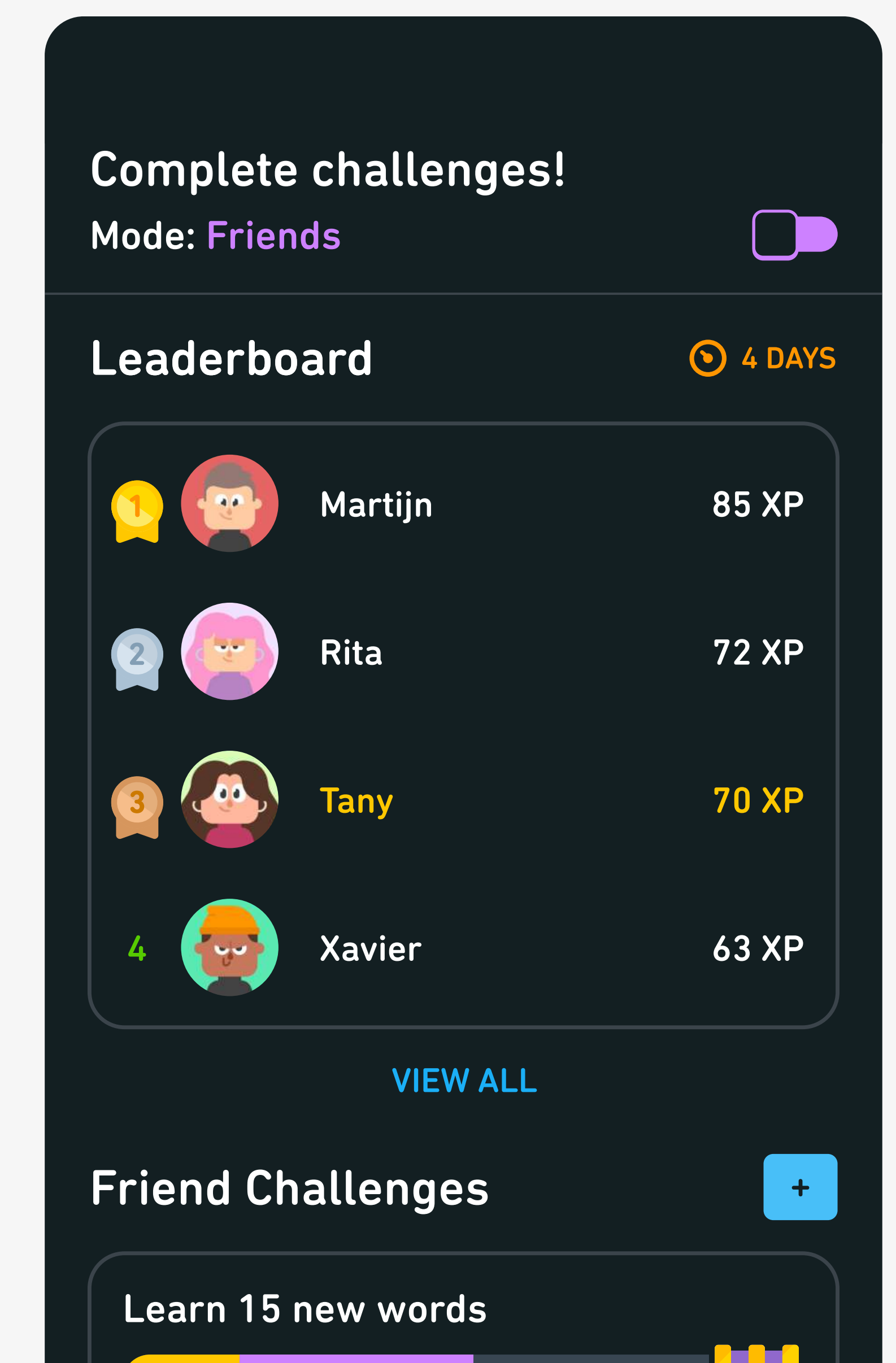
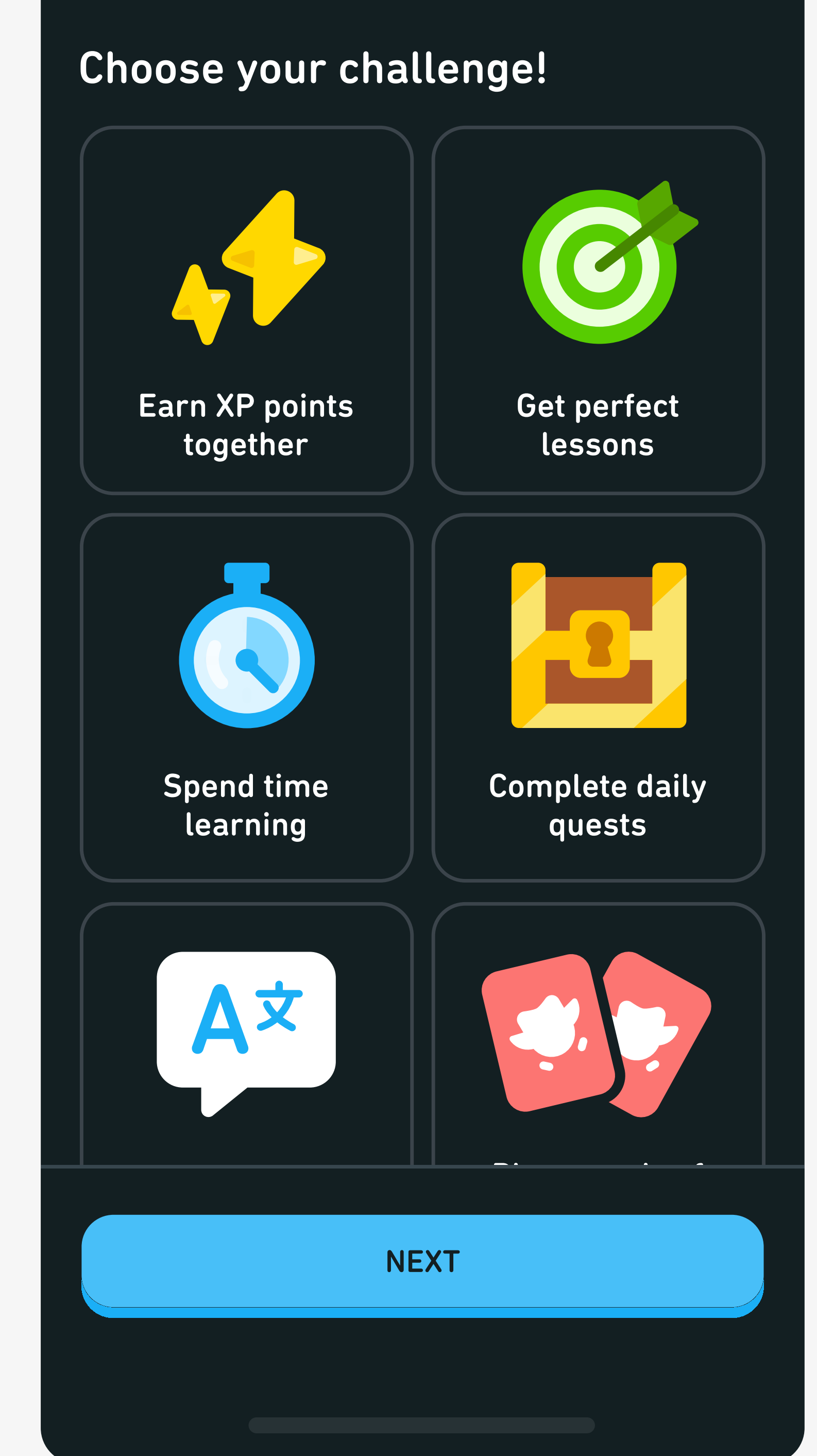
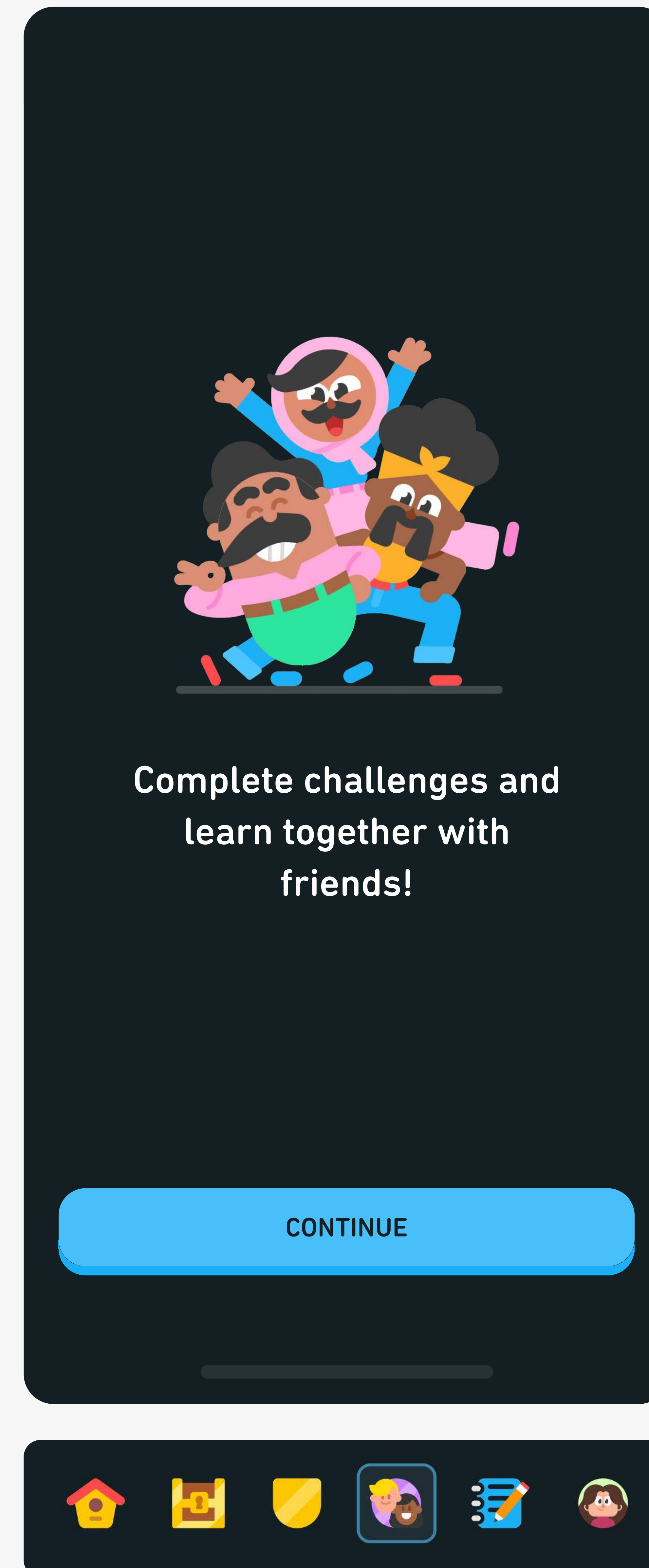
#2: Learning with Friends

The second feature I chose to implement is an expanded system for learning with friends, an idea that stemmed from one of my interview participants. It was noted that although Duolingo allows you to add friends, there isn't much to do with them aside from app-controlled challenges/quests and maintaining a streak; conversely, having no friends on the app means users miss out on collaborative learning experiences.

Learning with Friends was designed to make the friend system in Duolingo more interactive and engaging. Users can now select custom challenges and invite their friends to participate. Healthy competition and rivalry is encouraged through a friends-only leaderboard.



The Icon: Two Duolingo users beside each other, representing friends on the app.



Learning with Duo & Co.

The second component to Learning with Friends is designed to cater to users who don't have friends on the app. Instead of learning alone, **Duo and the app's characters** can step forward to act as partners, including iconic personas such as Zari, Eddie, Oscar, Bea and others. This feature can be toggled on even if users have friends, making it easy to switch and earn more rewards for learning with Duolingo.

The progress made by the app's characters would be dependent on their personalities. For example, Zari is depicted as a studious person who is eager to learn; she is more likely to contribute more to a quest than someone like Junior, who is depicted as a young child and easily distracted by other interests.



ABOVE: The Duolingo cast of characters.
From left to right: Bea, Vikram, Oscar, Junior, Eddie, Zari, Lily, Lin, Lucy, Falstaff.

Complete challenges!

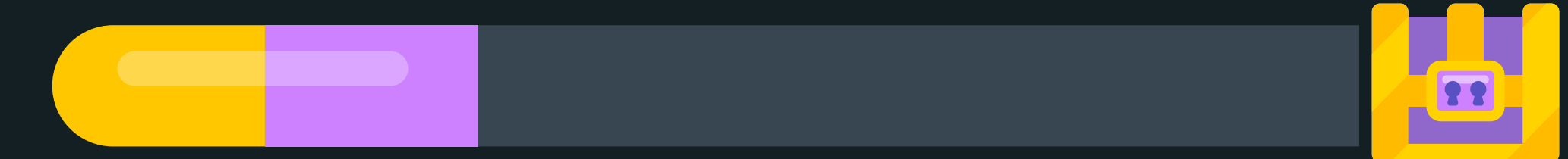
Mode: Duo & Friends



Challenges

4 DAYS

Earn 100 XP



IN PROGRESS



You

15 XP



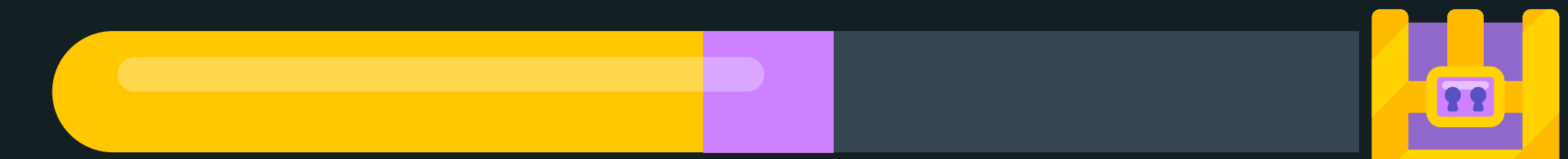
Zari

15 XP



HIGH FIVE ZARI!

Get 10 perfect lessons



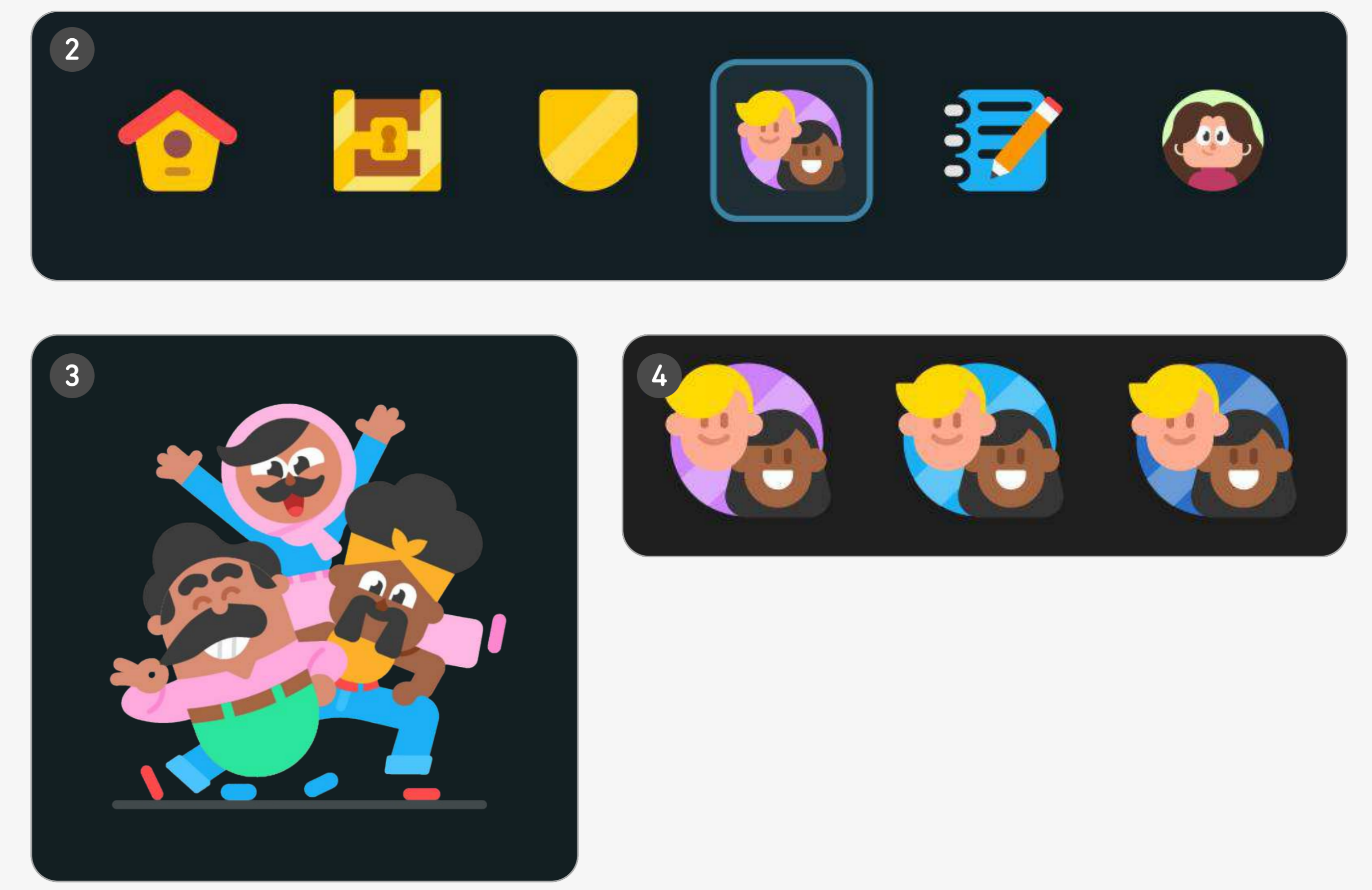
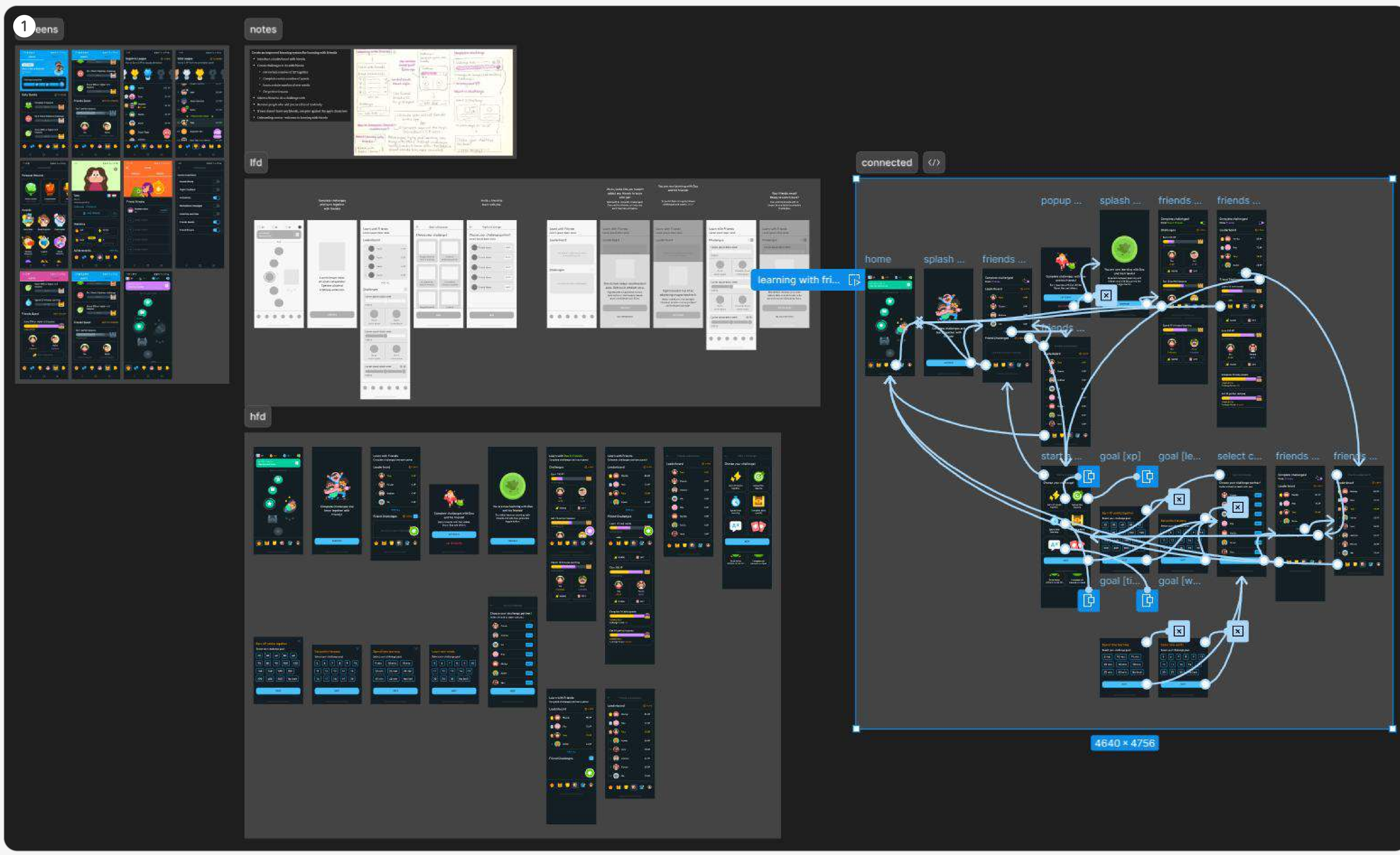
IN PROGRESS



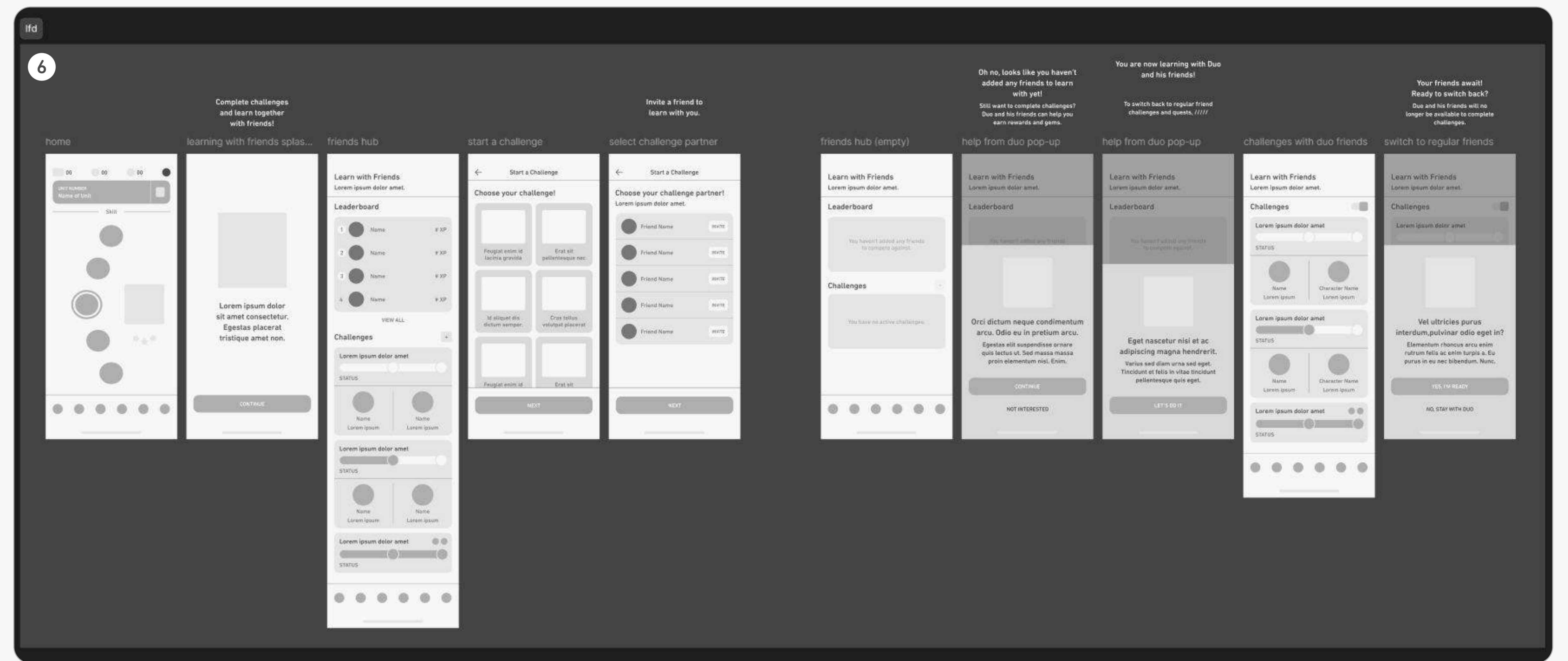
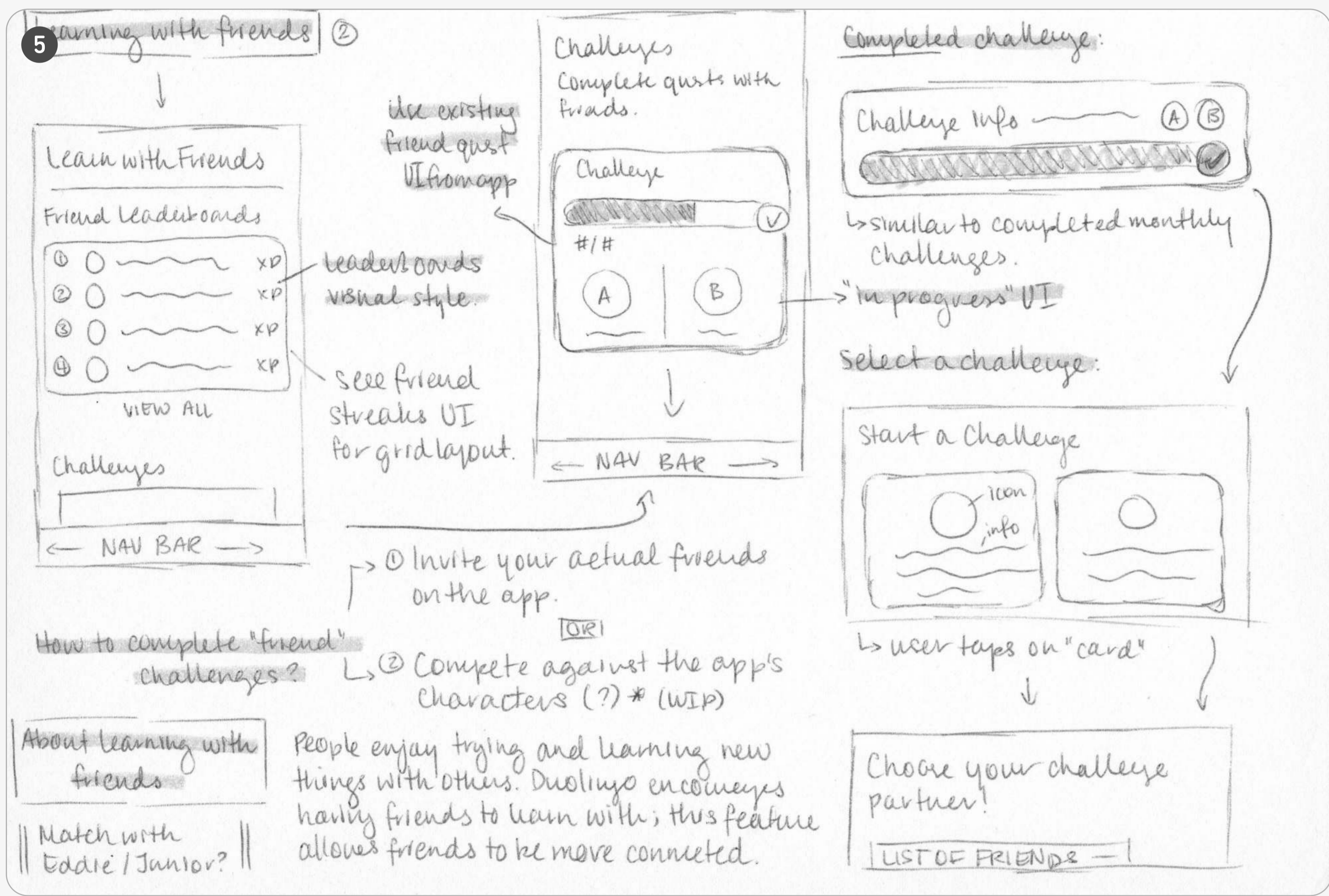
You



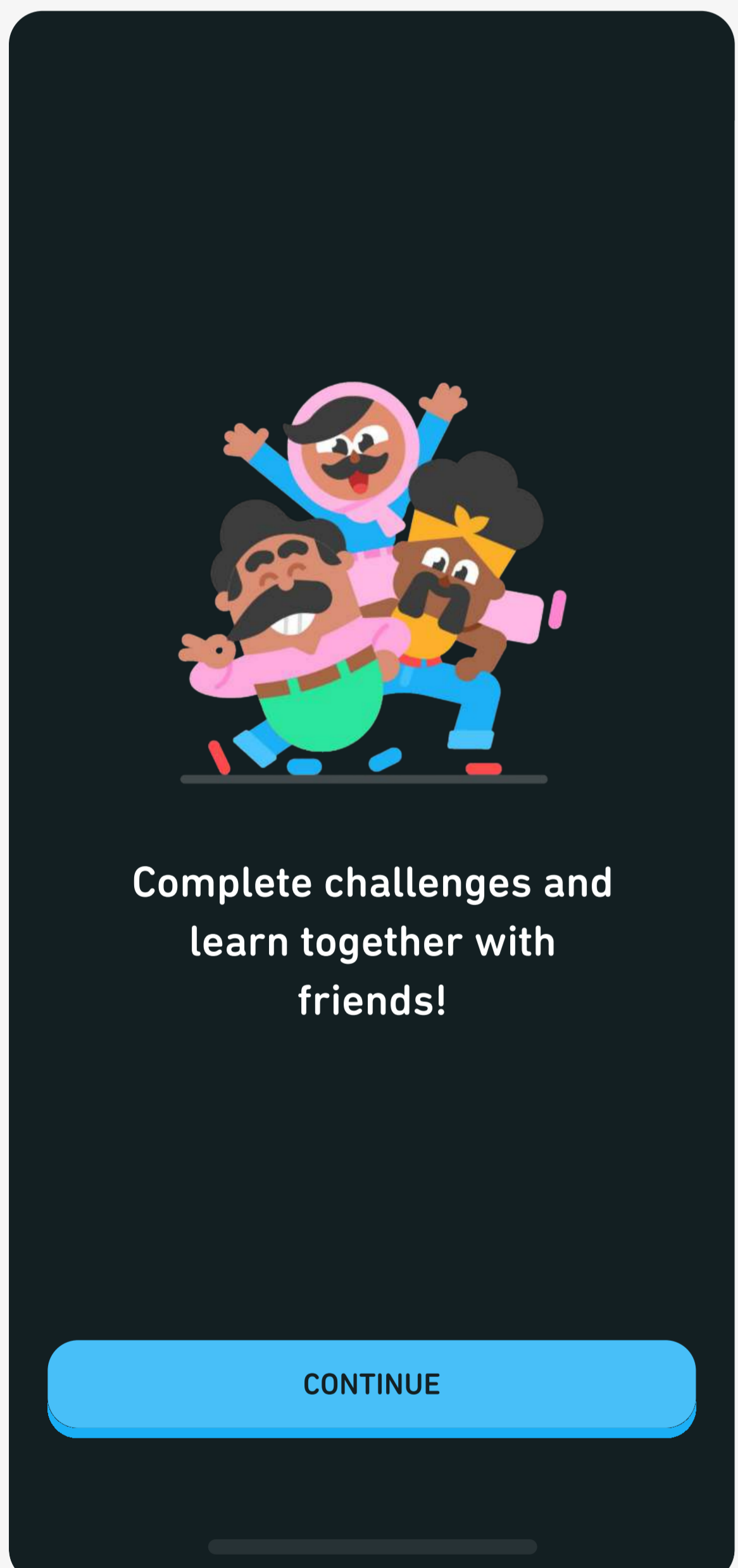
Eddie



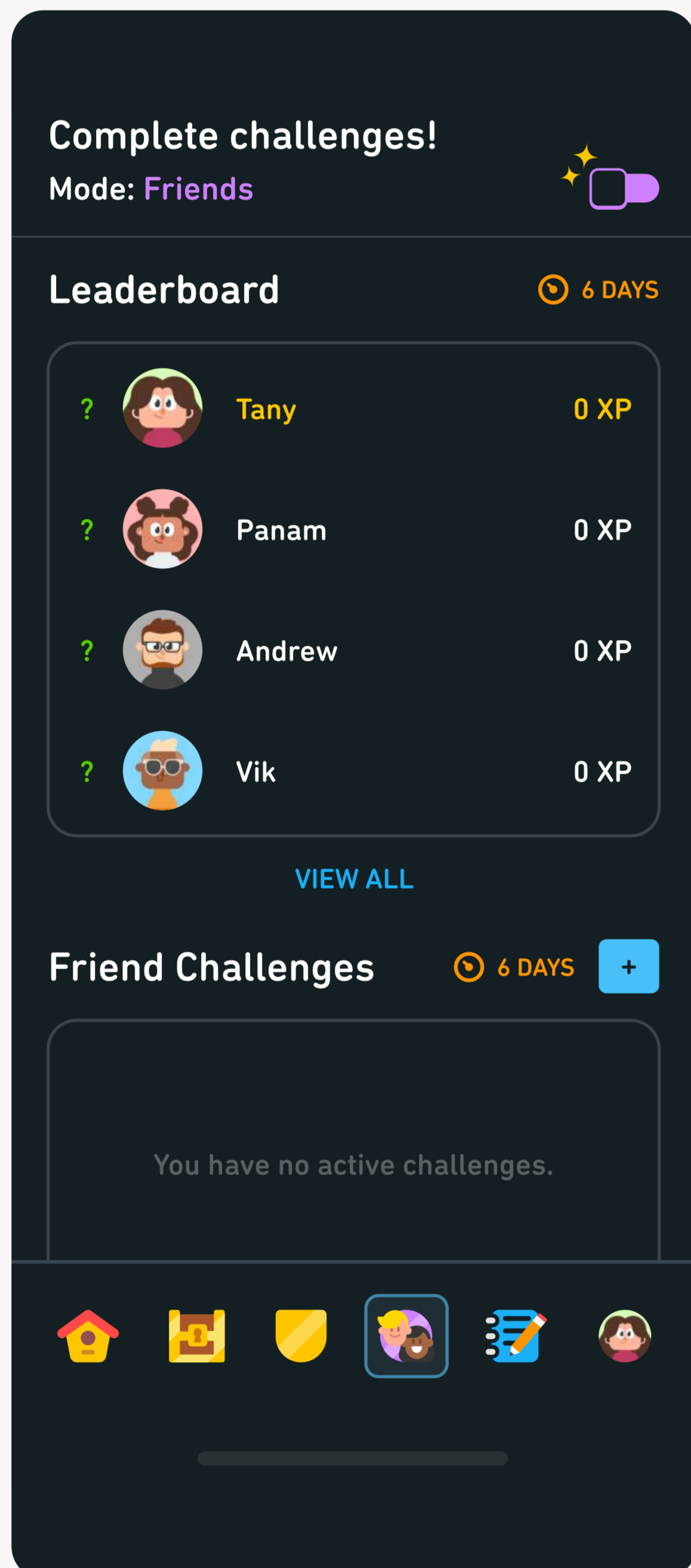
- 1 Page in Figma for Learning with Friends, with reference screenshots, requirements, notes, wireframe sketches, low-fidelity versions, high-fidelity designs, and connected prototype.
- 2 The Learning with Friends icon on the app's navigation bar at the bottom of the screen.
- 3 The illustration for Duolingo Notes, featuring Oscar, Zari and Bea with moustaches. This is from the November 2021 monthly challenge titled "Oscar's Moustache Marathon".
- 4 Variations of colour combinations for the Learning with Friends icon.
- 5 Initial brainstorming through wireframe sketches on pen/paper.
- 6 Low-fidelity versions with placeholder content.



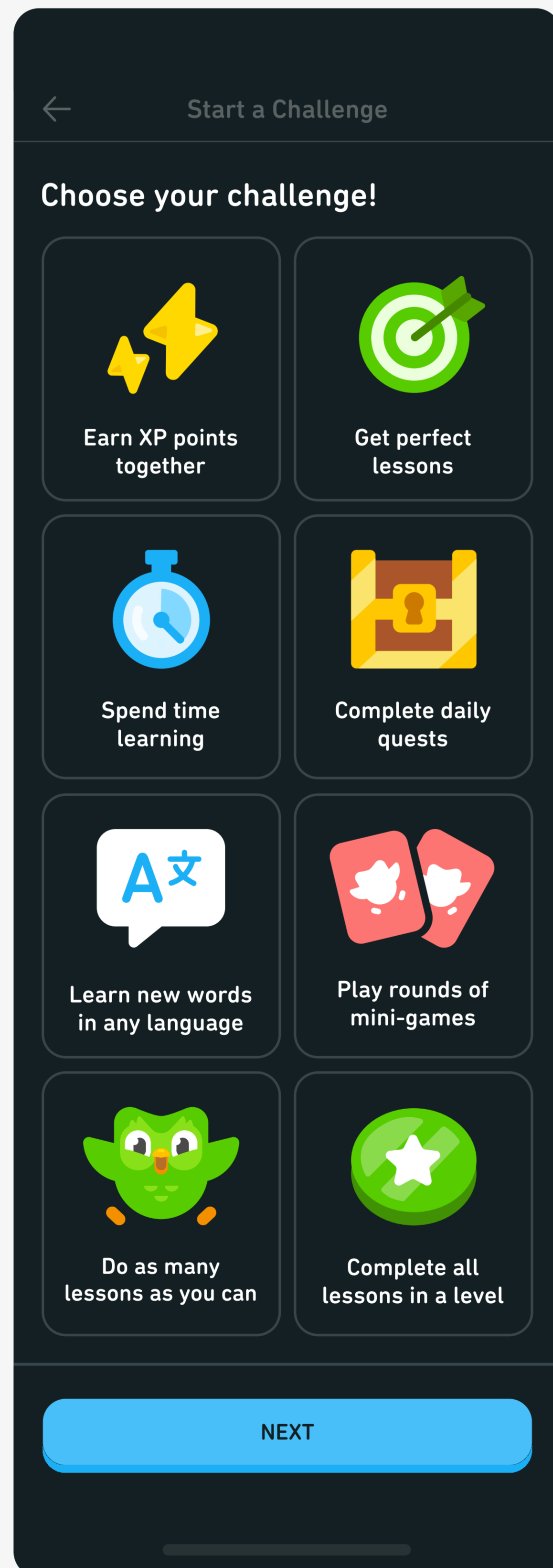
High-Fidelity Screens



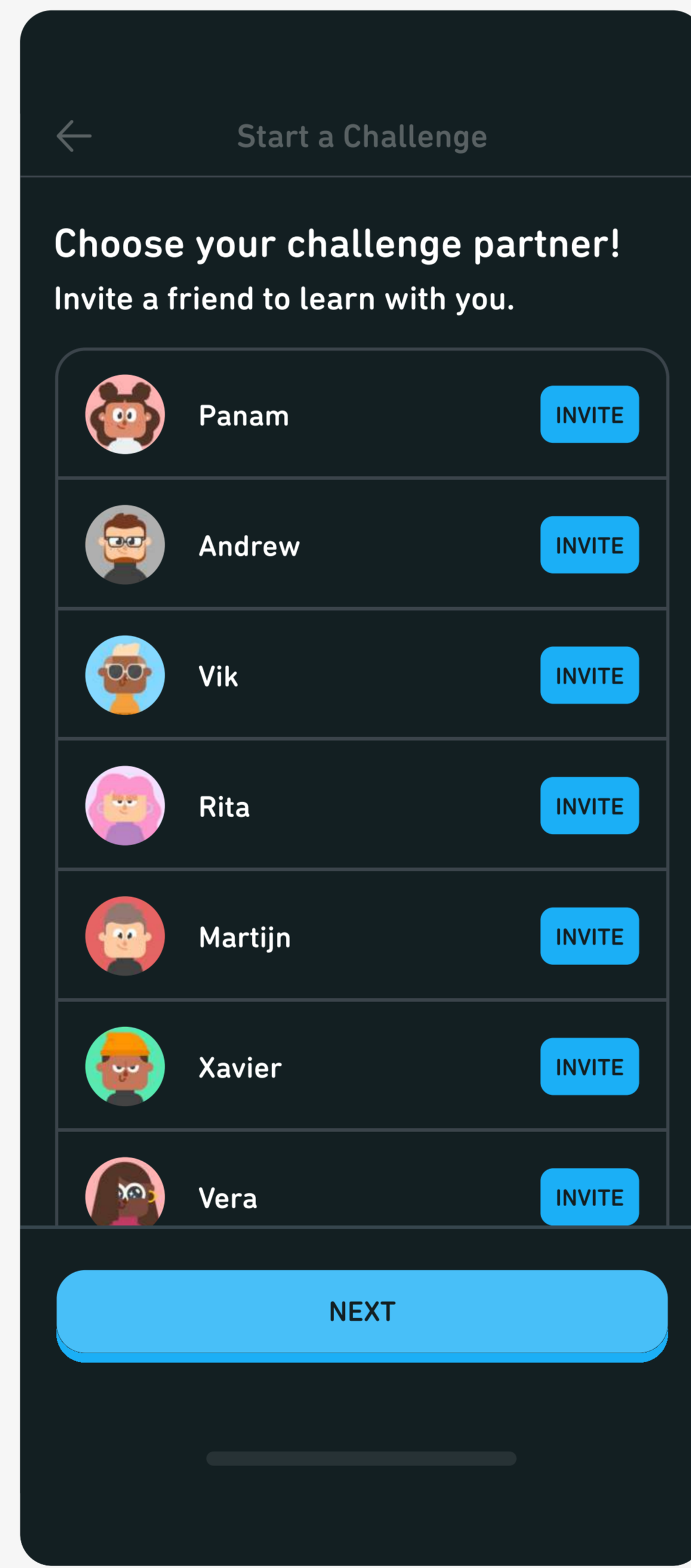
Home



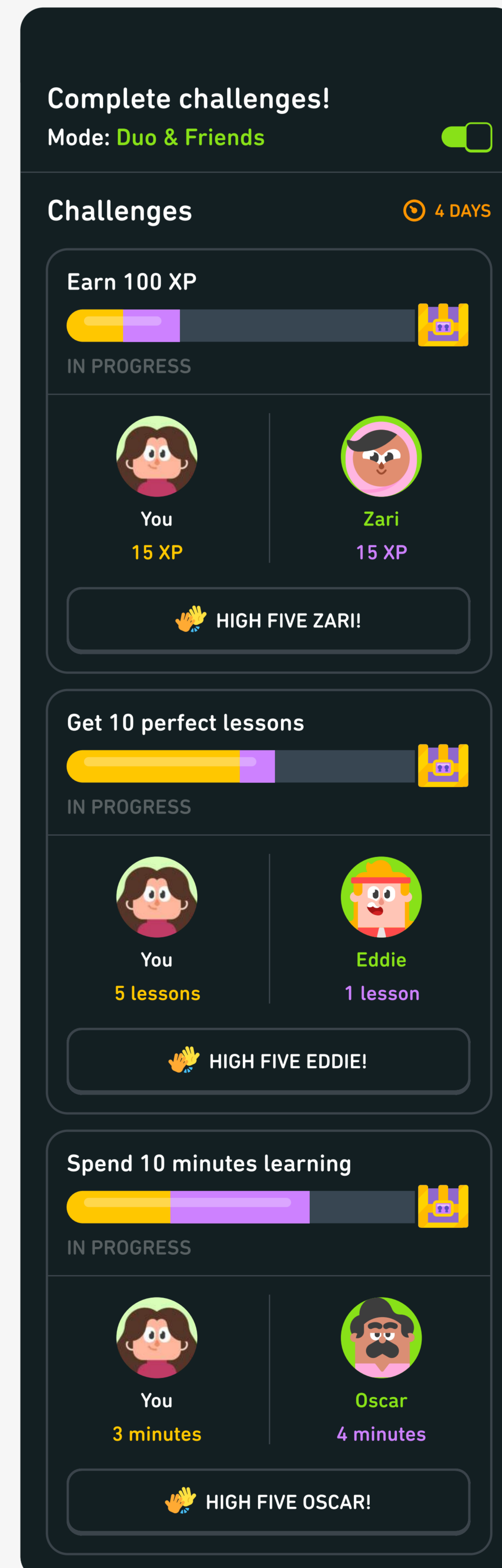
Learning with Friends hub



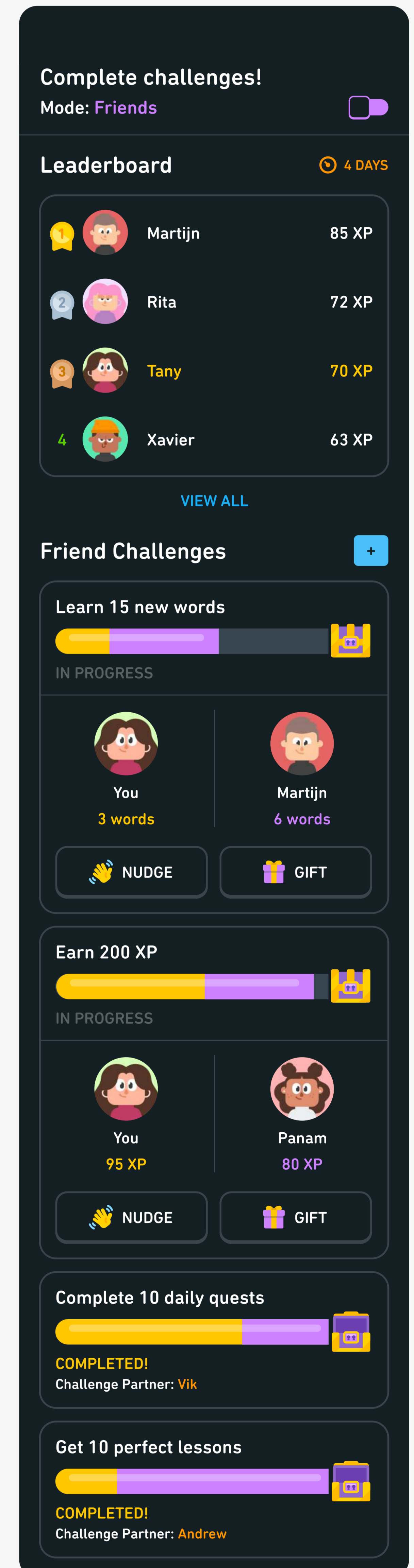
Choose a challenge



Select a challenge partner

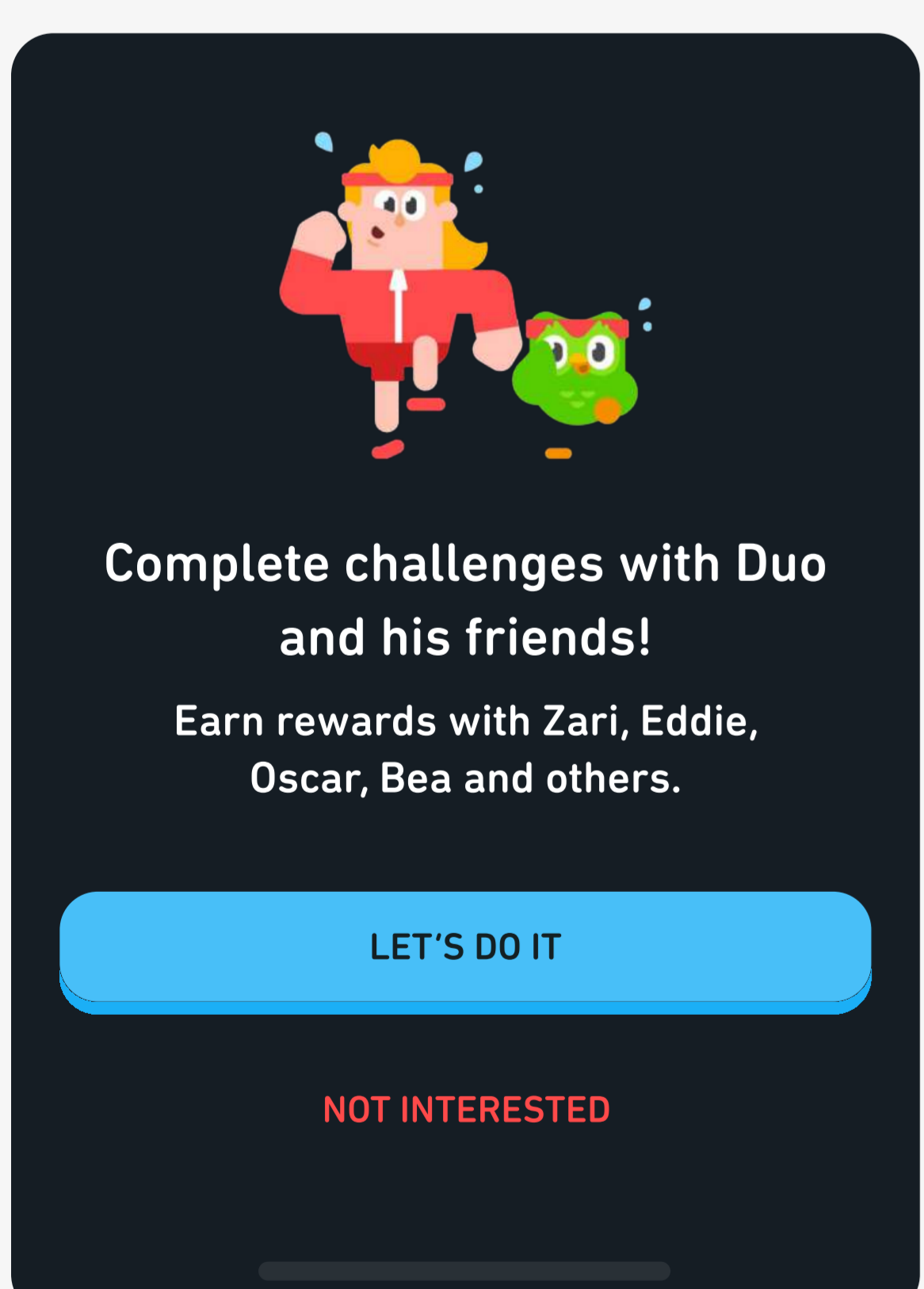


Friends hub (Duo & Friends mode)

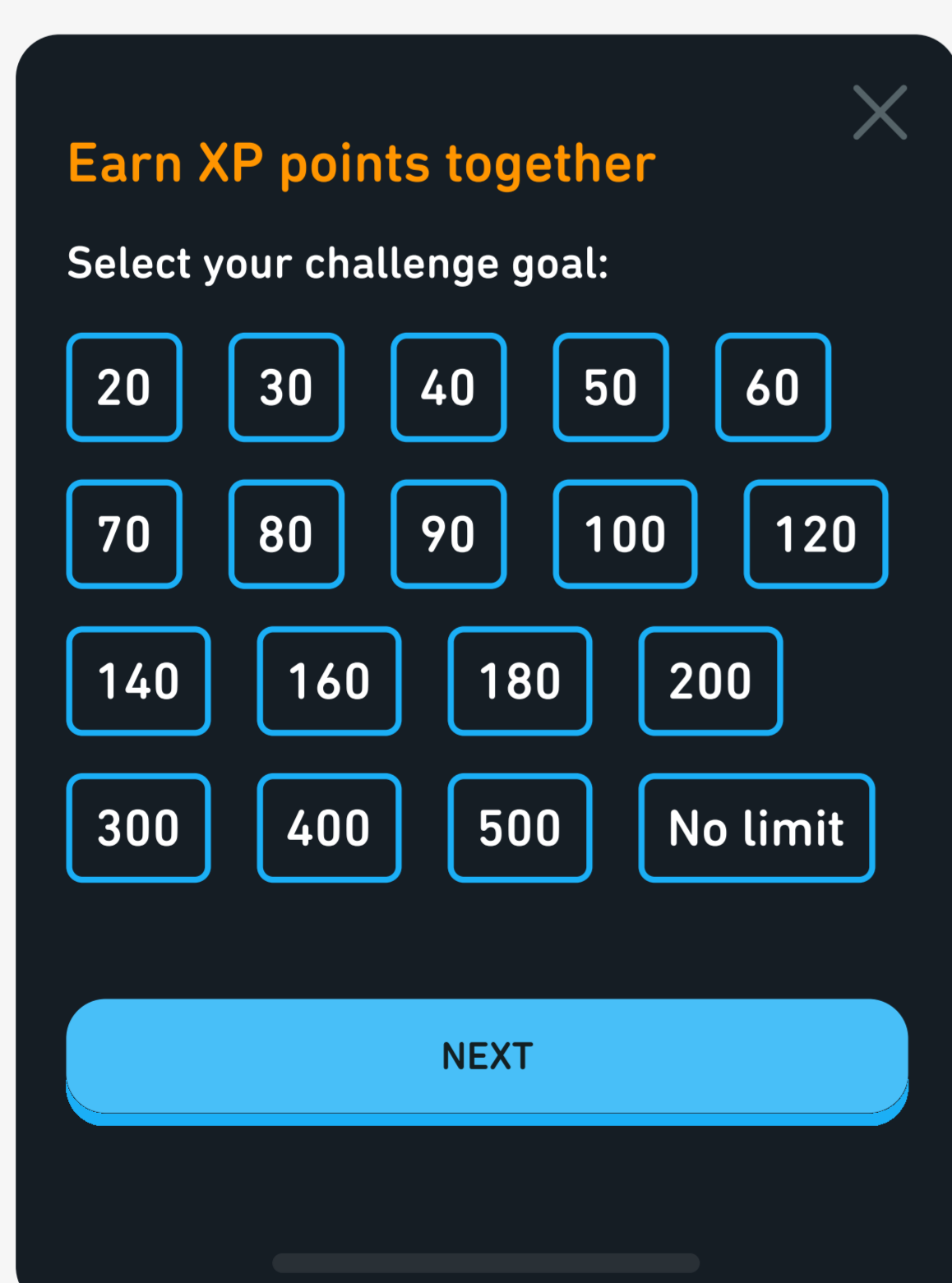


Friends hub (Friends mode)

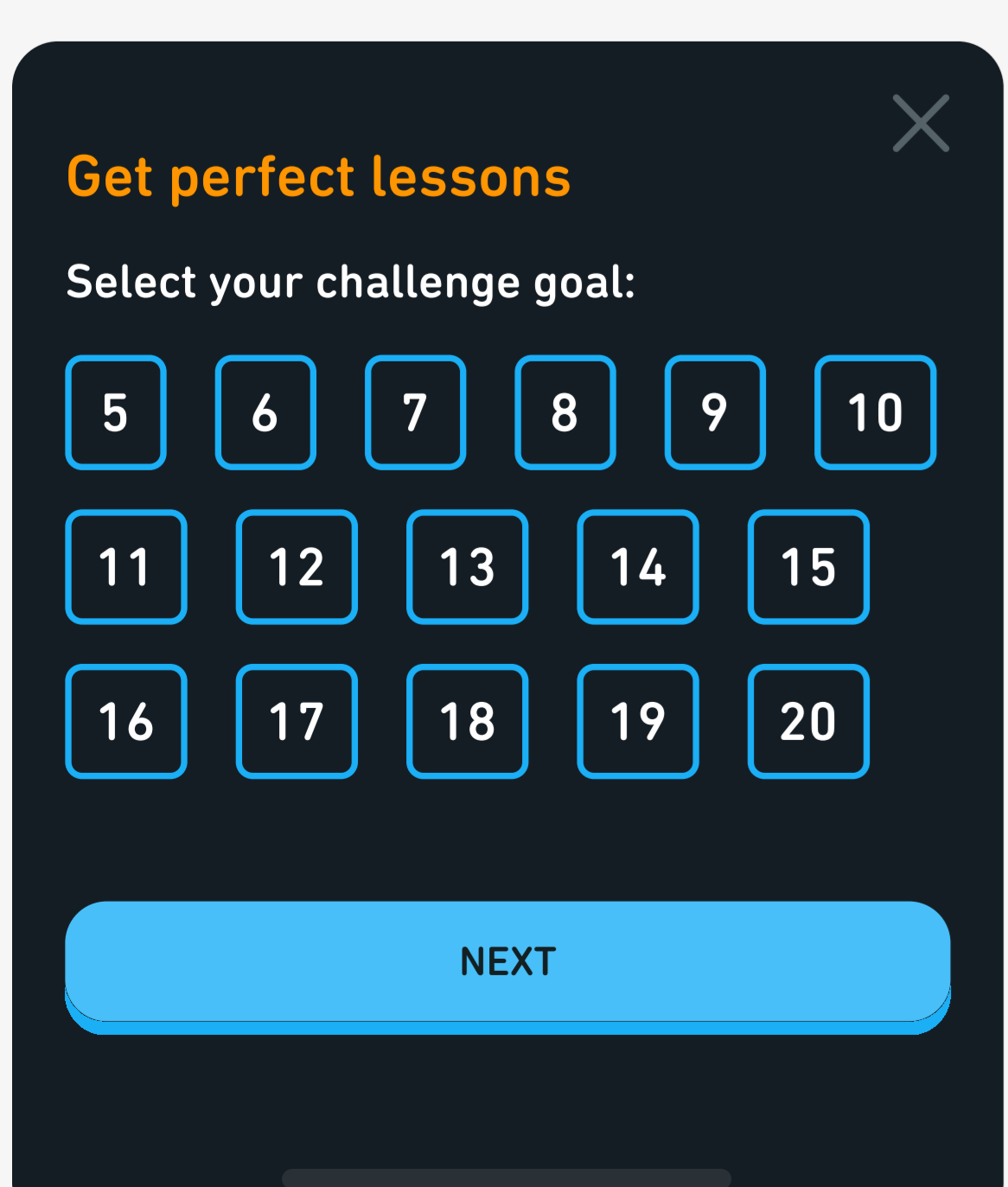
Pop-up Overlays



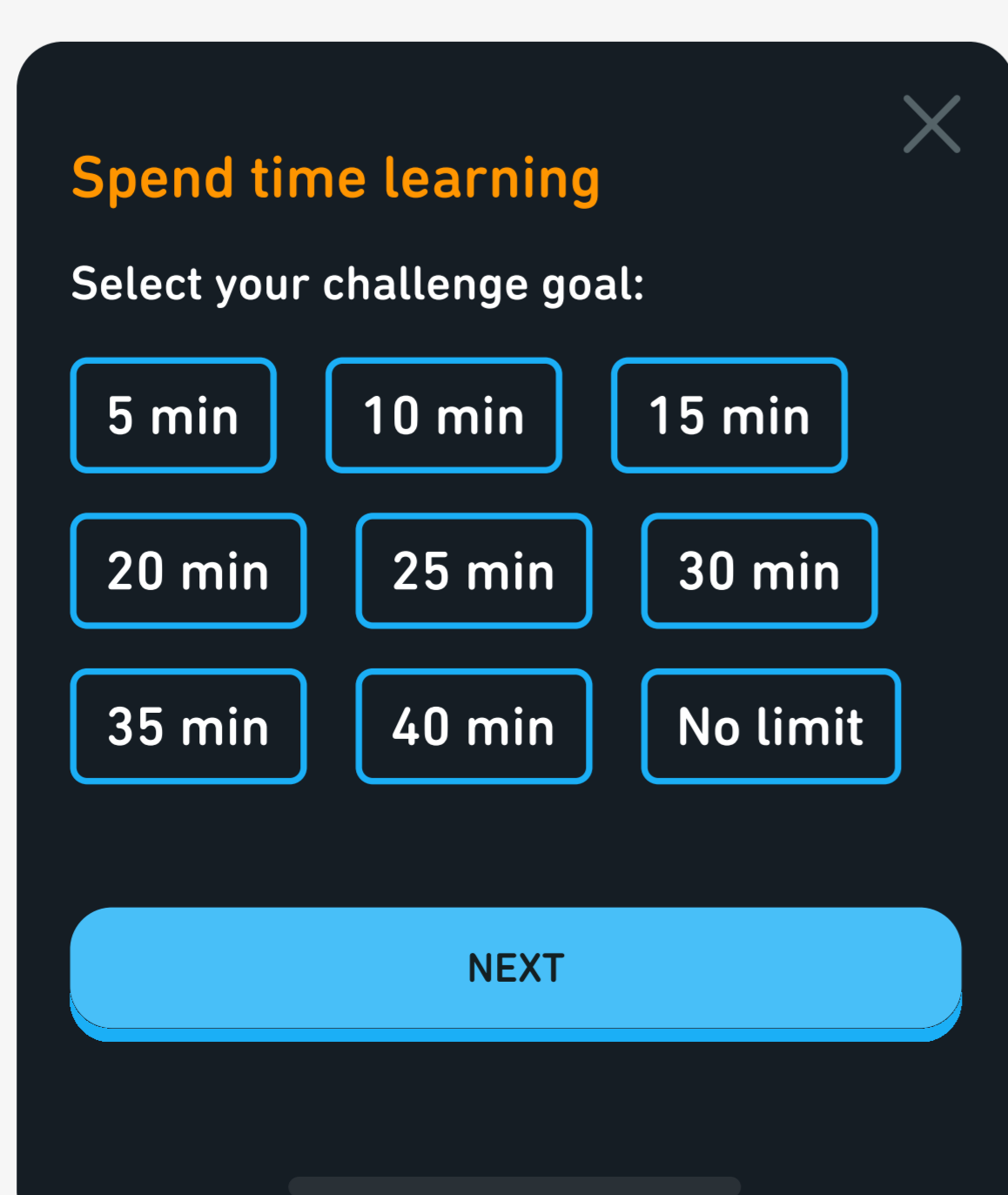
Transition pop-up for switching modes



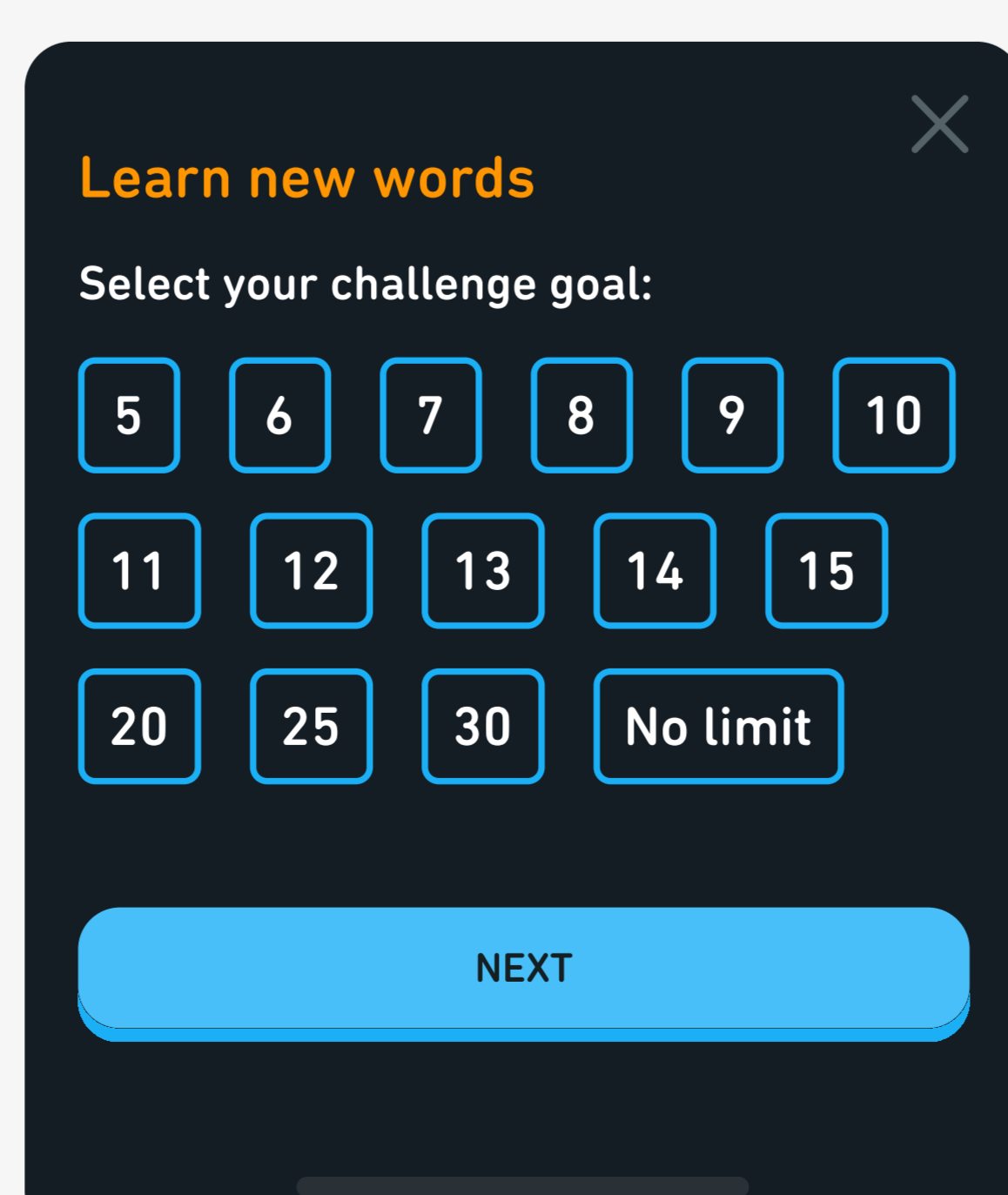
Challenge: Earn XP



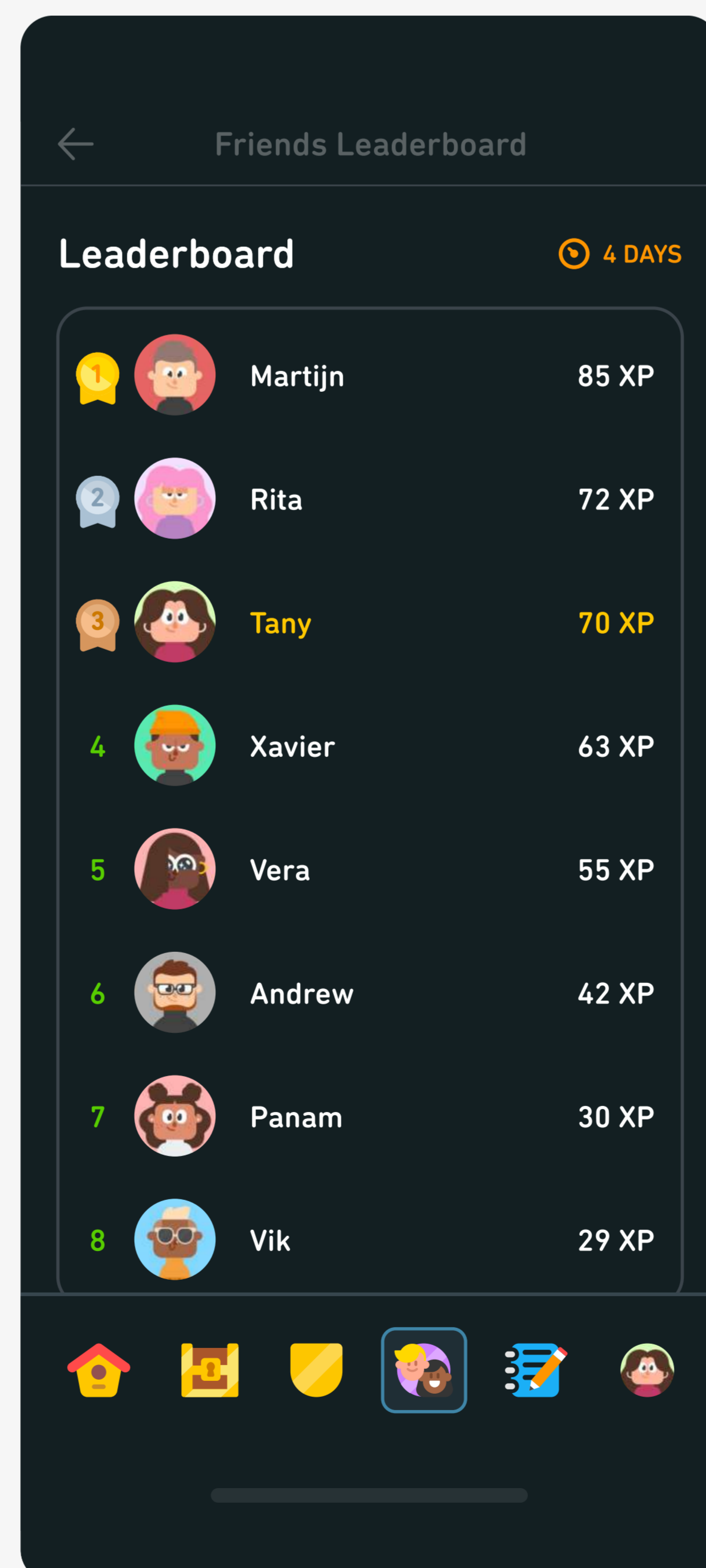
Challenge: Get perfect lessons



Challenge: Spend time learning



Challenge: Learn new words



Friends leaderboard

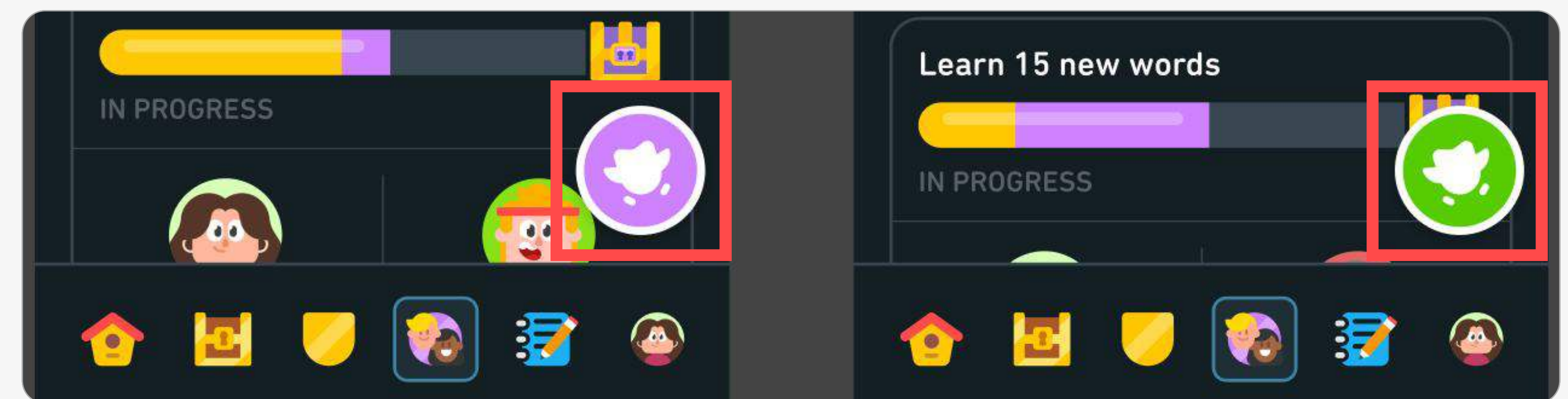


Transition splash screen for modes

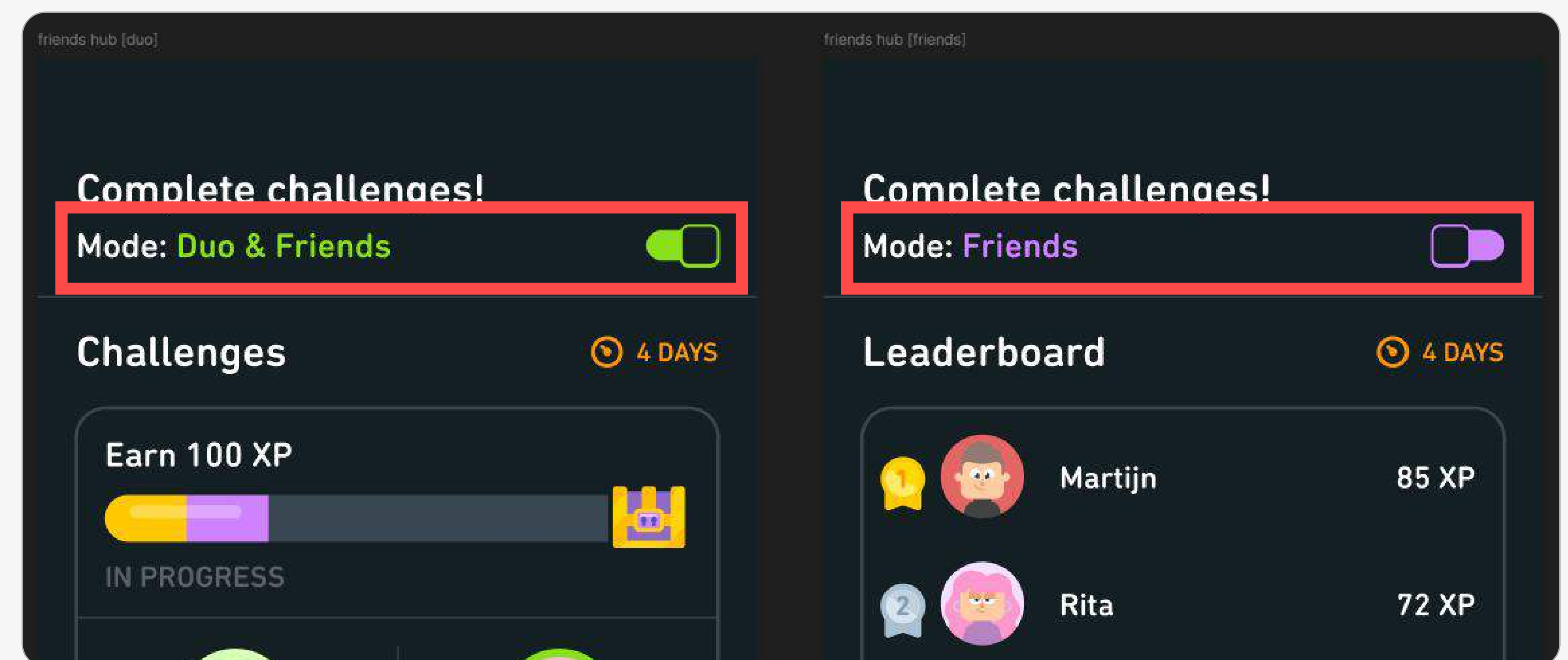
User Testing for Learning with Friends

In a similar manner to the previous testing session for Duolingo Notes, four (4) testers interacted with the prototype for Learning with Friends. Testers were mostly unaware of the details of the feature, unlike what was mentioned in the interviews about a potential note-taking feature. A majority of the feedback that I received as a whole for the project was derived from this feature.

There seemed to be difficulty finding and using the toggle button for switching between learning with added friends and learning with the app's cast of characters. Some testers felt that the button blended in too much amongst the other elements; a suggestion was made by one tester to change the placement of the button by moving it to the top of the screen. This idea was echoed by another tester, who suggested that the design of the button didn't resemble a toggle and should be changed. In turn, this would allow users to better form the mental connection between the words "toggle button" and the button itself.

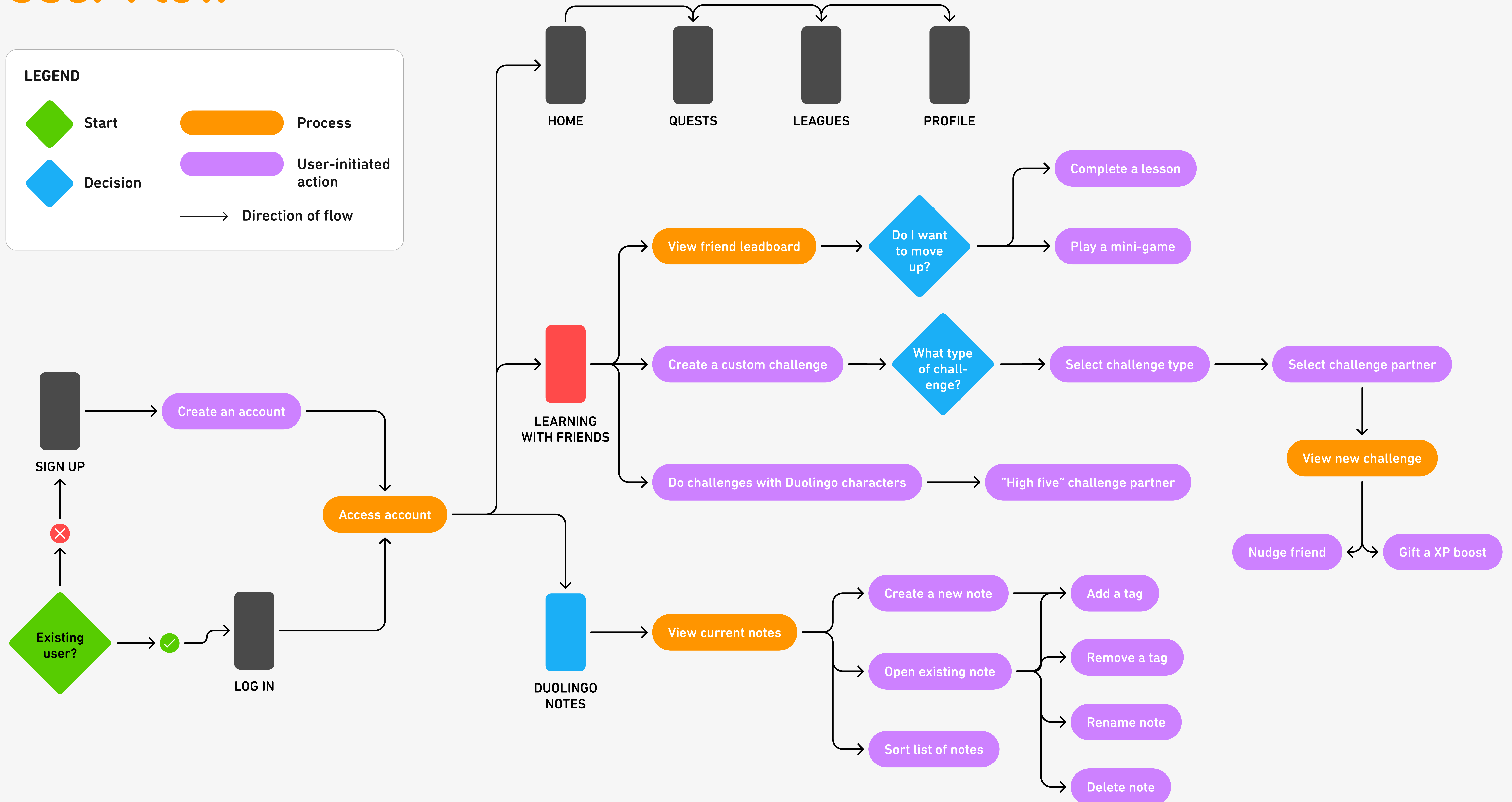
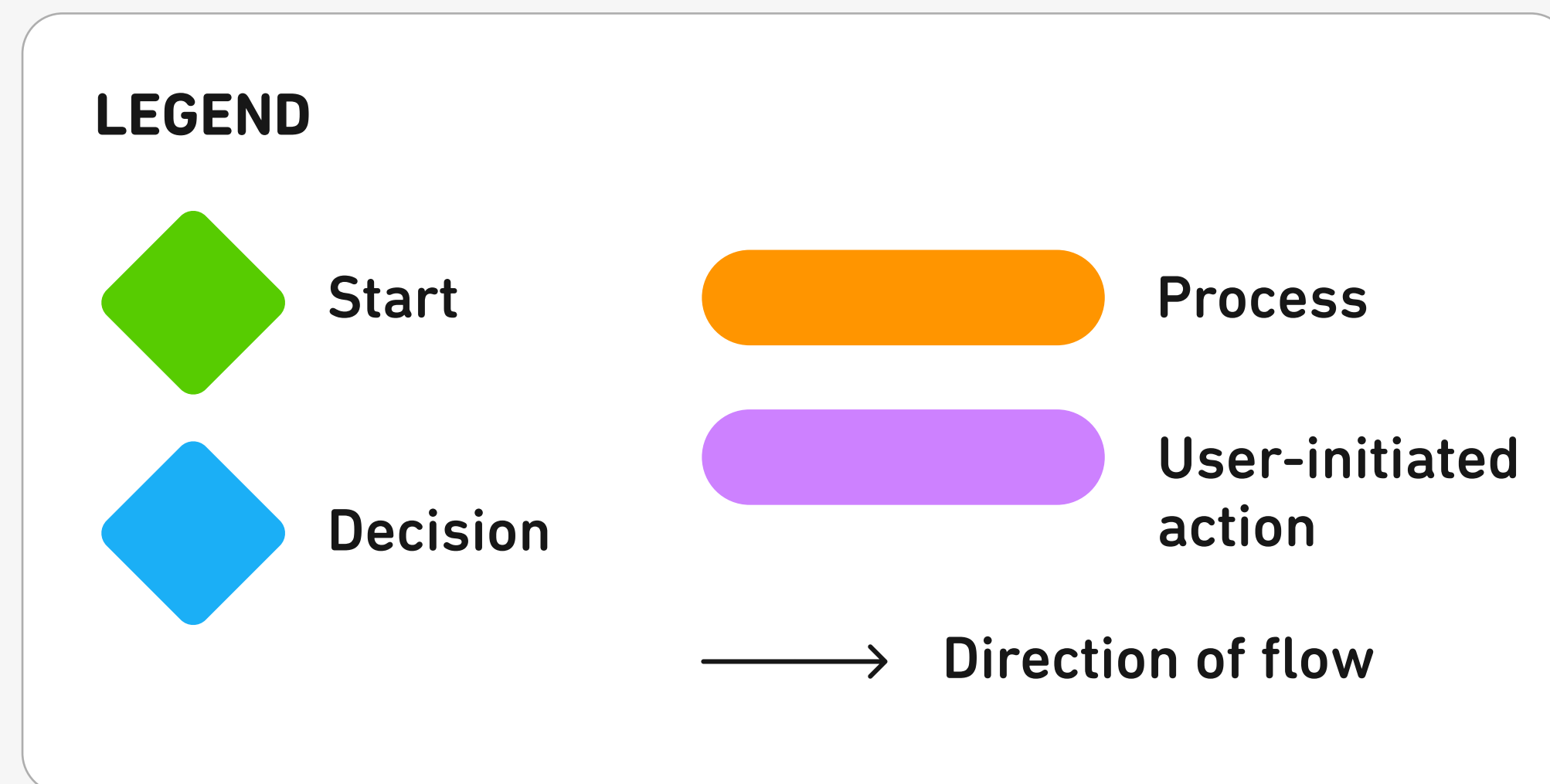


ABOVE: Original toggle design for switching between modes.



ABOVE: New toggle design, as suggested from user feedback.

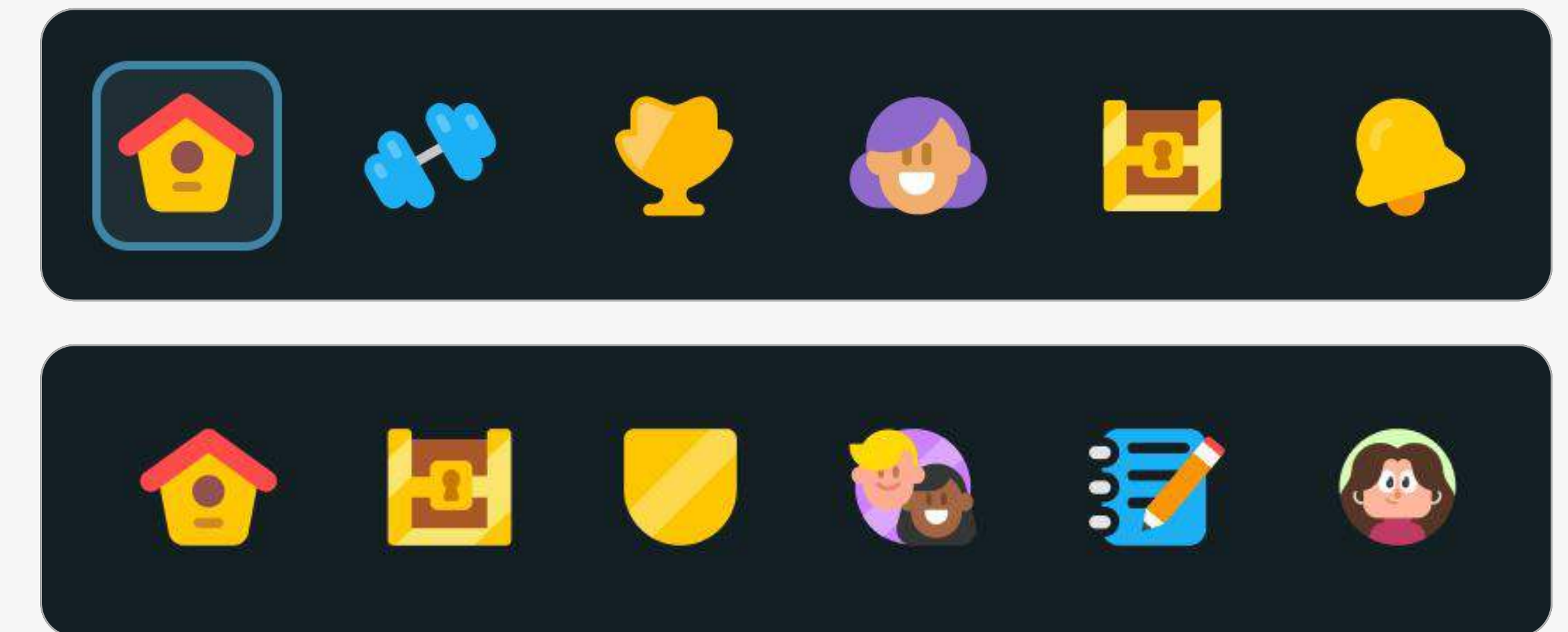
User Flow



Notes on Prototypes

NAVIGATION BAR

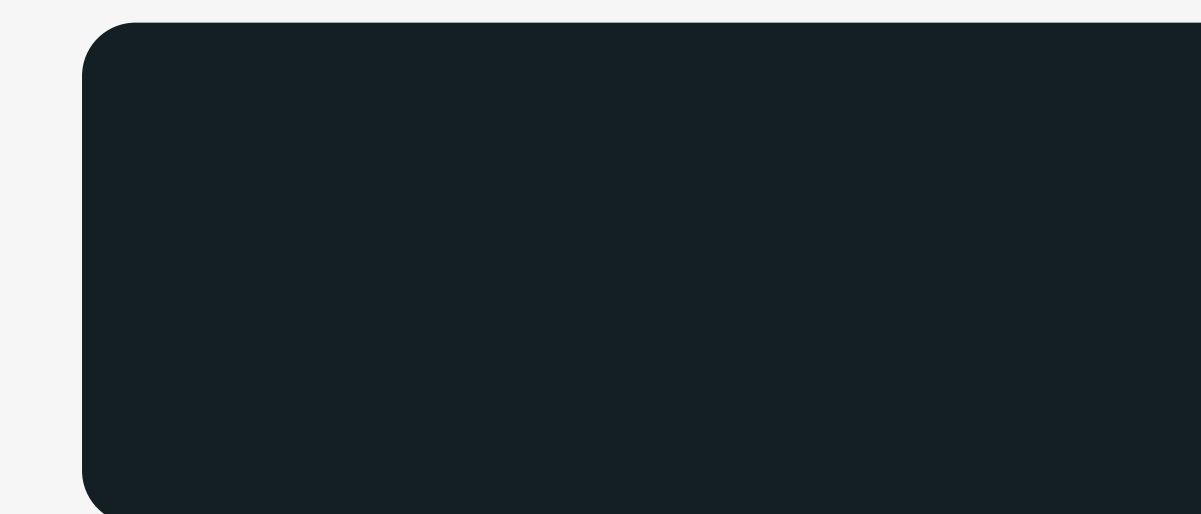
The design of the navigation bar was changed from the original Duolingo UI. The Super Duolingo icon was removed to make room for Duolingo Notes and Learning with Friends. The Profile icon was moved to the far right; this is where many social media apps tend to place the user profile in bottom bar navigations (ex. Instagram, Discord).



ABOVE: Original navigation UI vs. new UI in prototypes.

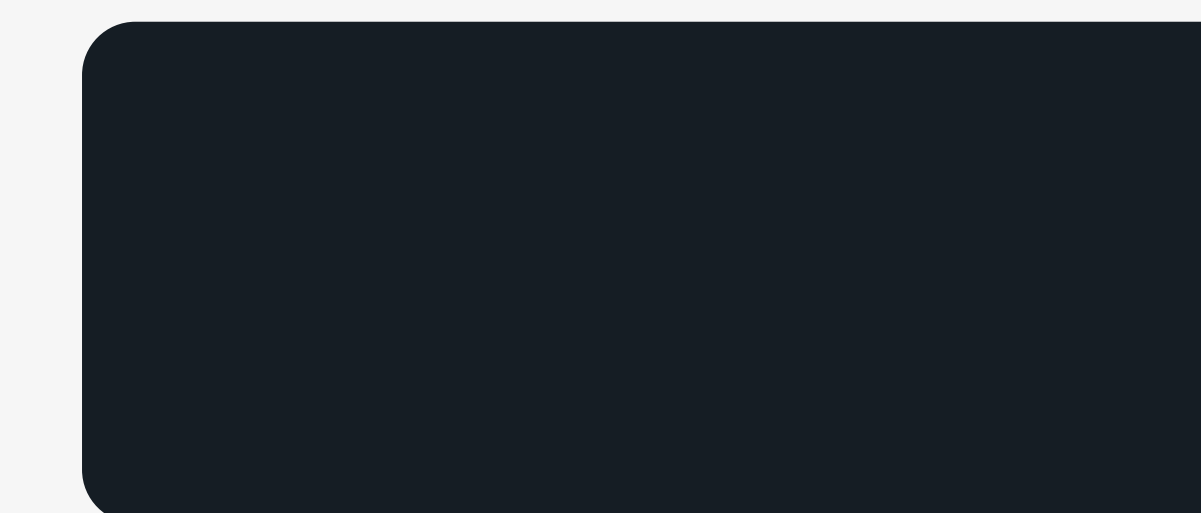
BACKGROUND COLOURS

When selecting the background colours from the reference screenshots, I noticed that there were two variations of the same colour that were used by Duolingo. However, the visual differences are barely noticeable upon first glance. To retain the originality of the existing UI, I used both colours in the way they were used on the app.



#141F23

Used as the primary background colour for most screens.



#151E25

Used as the background colour for pop-ups.

TYPING INPUT

For Duolingo Notes, I wanted to implement a plugin that would allow me to simulate typing, however all of the community-developed Figma plugins required the use of variable and conditional interactions — these are only available to users on the Figma paid plan. As a result, there is no typing input integrated.

Reflection →

Reflection

Overall, I was quite satisfied with the process of creating these concepts and working on the project as a whole. Taking on the task to analyze Duolingo and language learning was a challenge that broadened my knowledge not only about user experience design, but also about service design – I was tying in concepts taught from the Design Thinking for Services module, which I found to be really helpful in analyzing the system of MALL apps.

When I initially planned this project, I wanted to push for the high-fidelity stage while also ensuring that I was taking the time to really understand the design process from the perspective of a user. While I wasn't able to improve on the learning content itself, I felt that suggesting improvements to features outside of the lessons could still contribute to a more positive and engaging user experience.

The participants that shared their experiences saw potential in Duolingo to become a strong asset for language learning, but felt that the app still lacked a personalized touch for users to really customize their learning journeys. With the integrated notes system and more ways to learn with friends, the control would be placed back into the users' hands; this was ultimately my bigger goal: **to help learners grow a passion for learning languages in a way that is engaging, intuitive and fun.**



References

[1] Heil, Catherine Regina, Jason S. Wu, Joey J. Lee, and Torben Schmidt. "A review of mobile language learning applications: Trends, challenges, and opportunities." *The EuroCALL Review* 24, no. 2 (2016): 32-50.

[2] Bączkowska, Anna. "An overview of popular website platforms and mobile apps for language learning." In *Forum Filologiczne Ateneum*, no. 1 (2021): 9-35.

[3] Loewen, Shawn, Dustin Crowther, Daniel R. Isbell, Kathy Minhye Kim, Jeffrey Maloney, Zachary F. Miller, and Hima Rawal. "Mobile-assisted language learning: A Duolingo case study." *ReCALL* 31, no. 3 (2019): 293-311.

[4] Pikhart, Marcel. "Intelligent information processing for language education: The use of artificial intelligence in language learning apps." *Procedia Computer Science* 176 (2020): 1412-1419.

**Remember to do your daily Duolingo...
or Duo will hunt you down!**

