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Carolina Miguel Vidal Ferreira Baptista

Students' Experience within a Participatory Design Process: Redesigning the EduCITY App

Experiência de Alunos no âmbito de um Processo de Design Participativo: o Redesign da App EduCITY

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“Design is the courage to imagine something better - and the persistence to make it real.”

o júri

presidente	Prof. Doutor Luís Francisco Mendes Gabriel Pedro Professor Associado da Universidade de Aveiro
vogal – arguente principal	Prof.ª Doutora Andreia Pinto de Sousa Professora Auxiliar da Universidade Lusófona – Faculdade de Comunicação, Arquitetura, Artes e Tecnologias da Informação
vogal – orientador	Prof. Doutor Óscar Emanuel Chaves Mealha Professor Catedrático da Universidade de Aveiro

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palavras-chave

User experience (UX), Design Participativo (PD), *Design-Based Research* (DBR), Tecnologia Educativa, Prototipagem, *Mobile Learning*

resumo

O presente trabalho investiga de que forma técnicas de design participativo podem melhorar a perceção da experiência do utilizador (UX) por parte de alunos do 3.º ciclo ao utilizarem a aplicação EduCITY. Desenvolvida no âmbito de um projeto interdisciplinar da Universidade de Aveiro, a app EduCITY integra funcionalidades como georreferenciação, *quizzes* e realidade aumentada, promovendo atividades educativas em ambientes exteriores.

Procurando alinhar a aplicação com as expectativas e necessidades dos seus utilizadores finais, esta investigação procura responder à seguinte questão: *De que forma um processo de design participativo pode influenciar a perceção da experiência de utilização da app EduCITY por parte de alunos do 3.º ciclo?* Para tal, foi proposto um *redesign* da interface da app, baseado em metodologias centradas no utilizador e desenvolvido com o envolvimento de alunos, professores e especialistas em UX/UI ao longo do processo.

A metodologia adotada segue uma abordagem de *Design-Based Research*, estruturada em cinco etapas: análise exploratória, análise de expectativas e diagnóstico da app, desenvolvimento do protótipo, avaliação comparativa; e proposta de uma revisão da aplicação do modelo EduCITY enquanto app mobile. As técnicas de recolha de dados incluíram *focus groups* com estudantes, entrevistas semiestruturadas com professores e especialistas em UX/UI e testes comparativos entre app e protótipo com outros estudantes.

A amostra incluiu 13 alunos do 8.º ano, bem como dois professores e dois especialistas em UX/UI, selecionados através de amostragem por conveniência e intencional. O estudo decorreu entre fevereiro e maio de 2025, no Agrupamento de Escolas de Gafanha da Nazaré com todas as validações éticas e autorizações institucionais necessárias, nomeadamente da Direção do Agrupamento e do Ministério da Educação. Apesar de limitações como o número reduzido de participantes e os constrangimentos técnicos do protótipo, os resultados sugerem que a abordagem participativa contribuiu para uma experiência de utilização mais apelativa e intuitiva. Os estudantes classificaram consistentemente o protótipo como mais atrativo visualmente e mais fácil de utilizar do que a app, o que reforça a importância de envolver os utilizadores de forma significativa no design de tecnologias, mais concretamente, as educativas.

Em última análise, este estudo contribui para a melhoria da app EduCITY e para o campo mais vasto da tecnologia educativa, ao demonstrar o potencial de práticas de design colaborativas e centradas no utilizador na melhoria da perceção de experiências, por parte dos alunos. Adicionalmente, propõe uma revisão crítica dos pilares estruturantes do modelo subjacente ao projeto EduCITY, através da introdução de um novo pilar - *User-Centered* - que sublinha a relevância de integrar as perspetivas dos utilizadores em todas as fases de conceção, planeamento e desenvolvimento de tecnologias educativas.

keywords

User experience (UX), Participatory Design (PD), Design-Based Research (DBR), Educational Technology, Prototyping, Mobile Learning

abstract

This study investigates how participatory design techniques can enhance middle school students' perception of user experience when using the EduCITY app. Developed through an interdisciplinary project at the University of Aveiro, EduCITY integrates features such as geolocation, quizzes, and augmented reality to support location-based outdoor learning.

To address the need to align the app with user expectations and needs, this research seeks to answer the following question: *How can a participatory design process influence middle school students' perception of the user experience when using the EduCITY app?* To this end, a redesign of the app's interface was proposed, grounded in user-centered methodologies and involving students, teachers, and UX/UI experts throughout the process.

The methodology follows a Design-Based Research framework, structured into five key stages: exploratory analysis, expectation analysis and app diagnosis, prototype development, comparative evaluation, and a proposed revision of the application of the EduCITY model as a mobile app. Data collection techniques included focus groups with students, semi-structured interviews with teachers and UX/UI experts, and comparative tests between the app and prototype with other students.

The sample included 13 eighth-grade students, as well as teachers and UX/UI experts selected through convenience and purposive sampling. The study took place between February and May 2025 at the Gafanha da Nazaré School Cluster, with all the necessary ethical approvals and institutional authorizations, namely from the school cluster's Director, and the Portuguese Ministry of Education. Despite limitations such as the small number of participants and technical constraints of the prototype, results suggest that the participatory approach contributed to a more appealing and intuitive user experience. Students consistently rated the prototype as more visually attractive and easier to use than the app, reinforcing the importance of meaningfully involving users in the design of technologies, more specifically, educational ones.

Ultimately, this study contributes to the improvement of the EduCITY app and to the broader field of educational technology by demonstrating the potential of collaborative, user-centered design practices in enhancing students' perception of experiences. It also proposes a revision of the foundational pillars of the model underlying the EduCITY project, by introducing a new pillar - *User-Centered* - that reinforces the importance of integrating user perspectives into all phases of the conception, planning and development of educational technologies.

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Index

List of Figures

List of Tables

List of Symbols and Acronyms

AI – Artificial Intelligence

AR – Augmented Reality

GBL – Game-based learning

Hi-fi – High-fidelity

IQR – Interquartile range

LBG – Location-based games

Lo-fi – Low-fidelity

M3 – Material 3

MAR – Mobile Augmented Reality

PD – Participatory Design

SD - Standard Deviation

SLR – Systematic Literature Review

UCD – User-Centered Design

UEQ – User Experience Questionnaire

UI – User Interface

UK – United Kingdom

UX – User Experience

VD – Visual Design

XP – Experience Points

INTRODUCTION

In recent years, the integration of technology in education and its influence on learning outcomes and student engagement have gathered significant attention. Young students' wide exposure to technology has reshaped what they expect from educational experiences.

A systematic review by Akintayo et al. (2024) on learning outcomes in higher education indicates that, when implemented thoughtfully on teaching and learning processes, educational technologies can improve student engagement, academic performance and knowledge retention. Similarly, An et al. (2024) found that students' perception of technology's ease of use and usefulness significantly influence their learning and motivation. Another systematic review by Akram et al. (2022) suggests that teachers who perceive technology as having pedagogical value are more likely to create motivating learning environments for their students. Giving that teachers possess the theoretical knowledge related to the subjects taught in schools, they play a crucial role in fostering students' motivation to learn. Therefore, involving teachers alongside students in design and development of educational technology is essential. Considering this, following an approach that actively involves users - such as students and teachers - throughout the design process can result in solutions that are more aligned with their needs, expectations and contexts. By integrating user feedback early in the design process, educational tools can be better tailored to improve overall user experience (Shneiderman et al., 2016).

A project that leverages educational technologies to enhance learning is EduCITY, which also serves as the context for this research. Developed at the University of Aveiro, EduCITY promotes interdisciplinary learning through innovative strategies in outdoor contexts, with a strong focus on education for sustainability. It combines technology with mobile learning, leveraging Augmented Reality (AR) in urban settings, within a game-based learning approach (Marques & Pombo, 2023). Through its web-based platform, EduCITY empowers users - including its own team and community members - to create educational games without requiring programming skills. The platform also supports the integration of diverse multimedia content (e.g., images, video, audio, etc.). The EduCITY mobile app acts as a central hub, aggregating and displaying these games for users. Designed for students across all educational levels, as well as the wider community, each game is tailored to a specific educational level and route, defined by the game's creator, encouraging users to actively explore the city (Marques & Pombo, 2023).

With an educational purpose, the EduCITY app can be applied in several teaching contexts, such as non-formal and informal education. According to Coombs & Ahmed (1974), non-formal education refers to "any organized, systematic, educational activity carried on outside the framework of the formal system to provide selected types of learning to particular subgroups in the population, adults as well as children" (p. 8). Typically, such activities have well-defined goals and are often articulated with the work developed in class (Paixão & Jorge, 2014). Conversely, informal education is defined as "the lifelong process by which every person acquires and accumulates knowledge, skills, attitudes and insights from daily experiences and exposure to the environment ... Generally, [it] is unorganized and often unsystematic; yet it accounts for the great bulk of any person's total lifetime learning-including that of even a highly 'schooled' person" (Coombs & Ahmed, 1974, p. 3). Informal learning often arises as a byproduct of other activities, rather than through intentional educational efforts (M. Johnson & Majewska, 2022). It frequently involves tacit knowledge, as Eraut (2004) notes, being "largely invisible, because much of it is either taken for granted or not recognised as learning; thus,

respondents lack awareness of their own learning" (p. 249). Nevertheless, learners may sometimes become aware of such unintended learning outcomes (M. Johnson & Majewska, 2022).

Although the EduCITY app has predominantly been used within non-formal educational contexts - where students and their teachers engage in planned activities with a clear learning purpose, often alongside the EduCITY team, throughout the campus or city of Aveiro - it is important to highlight that the app is versatile and can also be adapted to other contexts, where no explicit learning goals have been predefined. In line with this, the present study does not have the purpose of assessing learning outcomes. Instead, it focuses on understanding how students perceive their user experience (UX) when interacting with the EduCITY app in outdoor, non-formal educational environments.

Considering that the EduCITY app was developed under significant time constraints, this may have limited the extent to which users' perspectives could be fully integrated into its design. The work reported in this dissertation, adopting a Participatory Design (PD) approach, which involves users throughout the design process, aims to evolve the EduCITY app into a more user-centered educational tool and holds considerable empirical potential for improving the app's user experience and better aligning it with the actual needs and expectations of its users.

The extent to which the PD approach relates to students' perception of an improved UX, particularly in outdoor educational contexts, remains unclear. The **goal** of the present study is to address this gap by investigating middle school students' perceptions of user experience through UX testing, comparing the current EduCITY app with a prototype of its redesigned version developed using a PD approach. Considering the study's purpose, the research will be guided by the following research question:

"How can a participatory design process influence middle school students' perception of the user experience when using the EduCITY app?".

Through the articulation of specific objectives, the study builds a coherent structure that will guide the development of a construct capable of addressing the research question. In line with the goal and research question outlined above, the study's specific objectives are as follows:

1. To conduct comparative UX testing between a redesigned prototype and the current app version, evaluating the user experience, particularly in outdoor educational contexts.

2. To improve the app's user experience and user interface design, based on the expectations of students, opinions of experts, and teachers.

3. To develop a high-fidelity prototype as a proposal for the EduCITY app, that reflects insights from expert reviews and end-users' perceptions.

4. To apply participatory research based on design methodologies related to the UX/UI improvement process, including focus groups with end-users, interviews with experts and teachers, and comparison of scenarios within the EduCITY app and its redesigned prototype version.

In terms of methodological approach, this study adopts a Design-Based Research (DBR) framework, which is particularly suited for investigating educational technologies in real-world settings. DBR is characterized by its iterative nature, aiming to develop effective interventions and contribute to theoretical knowledge. Within this approach, the previously mentioned PD approach plays a central role, engaging users — students, teachers, and experts — throughout the process to inform iterative improvements. Following a user-centered and collaborative process, the study proceeds through multiple stages: an exploratory analysis of expectations, app diagnosis, prototype development, comparative evaluation, and synthesis of findings.

At this point, it is also relevant to highlight that the researcher has participated as co-author and editorial designer of the book *Lessons Learned – EduCITY* (Pombo et al., 2025), a research output of the EduCITY project. Conceived as both a reflective narrative and an interactive experience, the book documents the project's key outputs while capturing its transformative vision and long-term commitment to digital, environmental, and social sustainability in education.

To facilitate a clearer understanding of the study, this dissertation is organized into six main chapters, in addition to the Introduction and Conclusions. The first chapter, Interaction Design Theories and Methods, establishes the theoretical background, addressing key principles of User-Centered Design, User Experience, User Interface, and Participatory Design. The second chapter, Mobile Apps in Educational Contexts, explores perspectives on mobile learning, the role of Augmented Reality in educational apps, and presents a benchmark of apps with a learning purpose. The third chapter, EduCITY, presents the EduCITY project and app, highlighting its pedagogical approach and potential for improvement. The fourth chapter, Methodology, outlines the study's design-based research approach, the research stages, participant profiles, and the data collection techniques and instruments employed. The fifth chapter, Data Processing and Analysis, discusses the empirical findings, structured into two main components: the analysis of user expectations and interface diagnosis, and the prototyping and comparative evaluation of the redesigned version. The sixth chapter, Insights and Key Contributions, revisits the methodology and the conceptual model of EduCITY in light of the study's outcomes, and synthesizes the main contributions and practical implications for similar educational technology projects. Finally, the Conclusions chapter summarizes the key insights from the study, identifies the study's limitations, reflects on the extent to which the initial objectives were achieved, proposes directions for future work, including the potential integration of insights into similar projects and offers a personal reflection on the challenges and growth experienced throughout the researcher's journey.

1. Interaction Design Theories and Methods

The theoretical framework of this dissertation aims to establish a comprehensive foundation for understanding the key concepts, and practices relevant to the research. By examining the intersection of user-centered design (UCD), user experience (UX) design and user interface (UI) design this section provides the context and justification for the proposed study.

The field of interaction design has evolved significantly, shifting from machine-centered approaches to broader frameworks such as user-centered or even people-centered design, which emphasize the holistic experiences of individuals interacting with technology (Giacobone et al., 2024). These frameworks are particularly relevant in educational settings, where digital tools must meet usability standards and enhance engagement, motivation, and learning outcomes (Cesário & Nisi, 2023).

This study also situates itself within the participatory design (PD) paradigm, which advocates for active user involvement throughout the design process. By integrating user feedback iteratively, PD ensures that products are aligned with users' needs and expectations. In the context of this study, this approach is applied to understand and improve the experience of use of the EduCITY app, particularly as perceived by middle school students in outdoor educational activities.

1.1. User-Centered Design

Don Norman, a prominent figure in the field of UX/UI design, advocates for a human-centered approach that considers users as individuals rather than mere consumers (D. Norman, 2014). This shift in perspective, where "The emphasis is on people, rather than the technology." (D. A. Norman & Draper, 1986) highlights the importance of ensuring that products are tailored to meet the needs of users. Aligning with Norman & Draper's view that products should adapt to users, not the other way around, Frank Chimero once said "People ignore design that ignores people". This statement underscores the importance of prioritizing human experience in design. This idea is further supported by Shneiderman et al. (2016, p. 137) in *Designing the User Interface: Strategies for Effective Human-Computer Interaction*, who discuss the failure of software development projects: "The result is often systems and interfaces that force the users to adapt and change their behavior to fit the interface rather than an interface that is customized to the needs of users".

Building on the idea of "users over technology", user-centered design (UCD) applies these principles by placing users' needs, preferences, limitations and feedback at the core of the design process (Lowdermilk, 2013; Shneiderman et al., 2016). It is an iterative design process that actively involves users through various research and design methods – like surveys or interviews – to develop frustration-free usable and accessible products (Interaction Design Foundation - IxDF, 2016c). Garrett (2010, p. 17) reinforces the importance of user involvement in his book *The Elements of User Experience: User-Centered Design for the Web and Beyond*: "The concept of user-centered design is very simple: Take the user into account every step of the way as you develop your product". By incorporating users in the process, design teams' assumptions are constantly being challenged regarding users' real behaviors and actual needs (Shneiderman et al., 2016). This aligns with Lowdermilk's (2013, p. 7) perspective as he argues that "The user-centered design process works against subjective assumptions about user behavior. It requires proof that your design decisions are effective. If user-centered design is done correctly, your application becomes an outcome of actively

engaging users. Therefore, any design decisions that were made by observing and listening to them will not be based on whims or personal preferences."

The UCD approach typically follows four main stages (Interaction Design Foundation - IxDF, 2016c), depicted in Figure 1.

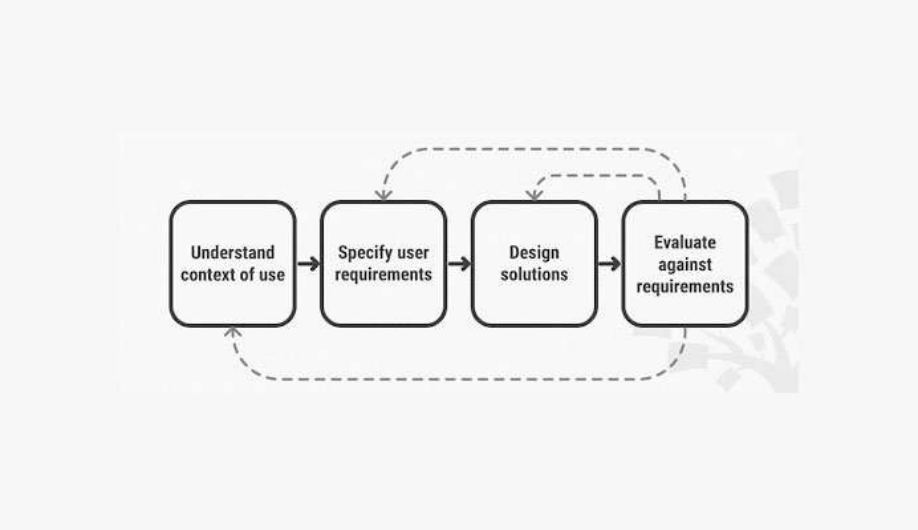


Figure 1 - Stages of a User-Centered Design Process (Interaction Design Foundation - IxDF, 2016c).

The four main stages are described below:

1. **Understand and Specify the Context of Use:** designers should begin by gaining a clear understanding of the context in which users will interact with the system. This includes identifying who the users are, understanding their interests, and needs. "The problem definition for the product design will come from this deep understanding of the goals the people are trying to accomplish and the impediments they experience." (D. Norman, 2014, p. 222).

2. **Specify User Requirements:** at this stage, the focus is on identifying and defining the key needs and expectations of users to ensure that the product aligns with their requirements, is usable, understandable and enjoyable (D. Norman, 2014; Raghavan, 2022).

3. **Design Solutions:** this is where ideas and potential solutions are generated, tested and iteratively refined based on the user requirements gathered in the previous stage. It is especially important for designers to involve users throughout this process to ensure the product is continuously adjusted to meet user needs and expectations (Raghavan, 2022).

4. **Evaluate and Refine:** at this stage, designers evaluate how well the product aligns with user needs and the intended context of use defined earlier in the process (Interaction Design Foundation - IxDF, 2016c). By involving end-users in the evaluation process, ideally in conditions as close to the actual context of use, designers can gain valuable insights into how people really interact with the product and make any necessary adjustments to make it more user-friendly (D. Norman, 2014; Raghavan, 2022). In *The*

Design of Everyday Things, D. Norman (2014) emphasizes the importance of observing users during testing without interfering; instead, it is preferable to question them only after the test is complete.

Involving users throughout the process is crucial to UCD. Although initially it can take more time, money and effort from teams, addressing UCD considerations early in the development stages can ultimately reduce both time and costs, as it leads to technology with lower maintenance expenses over its lifetime (Shneiderman et al., 2016). UCD is advantageous as user feedback helps identify strengths and weaknesses in the design that might otherwise go unnoticed. By actively engaging users, designers can uncover critical aspects related, for example, to the product's **usability**, ensuring these factors are integrated from the beginning, rather than being treated as secondary concerns (Interaction Design Foundation - IxDF, 2016c).

The International Organization for Standardization (ISO) (2019) defines "usability" as the "extent to which a system, product or service can be used by specified users to achieve specified goals with **effectiveness, efficiency and satisfaction** in a specified context of use". This definition points out three aspects related to usability: effectiveness, which refers to the accuracy and completeness with which users achieve their intended goals; efficiency, which relates to the resources expended - such as time, effort, and cognitive load - in completing tasks; and satisfaction, which reflects users' subjective perceptions of comfort, acceptability, and overall experience when interacting with the system (Nielsen, 1993). Considered one of the world's leading experts on web usability, Nielsen (1993, p. 25) defined it in *Usability Engineering* as "how well users can use a functionality". He also identified five usability attributes:

1. **Learnability:** systems need to be easy, quick, and simple for novice users to learn.

2. **Efficiency:** once users have learned how to use the system (becoming expert users), they should be able to perform tasks quickly and productively.

3. **Memorability:** even after a period of non-use, users should be able to recall how to interact with the system, based on their previous learning. Nielsen notes that "(...) improvements in learnability (the first attribute) often also make an interface easy to remember (...)" (Nielsen, 1993, p. 31).

4. **Errors:** errors are "any action that does not accomplish the desired goal (...)" Nielsen, p. (1993, p. 32). They are related to the use of the system and should be minimized as much as possible. However, when they do occur, users should be able to easily recover from them.

5. **(Subjective) Satisfaction:** this attribute refers to how pleasant the system is to use, which is particularly important for nonwork-related systems, such as games. Nielsen also discusses measuring subjective satisfaction through questionnaires, where users score the system using Likert scales (1-5 or 1-7). He adds that "If subjective satisfaction ratings are available for several (...) different versions of the same system, it is possible to consider the ratings in relation to the others and thus to determine which system is the most pleasant to use." (Nielsen, 1993, p. 37).

Some usability attributes may need to be compromised in favor of others; it is not always possible to achieve maximum scores on all simultaneously (Nielsen, 1993). For example, an interface might be made less efficient to prevent users from making critical errors, such as requiring confirmation before executing a delete command. Nielsen also published a list of *10 Usability Heuristics for User Interface Design*. These heuristics still apply today, and they are:

1. **Visibility of System Status:** the interface should consistently provide users with clear and frequent feedback on what is happening. Keeping users informed about the system's status helps them understand and learn the results of their actions and decide on their next steps. A transparent and predictable system fosters trust in both the product and the brand (Nielsen, 1994b).

2. **Match Between the System and the Real World:** the design should present information and interactions that align with users' prior knowledge and everyday experiences. This means using words, symbols, and concepts that are familiar to them, rather than technical jargon or abstract concepts. For example, when designing for middle school students, it is essential to consider their level of experience with digital interfaces and their understanding of specific terms or visual elements. What may seem intuitive to adults or experienced users might not be immediately clear to younger students. Ensuring that terminology, icons, and images reflect their expectations can make the system more accessible and engaging (Nielsen, 1994b).

3. **User Control and Freedom:** users should have the ability to easily undo actions or exit unintended processes without unnecessary effort. Providing clear ways to reverse mistakes (like *Cancel*, *Undo* and *Redo* buttons) enhances their sense of control and confidence, preventing frustration and ensuring a smoother interaction with the system (Nielsen, 1994b).

4. **Consistency and Standards:** the system should use consistent terminology, design patterns, and behaviors to avoid confusion. The same word needs to have the same meaning, always. Following industry standards helps users rely on previous experience, reducing cognitive load. Since users interact with many digital products, aligning with their expectations makes navigation more intuitive and efficient (Nielsen, 1994b).

5. **Error Prevention:** while clear error messages are important, the best designs focus on preventing these errors from happening in the first place. This can be achieved by eliminating error-prone situations or providing users with confirmation options before they proceed with critical actions, like submitting something. Errors can be categorized into two types: slips, unconscious errors which occur due to inattention or oversight; and mistakes, conscious errors that result from a mismatch between the user's expectations and the system's design (Nielsen, 1994b).

6. **Recognition Rather than Recall:** to make the interface easier to use, elements, actions, and options should be clearly visible. Users should not need to remember information from different parts of the interface. Essential information, such as field labels or menu options, should be visible or easily accessible when needed. Since humans have limited

short-term memory, interfaces that support *recognition rather than recall* minimize cognitive effort, making the experience more intuitive (Nielsen, 1994b).

7. **Flexibility and Efficiency of Use:** to accommodate both novice and expert users, the design can include shortcuts (accelerators) that are hidden from beginners but can speed up interactions for more experienced users. Flexible processes should provide different ways to complete tasks, enabling users to choose the method that suits them best (Nielsen, 1994b).

8. **Aesthetic and Minimalist Design:** Interfaces should avoid including information that is irrelevant. Each additional piece of information in the interface competes with the more relevant elements, reducing their relative visibility. This heuristic doesn't suggest adopting a minimalist design but rather emphasizes keeping the content and visual design (VD) focused on what is essential. It's important to ensure that the visual elements of the interface support the user's main goals (Nielsen, 1994b).

9. **Help Users Recognize, Diagnose, and Recover from Errors:** Error messages should be written in simple, clear language (avoiding errors in the form of code like *404 Error*). It is important to clearly describe the issue and offer helpful guidance on how to fix it. Additionally, these messages should be displayed with visual cues that make it easy for users to notice and identify them through elements like color or size.

10. **Help and Documentation:** Ideally, the system should be intuitive enough to require no further explanation. However, in some cases, providing documentation might be necessary to assist users in completing their tasks. Help and documentation should be easy to find and navigate and focused on user goals. It should be concise, outlining clear steps to follow.

Usability heuristics are essential guidelines that aid designers in creating effective and user-friendly products. They serve as a theoretical foundation for assessing design quality and can be particularly beneficial in educational contexts, as their application helps ensure that educational apps are not only functional but also engaging to learners (Garcia, 2020; Labrie & Cheng, 2020). Marques & Pombo (2023) underscore the importance of usability in mobile apps to ensure that educational content is accessible and engaging for learners. Likewise, TAŞ & YAVUZ (2023) demonstrated that well-designed mobile apps can significantly improve learner interaction and access to resources, both of which are vital for effective learning experiences. Dirin & Laine (2018) explored the user experience in Mobile Augmented Reality (MAR) apps, focusing on the emotional responses and challenges faced by users when interacting with these technologies. The study reveals that users' overall impressions of AR apps are significantly shaped by usability attributes. However, it is important to critically reflect on the limitations of design heuristics, particularly in dynamic and rapidly evolving contexts such as educational technology.

While heuristics provide valuable guidance, they may not account for the complexities and unique challenges presented by different learning environments and user demographics (Suryani et al., 2023). The reliance on heuristics can sometimes lead to oversimplification, potentially overlooking nuanced user needs and preferences that are critical for effective learning experiences (Miya & Govender, 2022).

Usability heuristics may offer a structured approach to enhancing usability and overall UX, but it is essential to remain aware of their limitations and to complement heuristic evaluations with user-centered research and iterative design practices (Miya & Govender, 2022). Such a balanced approach, as promoted by UCD, can help ensure that educational technologies are not only usable but also genuinely effective in meeting the diverse expectations and needs of users.

UCD encourages close collaboration between designers and users, which fosters empathy - a crucial element in designing ethical and respectful digital experiences (Interaction Design Foundation - IxDF, 2016c). Ultimately, it promotes the development of systems that are more intuitive, efficient, and tailored to actual user needs, helping to avoid the creation of solutions that fail to meet user expectations (Shneiderman et al., 2016).

These are core concerns of UX, which goes beyond usability to also encompass users' emotional responses, expectations, and the broader context of interaction. For this reason, the next subchapter takes a closer look at the concept of UX.

1.2. User Experience

The International Organization for Standardization (ISO) defines UX as the "user's perceptions and responses that result from the use and/or anticipated use of a system, product or service" (International Organization for Standardization (ISO), 2019, Section 3). This means that for there to be an experience, there needs to be a user – that is, a human. According to Garrett (2010, p. 6), "(...) every product that is used by someone creates a user experience (...)", meaning that UX refers to the user's overall real-world experience when interacting with a product, including their perceptions, emotions and responses during the interaction process.

User experience focuses on how users feel about a product (Rebelo et al., 2012). While designers can influence the way a product works and looks, for the experience to be as intuitive and seamless as possible, the user's subjective experience and feels while using that product remain personal (Interaction Design Foundation - IxDF, 2016a). Don Norman, the inventor of the term "User Experience", and Jakob Nielsen emphasize that "The first requirement for an exemplary user experience is to meet the exact needs of the customer, without fuss or bother. Next comes simplicity and elegance that produce products that are a joy to own, a joy to use. True user experience goes far beyond giving customers what they say they want, or providing checklist features. In order to achieve high-quality user experience in a company's offerings there must be a seamless merging of the services of multiple disciplines, including engineering, marketing, graphical and industrial design, and interface design." (D. Norman & Nielsen, 1998, para 1).

In the book *Human-Computer Interaction: Fundamentals and Practice*, G. J. Kim (2015) describes UX as a concept that extends beyond functionality, usability and aesthetics, becoming an integral part of users' daily lives and even shaping new ways of interacting with technology. This shows how important it is for designers to always keep in mind the users' needs and goals. In the context of digital products, this means translating complex, technology-driven concepts into easy, intuitive, and enjoyable experiences (Cooper et al., 2014).

One crucial aspect of delivering a seamless and enjoyable user experience is how information is conveyed to the user. As D. Norman (2014) explains in *The Design of Everyday Things*, users need to

quickly understand how a product works: what it does, how to interact with it, and what operations are possible. This process, referred to as discoverability, is supported by the appropriate application of five core design principles: affordances, signifiers, constraints, mappings, and feedback. There are three that are particularly important to mention in this subchapter, those being *affordances, signifiers*, and *feedback*. A sixth principle, *the conceptual model*, is even more important, as it determines how users build mental models to make sense of the product.

Affordances define what actions are possible based on the relationship between the user and the object. However, D. Norman, p. (2014, p. xv) later clarified that affordances, while useful in physical contexts, can be misleading in digital interfaces. In his revised edition, he writes: "Affordances make sense for interaction with physical objects, but they are confusing when dealing with virtual ones. (...) Affordances define what actions are possible. Signifiers specify how people discover those possibilities: signifiers are signs, perceptible signals of what can be done. Signifiers are of far more importance to designers than are affordances."

Signifiers, therefore, are the perceivable cues that communicate where actions should occur and how they should be performed. They are essential for usability, as they guide users intuitively through the interface. A signifier can take the form of a word, an icon, a sound, or a graphical illustration - any signal that effectively communicates functionality.

Feedback, on the other hand, refers to the system's response to user actions. It must be immediate and clear, as delays or vague responses can create confusion and lead users to abandon the task.

These three principles are tightly connected to what Norman defines as the *system image* – a concept to refer to all the information available to users that helps them form conceptual models – the sixth principle - to achieve their goals and understand the devices they interact with. The designer's and user's conceptual models both come into play in this user-system interaction model, illustrated in Figure 2.

Figure 2 - The Designer's Model, the User's Model, and the System Image (D. Norman, 2014, p. 32).

The three elements represented in the model are briefly described below:

- The **designer's conceptual model** represents how the designer envisions the product.
- The **user's conceptual model** is shaped by the system image, direct interaction with the product, and searching about it (external information).
- The **system image** encompasses the way the system presents itself to the user, including its interface, documentation, and feedback mechanisms.

Considering that the *system image* is the only source of information that is available to the user regarding its functioning, if it does not accurately convey the designer's conceptual model, users may struggle to understand how the system works, leading to frustration and ultimate abandonment of the product (Norman, 2014). This aligns with Hassenzahl's (2003) perspective, which suggests that when users encounter a product, they first build a perceived product character – a personal interpretation of what the designer intended. This perception is then assessed in light of the current context, leading to judgements about the product's appeal, and potentially triggering emotional and behavioral responses from users (Hassenzahl, 2003). Thus, designers must ensure that the *system image* accurately reflects both the product's intended functionality and user expectations, fostering a positive user experience (Cooper et al., 2014).

Building on the idea that UX is a multi-layered construct, several models have been developed to help designers conceptualize and evaluate the many dimensions involved in creating meaningful experiences. One such model is the UX Honeycomb (illustrated in Figure 3), by Morville (2004), which defines seven facets of UX design that contribute to a meaningful and effective user experience: useful, usable, desirable, findable, accessible, credible, and valuable.

Figure 3 – Morville's User Experience Honeycomb (Morville, 2004).

Below is a breakdown of each facet:

- **Useful:** this facet is about having the courage and creativity to question whether the product or its features are useful and valuable to users, with the goal of creating innovative solutions (Morville, 2004). If a product isn't useful, it serves no purpose (UXPin, 2024).

- **Usable:** usability is significant in shaping the user experience: "A product might be useful, but if it frustrates users, then it isn't usable." (UXPin, 2024, Section 3). Designers should develop clear and intuitive UIs to ensure users can easily navigate the interface and complete tasks.

- **Desirable:** this facet focuses on aesthetics and desirability, emphasizing the importance of layouts, VD and other UI elements, such as image, identity, brand and other emotional design elements - that engage users (Morville, 2004; UXPin, 2024).

- **Findable:** this facet emphasizes the importance of making content and features that are easy for users to find, according to their needs, but also the business' goals (UXPin, 2024). For example, designers must decide which key features should be directly accessible from the main navigation, and which can be placed within secondary menus to maintain a clean and intuitive interface.

- **Accessible:** Morville (2004) points out that more than 10% of the population has some sort of disability. Digital products should be designed to accommodate these users, ensuring accessibility regardless of physical, cognitive, or sensory limitations—whether permanent, situational, or environmental (UXPin, 2024). For example, subtitles are essential for individuals with hearing impairments, but they can also benefit users in noisy environments.

- **Credible:** it is essential that products convey a sense of trust and credibility to their users, meaning that they meet users' expectations and do not mislead (Morville, 2004; UXPin, 2024). For example, a product that allows users to easily downgrade or cancel a paid subscription reinforces trust, increasing the likelihood of future engagement.

- **Valuable:** digital products must deliver value – whether it be monetary, time-saving, helping to transmit the brand identity or improve customer satisfaction (Morville, 2004). "Understanding users and delivering services that satisfy their wants and needs makes a product valuable." (UXPin, 2024, Section 3).

The UX Honeycomb serves as more than just a conceptual framework; it is a practical tool for prioritizing design decisions. The honeycomb helps teams go beyond usability by prompting discussions about priorities (Morville, 2004). The facets should all be considered, but the ones that are more important depend on the context, content, and users of the product.

The UX Honeycomb is particularly valuable for evaluating existing products and design teams can use it in several scenarios (UXPin, 2024):

- **Erasing design debt**: While some usability issues are easy to fix, others require a structured approach to uncover the root cause. The UX Honeycomb allows designers to examine problems from multiple perspectives (Morville, 2004).

- **UX checklist**: The framework serves as a foundational UX checklist during design evaluations.

- **Redesigns:** Before a redesign, the UX Honeycomb helps identify experience flaws in an existing product, ensuring improvements address core usability and UX concerns.

By applying this framework strategically, designers can make informed decisions that enhance UX, ensuring products are not only functional but also engaging, accessible, and valuable to their audience.

1.3. User Interface

User Interface (UI), despite being a part of UX, is more concerned with the look and overall feel of the interface (Interaction Design Foundation - IxDF, 2016b). It is about delivering intuitive and pleasurable experiences that fulfill users' needs in the most seamless way: it focuses on the design of the visual and interactive elements of a product, such as buttons, icons, and layouts, aiming to create an aesthetically pleasing, functional and easy to use interface that facilitates user interaction and task completion (Interaction Design Foundation - IxDF, 2016b). Shneiderman et al. (2016) listed eight "Golden Rules of Interface Design" for interactive systems in the book *Designing the User Interface: Strategies for Effective Human-Computer Interaction*, those being:

1. **Strive for consistency**: "Consistent sequences of actions should be required in similar situations;" (Shneiderman et al., 2016). Designers should use familiar terminology, icons, colors, menu hierarchy, and user flows when designing similar situations (Shneiderman et al., 2016; Wong, 2025). There are exceptions to this rule when it comes to critical commands, like a confirmation of the delete command; however, they should be limited (Shneiderman et al., 2016).

2. **Seek universal usability**: users may have different levels of expertise, ages and disabilities, and the interface should accommodate all of them. Considering diverse user profiles - such as providing tutorials for beginners and shortcuts for experts - enhances interface design and improves its perceived quality (Shneiderman et al., 2016).

3. **Offer informative feedback**: this rule emphasizes letting users always know where they are and what is happening within the interface. Every user action should trigger clear and understandable feedback (Shneiderman et al., 2016; Wong, 2025). Wong (2025) illustrates this principle with the example of a multi-page questionnaire, where users should always be able to know in which page or section, they're in. Conversely, this

principle isn't being applied when users receive an error message in the form of a code instead of a human-readable explanation.

4. **Design dialogs to yield closure**: Interfaces should structure user actions into clear sequences with a beginning, middle, and end. Providing informative feedback at the completion of a task reinforces a sense of accomplishment and helps users mentally transition to the next step (Shneiderman et al., 2016). For example, e-commerce platforms implement this principle by displaying confirmation pages and receipts after a purchase, ensuring users know their transaction was successful (Wong, 2025).

5. **Prevent errors**: interfaces should be designed to minimize the possibility of users making errors (Shneiderman et al., 2016). However, when errors do occur, the system should provide a clear, intuitive and step-by-step way to help users recover quickly and painlessly from it (Wong, 2025).

6. **Permit easy reversal of actions**: allow users obvious ways to easily reverse their actions. As Shneiderman et al. (2016) state: "This feature relieves anxiety, since users know that errors can be undone, and encourages exploration of unfamiliar options."

7. **Keep users in control**: giving users a sense of control over the interface, allowing them to feel in charge of the system (Shneiderman et al., 2016). Designers can earn users' trust by ensuring the system behaves as they expect (Wong, 2025).

8. **Reduce short term memory load**: interfaces should be simple, considering that human attention and memory is limited (Shneiderman et al., 2016; Wong, 2025). Designers should prioritize recognition over recall, as "Recognizing something is always easier than recall because recognition involves perceiving cues that help us reach into our vast memory and allowing relevant information to surface." (Wong, 2025).

Shneiderman's eight "Golden Rules" help designers make users' lives a little bit easier by providing them intuitive and usable UIs. A lot of previously mentioned elements, such as color, layout and typography - are related to VD, a big part of UI. VD makes use of images, typography, space, layout and color to highlight important elements and enhance UX (K. Gordon, 2020; Interaction Design Foundation - IxDF, 2016d).

As previously mentioned, the way VD is applied highly depends on the product, the industry, and the target users, including their characteristics and culture (Interaction Design Foundation - IxDF, 2016d). For example, a learning app designed for young children should differ greatly from one designed for older adults in aspects like color, size and spacing, considering the different needs and challenges of each audience.

Through an article published on Nielsen Norman Group, K. Gordon (2020) lists five VD principles (illustrated in Figure 4) that inform how design elements - like lines, shapes, color, grids or space - can go together to increase a product's usability and engagement, with an impact on UX.

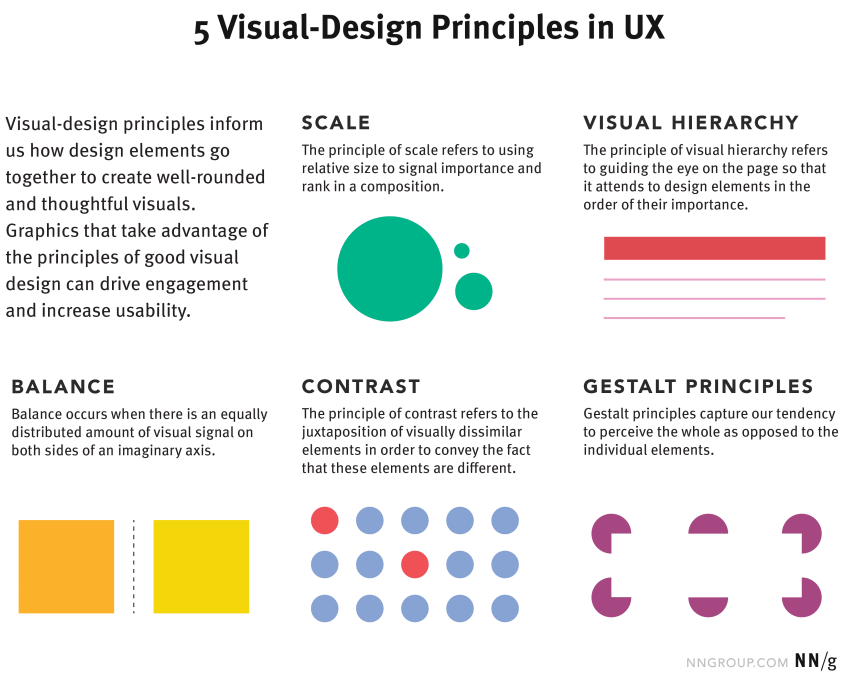


Figure 4 - 5 Visual-Design Principles in UX (K. Gordon, 2020).

Those visual-design principles are:

1. **Scale:** using relative size to emphasize elements and establish importance (Poulin, 2018). This means that elements that are big should be more important than small ones; this is because something bigger is more easily noticed. The layout benefits from having different sized elements because this adds variety and establishes visual hierarchy (K. Gordon, 2020).

2. **Visual Hierarchy:** making sure that the user scans the design elements in the right order by guiding the eye through the layout. A layout that has a good visual hierarchy is easily understood by users. Designers can make use of color, spacing, scale and placement to obtain this hierarchy (Lupton & Phillips, 2015). For example, using different font sizes or an accent color on a layout can also help users distinguish the importance of elements.

3. **Balance:** distributing elements evenly, through arrangement or proportions, to make the design satisfying. Balance is obtained when visual elements are equally – not necessarily symmetrically – distributed on both sides of an imaginary - vertical or horizontal - axis splitting the screen (Lupton & Phillips, 2015). K. Gordon (2020) notes that different types of balance convey different meanings:

    - Symmetrical: elements are symmetrically distributed on either side of the central axis, creating a sense of stability and calm.

    - Asymmetrical: elements are asymmetrically distributed relative to the central axis, giving a sense of movement and energy to the composition.

    - Radial: elements are distributed in a circular direction, radiating out from a central point, naturally drawing the eye to the center. This is how elements are distributed in a classic watch.

4. **Contrast:** intentionally using visually different elements - like color or size - to let the users know they are in fact different (e.g., indicating different behaviors or functions). This principle is often applied through color due to its symbolic meaning (Poulin, 2018). For instance, when users attempt to delete something, a confirmation pop-up may appear. Typically, the deletion confirmation button is red, signaling danger and making it stand out from the other elements in the interface because of its high contrast in relation to the surrounding layout. Additionally, something that designers need to be very conscious about is the contrast between text and background, often overlooked. When text contrast is low, legibility can be severely compromised, making the content unreadable and inaccessible (K. Gordon, 2020).

5. **Gestalt Principles:** a set of principles established by Gestalt psychologists of how people perceive and simplify complex images by subconsciously arranging the parts into a whole, instead of interpreting them as individual elements (Lupton & Phillips, 2015). Gestalt principles include similarity, continuation, closure, proximity, common region, figure/ground, and symmetry and order. K. Gordon (2020) emphasizes the significance of the proximity principle in UX, as elements place together are perceived as belonging to the same group.

The Interaction Design Foundation - IxDF (2016d) identifies two other VD principles that help direct users' attention to key elements in an interface:

1. **Unity:** used to ensure harmony among elements, preventing distractions caused by disorganized or misaligned layouts.

2. **Dominance:** emphasizing specific elements through attributes like size or color, making them stand out from the rest.

VD principles go beyond making an interface aesthetically pleasing. By understanding and applying them, designers can:

- **Enhance usability:** Thoughtful VD contributes to intuitive and easy to use layouts (K. Gordon, 2020).

- **Evoke positive emotions:** visually appealing interfaces can enhance user experience by making interactions more enjoyable. The aesthetic-usability effect suggests that users may overlook minor usability flaws if a design is visually engaging. By following VD principles, designers can create UIs that look good, making users feel good. And as previously mentioned, when an experience is positive, users tend to come back (Garrett, 2010).

- **Reinforce brand identity:** a cohesive visual system strengthens brand perception, builds trust, and makes a product more recognizable and appealing to users.

Understanding how UI contributes to a positive UX is crucial, as it enables the creation of products that are not only visually appealing to the intended users but also user-friendly. This is essential for designing products that meet user needs while delivering "an experience that is cohesive,

intuitive, and maybe even pleasurable - an experience in which everything works the way it should." (Garrett, 2010, p. 17). While traditional design paradigms consider user needs in limited or indirect ways, some methodologies advocate for a more direct user involvement and iteration throughout the design process, with proponents arguing that these factors are critical to product success and overall good design (Robertson & Simonsen, 2012; Schuler & Namioka, 1993).

Participatory Design is one such approach.

1.4. Participatory Design

Participatory Design (PD) is an approach that fosters collaboration between designers and "the people destined to use the system" (Schuler & Namioka, 1993, p. xi), with the aim of ensuring that the final product is aligned with users' needs (Interaction Design Foundation - IxDF, 2023).

As this study draws upon participatory principles, it was considered important to identify how PD has been applied in recent mobile learning initiatives. To this end, a Systematic Literature Review (SLR) started to be carried out in Stage 1 (Literature Review) of this study, which enabled the identification of approaches, tools, and participatory techniques relevant to the context of this study. Several of the references discussed in this section emerged from that review, including studies by Cesário & Nisi (2023), Di Fuccio et al. (2024), Garcia (2020), Giacobone et al. (2024), Howard et al. (2022), Koutsabasis et al. (2022), Mackay et al. (2024), Malamsha et al. (2021), Mosbak & Bjorner (2022), O'Connor et al. (2023), and Reiersølmoen et al. (2018). A more detailed explanation of how the selection process for the SLR occurred can be found in the subchapter "Research Stages".

The origins of PD date back to Europe in the 1970s - a period of significant transformation in workplaces due to the introduction of computers - and are closely linked to the Scandinavian workplace democracy movement (Muller & Kuhn, 1993; Robertson & Simonsen, 2012). At that time, PD researchers came together "not just to question existing approaches to the computerization of the workplace, but most importantly, to create visions of different kinds of future workplaces and practices and to design the new computer-based systems that would shape them" (Robertson & Simonsen, 2012, p. 2).

By placing a strong emphasis on collaboration and co-creation, PD actively involves users in the design process, fostering deeper user engagement and ownership over the design process (Schuler & Namioka, 1993) This participatory involvement contributes to outcomes that more accurately reflect users' real needs. PD is inherently iterative, involving continuous cycles of refinement based on user feedback. These iterations are not limited to the development of new technologies - they can also include the evaluation and improvement of products that have already been in use (Robertson & Simonsen, 2012). This adaptability helps ensure that the design increasingly aligns with users' expectations and real-world experiences (Giacobone et al., 2024). PD projects are guided by a structured reflection of how users can be meaningfully engaged as equal partners in the design process, as well as how their participation can evolve over time (Giacobone et al., 2024; Robertson & Simonsen, 2012; Trischler et al., 2019). Considering this, PD involves fostering ongoing processes of shared learning, where all participants - both users and designers - collaboratively explore and

develop understandings about the design itself, its future users, and each other's perspectives and practices (Burkett, 2012; Robertson & Simonsen, 2012). Although users are central to this approach, expertise should not be disregarded. Rather than serving as a source of unquestionable authority, expert input - technical and interpersonal - should complement the design process, supporting the collaboration with users and sharing responsibility for the outcomes (Schuler & Namioka, 1993). Some studies include expert feedback through **interviews**, particularly in the early stages of the design process (Mosbak & Bjorner, 2022; O'Connor et al., 2023; Reiersølmoen et al., 2018).

There are several participatory techniques that promote active and engaged user participation in design activities. These include **co-design workshops**, which allow participants to freely express their concerns, hopes, and expectations, and collaborate towards a shared vision in a safe and creative space (Cesário & Nisi, 2023; Di Fuccio et al., 2024; Garcia, 2020; Giacobone et al., 2024); **scenarios**, which help incorporate the perspectives and engage those who will use whatever is being designed (Di Fuccio et al., 2024; Grudin & Pruitt, 2002); and **personas**, which enhance empathy and realism in the design (Cesário & Nisi, 2023; Grudin & Pruitt, 2002). Other relevant techniques include the use of visual and material representations to support shared understanding; **iterative prototyping**, which enables all participants to critically reflect on and shape evolving design solutions (Cesário & Nisi, 2023; Giacobone et al., 2024; Robertson & Simonsen, 2012); and **brainstorming sessions**, which foster creativity and encourage user contributions (Cesário & Nisi, 2023; Mackay et al., 2024). **Focus groups** are also a common participatory technique, especially for exploring expectations, values, and collective reasoning in early stages (Giacobone et al., 2024; Howard et al., 2022; Malamsha et al., 2021). In later stages, **field playtesting** may be conducted to evaluate interactive experiences in real-world settings, allowing to collect feedback and perceptions in actual use contexts (Cesário & Nisi, 2023; Koutsabasis et al., 2022).

Among the various fields where PD has been successfully applied, museums present a particularly relevant context, especially when designing experiences for younger audiences. One illustrative example is the study by Cesário & Nisi (2023), which demonstrates how PD principles and techniques can be put into practice to co-create more engaging museum visits with and for teenagers. This study emphasizes the importance of directly involving adolescents in the design process to explore how museums can become more appealing to this often-overlooked audience segment. By integrating PD approaches - such as co-design sessions, prototype testing and focus groups - alongside gamification and interactive technologies, the researchers sought to better understand teenagers' interests and expectations regarding museum visits. The study was conducted with 223 Portuguese high school students, aged 15 to 19, from the island of Madeira and enrolled in informatics, multimedia, and social sciences courses – a particular sample, so the results might not reflect broader teenage audiences. In addition to the students, the study involved 12 museum professionals from three Portuguese museums, who contributed to the ideation and development of interactive experiences for teenagers by being actively involved in co-design sessions, where they shared their perspectives on teenage audiences and helped shape the experiences by articulating the messages they wished to communicate. However, the study also pointed out a recurring challenge: while museum experts tend to prioritize storytelling and content curation, they may give less attention to the technological tools that could make these experiences more attractive to younger visitors. This reinforces the need for collaborative methods like co-design to align institutional goals with the interests and expectations of teenage users. By involving both curators and teenagers in iterative prototype development, the study fostered mutual understanding and enabled the creation of interactive experiences more aligned with teenagers' interests and museums' educational missions.

Nevertheless, the results should be interpreted within the specific geographic and demographic context of the study and not assumed to be universally applicable.

Despite its many advantages, PD also presents challenges, particularly in maintaining user involvement throughout the entire development and implementation process. One key difficulty lies in ensuring that mutual learning - a central pillar of PD - is not prematurely interrupted, but rather fully developed. In today's contexts, where technologies are often not created from scratch but instead configured from pre-existing components or adapted to specific environments, sustaining participatory practices until later stages of implementation has become increasingly complex (Robertson & Simonsen, 2012). PD is rooted in a commitment to fostering genuine partnerships between designers and end-users - a stance that reflects deeper values about the role and responsibility of designers. However, creating the conditions in which these partnerships can truly thrive remains an ongoing challenge. It requires not only logistical and organizational effort, but also the continuous development of appropriate tools, methods, and processes that support active and meaningful participation across all phases of design (Robertson & Simonsen, 2012).

2. Mobile Apps in Educational Contexts

This chapter presents a discussion on educational mobile apps and related technologies, with a particular emphasis on the use of AR in educational contexts. Furthermore, a selection of educational apps considered competitors or comparable alternatives to EduCITY - identified through app stores and academic research - is conducted. Their main features are analyzed and synthesized in a benchmarking table to support a comparative analysis.

Many of the academic references cited throughout this chapter were retrieved from the SLR conducted during Stage 1 of this study. These include studies by Cesário & Nisi (2023), Di Fuccio et al. (2024), Garcia (2020), Koutsabasis et al. (2022), Malamsha et al. (2021), Mercier et al. (2023), Ntagiantas et al. (2022), and Reiersølmoen et al. (2018). The SLR's protocol and inclusion criteria are detailed in the subchapter "Research Stages".

2.1. Perspectives on Mobile Learning Apps in Education

The integration of mobile apps into education has attracted considerable attention due to their potential to enhance engagement and improve learning outcomes (Cesário & Nisi, 2023; Di Fuccio et al., 2024; Malamsha et al., 2021; Ntagiantas et al., 2022). For example, the Discord app has been explored for its capacity to facilitate interactive learning experiences, demonstrating that the incorporation of media can positively influence students' critical thinking and problem-solving skills (Marques & Pombo, 2023; Salehudin et al., 2023).

Mobile learning involves the use of mobile devices like smartphones and tablets to support educational activities, enabling interaction with content and peers across various locations, contexts, and times, while fostering innovation, collaboration, and "anytime, anywhere" learning (Marques & Pombo, 2020). According to Reiersølmoen et al. (2018), mobile learning can promote situated engagement, which occurs when participation takes place at a specific physical location through immersive experiences. This type of engagement not only facilitates active participation but can also enhance participants' awareness of challenges and opportunities, potentially fostering a more sustainable and meaningful connection with the environment (E. Gordon et al., 2011; Korn, 2013). Gamification, defined by Deterding et al. (2011, p. 9) as "the use of game design elements in non-game contexts", has emerged as an effective strategy within mobile learning, as it has been shown that game-based mechanics, aesthetics and game thinking have the potential to motivate learners by fostering a sense of achievement, competition and problem solving (Kapp, 2012). In *The Gamification of Learning and Instruction: Game-based Methods and Strategies for Training and Education*, Kapp (2012, pp. 10–12) deconstructs the key elements of gamification:

- **Game-based:** when there is an intention to create a game that engages learners or players in a challenge that follows rules, is interactive and provides feedback – an experience in which people are willing to invest their time and energy.

- **Mechanics:** a game may include mechanics such as levels, badges, point systems, scores, and time constraints. These are essential elements used in games, but they are not sufficient on their own to turn a boring experience into an engaging one.

- **Aesthetics:** the look and feel of the experience that evokes emotion (A. J. Kim, 2011). An aesthetically pleasing and engaging UI is crucial for gamification to succeed. Kapp emphasizes that users' perception of aesthetics strongly influences their willingness to accept gamification.

- **Game Thinking:** described by the author as the "most important element of gamification." (Kapp, 2012, p. 11). It involves taking an everyday experience and transforming it into a game-like experience through "elements of competition, cooperation, exploration and storytelling".

- **Engage:** the ability to capture a person's attention and involvement.

- **People:** the learners, consumers or players who are expected to be engaged and motivated to act within the experience.

- **Motivate Action:** driving individuals to participate in specific actions or activities. To sustain motivation, challenges must be carefully balanced in terms of difficulty.

- **Promote Learning:** many elements of gamification draw from teaching techniques, such as attributing points, providing constructive feedback, and encouraging. Gamification adds a layer of interest and motivation to these elements, engaging and educating learners.

- **Solve Problems:** the collaborative and competitive nature of games motivates individuals to perform at their best to achieve the ultimate goal.

As an application of gamification in mobile learning, location-based games (LBGs) offer a powerful approach to blending physical and digital experiences, fostering active learning through interaction with real-world environments and real-time, on-site feedback (Reiersølmoen et al., 2018).

An illustrative example of how LBGs can be applied in educational contexts is the *Mouseion Topos* project. In this study, Koutsabasis et al. (2022) aimed to promote awareness of the tangible and intangible cultural heritage of the Aegean islands. Using a PD approach involving cultural heritage professionals, local community members, and visitors, the researchers developed games incorporating challenges, rewards, storytelling, and AR elements. Aligned with Kapp's (2012) findings, these game mechanics encouraged users to engage with content in an immersive and exploratory way.

Additionally, Cesário & Nisi (2023) explore the incorporation of gamified elements in museum settings, such as points, badges and leaderboards (PBL), demonstrating how these features can attract and better engage teenage audiences by encouraging exploration and learning. However, Kapp (2012, p.12) argues that PBL alone does not constitute gamification. Instead, "the real power of game-based thinking is in the other elements of games: engagement, storytelling, visualization of characters, and problem solving". In line with this, Skydsgaard et al. (2016) found that when museums incorporate gamified elements such as challenge, narrative and participation into their exhibitions, these experiences are more likely to capture students' attention, fostering reflection and sustained

discussion. This approach proved especially effective in promoting meaningful dialogue and deeper engagement among teenage visitors.

Mobile learning games seem to offer individuals the chance to take greater risks by providing opportunities to try again after experiencing failure (A. J. Kim, 2011; Malamsha et al., 2021; Scholes et al., 2014). This aligns with Kapp's (2012, p. 48) perspective that "Allowing a player to fail with minimal consequences encourages exploration, curiosity and discovery-based learning". Considering this, the use of game-like techniques - such as using time constraints as motivators, providing frequent and constructive feedback as possible, incorporating badges, rewards, levels, storytelling and allowing failure - can contribute to the creation of engaging learning experiences, enhancing both knowledge retention and the application of learning.

2.2. AR in Educational Apps

AR is becoming an increasingly popular technology in mobile apps markets (Dirin & Laine, 2018). It can be defined as blending of real-world environment and digital and virtual components, enriching reality rather than replacing it (Azuma et al., 2001; Di Fuccio et al., 2024; Kapp, 2012). Mobile Augmented Reality (MAR) involves using mobile devices to display and interact with virtual content superimposed on a real-time camera view of the physical world: this content is often context-sensitive and can include various formats such as 3D models, animations, annotations and videos (Laine, 2018).

AR has been integrated into educational contexts across a wide range of subjects, often in combination with gamification elements (Kapp, 2012). For instance, Garcia (2020) developed HARA, a MAR app designed to enhance history education by immersing 6th grade students in 3D storytelling experiences that reconstruct historical events from the American colonization of the Philippines. Similarly, Mercier et al. (2023) introduced BiodivAR, a location-based AR tool that facilitates immersive educational experiences in natural environments. By enabling users to visualize geolocated media – such as text, images and 3D objects - within AR, the app promotes contextual and exploratory learning.

Researchers have increasingly focused on understanding how AR contributes to meaningful learning experiences. For example, Di Fuccio et al. (2024) explored the role of AR in fostering engagement and learning efficiency in a multicultural and multilingual academic context by evaluating the EULALIA app. This app was designed to improve foreign language learning and cultural knowledge among Erasmus students. By combining both quantitative data and qualitative feedback from users regarding their experience with and without the app, the authors concluded that learners who used the EULALIA app not only achieved better results in knowledge compared to the reference group (that didn't use the app) but also showed a positive effect on their involvement in the learning process, with teachers reporting increased student responsibility and active participation.

The acceptance and use of AR in educational settings are influenced by a combination of factors. Students are more likely to embrace AR tools when they perceived them as useful, easy to use and enjoyable (Alhebaishi & Stone, 2024; Papakostas et al., 2023). Furthermore, the overall quality of the AR experience plays a key role in sustaining students' interest and supporting effective learning (Alhebaishi & Stone, 2024). AR's ability to transform abstract concepts into interactive, tangible

experiences makes it a powerful tool for improving learning outcomes (Czerkawski & Berti, 2021). According to Alhebaishi & Stone (2024), "AR can enhance academic performance, reduce cognitive load, and increase motivation and interest among students" (p. 33).

Taken together, these examples and findings demonstrate AR's significant potential to transform traditional educational practices by making learning more interactive, engaging, and meaningful. In this context, it is worth taking a look at EduCITY, a project with a mobile app that integrates AR to promote learning.

2.3. Critical App Review for Learning Purposes

In this section, an analysis of EduCITY's competitors is carried out, with the aim of identifying apps that share similar features, characteristics, and types of games.

The most relevant characteristics that drove this app review were: AR, geolocation, quizzes, teambuilding components, gamification and multimedia resources. These initial criteria guided the first stage of the app selection. However, as the benchmarking progressed, additional relevant characteristics emerged inductively from the reviewed apps, such as media sharing and challenges. They were subsequently incorporated into the analysis, ensuring a more comprehensive and grounded comparison.

This review draws on multiple sources – including mobile app stores and academic research, thereby reinforcing the transversality and richness of the analysis through diverse perspectives.

2.3.1. Apps from App Stores

A general search was first conducted on platforms such as Google's Play Store and Apple's App Store, given that the EduCITY app is available on mobile devices. The researcher then selected a number of games based on criteria such as popularity, number of downloads, user reviews, and the date of the most recent update. These parameters helped to narrow the scope of the analysis to the most relevant and highly rated apps. As a result, a more in-depth analysis was conducted on eight selected games: Actionbound, ClueKeeper, Quizzland, Goosechase, Official Millionaire Game, Trivia Crack, Kahoot and Duolingo.

- **Actionbound**

Actionbound (Figure 5) is an app that allows users to create and participate in digital treasure hunt games with a touristic or educational/general knowledge purpose. This is combined with a gamification component that integrates quiz elements and features that encourage exploration. It is widely used in educational settings, corporate events, museums, and recreational activities, resulting in a broad target audience, ranging from children to adults. Some of the most relevant features and functionalities of this app include: geolocation, AR, media sharing (images, videos, audio, etc.), challenges and interactive quizzes, scoring, and teambuilding strategies.

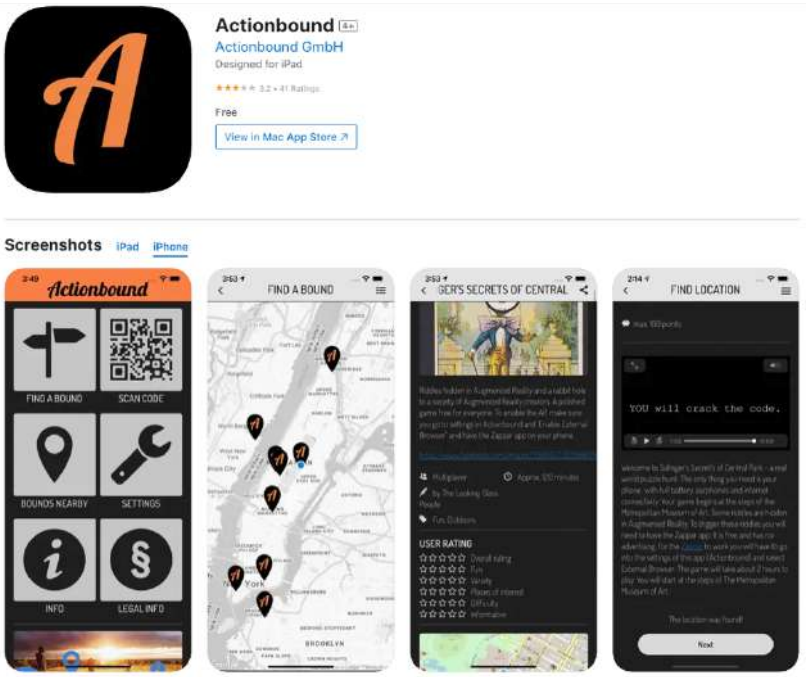


Figure 5 - Actionbound's Interfaces on Apple's App Store.

- **ClueKeeper**

ClueKeeper (Figure 6) is a platform for creating and conducting interactive treasure hunt adventures, with a focus on puzzle-solving and geolocation-based challenges. While it is more commonly used in educational school activities, event organizers can also design games for corporate events or escape room competitions. It offers features such as custom puzzle creation, geolocation, AR, cryptography, gamification, teambuilding strategies, and hints for quizzes or riddles.

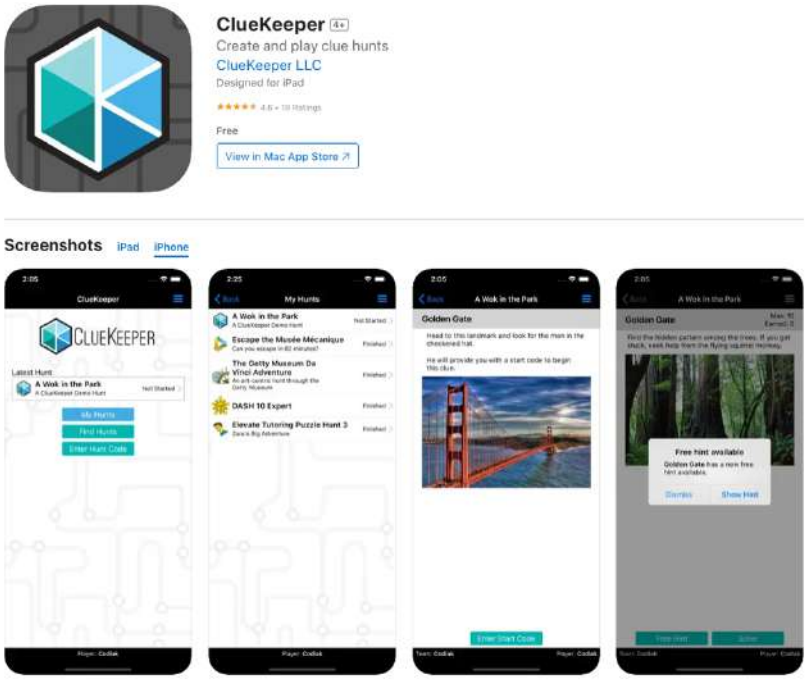


Figure 6 – ClueKeeper's Interfaces on Apple's App Store.

- **QuizzLand**

QuizzLand (Figure 7) is a quiz game that covers a range of topics, including nature, biology, history, culture, cinema, and technology, among others. In this game, players advance through a path by answering questions, which in turn unlock new ones. The target audience consists mainly of casual players, teenagers, young adults, and adults. Although it does not integrate particularly innovative features, the game successfully delivers a satisfying gameplay experience. Key features include: power-ups to assist with questions, a lives system, and post-answer comments.

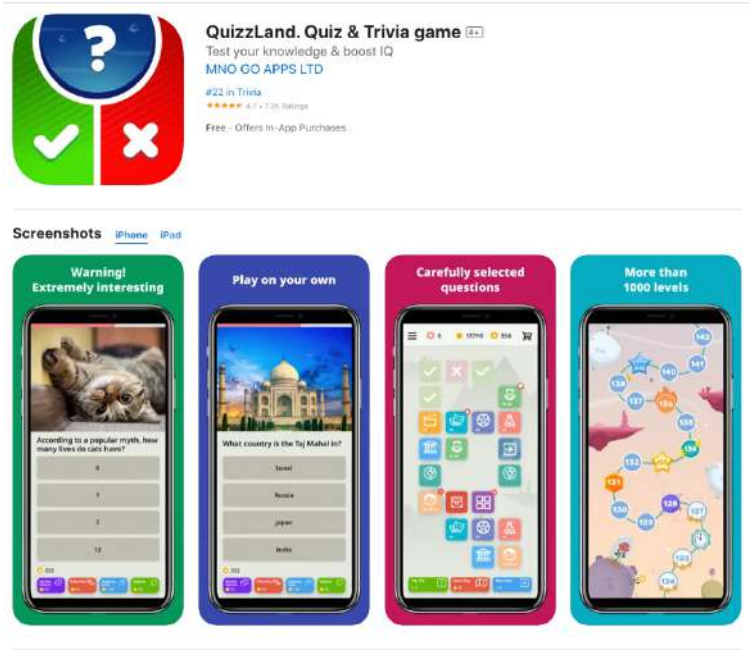


Figure 7 – QuizzLand's Interfaces on Apple's App Store.

- **Goosechase**

Goosechase (Figure 8) is a gamified platform inspired by treasure hunts, designed to promote collaborative experiences adapted to various contexts. Participants complete missions to earn points - for example, taking a photo of a monument while reenacting a historical moment. The experience is customizable, with an administrator responsible for creating missions, managing the activity, and monitoring scores. Notable features include: creation and management of multiple experiences, a library of pre-made missions, live feed of submissions, notifications, privacy options, real-time leaderboard, control dashboard, and a list of media content submitted by participants.

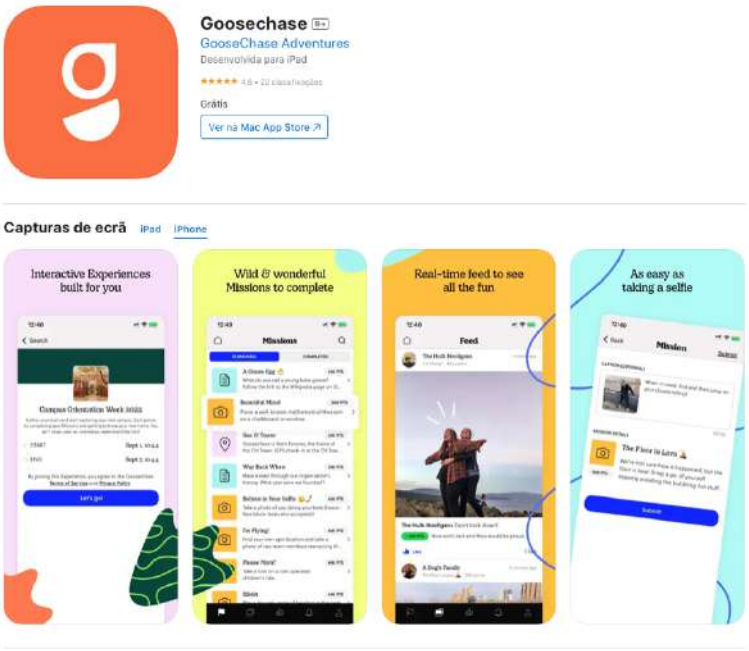


Figure 8 – Goosechase's Interfaces on Apple's App Store.

- **Millionaire Trivia**

Based on the famous *Who Wants to Be a Millionaire?,* this app (Figure 9) replicates the feel of the television show while adding new layers of gameplay to appeal to a broader and more diverse audience. The game aims to go beyond the original quiz format, even though there are no real monetary prizes. Key features include: onboarding with character introductions and game mechanics, a progression system, internal economy to unlock aids and bonuses, mystery boxes purchasable with real money, daily bonuses to encourage player retention, global leaderboards for competition, tiered progression systems, and "experts" (unlockable aids to help answer questions).

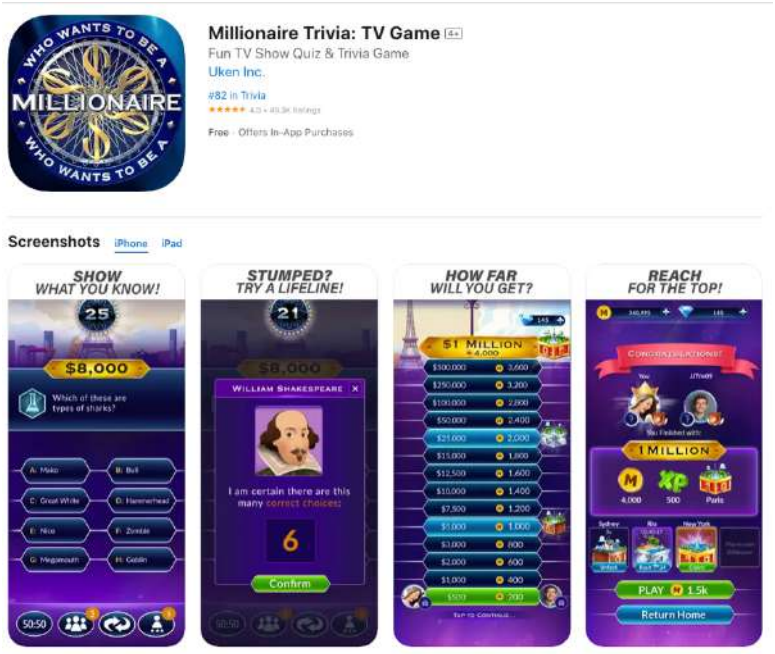


Figure 9 – Millionaire Trivia's Interfaces on Apple's App Store.

- **Trivia Crack (Perguntados)**

Trivia Crack (Figure 10) is a quiz game where players compete by correctly answering questions across six categories: History, Geography, Science, Entertainment, Art, and Sports. The goal is to collect characters representing each category by answering questions correctly or winning duels. The main features of this game include: competitive two-player mode, special powers to eliminate answers or gain extra time, endless question mode, community-created and rated questions, chat with opponents, achievements and trophies, daily missions and events with rewards, and global rankings to compare performance with other players.

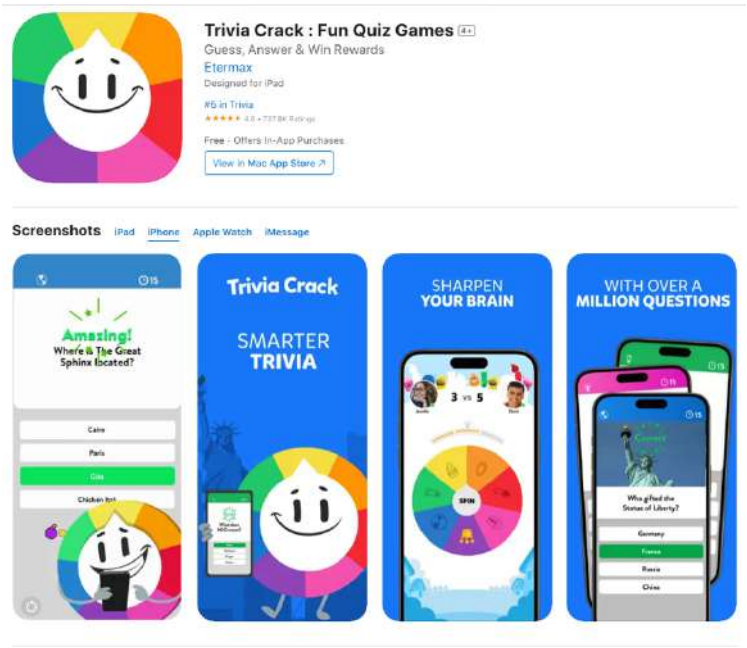


Figure 10 – Trivia Crack's Interfaces on Apple's App Store.

- **Kahoot**

Kahoot (Figure 11) is a popular interactive platform used in educational settings to create real-time quizzes. Players can create quizzes or use ones from the existing library and invite others to respond, with scores based on accuracy and speed. Kahoot's main features include: scoring based on correctness and speed, individual or team game modes, live quiz options (classic mode) or asynchronous play (challenge mode), instant feedback, social interaction for discussion, customization of questions with images and videos, and detailed performance and progress reports for players.

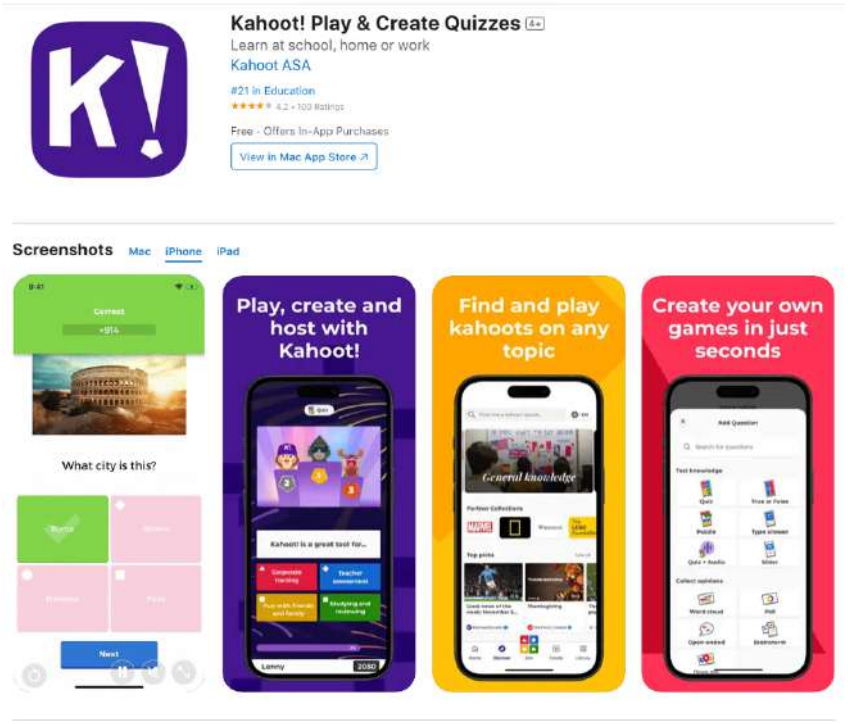


Figure 11 – Kahoot's Interfaces on Apple's App Store.

- **Duolingo**

Duolingo (Figure 12) is one of the world's most popular educational apps, with millions of users that can learn over 40 different languages through short, interactive lessons. The app uses a gamified approach to develop reading, writing, listening, and speaking skills. Beyond language learning, it also offers Math and Music courses, enabling users to practice calculating, identifying patterns, reading music, and playing simple songs – all within the app and without needing any instruments. Some of its key features include: game-like lessons with animated characters, a reward and achievement system to encourage daily practice, competitive leaderboards, level progression, "Super Duolingo" for additional perks, and completely free access to all courses. The app is designed using evidence-based teaching methods developed by learning experts, ensuring long-term knowledge retention and sustained motivation. It is suitable for a wide range of learners, whether they are studying for travel, education, career advancement, or personal growth.

Figure 12 – Duolingo's Interfaces on Apple's App Store.

2.3.2. Apps from Research Studies

Besides consulting app stores, the researcher also searched for and analyzed apps arising from research studies, specifically those developed through participatory or co-design approaches.

The following apps – *Mouseion Topos Interactive* and *HARA* - were retrieved from two of thirteen studies included in the SLR that started to be conducted during Stage 1 of this study. These apps were selected due to their relevance to the research objectives, and their development processes are discussed in detail in the corresponding publications. The SLR procedure, which is fully described in the subchapter "Research Stages", served as a state-of-the-art contribution to this research.

- **Mouseion Topos Interactive Apps**

The Mouseion Topo's apps (Figure 13), three LBGs developed as part of the Mouseion Topos project, were designed through participatory and co-design methods to promote the cultural heritage and traditional crafts of three Aegean islands in Greece (Koutsabasis et al., 2022). Each app is linked to a local museum and aims to engage users in heritage exploration through playful, on-site experiences.

The apps (Mouseion Topos #Tinos, #Levos and #Chios) "share a common system design and gameplay but have different visual identities, media, content and graphics inspired by local context and heritage" (Koutsabasis et al., 2022, p. 3). Players interact with missions and challenges situated in real-world locations, earning experience points (XP) and collecting virtual 3D tools related to heritage artifacts, which are presented through AR. Some of the key features include mission-based exploration, culturally themed challenges, a level progressions system (apprentice, assistant, master), rewards and collectible items, hints mechanisms via virtual characters, interactive maps, and embedded narratives that deepen the cultural experience. The apps are designed to promote

discovery, learning, and emotional engagement through game dynamics that respond to the user's location and interaction.

Even though Koutsabasis et al. - the authors of the study - state that the apps are available on Google's Play Store, the researcher was not able to locate them. The apps are promoted on the project's official website, but clicking on the provided download links leads to a Play Store error page. Additionally, the apps do not appear to have ever been available on Apple's App Store.

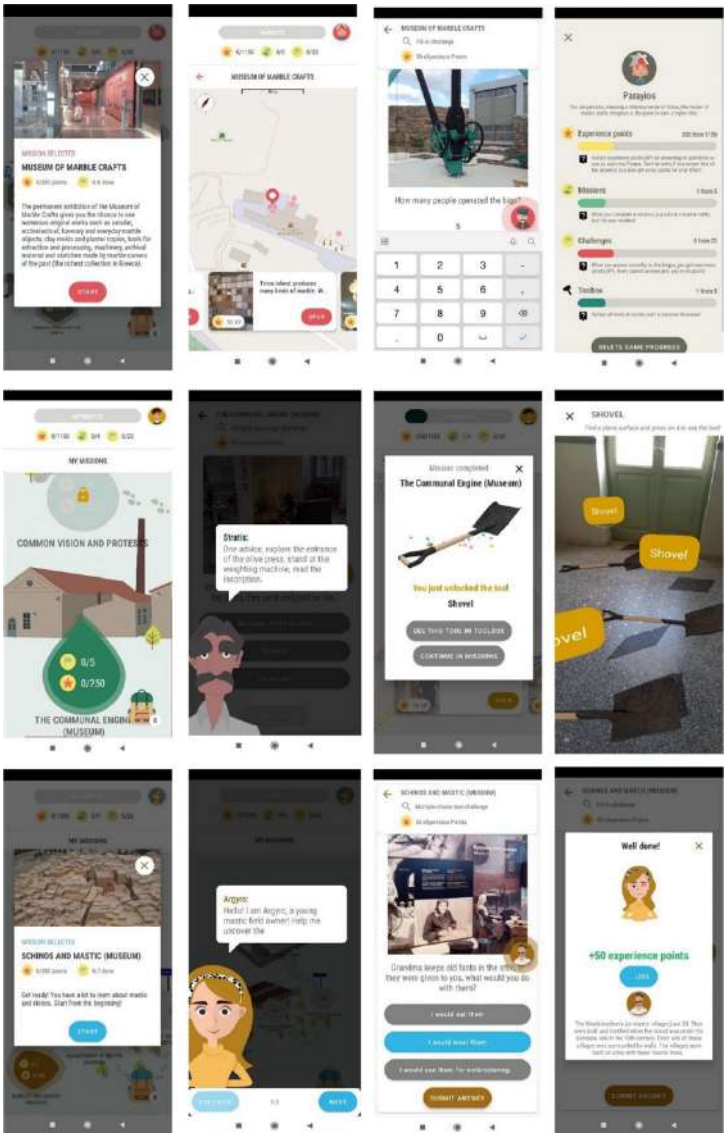


Figure 13 – Mouseion Topos' Interfaces (Koutsabasis et al., 2022, p. 22).

- **HARA**

The History Augmented Reality App (HARA), shown in Figure 14, was co-designed with history teachers and students to enhance the teaching of the American Colonization Period in the Philippines. Its core feature is Augmented Reality (AR), using image recognition and 2D tracking of flashcards to trigger animated 3D scenes that depict key historical events. Through these visualizations, students are invited to "see the invisible" and engage with history in an immersive and interactive way.

The app includes an immersive narrative approach, turning historical events into engaging story-based content. Additional features in the beta version include an interactive historical timeline (History Explore), character profiles of Filipino heroines, trivia sections, an AR tutorial, and settings for 3D rendering and notifications. HARA was designed as a mobile app aligned with "bring your own device" policies in schools, encouraging accessibility and ubiquity.

The evaluation of HARA focused on knowledge acquisition, acceptability, motivation, attitudes, and usability. While the app was well received and positively impacted students' motivation and engagement, its effect on actual knowledge gain was not statistically significant. Based on the study, HARA was developed and tested as a beta version made accessible via a private server, but there is no confirmation that it was ever publicly released on app stores.

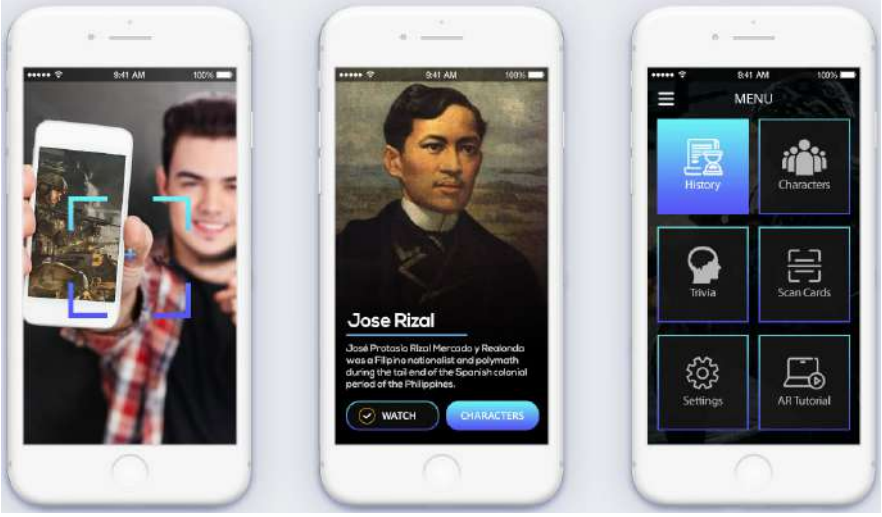


Figure 14 – HARA app Interfaces (Garcia, 2020, p. 244).

2.3.3. Comparison of Apps

To allow for the comparison of EduCITY with the apps/games analyzed, the researcher determined a set of specific parameters, based on the key features that were most prevalent during the benchmarking. As previously mentioned, the researcher's original concern was to identify characteristics related to AR, geolocation, quizzes, teambuilding components, gamification, and multimedia resources. However, as an outcome of the app review process, two more characteristics were augmented to this benchmarking study - media sharing and challenges.

The final list of characteristics considered is:

- **AR**: The app/game integrates augmented reality.
- **Geolocation**: The app/game incorporates geolocation-based interaction mechanisms.
- **Quizzes**: The app/game includes quiz mechanics, with questions, answers, and feedback.
- **Teambuilding**: The app/game promotes collaboration among users/players and fosters team building. It may include features such as chat, feed, or any other collaborative dynamics.
- **Gamification**: The app/game integrates gamification systems that complement the main features. These may include internal game economy, mystery boxes, customization systems, bonuses, among others.
- **Media Sharing**: The app/game allows users to share media (photos and videos).
- **Challenges**: The app/game includes challenges that may be organized by different difficulty levels and incorporate progression systems. This parameter includes features such as leaderboards, tiers, progress maps, multiple game modes, among others.
- **Multimedia Resources**: The app/game contains and provides access to multimedia resources such as video, image, audio, among others.

To present the comparison in a table, the researcher used a three-point scale, which indicates whether the game includes the functionality (green), partially integrates some aspects (yellow), or does not include the functionality at all (red). The comparison of EduCITY with the apps analyzed is in Table 1.

Table 1 - Benchmarking table with EduCITY and its competitors.

	EduCITY	Actionbound	ClueKeeper	QuizzLand	Goosechase	Millionaire	Trivia Crack	Kahoot	Duolingo	Mouseion Topos	HARA
AR	🟢	🟢	🟢	🔴	🔴	🔴	🔴	🔴	🔴	🟢	🟢
Geolocation	🟢	🟢	🟢	🔴	🟢	🔴	🟢	🔴	🔴	🟢	🔴
Quizzes	🟢	🟢	🟢	🟢	🔴	🟢	🟢	🟢	🟢	🟡	🟡
Teambuilding	🟢	🟢	🟢	🔴	🟢	🔴	🔴	🟡	🟢	🟢	🔴
Gamification	🟡	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟡
Media Sharing	🔴	🔴	🟡	🔴	🟢	🔴	🔴	🔴	🔴	🔴	🔴
Challenges	🔴	🟢	🟢	🟡	🟢	🟢	🟢	🟢	🟢	🟢	🟡
Multimedia Resources	🟢	🟢	🟢	🟡	🟢	🔴	🔴	🟢	🟢	🟢	🟢

The results presented in Table 1 show that while certain features such as AR, media sharing, geolocation, and teambuilding are relatively uncommon among the benchmarked apps, they are central to EduCITY's concept and design, as discussed in more detail in the chapter "EduCITY". This positions EduCITY as a distinctive app within its category, particularly due to its strong integration of collaborative challenges in real-world contexts. However, the comparison also reveals areas where EduCITY could be strengthened.

As a first insight, apps such as Goosechase and Actionbound place a clear emphasis on structured challenges, goal-oriented missions, and reward systems - all of which contribute to user motivation and re-engagement. These platforms often incorporate elements such as points, badges, and timers to sustain player interest. While EduCITY promotes learning through exploration, it currently lacks these explicit motivational structures, which may limit its appeal to some user profiles, particularly younger students used to gamified environments.

As a second insight, apps like Duolingo and Kahoot present highly polished interfaces. Compared to these, EduCITY's current interface appears more basic and could benefit from refinement, especially in aspects such as navigation clarity, visual hierarchy, and feedback mechanisms. While EduCITY is still evolving, these examples demonstrate how thoughtful interface design can enhance usability and engagement, even in educational apps.

It is important to note that these differences should not necessarily be viewed as design flaws. EduCITY was developed with specific pedagogical goals in mind, emphasizing collaboration, and outdoor learning rather than competition or reward-driven engagement. Nonetheless, the comparative analysis highlights potential areas for improvement that could be explored in future iterations, especially if the aim is to balance educational value with engaging and intuitive user experiences.

Besides comparing features, it is also worth making a critical reflection on the characteristics of educational apps found in app stores and research studies. The researcher did just that, aiming to highlight their general strengths and limitations. The analysis of apps sourced from app stores revealed products that generally benefit from significant investment in UI and UX design. These apps are often developed by multidisciplinary teams, resulting in visually appealing and intuitive interfaces. Their availability to the public, combined with high numbers of downloads and user reviews, suggests a certain level of maturity and usability. However, despite their popularity, it is difficult to assess their actual impact on learning or sustained engagement.

App store data typically lacks information on whether these tools genuinely support educational goals or what motivates users to return to - or abandon - them over time. In contrast, apps from studies tend to focus more heavily on conceptual design and user-centered development processes. These apps are often created in academic or experimental contexts, where the emphasis is placed on the pedagogical framework and intended outcomes rather than polished interfaces. Many lack input from professional designers, with the UI frequently handled by developers or left underdeveloped. While this can result in a less refined user experience, it also offers a valuable perspective: access to detailed documentation and insights into the design rationale, goals, and iterative processes behind the apps. A recurring limitation, however, is that many of these apps never reach a public release stage, remaining confined to pilot phases or internal testing.

By combining both types of sources in the benchmarking process, it was possible to achieve a more comprehensive and critical understanding of the current landscape. On one hand, apps from app stores illustrate best practices in design and user experience, while on the other, academic projects provide a richer understanding of pedagogical intentions and development challenges. Together, these perspectives can offer useful guidance for identifying areas of improvement in the EduCITY app, both in terms of user expectations and educational effectiveness.

3. EduCITY

The EduCITY app, central to this research, serves as a practical example for applying the principles of UX/UI and PD in the development of educational apps. By first introducing the project and then analyzing some of the app's features, such as AR and its gamification elements, and previous studies conducted to evaluate its UX, this study identifies both strengths and areas for improvement.

3.1. The EduCITY Project

The *EduCITY - Smart and sustainable cities with Augmented Reality mobile educational games made by and for the Citizens* project, funded by the Foundation for Science and Technology (FCT), under the grant PTDC/CED-EDG/0197/2021, represents an innovative approach to integrating technology into education through location-based challenges and AR tools (Marques & Pombo, 2023; Pombo & M. Marques, 2023).

Following EduCITY, the next project will be *Edu4Health – New Challenges in Education for Health and Well-being, a research and training project with Augmented Reality and Gamification strategies for schools*. This project, funded by FEDER, builds on the knowledge and tools developed in EduPARK and EduCITY, confirming the scalability and adaptability of these models to new educational challenges.

Building on the success of its predecessor - the EduPARK project (Pombo & Marques, 2019a, 2019b) - EduCITY extends the boundaries of outdoor learning from the Aveiro City Park to urban environments, fostering sustainable and interdisciplinary educational practices (Pombo & M. Marques, 2023).

The EduPARK project, implemented from 2016 to 2019, transformed the Aveiro City Park into an educational laboratory, using a mobile app with AR resources, geocaching, and game-based learning to motivate students (Pombo et al., 2019). Its educational games combined challenges, orientation tasks, and enigmas, fostering healthy competition and a passion for learning while promoting environmental sustainability (Pombo et al., 2019).

Expanding on EduPARK's foundations, EduCITY leverages the entire urban landscape as a learning environment. Its innovations include the use of low-cost environmental sensors, AR technology and 3D animations, along with the active involvement of citizens in co-creating games and AR content, even without programming skills (Pombo et al., 2025). This project shifts the focus towards fostering sustainable cities by engaging communities in developing educational resources, sharing knowledge among schools and communities, and enabling the app's scalability to be used in any city or territory (Pombo et al., 2022, 2025). EduCITY's primary objective is to create a Smart Learning City Environment, where citizens, including students of all levels and teachers, can co-create and interact with AR-based educational games (Marques & Pombo, 2023; Pombo & Marques, 2023). The games leverage real-world contexts and digital resources, such as environmental sensor data, 3D animations, and informative spots, to foster a deeper understanding of sustainability (Pombo & M. Marques, 2023). Through workshops and training courses, the project empowers communities to design and explore engaging challenges that contribute to sustainable cities, transforming urban spaces into living laboratories for learning (Pombo et al., 2025).

According to Pombo et al. (2022), EduCITY's games aim to empower citizens, particularly students, to make informed decisions and take responsible actions for environmental sustainability. Participants navigate urban spaces, interact with points of interest enriched by AR, and engage in challenges that incorporate sensors for collecting real-time environmental data, such as noise levels or air quality. These games act as motivators for civic action, encouraging reflection and active participation in addressing local environmental issues. The project actively involves citizens not only as users but also as creators of content and games, fostering a sense of ownership and responsibility for their cities (Pombo et al., 2025). Throughout its duration, EduCITY has organized diverse activities, such as workshops, teacher training sessions, and public demonstrations to disseminate its tools and promote environmental education.

At the heart of this project lies the EduCITY mobile app.

3.2. The EduCITY App

The EduCITY app, available on Google Play and the App Store, is a pivotal component of the project, designed to enhance outdoor educational experiences (Pombo et al., 2025). The app offers interactive city tours provided by educational games, and geolocated challenges, blending traditional pedagogical approaches with digital innovation (Marques & Pombo, 2023; Pombo & M. Marques, 2023). Targeted at the entire community, but with a primary focus on educational contexts, the app integrates mobile learning with gamified elements. Key concepts include:

- **Mobile Learning:** EduCITY aligns with the principles of mobile learning, emphasizing flexibility, accessibility, and situational context. By leveraging the mobility of smartphones and tablets, EduCITY goes beyond classroom walls, reaching outdoor urban environments (Marques & Pombo, 2023; Pombo & Marques, 2023).

- **AR:** the EduCITY app uses image-based AR, where the device's camera recognizes AR markers to generate AR content based on an image (Rodrigues & Pombo, 2024). Over the course of the project, these markers were refined to enhance the quality of their content (Marques & Pombo, 2023; Pombo & Marques, 2023). The AR features aim to complement the observable reality at specific city locations, provide insights into phenomena that is not visible at the time or place, and to promote education for sustainability (Marques & Pombo, 2023; Pombo & Marques, 2023; Pombo & Rodrigues, 2024)

- **Gamification:** encouraging active participation through game-based elements that make learning engaging and dynamic (Marques & Pombo, 2023).

EduCITY makes use of mobile learning, AR and gamification to create meaningful educational experiences, with an ability to support interdisciplinary learning, especially about education for sustainable development (Pombo et al., 2024). This app not only enhances the educational experience by offering diverse learning opportunities but also encourages students to engage with their environment in a meaningful way (Marques & Pombo, 2023). The EduCITY app offers an engaging learning environment through educational games that incorporate AR, low-cost environmental sensors, 3D animations, and multimedia resources. Designed to promote sustainability and environmental awareness, the app targets students, teachers and the broader community (Pombo & Marques, 2023).

On the home screen, presented in Figure 15 a), users can start a new game, explore freely (explore AR without having to play a game, also known as “free mode”), check scores, and learn the game rules. When selecting the new game, the users are directed to a game selection screen that allows users to explore a list of available games (game mode screen, as portrayed in Figure 15 b)). Each game contains additional information, as illustrated in Figure 15 c), such as the target level of education, main subjects, the number of points of interest and questions, and whether AR or environmental sensors are integrated (Pombo & Marques, 2023).

Figure 15 – a) Home screen; b) List of games screen; and c) Game information screen.

Upon selecting a game with sensor integration, the app prompts users to connect a sensor kit to measure environmental data like particulate matter or noise (Pombo & Marques, 2023). This only occurs on Android devices since the integration of environmental sensors on iOS devices has not yet been accomplished.

EduCITY uses three types of AR markers:

1. **AR Books (Physical markers):** the project contains 36 plaques placed near significant trees in Aveiro, serving as AR triggers. Scanning these plaques with the app reveals a menu with information about the tree species, as illustrated in Figure 16.

2. **3D object (Custom markers):** any identifiable image (like the one on a bookmarker, as Figure 17 illustrates) can act as an AR marker, enabling the creation of AR content on diverse topics. For example, markers can provide air quality information through interactive menus.

3. **Augmented Markers (Natural markers):** items such as architectural tiles, demonstrated by Figure 18, or plaques can also act as AR triggers.

Figure 16 - Illustration of the ARBook mechanism, which triggers information about the species in an interactive menu with several pages and 3D content.

Figure 17 - Examples of 3D objects triggered by images on bookmarks.

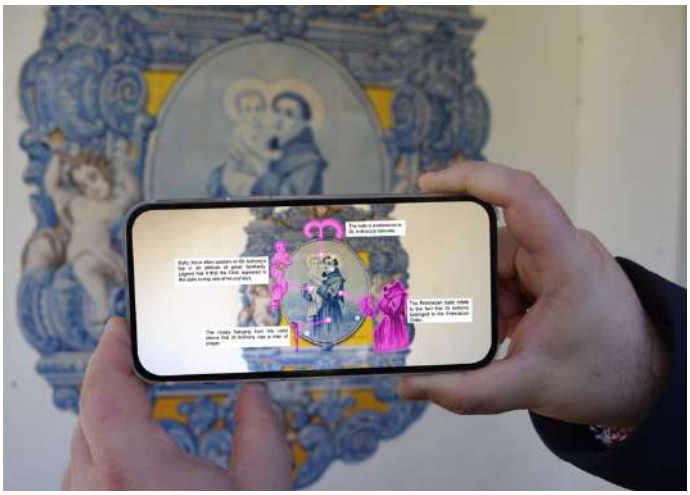


Figure 18 - Montage that illustrates the interaction that it is possible to achieve with an Augmented Marker triggered by architectural tiles.

These AR features guide users to explore city landmarks, access multimedia content, and engage with educational resources that complement the observed environment.

The gameplay begins with a friendly welcome by EduCITY's Flamingo mascot, as shown in Figure 19 a), that guides and encourages the users throughout the game. Directions to the first point of interest are provided. Upon arrival, a brief introduction contextualizes the question and provides relevant information through text, images, videos, audio, or AR content. Players then answer multiple-choice questions, as Figure 19 b) demonstrates.

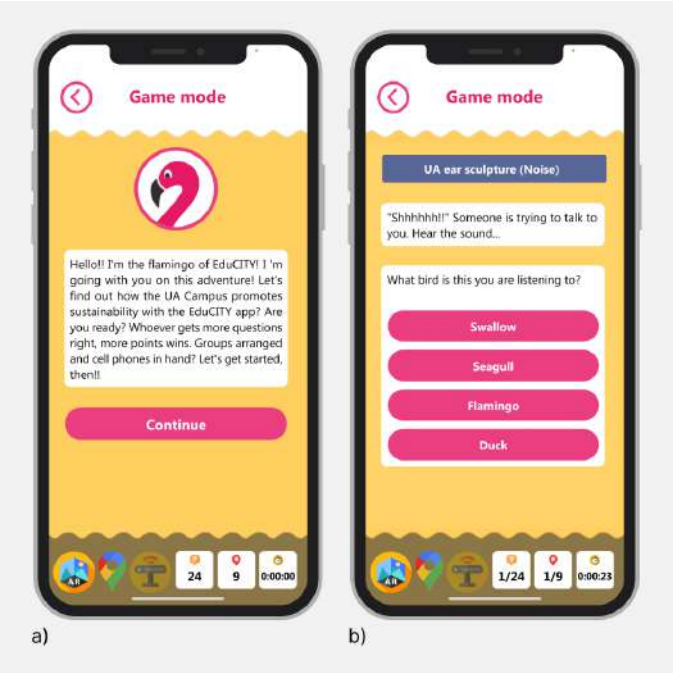


Figure 19 – a) Game introduction screen; and b) Multiple choice question screen.

Right after selecting an option, players receive immediate, tailored feedback based on their responses, as Figure 20 a) and b) demonstrates, reinforcing the learning process (Pombo & Marques, 2023). For example, feedback may include text explanations, videos, or other multimedia resources. After completing all challenges attributed to a point of interest, users receive guidance to the next location.

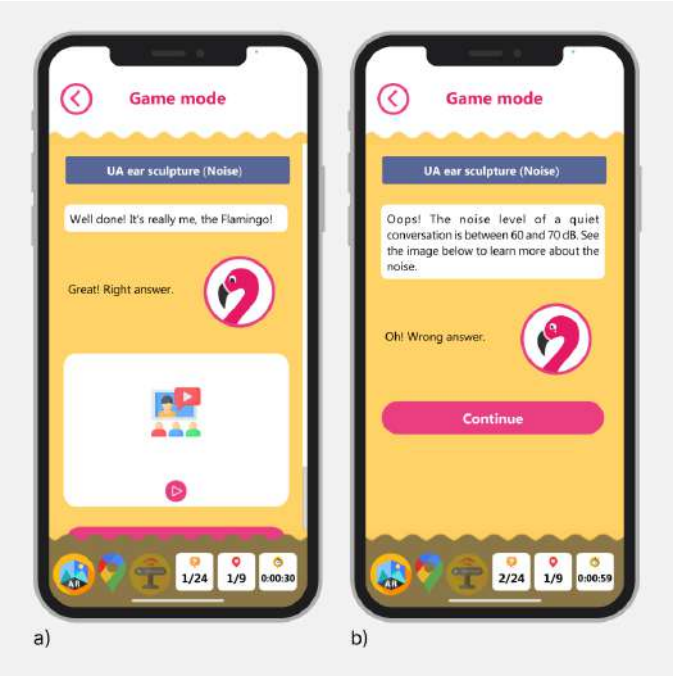


Figure 20 – a) Positive feedback screen; and b) Negative feedback screen.

The game experience concludes with a summary screen (Game result, as shown in Figure 21, where users can review their scores, the number of correct answers, time of play, and gameplay details, fostering reflection and motivation for further exploration (Pombo & Marques, 2023).

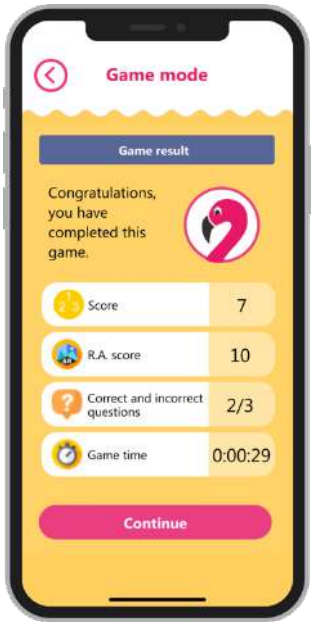


Figure 21 – Game result screen.

In addition to the mobile app, the EduCITY project features a web platform that allows users to easily create educational games and AR content. These resources, once verified by the EduCITY team, can be integrated into the app. This co-creation process involves the school community, academics, and the public, making it possible to design interdisciplinary challenges for citizens exploring the city (Pombo & Marques, 2023).

3.3. Potential for Improvement

Despite its successes, the EduCITY app still presents some challenges regarding its usability and overall UX. The studies conducted by Marques & Pombo (2023) and Sousa et al. (2024) provide substantial information into the app's performance from the perspectives of different user groups, identifying some areas that may benefit from refinement.

Marques & Pombo (2023) evaluated the UX of the EduCITY app using the User Experience Questionnaire (UEQ) with 73 international doctoral students in Education. In addition to the quantitative data from the UEQ – which measures task-related and non-task-related attributes, as well as the overall appeal of the software (Rauschenberger et al., 2013) – participants were invited to provide open-ended feedback.

One of the key issues that raised concerns was "Dependability", which reflects predictability and control over interactions (Rauschenberger et al., 2013). Users noted concerns about pedagogical quality and suggested reducing the overreliance on images to foster deeper engagement with real-world locations. Technical problems were also mentioned, such as app crashes related to AR content, emphasizing the need for bug fixes and more robust functionality (Marques & Pombo, 2023).

"Efficiency", related to how easily users achieve their goals (Rauschenberger et al., 2013), was another area requiring attention. Suggestions included optimizing battery consumption and improving usability features, such as making the language switch button easier to find. While "Attractiveness", which relates to the general impression of the product, and "Perspicuity", related to easiness of use and understanding (Rauschenberger et al., 2013), received positive evaluations overall, users still proposed adjustments, such as revising the multimedia resources (e.g., shorter videos), reconsidering the use of pink as the main color and improving the clarity of texts, such as map instructions. Although these aspects were not as critical as "Dependability" and "Efficiency," they were still seen as valuable for refining the experience.

In contrast, "Stimulation", which relates to how interesting and exciting is to use the product, and "Novelty", related to whether the design of the product is creative and innovative (Rauschenberger et al., 2013), received no improvement suggestions, indicating overall satisfaction in these areas (Marques & Pombo, 2023). A further suggestion, however, was the desire for broader accessibility, particularly through iOS and app store availability—an issue that has since been resolved, enhancing the app's reach across devices.

Sousa's et al. (2024) study brought a different perspective by involving 82 school students (7th to 11th grade) from Aveiro. Similarly to the doctoral students, they rated "Attractiveness" and "Stimulation" highly, while "Dependability"- related to the app meeting users' expectations - was the lowest scoring scale. Interestingly, "Novelty" was positively evaluated by doctoral students, but received lower scores from teenagers. Sousa et al. (2024, p. 3397) suggest that improvements to the app's design and content could help increase its perceived novelty among teenage students.

Conversely, "Efficiency" scored well among teenagers, unlike the doctoral group. Feedback from school students is particularly valuable, as their needs and expectations can differ considerably from those of international doctoral students. According to Sousa et al. (2024), these differences may be related to doctoral students' deeper familiarity with educational processes, while teenagers may have more experience with emerging technologies – factors that shape how each group interacts and

evaluates digital tools. The authors highlight the need for further research to better understand these differences. The study from Sousa et al. (2024) identified challenges that were not raised in Marques & Pombo's evaluation, such as issues with navigation, the relevance of content, and overall engagement. These findings point to the need for a redesign process, ensuring the app considers user expectations.

To address these limitations and improvement suggestions, a redesign of the EduCITY app based on PD principles has been proposed. By actively involving students, teachers, and other stakeholders like UX/UI experts throughout the design process, it is expected that the app better meets their needs and expectations, ultimately improving the users' perception of experience. Additionally, by integrating UX/UI best practices, the redesign aims to enhance navigation, accessibility, and overall user satisfaction. This process aligns with EduCITY's ethos of co-creation and community involvement, reinforcing its commitment to innovative education.

4. Methodology

This study adopts an interpretive approach, focusing on people and their emotions, as it seeks to understand how individuals make sense of their experiences (Denzin & Lincoln, 2011; Pope, 1982; Schutz, 1967). It aims to explore the experiences of users and understand the feelings associated with using an artifact, which is in this particular case, a product (Pope, 1982). The study engages participants to gain insights into their perspectives and motivations throughout the process.

The research follows an inductive approach, with the goal of exploring user insights that will inform the redesign of the EduCITY app. By focusing on user perspectives and experiences, the study aims to build knowledge from the ground up (Lincoln & Guba, 1985). However, it also incorporates elements of a deductive approach, as it tests whether applying PD techniques leads to an improved UX (Lincoln & Guba, 1985).

Research methodology is a fundamental element of the research process, providing a structured framework that guides researchers throughout the study (Creswell, 2007). It ensures the credibility and trustworthiness of the findings, ultimately contributing to the advancement of knowledge in the field (Creswell, 2007; Lincoln & Guba, 1985). Therefore, selecting an appropriate methodology is essential to ensure the research produces reliable and meaningful outcomes (C. G. Thomas, 2015). Research methodology encompasses the planning, execution, and analysis of a study. It is essential for guiding the researcher in systematically collecting, analyzing and interpreting data, all of which need to be rigorously executed to avoid errors or biases (J. L. Johnson et al., 2020). The chosen methodology plays a significant role in the quality of the results, considering that it affects the validity, reliability and applicability of the study's conclusions (Lincoln & Guba, 1985). A well-defined methodology ensures that the research is carried out in a structured and valid way, which is essential for generating accurate insights.

Based on previous considerations, the methodology chosen for this study is Design-Based Research (DBR).

4.1. Design-Based Research

DBR is a methodological approach that seeks to investigate "educational designs applied to real-life settings" (Ørngreen, 2015, p. 20), with the dual purpose of solving practical problems and generating theoretical insights that can inform future educational practices (Anderson & Shattuck, 2012).

Anderson & Shattuck (2012) highlighted key characteristics that a quality DBR study should have, through a review of the five most cited papers between 2000 and 2010. They are presented below:

- **Being Situated in Real Educational Contexts**, to enhance the study's credibility and ensure that its results can be used to evaluate, guide and refine practices in that context and potentially similar ones.

- **Focusing on the Design and Testing of a Significant Intervention.** Brown (1992), considered the first researcher to develop DBR, noted that "an effective intervention should be able to migrate from our experimental classroom to average classrooms operated by and

for average students and teachers, supported by realistic technological and personal support" (p. 143). The intervention must be informed by relevant literature, theory, and established practices from other contexts, while being grounded in a thorough understanding of the local setting, being deliberately designed to address a specific issue or to improve practice (Anderson & Shattuck, 2012). An indicator of the study's quality and results is the design of the intervention: the authors suggest that the researchers carefully document the process involved in the creation and design of the intervention so that readers of the study can assess its feasibility and determine whether similar or improved outcomes might be achieved in their own contexts. This includes detailing any contingencies encountered during implementation.

- **Using Mixed Methods.** DBR studies use a variety of methods, research tools and techniques complementary to each other, to collect and analyze both qualitative and quantitative data (Cumming, 2015). This way, researchers can select the methods that better align to their needs to analyze an unknown reality (Anderson & Shattuck, 2012).

- **Involving Multiple Iterations.** DBR is characterized by its iterative nature, where interventions evolve through continuous testing and refinement of prototypes based on feedback and observations within real-world educational contexts (Cumming, 2015). Anderson & Shattuck (2012) argue that "Design-based interventions are rarely if ever designed and implemented perfectly; thus there is always room for improvements in the design and subsequent evaluation" (p. 17) and also note that this characteristic is also one of DBR's biggest challenges, considering that it is difficult – if even possible – to know when the research is complete.

- **Collaborative Partnerships Between Researchers and Practitioners**. A key feature of DBR is its emphasis on collaboration among stakeholders - including educators, learners and researchers - to ensure the interventions are relevant. This collaborative nature is crucial for fostering a sense of ownership between participants, which can lead to more sustainable educational innovations (Ørngreen, 2015). By allowing for the integration of feedback from stakeholders, the iterative design process enhances the quality and applicability of the research outcomes, bridging the gap between research and practice (Ørngreen, 2015).

- **Evolution of Design Principles.** In DBR, designs not only evolve from, but also lead to the creation of design principles. These design principles are grounded in theoretical foundations and are once again used in the final stage of a DBR study. They are shaped by the specific conditions in which they were applied and serve to support the understanding and adaptation of the context and the intervention itself, with the ultimate goal of enhancing learning outcomes (Anderson & Shattuck, 2012). According to the authors, "this requirement to develop practical design principles is a key strength of DBR, and it disadvantages those types of research that unilaterally descend for testing in a classroom and then disappear with the researcher once the experiment has been concluded" (p. 17).

- **Comparison to Action Research.** DBR is often mistaken for "action research" due to their similar characteristics. However, Anderson & Shattuck (2012) point out that while action research is often conducted by individual teachers – thus lacking the input and collaboration of a dedicated researcher and design team, which is typical of DBR – DBR is explicitly

concerned with generating theoretical knowledge while addressing practical problems. This dual focus sets DBR apart from other approaches, as highlighted by Barab & Squire (2004), who state that "design-based research is concerned with using design in the service of developing broad models of how humans think, know, act and learn" (p. 5).

- **Practical Impact on Practice.** A DBR study has the purpose of improving educational and assessment practices (Cumming, 2015). This emphasis on generating impact within real educational contexts is also underlined by Barab & Squire (2004), who argue that "design-based research that advances theory but does not demonstrate the value of the design in creating an impact on learning in the local context of study has not adequately justified the value of the theory" (p. 6).

The iterative and cyclic nature of DBR, as well as its research approach, are emphasized in a model proposed by de Villiers & Harpur (2013), presented in Figure 22. This model incorporates the rigorous ADDIE Model (Analyze, Design, Develop, Implement, and Evaluate).

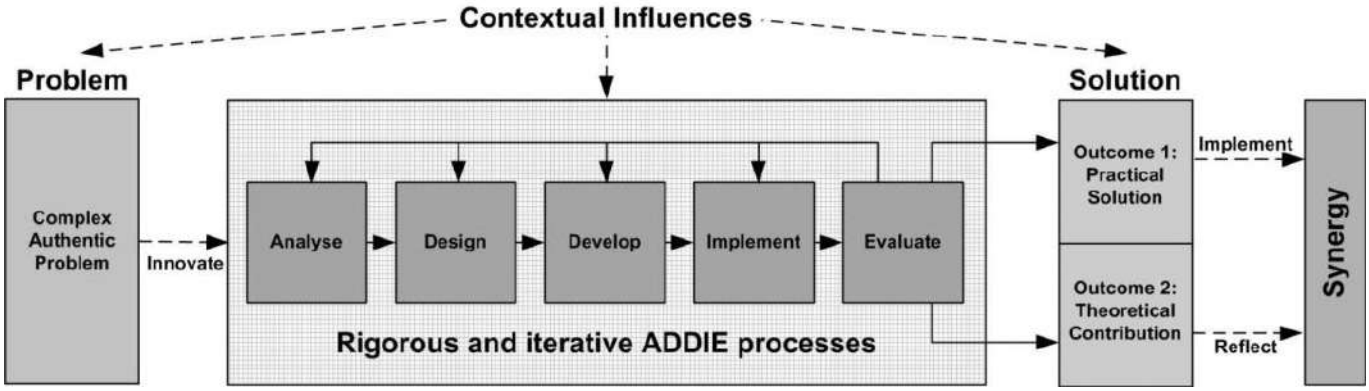


Figure 22 - Generic model of the Design-Based Research process within a context (de Villiers & Harpur, 2013).

According to the model, the process begins with the identification of the problem (on the left) and progresses towards a potential solution (on the right). As explained by the authors, "the left side shows the initial complex problem and the need for innovation on which a pragmatic approach to the solution should be based, while the right side indicates the synergy that should result between practice and theory and between design and research" (de Villiers & Harpur, 2013, p. 256). Aligning with the view previously discussed by Anderson & Shattuck (2012), the authors of the model argue that, when this approach is correctly applied, it should generate not only practical solutions but also theoretical contributions.

In the context of this study, the use of DBR aligns seamlessly with the objectives related to redesigning the EduCITY app. By engaging teachers, students and other stakeholders (like UX/UI experts) through a PD process, this approach facilitates the creation of a user-centered solution. The iterative nature of DBR ensures that the feedback collected throughout the process directly informs the refinement of the app, enabling the design of an improved interface. Through this methodological lens, the study not only aims to enhance the EduCITY app but also to contribute to the broader understanding of how PD can improve UX, specifically in educational technology.

4.2. Research Stages

The study is divided into five stages, as illustrated in Figure 23. This process aligns with both the DBR and PD approaches (explained in detail in the subchapters "Design-Based Research" and "Participatory Design", respectively), particularly in their iterative nature - each stage builds on the findings of the previous one to ensure continuous progression – and in the active involvement of key stakeholders. Students, teachers and UX/UI experts contribute by collaboratively exploring expectations, identifying needs, and co-creating solutions for the EduCITY app.

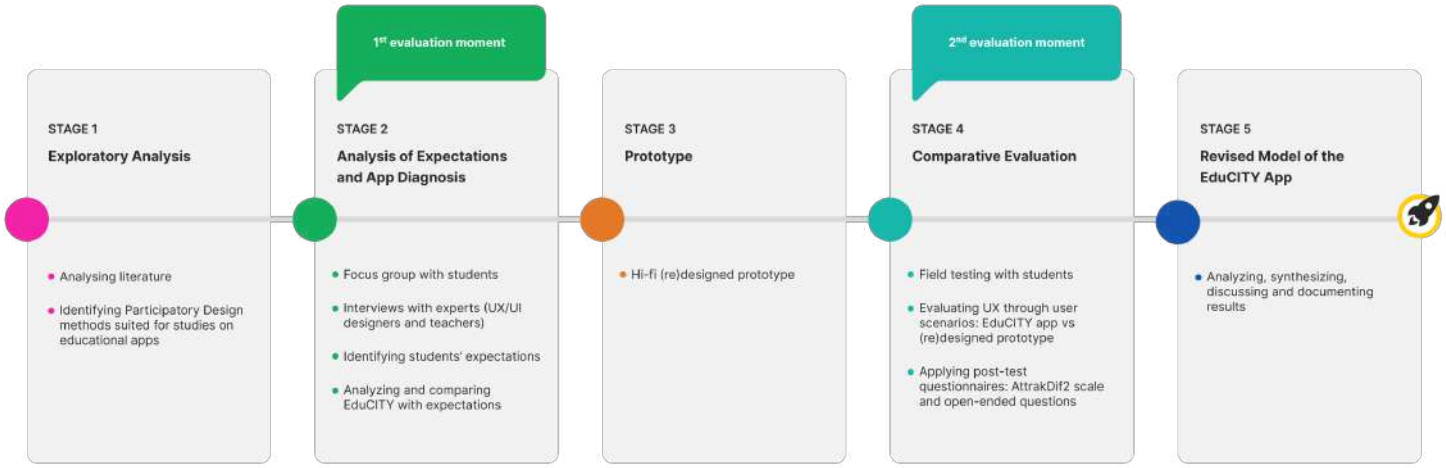


Figure 23 - Research Stages.

The five stages of the study are described below.

Stage 1 (Exploratory Analysis) establishes the theoretical foundation of the study by conducting a literature review that supports the main theoretical themes and contextualizes the EduCITY project and its app. This stage also synthesizes insights on PD methods, guiding the collaborative approach adopted and informing the subsequent stages of the study.

Simultaneously, an SLR began to be conducted to explore the use of mobile apps in educational contexts. The review process contributed insights that informed the study's theoretical framework and methodological decisions. The SLR intended to answer the following question: **"In the timespan 2014-2024, what have been the most frequent approaches to design and evaluate educational apps, especially those with georeferencing, augmented reality resources and quizzes, and how do they contribute to a better user experience?"**.

To be eligible for inclusion, the documents had to cumulatively meet the criteria of having been published between 2014 and 2024, to fall within the specific thematic scope of the SLR, that is, the creation and/or evaluation of digital products involving a collaborative design process, to present sufficient information on a methodological approach that contributed to the integration of feedback from stakeholders to improve user expectation and experience and to be written in English or Portuguese. All the documents that did not meet the inclusion criteria, as well as documents reporting studies whose participants were under the age of 8, or involved older adults, who had any neurocognitive disorder, learning limitations, intellectual or sensorial disabilities were excluded. Conference reviews, books, and book chapters were also excluded. Documents that the researcher

could not access or were duplicated in the databases used were also excluded from the selection process.

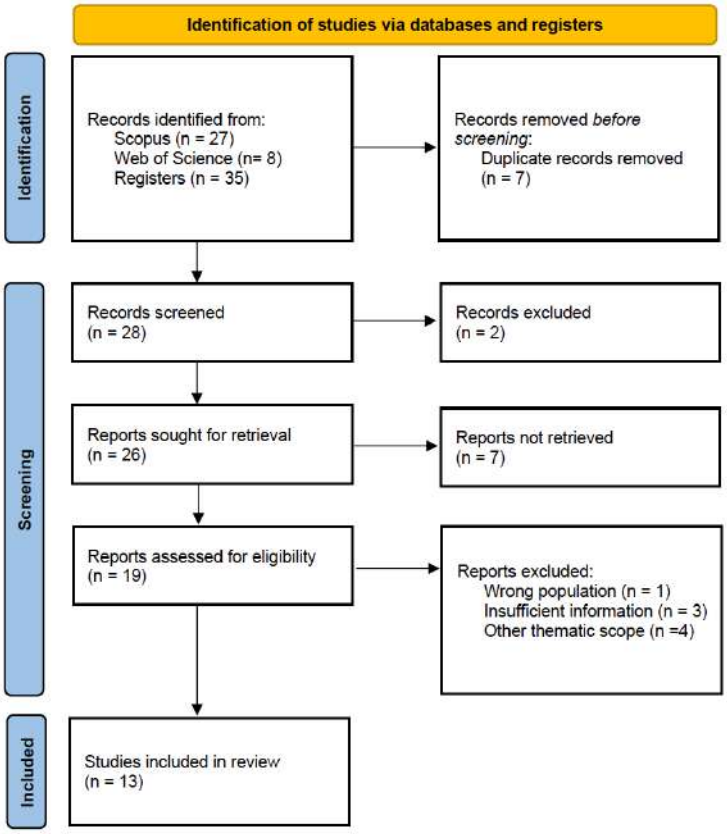
The search was conducted in Scopus and Web of Science, using the queries detailed in Table 2. Where possible, the use of complete words was privileged. The only acronyms used were UX, UI and GBL (Game-Based Learning).

Table 2 - Queries that were used in each database.

Database	Query
Scopus https://www.scopus.com/	(TITLE-ABS-KEY (mobile OR "mobile learning" OR "mobile app" OR smartphone OR app OR tablet) AND TITLE-ABS-KEY ("user experience" OR ux OR usability OR "user interface" OR ui OR interface OR "interaction design") AND ALL ("game based learning" OR "game-based learning" OR gam* OR "education* games" OR gbl) AND TITLE-ABS-KEY (participatory OR "participatory design" OR "participatory approach" OR "co-design*" OR "co-creat*") AND ALL ("augmented reality" OR ar OR quizz* OR georefe*) AND TITLE-ABS-KEY (teach* OR student* OR education* OR learn*) AND NOT TITLE-ABS-KEY (autism OR "special needs" OR dementia OR blind* OR disabilit* OR deaf*) AND NOT TITLE-ABS-KEY (preschool OR kindergarten)) AND PUBYEAR > 2013 AND PUBYEAR < 2025 AND (EXCLUDE (EXACTKEYWORD , "Mixed Reality") OR EXCLUDE (EXACTKEYWORD , "Extended Reality") OR EXCLUDE (EXACTKEYWORD , "Virtual Reality")) AND (EXCLUDE (DOCTYPE , "bk") OR EXCLUDE (DOCTYPE , "ch") OR EXCLUDE (DOCTYPE , "cr")) AND (LIMIT-TO (LANGUAGE , "English"))
Web of Science https://www.webofknowledge.com/	mobile OR "mobile learning" OR "mobile app" OR smartphone OR app OR tablet (Topic) and "user experience" OR ux OR usability OR "user interface" OR ui OR interface OR "interaction design" (Topic) and "game based learning" OR "game-based learning" OR gam* OR "education* games" OR gbl (All Fields) and participatory OR "participatory design" OR "participatory approach" OR "co-design*" OR "co-creat*" (Topic) and "augmented reality" OR ar OR quizz* OR georefe* (All Fields) and teach* OR student* OR education* OR learn* (Topic) not autism OR "special needs" OR dementia OR blind* OR disabilit* OR deaf* (Topic) not preschool OR kindergarten (Topic)

The study selection process is visually summarized in Table 3, through a PRISMA diagram completed by the researcher.

Table 3 - PRISMA Diagram for Systematic Literature Review.



Once selected, the papers were fully read and analyzed in detail. This SLR process was essential as it enabled a systematic coding and analysis of how PD methodologies were applied, how user engagement was fostered, and how design processes addressed specific contextual challenges. The review included 13 studies: Cesário & Nisi (2023), Di Fuccio et al. (2024), Garcia (2020), Giacobone et al. (2024), Howard et al. (2022), Koutsabasis et al. (2022), Mackay et al. (2024), Malamsha et al. (2021), Mercier et al. (2023), Mosbak & Bjorner (2022), Ntagiantas et al. (2022), O'Connor et al. (2023), and Reiersølmoen et al. (2018). Together, they provided a comprehensive overview of how participatory and co-design approaches have been applied in the development of mobile educational apps.

Across the included studies, methodological patterns emerged: most adopted iterative and user-centered strategies, including **co-design workshops** (Cesário & Nisi, 2023; Di Fuccio et al., 2024; Garcia, 2020; Giacobone et al., 2024; Koutsabasis et al., 2022), **field testing** (Koutsabasis et al., 2022; Mercier et al., 2023), **focus groups** (Cesário & Nisi, 2023; Giacobone et al., 2024; Howard et al., 2022; Malamsha et al., 2021), and **stakeholder interviews** (Cesário & Nisi, 2023; Di Fuccio et al., 2024; Giacobone et al., 2024; Malamsha et al., 2021; Mercier et al., 2023; Mosbak & Bjorner, 2022; Ntagiantas et al., 2022; O'Connor et al., 2023; Reiersølmoen et al., 2018). These methods proved essential to systematically integrate feedback from end users, particularly students and teachers, into the development process. These approaches supported the alignment of each app with pedagogical goals, users' expectations, and contextual specificities.

Another relevant pattern identified in the SLR concerns the frequent use of **mixed-method approaches** (Di Fuccio et al., 2024; Giacobone et al., 2024; Malamsha et al., 2021; Mosbak & Bjorner, 2022; Ntagiantas et al., 2022; O'Connor et al., 2023; Reiersølmoen et al., 2018), combining quantitative techniques - such as surveys, usability testing, and statistical comparisons - with qualitative data collection - such as interviews, focus groups, and user observation. This methodological combination proved particularly effective in capturing both measurable outcomes and in-depth user perspectives, enabling a richer understanding of how users engage with educational technologies (Di Fuccio et al., 2024; Giacobone et al., 2024; Mosbak & Bjorner, 2022; Ntagiantas et al., 2022; Reiersølmoen et al., 2018). The prevalence of mixed-methods research in the reviewed studies also reinforced the decision to adopt a DBR framework in the present study, which embraces both quantitative and qualitative insights, as previously explained in the subchapter "Design-Based Research". In this sense, the SLR contributed not only to defining the theoretical focus of the study, but also to shaping its methodological approach.

The insights obtained through this SLR were instrumental in shaping the PD logic and the UX evaluation strategy adopted in the present study. Additionally, it is worth noting that, as previously mentioned, both apps used in the subchapter "Apps from Research Studies" – Mouseion Topos (Koutsabasis et al., 2022) and HARA (Garcia, 2020) - were retrieved from two of the 13 articles included in the SLR.

Stage 2 (Analysis of Expectations and App Diagnosis), aimed at understanding users' expectations for an app like EduCITY and comparing them with the current version of the app, marks the introduction of collaborative techniques. This stage combines PD techniques to identify user expectations and evaluate the current version of the EduCITY app. Using **focus groups** conducted with students and **semi-structured expert interviews** to gather feedback from UX/UI designers and teachers, this stage allowed for the identification of the app's strengths, weaknesses, and areas for improvement, acting as the basis for the subsequent design process.

A **focus group** is a qualitative technique that facilitates moderated discussions among a relatively homogenous group of people, encouraging participant interaction to uncover diverse opinions and perspectives (Krueger & Casey, 2000). According to Krueger & Casey (2000), focus groups can be particularly useful at key stages of product development: **1) early in the design process**, to help researchers understand participants' experiences and values, which design experts can then use to create prototypes aligned with users' perceptions; **2) during prototype testing**, to allow potential users to compare options, providing feedback on what they like and don't like about each one, informing design decisions; and **3) after a product has been launched**, to evaluate whether it meets users' expectations and needs, and to identify areas of improvement.

However, no method is without limitations, and it is important to reflect on the disadvantages of focus groups. For instance, although participants tend to see themselves as thoughtful, rational creatures, a lot of human behavior is unconscious. This means that when the goal is to gather information regarding participants' behavior, researchers should proceed with caution and consider combining focus groups with other methods that do not rely solely on questions and answers (Krueger & Casey, 2000). Another risk is that participants may provide answers they believe are expected, particularly if they are not familiar with the topic under discussion. This means there is a risk of the focus group to "give us a picture of how the consumer wants to be seen by others, as opposed to their actual lives" (Krueger & Casey, 2009, p. 14). The size of a focus group also matters. If there are too

many participants (e.g., 10-12) and the topic is complex, the discussion may yield superficial results. It is advisable to reduce the number of participants when time is limited, or the topic is complicated. Additionally, dominant individuals may try to dominate the conversation, which undermines one of the main strengths of focus groups: the diversity of opinions and perspectives. Therefore, it is crucial that the moderator is prepared to manage group dynamics effectively to allow all participants to feel comfortable when giving feedback (Krueger & Casey, 2009).

In addition to focus groups, **semi-structured expert interviews** were also conducted during Stage 2, involving middle school teachers and UX/UI experts, to explore their domain-specific knowledge. This qualitative technique allows researchers to start the interview with predefined topics while having the freedom to follow the natural flow of the conversation (Ahlin, 2019). By allowing for relevant follow-up questions and the exploration of themes introduced by participants, semi-structured interviews provide a deeper understanding of how and why certain perceptions emerge, making them particularly useful to collect and analyze exploratory data (Ahlin, 2019). Moreover, semi-structured interviews can be considered participatory in nature, as they are conducted with the stakeholders, allowing for a blend of research and practice. This characteristic aligns with the PD approach and DBR methodology adopted in this study. Their use is particularly appropriate in this context, as open-ended questions facilitate the collection of in-depth perspectives regarding the app's design, usability, and educational relevance. Nevertheless, these same open-ended questions may also affect the reliability and replicability of the study, as each interview may follow a different course (Ahlin, 2019). Interview duration is also something to consider, as durations exceeding 30 to 90 minutes may be too long for some participants, potentially affecting their engagement (Ahlin, 2019). Additionally, the role of the interviewer is crucial, as it can be difficult to ask relevant follow-up questions in order to obtain in-depth answers and additional information (Ahlin, 2019).

Stage 3 (Prototype) embodies the iterative nature of DBR and PD, integrating theoretical insights and participant feedback collected during Stages 1 and 2 to develop a high-fidelity prototype. The design process aligns with user expectations, addressing identified needs and introducing meaningful improvements to enhance the app's functionality and overall UX.

Stage 4 (Comparative Evaluation) involves scenario-based testing, where middle school students interact with both the current EduCITY app and the (re)designed prototype from Stage 3. This fourth stage aims to assess which version of the app provides a better UX, from the participants' perception, using questionnaires.

To assess the user experience of both the current and redesigned versions of the EduCITY app, the AttrakDiff2 scale (Hassenzahl et al., 2015) was employed in the questionnaires. Introduced by Hassenzahl et al. (2003) in German, the AttrakDiff instrument evaluates a product's UX by considering its functional and emotional aspects during interaction (Carneiro, 2018; Lallemand et al., 2015). The updated version, AttrakDiff2, has two different categories of perceptions (Hassenzahl et al., 2015):

- **Pragmatic Quality:** the product's perceived potential to enable users to achieve their goals through its features (Carneiro, 2018; Hassenzahl et al., 2015).

- **Hedonic Quality:** the product's potential to evoke emotional responses of pleasure and use, such as stimulation - the desire for personal development, knowledge acquisition,

skill development - and identity - the expression of the self through the product (Carneiro, 2018; Hassenzahl et al., 2015).

The questionnaire uses a 7-point bipolar semantic differential scale with 21 items regarding: Pragmatic Quality (PQ), from the 1st to the 7th item; Hedonic Quality – Identity (HQ-I), from the 8th to the 14th item; and Hedonic Quality - Stimulation (HQ-S), from the 15th to the 21st item. Each item presents a pair of opposite adjectives (negative/positive), such as "complicated/simple" (Carneiro, 2018; Hassenzahl et al., 2015; Vieira et al., 2023).

According to Hassenzahl et al. (2015), data analysis involves calculating the mean score for each scale (PQ, HQ-I and HQ-S), as well as the overall mean across all 21 items, which reflects the general perception of the product's UX.

To assess the reliability of the responses for each scale, Cronbach's alpha coefficient (α) is often used. This indicator verifies the internal consistency of the responses. That is "the degree to which the items that make up the scale are all measuring the same underlying attribute" (Pallant, 2016, p. 27). Cronbach's alpha coefficient helps determine whether the data is free from random errors that could compromise the results (Vieira et al., 2023). Values range from 0 to 1, and the higher the value, the greater reliability. Normally, values equal to or above 0.70 are generally recommended for ensuring adequate reliability (Pallant, 2016; Vieira et al., 2023). However, these values highly depend on the number of items on a scale: when items are less than 10, which is the case of the AttrakDiff2 with only 7 items per scale, Cronbach's alpha values can be quite low. In situations like these, it is advised to also calculate the mean inter-item correlation for the items, which should range from 0.2 to 0.4 to be considered optimal (Pallant, 2016).

Although the original scale ranges from –3 to +3 (Vieira et al., 2023), in this study, the visual layout presented to participants used the labels 3, 2, 1, 0, 1, 2, and 3, with directional arrows pointing left (positive pole) and right (negative pole), as shown in Figure 24. This decision was made to reduce potential bias among younger participants, who might associate negative numbers with negative evaluations. Nevertheless, during data analysis, values were converted to the original -3 to +3 format, following the standard semantic orientation of the adjective pairs, which is from negative to positive (Carneiro, 2018).

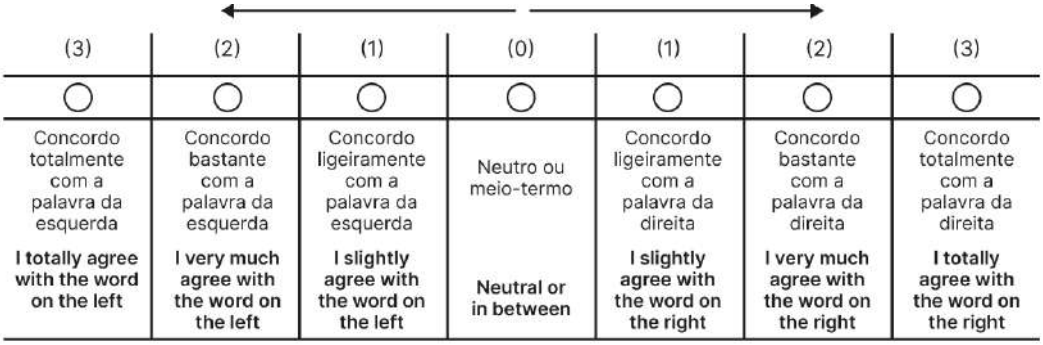


Figure 24 - Format of the 7-point semantic differential scale used in the questionnaire, showing values from 3 to 0 to 3 with directional arrows.

This instrument has been widely adopted in UX research due to its ease of application, having an easy-to-understand verbal scale, robust theoretical foundation and validated structure (Carneiro, 2018; Hartson & Pyla, 2012; Lallemand et al., 2015). Its inclusion might be of great significance for

this study, to understand the nuanced aspects of the UX, comparing both the original and redesigned interfaces.

Besides using the AttrakDiff2 scale, the questionnaires also include qualitative open-ended questions. So, Stage 4 generated both quantitative and qualitative data. This mixed-method approach is essential to capturing the multifaceted nature of UX and is aligned with the principles of DBR, which promote the integration of diverse research methods adapted to real-world educational contexts (Anderson & Shattuck, 2012). The key characteristics of DBR, particularly the recommended use of mixed research methods, is explored in more detail in the subchapter "Design-Based Research".

Stage 5 (Revised Model of the EduCITY App) analyzes, synthesizes, and discusses the results obtained throughout the study. This phase aims to answer the research question by combining insights from all previous stages and presenting the study's contributions within the context of existing literature. Once again, this approach follows the DBR methodology employed in this study, explained previously and in further detail in the subchapter "Design-Based Research".

4.3. Participants

This study considers the views and opinions of three key groups: middle school students, teachers, and UX/UI design experts.

The primary focus of this research is on middle school students, specifically those in grades 7 to 9 (3rd Cycle of Basic Teaching, in the Portuguese educational context), considering that students are the main users of the EduCITY app regarding its gameplay component. Their perspectives, needs, and preferences were central throughout the process, particularly during Stage 2 (Analysis of Expectations and App Diagnosis) and Stage 4 (Comparative Evaluation).

In an initial and exploratory phase, more specifically Stage 2 (Analysis of Expectations and App Diagnosis), feedback was also collected from teachers and UX/UI experts to complement the input from students. Teachers, who are one of the main target audiences of the EduCITY project as game creators, provided feedback on aspects of the app they find problematic or in need of improvement. Similarly, UX/UI experts contributed with an evaluation of the app's usability, interface, features, and overall aesthetics, helping to identify areas for enhancement and guiding the redesign process.

This study adopts PD methods, emphasizing the importance of involving end users as co-designers. While both students and teachers represent the primary target audience of EduCITY - with students playing the games and teachers creating them - the later phases of the study focus mainly on students, especially in the UX comparative tests. Teachers and experts played a more prominent role in the initial stages, offering feedback to establish a solid foundation for the redesign.

4.3.1. Description of the Sampling Process and Sample Size

Given the time constraints of the research process and the evaluation stages, non-probabilistic sampling techniques were employed. This approach facilitates participant recruitment while ensuring the inclusion of individuals with relevant profiles for each phase of the study (Babbie, 2010). All participants – students, teachers and UX/UI experts – were selected using a combination of convenience and purposive sampling: while the selection partly depended on the accessibility and willingness of participants (convenience sampling), it was also guided by specific criteria (purposive sampling) (Babbie, 2010). These criteria varied by participant group and are outlined below.

Regarding the students, the study took place in the school cluster "Agrupamento de Escolas de Gafanha da Nazaré", specifically at its secondary school, "Escola Secundária da Gafanha da Nazaré", with authorization granted by both the school cluster's Director and the Portuguese Ministry of Education under process no. 1697400001. Approximately 15 students from grades 7 to 9 participated in the study, based on their availability and willingness to take part, and with prior informed consent authorization from their legal guardians. As the primary focus of the research, students were involved in both the exploratory phase (focus group in Stage 2) and the comparative UX testing stage (Stage 4), as explained in greater detail in the subchapter "Research Stages".

Regarding the teachers and the UX/UI experts, two interviews per group were conducted during an initial and exploratory phase (Stage 2). Teachers were selected for their experience with digital educational tools and, specifically, for having previously participated in a training session on the EduCITY app, which they had already used with students in real field contexts. This ensured that their feedback was grounded in practical experience with the app's functionalities and educational implementation. UX/UI experts were chosen based on their professional background and expertise in usability and interface design, ensuring that their feedback served as a foundation for identifying improvement opportunities and informing the redesign process.

4.4. Data Collection Techniques and Instruments

Considering the complexity of the research, multiple techniques and instruments were employed to ensure a comprehensive understanding of user expectations, experiences, and interactions with the app, as well as to enhance the reliability and depth of the findings.

Every data collection technique and instrument were carefully selected to align with the study's goals and the type of data needed to answer the research question. Table 4 presents an overview of how each one contributes to addressing the research question and collecting relevant data.

Table 4 - Association between data collection methods and instruments, and the study's objectives.

Techniques and Instruments	Goals	Data Collected	Alignment with Research Question
Focus Group	To explore students' expectations, motivations, and suggestions regarding the app.	Qualitative data on perceptions, expectations, and suggestions for improvement.	Provides insights into user needs and expectations, directly informing the redesign of the app.
Semi-structured Interviews	To gather professional perspectives on usability and educational value.	Qualitative data on usability, interface design, and pedagogical alignment.	Helps understand how the app can be adapted for educational contexts and aligns with best UX/UI practices, providing complementary feedback.
UX Comparative Tests	To compare students' perceived UX over the current app and the prototype.	Mixed: quantitative (AttrakDiff2) and qualitative (open-ended questions).	Provides measurable data, allowing the comparison of the app and prototype, to understand which version offers a better UX perception and why.
AttrakDiff2 Questionnaire	To evaluate the pragmatic and hedonic qualities of the app and the prototype.	Quantitative data on pragmatic and hedonic dimensions of the user experience.	Helps measure perceived UX, user satisfaction and appeal of the app, contributing to the evaluation of the redesign.

To provide an overview of the methodology, focusing on research and data collection methods to be used throughout the study, Table 5 was created.

Table 5 - Overview of data collection methods.

	STAGE 1 **Exploratory Analysis**	STAGE 2 **Analysis of Expectations and App Diagnosis**		STAGE 3 **Prototype**	STAGE 4 **Comparative Evaluation**	STAGE 5 **Revised Model of the EduCITY App**
Technique(s)	Literature review & systematic literature review	Focus group	Semi-structured interviews	Prototyping	UX experience testing and survey	Data synthesis and reporting
Instrument(s)	Data extraction tools (Microsoft Excel and Word)	• Focus group guide • Audio recorder • Informed consent form	• Interview guide • Audio/video recorder • Informed consent form	Prototyping tool (Figma)	• Test guide • Scenarios • AttrakDiff2 scale • Open-ended questions • Informed consent form	• Report of qualitative and quantitative analysis • Triangulation of data
Participants	N/A	Middle school students	UX/UI experts and teachers	N/A	Middle school students	N/A
Goal(s)	To identify theoretical background, state of the art, best practices for developing apps and PD methods suited for studies on educational apps.	To explore expectations and gather feedback on the app's strengths and weaknesses, including suggestions for improvement.	To collect expert perspectives on the app, identifying key areas for redesign and improvement.	To create a hi-fi prototype based on theoretical findings and feedback from previous stages to address identified areas for improvement.	To compare the current app and the prototype to determine which provides a better perception of UX.	To combine insights from all phases to respond to the research question, discuss findings, and provide recommendations for future work.
Data Nature	Qualitative	Qualitative		N/A	Mixed	Mixed

Each stage of the study builds upon the findings from the previous one:

1. **Exploratory Analysis:** a literature review supported by data extraction tools, such as Microsoft Excel and Microsoft Word, informed about the theoretical framework, state of the art and common PD methodologies in the design of (educational) apps.

2. **Analysis of Expectations and App Diagnosis:** includes two complementary techniques:

    - **Focus Group:** engaging middle school students to facilitate discussions about their expectations, evaluate the current app, and suggest improvements, supported by a structured guide and a fictional use scenario.

    - **Semi-structured interviews:** gathering professional and educational perspectives from UX/UI experts and teachers on the app's usability, design and educational potential.

3. **Prototype:** a high-fidelity (hi-fi) prototype of the app will be developed using a prototyping tool, Figma. This prototype will incorporate theoretical findings and user feedback collected in previous stages, addressing the main areas identified for improvement.

4. **Comparative Evaluation:** testing the current app and the prototype with students, using tools like AttrakDiff2, and open-ended survey questions that will provide qualitative and quantitative data.

5. **Revised Model of the EduCITY App:** findings will be consolidated using triangulation to integrate qualitative and quantitative insights. This stage will focus on analyzing the data to answer the research question, providing a comprehensive discussion of the findings, and offering recommendations for future developments.

The following subchapters introduce the procedures adopted for each data collection moment used in the study. Each one is presented in a dedicated subchapter, namely "Focus Group", "Expert Interviews" and "Comparative UX tests". In each case, the structure of the data collection instrument is described first, followed by the technique used to apply it, ensuring consistency and reliability throughout the study.

4.4.1. Focus Group

In order to steer the Focus Group discussion, the researcher used a structured interview guide (Appendix 1). This guide was divided into four main sections: 1) Presentation and Introduction; 2) Scenario-based imagination exercise; 3) Presentation of the current app and Comparison with expectations; and 4) Conclusion.

The first section aimed to make participants feel more comfortable during the focus group. It began by ensuring that all Informed Consent Authorization Forms were properly signed and that everyone understood how the session would proceed. The researcher reminded the participants that the session would be audio-recorded. To help break the ice and motivate participants, the researcher gave a brief introduction of herself and then invited each student to do the same.

The second section focused on exploring the students' expectations regarding an educational app with characteristics similar to EduCITY, without revealing the app itself to avoid influencing their responses. The section started with the researcher reading aloud an imaginary scenario, encouraging participants to be imaginative and not feel comfortable proposing new ideas. To guide discussion, the researcher asked targeted questions, such as: "If this app was tailor-made for you, what would you like it to have? What kind of things do you think it should do?" or "Would you prefer to play this kind of game alone, with friends, or during a lesson with the teacher?". To end this section, the researcher presented pairs of interface images to gather participants' preferences regarding different UI styles. This activity is discussed in more detail next, and the image pairs used are included in Appendix 2.

The third section involved comparing the expectations discussed in the previous section with the actual EduCITY app. The researcher first introduced the EduCITY project and briefly explained the app's purpose and main features through a use scenario to provide context. After this, participants were invited to interact directly with the app by playing a test game indoors, simulating a typical outdoor EduCITY experience. Each student used a phone to explore the app. The session concluded with a reflection and comparison of initial expectations versus actual experience. Students were asked questions such as: "Is there anything you thought would be in the EduCITY app, but isn't?", "What could we add to the app to make it more useful or fun?" and "If you could change the look of the app, what would you do? What do you think of the colors?".

The fourth section concluded the focus group, with the researcher thanking participants for their presence.

Thanks to the structured guide, the focus group followed a clear and coherent flow, enabling the researcher to later analyze the results and draw insights.

Regarding the procedures adopted, a single focus group was conducted with five 8th grade students to explore their expectations, motivations, feelings and suggestions regarding the EduCITY app. The structured interview guide (available in Appendix 1) included a fictional use scenario to start the conversation. The session took place in a controlled school environment - a classroom - to facilitate discussion. The interview guide, along with other materials prepared for the focus group (such as pieces of paper in which every participant wrote their name to help the researcher remember everyone's names, allowing the conversation to flow more naturally), and the classroom in which the focus group took place are presented in Figure 25.

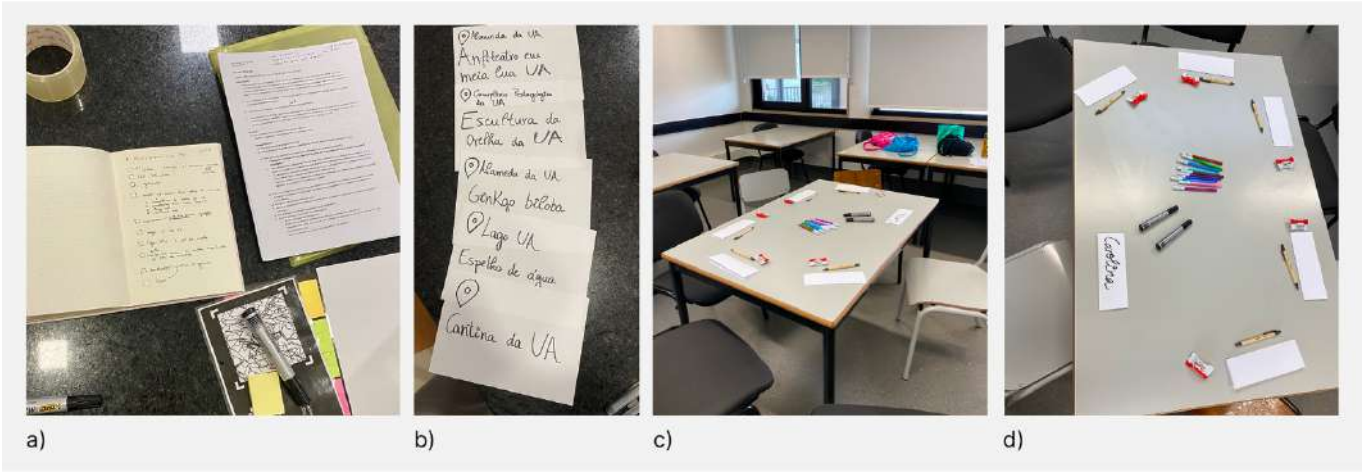


Figure 25 - a) Focus group preparation with interview guide; b) paper plaques made by the researcher to stick on the wall and simulate an outdoor experience; c) classroom where the focus group took place; and d) table where the participants and the researcher sat, with pieces of paper to write their names on.

The session was audio-recorded for later analysis. All participants, as well as their legal guardians (given that the students are minors), were required to sign an Informed Consent Authorization Form (provided in Appendix 3), in accordance with the General Data Protection Regulation (GDPR), to participate in the focus group. Following the analysis of the audio recording, all audio data was promptly deleted by the researcher. Participants were introduced to the purpose of the study and the focus group protocol. The moderator - in this case, the researcher - guided the session using the interview guide mentioned previously.

The session only began after the researcher ensured that all participants clearly understood the ground rules of the focus group. The discussion was structured in three main stages: 1) exploring participants' expectations regarding an educational app; 2) presenting the EduCITY app to participants; and 3) comparing their initial expectations with the actual app, to identify potential areas for improvement and enhance the overall UX of the app.

The first stage involved asking participants to imagine a hypothetical scenario of an educational app with the general characteristics of EduCITY (outlined in the interview guide in Appendix 1). For this reason, the students that took part in the focus group didn't have prior knowledge of the EduCITY app. This imagination exercise led to an open discussion about their expectations regarding such app.

Afterwards, the researcher presented pairs of interface images - sourced from a variety of projects on Behance, a platform where designers and creatives showcase their work – highlighting contrasting UI styles. To select these examples, the researcher conducted a visual analysis of interface designs, focusing mainly on mobile apps related to education, games, and quizzes. The selection process involved identifying different visual styles, based on criteria such as:

- **Color scheme** (dark vs. light mode or bright/neutral colors).
- **Tone and style** (cartoony/childish vs. minimalistic/serious).
- **Purpose** (educational vs. game-oriented apps).

These criteria help define the pairs used in the A/B testing, allowing participants to express preferences based on clearly contrasting characteristics. Figure 26 illustrates the categorization of selected interfaces according to the criteria.

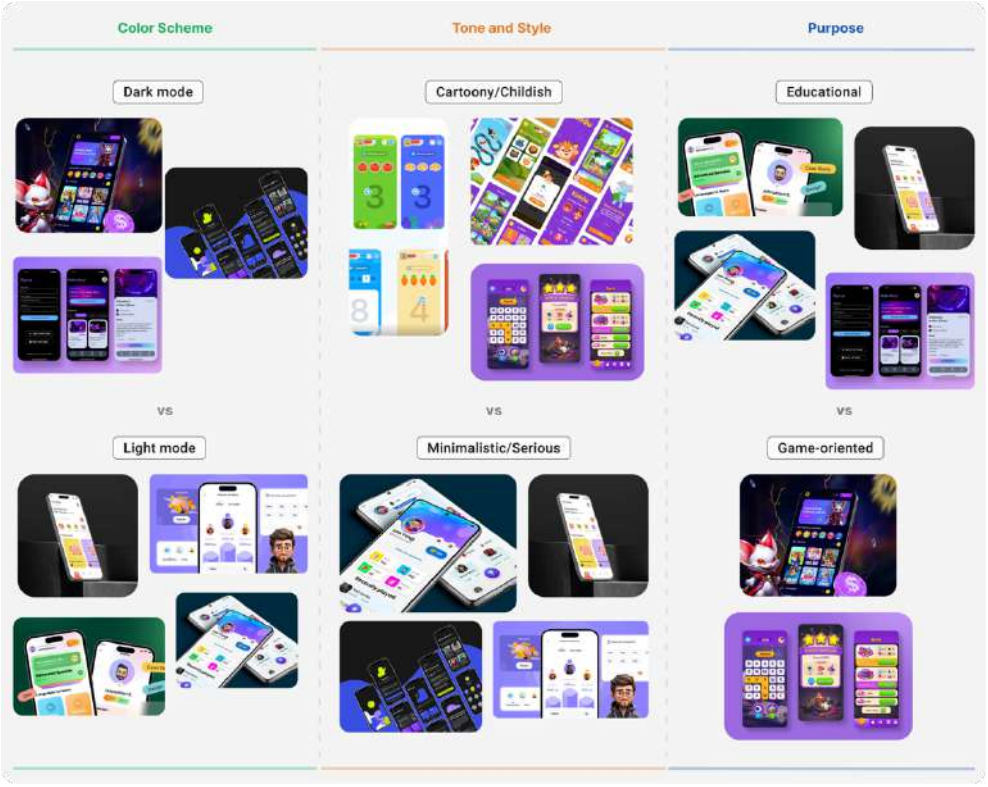


Figure 26 - Visual clusters of mobile UI designs retrieved from Behance, organized according to the criteria: color scheme (dark mode vs. light mode), visual tone (cartoony/childish vs. minimalistic), and purpose (educational vs. game-oriented interfaces).

The comparisons, partially illustrated in Figure 27 and fully available in Appendix 2, aimed to gather input on visual preferences that could inform the redesign of the EduCITY interface.

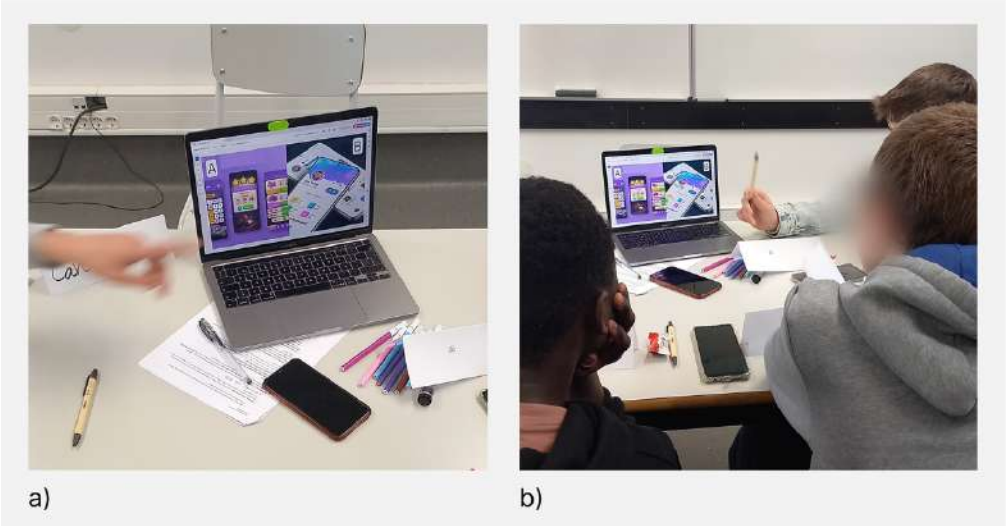


Figure 27 – One of the five pairs of images discussed during the focus group with students.

During this exercise, participants were asked to indicate their preferred option in each image pair and to explain the reasons behind their preferences or dislikes. This strategy aligns with Krueger & Casey's (2000) recommendation of encouraging potential users to compare prototypes during focus group sessions, to guide the design process more effectively, as previously detailed in the subchapter "Research Stages".

The second stage began after this activity and required participants to get familiar with the EduCITY app. Although the EduCITY app was designed to be used in outdoor contexts, due to time constraints related to this study and weather conditions, the experience was simulated indoors, in the same classroom where the focus group was taking place (as seen in Figure 28).

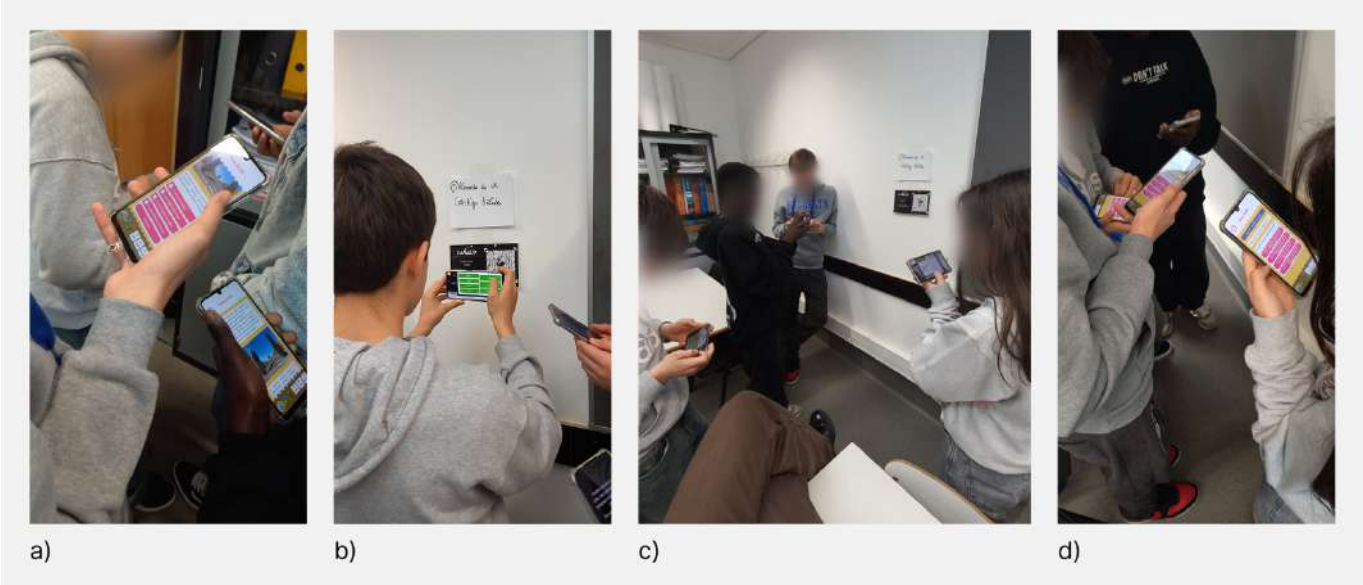


Figure 28 – Focus group participants using the EduCITY app: a) question with multiple correct answers; b) ARBook main screen; c) ARBook being explored by participants; and d) question with only one correct answer.

No students used their mobile phones, since the researcher brought smartphones from the EduCITY project, with the app already installed. The researcher first provided a general explanation of the app's purpose and structure, and then students were invited to play a test game (created by the researcher) on the app. This test included several types of questions, such as only one correct option or questions allowing multiple correct answers, as well as different multimedia resources, including an ARBook, images, audio, and video. By playing this game, participants were able to quickly explore most of EduCITY's key features.

After testing the EduCITY app, the third stage consisted of participants and the researcher sitting back down to reflect on the previously discussed expectations and compare them with their experience using the app. This final stage of the focus group also provided an opportunity to discuss potential improvements and gather suggestions from the participants. The session concluded with the researcher thanking the participants and emphasizing the value of everyone's contributions to the study. It lasted approximately 90 minutes and was scheduled according to the students' availability.

4.4.2. Expert Interviews

Similarly to the focus group, the **semi-structured expert interviews** were guided by an interview script (Appendix 4) divided into three main sections: 1) Presentation and Introduction; 2) Presentation of the current app and Critical Analysis; and 3) Conclusion.

The first section aimed to create a comfortable environment and introduce the purpose of the interview. The researcher ensured that the informed consent form was signed, that the expert understood how the session would proceed, and confirmed their agreement to audio and video recording, as outlined in the consent form.

The second section focused on collecting expert feedback on the current version of the EduCITY app, identifying issues and suggestions relevant to the redesign process. This section included tailored tasks and questions according to each area of expertise - either UX/UI design or education. Since the designers were unfamiliar with the EduCITY app, the researcher started by briefly introducing it, followed by asking them to perform certain tasks that allowed them to explore the interface of the app while offering constructive feedback. In contrast, no introduction was needed for teachers, as both had already used the app with their students.

The critical analysis phase was supported by questions aligned with each expert's background. For example, teachers were asked questions about the app's educational potential, such as: "How could the app be integrated into a traditional lesson or field trip?" or "Do you think students would learn better using this app individually or in groups? How could collaboration between students be worked on?". Meanwhile, designers were asked about usability, navigability and interface design, with questions such as: "Are the design elements (layout, typography, icons, colors) consistent and intuitive for end users? What aspects could be improved?" or "What opportunities do you see for improving the app experience, considering good UX/UI practices?". The section concluded with a discussion focused on specific improvement suggestions.

The third and final section wrapped up the interview. The researcher asked whether the participant had any final questions or comments, and then expressed appreciation for their time and insights, emphasizing the value of their contribution to the study.

The semi-structured expert interviews were conducted with two middle school teachers who had previously used the EduCITY app and two UX/UI experts, to provide complementary feedback, based on their area of expertise, on an early stage of the study. Three out of the four interviews were conducted via video call, because of convenience purposes. All sessions were video, and audio-recorded for subsequent analysis. Interviewees were required to sign an Informed Consent Authorization Form (provided in Appendix 5), in accordance with the GDPR. The video recordings were deleted immediately after transcription, and the audio files were deleted upon completion of their analysis. As in the focus group, the researcher acted as the interviewer, guiding the session with the support of the interview guide while allowing the conversation to follow its natural flow.

The interviews with the UX/UI designers began with a brief presentation of the EduCITY project and its app, followed by a use scenario that included a set of predefined tasks. This allowed the designers to navigate through all the intended screens, in a kind of usability test format, during which only qualitative feedback was collected. The game used in these interviews was the same as the one played by the focus groups participants, enabling the designers to interact with EduCITY's core

features. In addition, designers explored extra screens and provided detailed feedback on the app's usability and areas for improvement. A screenshot from the video call interview with one of the UX/UI designers is presented in Figure 29.

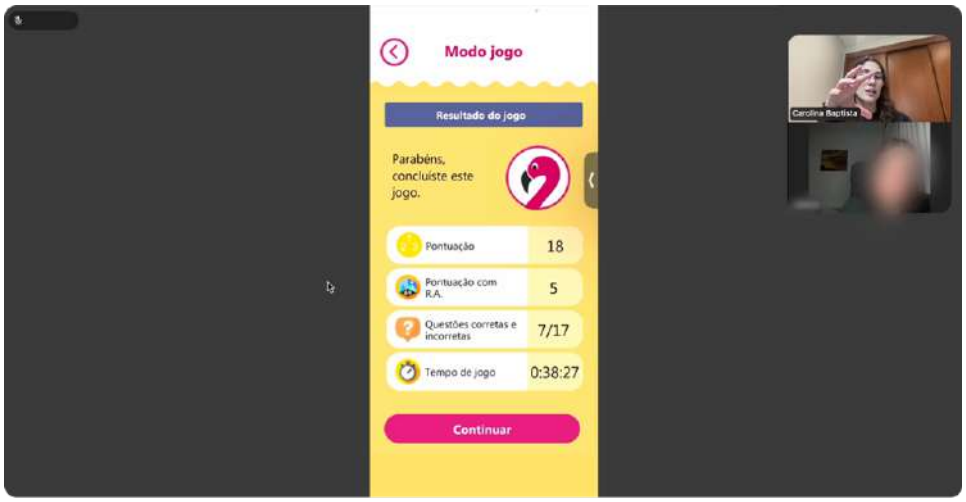


Figure 29 – Online interview conducted with a UX/UI designer.

The interviews conducted with teachers focused on exploring the app's educational potential and collecting feedback regarding its usability. Both teachers had prior experience using the EduCITY app with their students, which allowed them to offer informed insights. The teachers were from different schools within the Aveiro region. A screenshot from one of the two teacher interviews is presented in Figure 30.

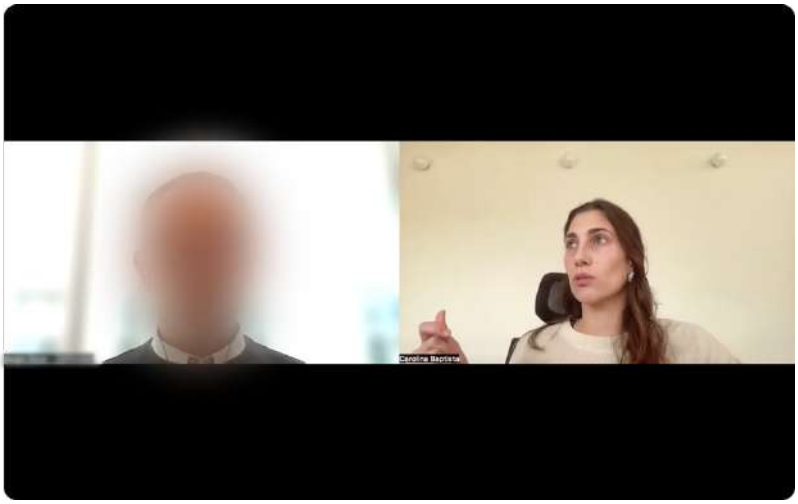


Figure 30 – Online interview conducted with a middle school teacher.

All interview sessions concluded with the researcher thanking the participants and emphasizing the value of their contributions to the study. The interviews with UX/UI designers lasted approximately 90 to 120 minutes, while those with teachers lasted between 30 and 45 minutes. All sessions were scheduled according to the participants' availability.

4.4.3. Comparative UX tests

As explained in greater detail in the subchapter “Research Stages”, the focus group and the interviews conducted during Stage 2 of the study informed the prototype (re)design developed in Stage 3. Following this, in Stage 4, **comparative UX tests** were carried out to evaluate the prototype.

The researcher used a structured guide (Appendix 6) during these tests. Given that this technique involved the highest number of participants and required a more complex procedure, it demanded a more comprehensive guide, divided into five sections: 1) Introduction; 2) Signing consent forms; 3) Testing one version of the app and filling the post-test questionnaire; 4) Testing the other version of the app and filling post-test questionnaire; and 5) Conclusion.

The first section had the goal of introducing the EduCITY project and app, as well as the researcher, and to provide participants with an overview of the testing procedure: using both versions of the app and answering a post-test questionnaire after each use.

The second section ensured that all Informed Consent Authorization Forms were signed by students and their legal guardians, an essential step as participants were not allowed to take part in the tests without this formal consent being signed.

The third and fourth sections followed the same structure. Participants were divided into two groups: one half began by using the current version of the app through a pre-defined use scenario, followed by the completion of a post-test questionnaire, and then repeated the same process with the (re)designed prototype. The other half did the opposite. The questionnaires start with the AttrakDiff2 scale, described in greater detail in the subchapter “Research Stages”, using the Portuguese version of 21 items translated by Carneiro (2018).

Additionally, the questionnaires include three open-ended questions on the final page: 1) “What did you like most about the app?”; 2) “What would you change or improve about the app?”; and 3) “Do you think this app would help you learn in a fun way? Why?". Furthermore, three additional open-ended questions for direct comparison between the two versions were added to the final post-test questionnaire each student completed. These were: 1) “Compared to the current app, what did you like best about the prototype?”; 2) “What did you think was better about the current app than the prototype?”; and 3) “In general, which of the two versions do you think would be better at helping to learn in a fun way? Why?”.

As usual, the final section consisted of the researcher thanking participants for their time and valuable contribution, which was essential to the improvement of the EduCITY app.

Regarding procedures, the previously made structured guide (available in Appendix 6) allowed the researcher to follow the steps needed to ensure alignment with research objectives. This guide contains predefined use scenarios for the participants to follow with both versions. The comparative tests were carried out with eight middle school students to evaluate and compare their perceptions on the UX of both versions of the app: the current EduCITY app and its redesigned prototype. Neither of the students that took part of the focus group took part in this activity, to ensure that there was no bias due to previous use of the EduCITY app.

The session was conducted in a practical environment, the school outdoor space, so that participants could interact with the app and the redesigned prototype. A picture taken by the researcher during the preparation of the prototype for the comparative evaluation is presented in Figure 31.

Figure 31 –a) Lo-fi prototype being designed; b) Lo-fi prototype designed according to the feedback collected during the A/B tests; c) Hi-fi prototype being designed in Figma according to the Lo-fi; and d) Figma prototype being tested by the researcher on the phones to be used by the participants during the comparative tests.

Similarly to the focus group, all participants and their legal guardians were required to sign an Informed Consent Authorization Form (provided in Appendix 7), in accordance with the GDPR, to participate in the comparative test. Participants were introduced to the purpose of the study and the comparative test protocol. The researcher, along with the help of a colleague, guided the session using the guide previously mentioned.

The session only began after the researcher ensured that all participants clearly understood how the tests would occur. It was structured in two main stages: 1) getting in touch with the app and the prototype; and 2) evaluating the overall UX of both versions.

First, the participants were divided into two groups: one started by testing the current app and the other half started with the prototype designed by the researcher, as Figure 32 illustrates.

Figure 32 – a) Students testing the EduCITY app; b) students testing the prototype version; and c) prototype interface.

This group-division strategy was a way of trying to avoid biases caused by the order in which the tests are carried out.

Each test, whether on the app or the prototype, was associated with a scenario that allowed for the exploration of the app, containing certain steps the researcher would tell the participants to follow, like the scenario presented in the focus group and interviews with UX/UI designers. However, the prototype scenario was a little more complex, as this version contained new features, those suggested by the students and experts during Stage 2, that are not in the current app version.

Starting from the home page, the steps asked for the students using the **app** to take involved: 1) accessing the list of games page; 2) seeing details about the game "EduCITY no campus da UA"; 3) downloading the game "Teste UX/UI", a game the researcher published on EduCITY's web platform with the main types of multimedia content used on quizzes (audio, image, video and AR); 4) playing the game, with different multimedia resources and different typologies of questions (such as single-option and multi-option questions); 5) exploring the ARBook on one of the questions; 6) seeing the game's results, which is the game's statistics; and 7) accessing the "Modo Livre" (free mode) page from the home page.

The **prototype** scenario included a few extra steps, considering its additional features. It also started from the home page and involved: 1) seeing details about the game "EduCITY no campus da UA"; 2) seeing both information and details about the previous game; 3) accessing the list of games page; 4) applying filters, them being "3.º CEB" (7th to 9th grade in Portuguese context) and "Gafanha da Nazaré" (location); 5) selecting the game "Teste UX/UI"; 6) downloading the game; 7) playing the game, with the same exact questions, types of questions and multimedia resources; 8) exploring the ARBook; 9) seeing the game's results; 10) accessing the AR page, that corresponds to the "Modo Livre" page on the app; 11) accessing the profile page; and 12) changing the profile picture.

Just like what happened during the focus group, no participant used their mobile device, as the researcher was the one providing the devices, with the EduCITY and Figma apps already installed. Each participant tested the app and the prototype individually.

After completing each of the tests, participants were asked to answer a post-test questionnaire (on paper) about their interaction experience: "Post-Test Questionnaire about the EduCITY app" and "Post-Test Questionnaire about the prototype" (attached in Appendix 8 and Appendix 9, respectively), as Figure 33 demonstrates.

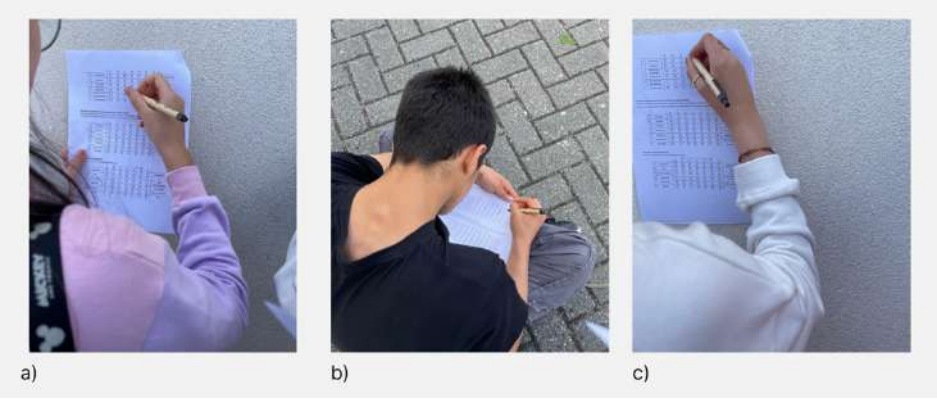


Figure 33 - a); b) and c) Students answering the pos-test questionnaires regarding their perceptions on UX of the app and the prototype.

The session concluded with the researcher thanking the participants and emphasizing the value of everyone's contributions to the study. It lasted about 60 minutes and was scheduled according to the students' availability.

5. Data Processing and Analysis

This chapter presents the analysis of the data collected previously, showing how each stage informed and shaped the next. In particular, it highlights the insights gathered from Stage 2 - Analysis of Expectations and App Diagnosis - through focus group with middle school students and expert interviews with UX/UI designers and teachers. These insights were key to Stage 3, the Prototyping phase, as they directly influenced the redesign of the EduCITY app. Following this, the chapter also explores Stage 4, Comparative Evaluation, where a series of UX tests were conducted to compare the current version of the app with the redesigned prototype. This demonstrates the DBR approach and PD techniques the study applied, with each section building on the previous and combining stakeholder input with iterative development and testing. These connections are illustrated in Figure 34.

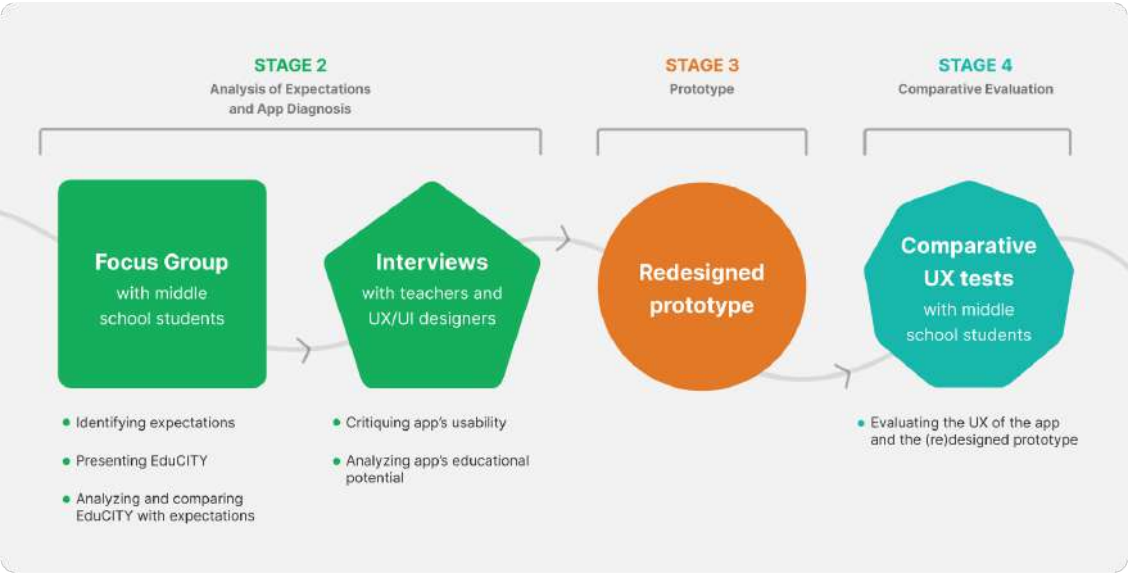


Figure 34 – Diagram showing the application of PD techniques and DBR approach in each of the study's stages.

5.1. Analysis of Expectations and App Diagnosis

This subchapter focuses on the outcomes of the activities carried out during Stage 2, namely the focus group with middle school students and the individual interviews with UX/UI experts and teachers. These techniques were used to explore users' expectations, identify usability issues, and assess the current version of the EduCITY app. Grounded in a PD approach, these activities positioned stakeholders as co-designers, whose perspectives represented a valuable contribution to the redesign. The analysis of this qualitative data identifies recurring themes and divergent perspectives, while providing the foundation for informed design decisions in the prototyping stage.

5.1.1. Focus Group

The focus group conducted with five middle school students provided valuable insights into participants' expectations, perceptions and suggestions for improving the EduCITY app. All participants had prior experience using apps and playing mobile games, a criterion requested by the researcher and communicated to the school in advance, to ensure that the feedback collected would be as informed and grounded as possible. The group consisted of four male students and one female

student. Although the gender distribution was unbalanced, the female participant actively contributed to the discussion, presenting strong arguments and expressing her views confidently throughout the session. She did not appear to feel intimidated by the group dynamic, and her input meaningfully enriched the overall findings.

The results were organized into three thematic areas: 1) Expectations prior to interacting with EduCITY; 2) Comparison with previous expectations; and 3) Suggestions for improvement. Highlights of feedback from students during the focus group can be found in Appendix 10.

Students started by expressing expectations regarding an educational app with characteristics similar to EduCITY (e.g., quizzes, AR, mascot, urban exploration), before any interaction with the app itself. When asked about this sort of app, they often refer to mainstream digital games such as Fortnite, Free Fire and Brawl Stars, as shown in Figure 35 a), b) and c). These references reflected a desire for a playful yet visually engaging experience, incorporating elements of customization and social competition. The concept of creating an avatar was particularly appreciated - one of the key moments when the previously mentioned games started being addressed - provided the design did not resemble content perceived as too childish. For instance, to illustrate what they considered a "childish" avatar, one student referenced the app *Avatar World*, shown in Figure 35 d).

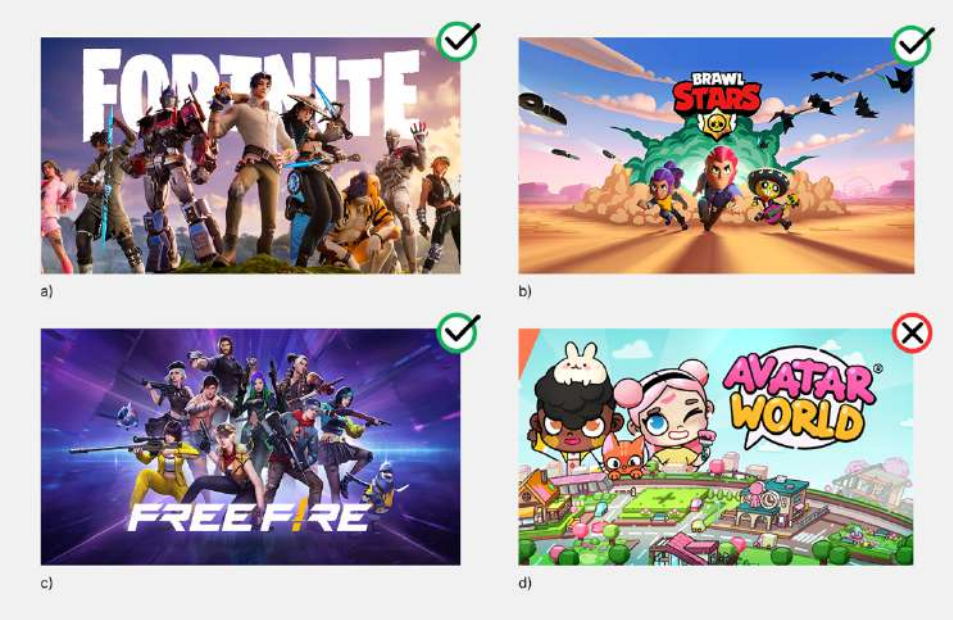


Figure 35 – Games mentioned during the first part of the focus group, regarding avatar style preferences: a) Fortnite; b) Brawl Stars; c) Free Fire; and d) Avatar World.

Furthermore, most participants claimed to envision themselves using the app either alone or simultaneously with friends, highlighting once again the appeal of a competitive context, one of the key elements of gamification, according to Kapp (2012). The topic of gamification, along with its key elements and its potential to promote learning, is discussed in greater detail in the subchapter "Perspectives on Mobile Learning Apps in Education".

All five participants also expressed enthusiasm about the integration of this type of app into classroom settings, describing it as a more engaging alternative to traditional educational methods. As one student put it, they "would be having fun and learning at the same time". Another participant reinforced this by stating "we would have a bigger desire to learn if we could be having fun

simultaneously". A third student highlighted the potential of the app to support learning reinforcement, suggesting it could be used to "consolidate subjects with subject-related questions after learning about them in the classroom with the teacher" and added "instead of doing exercises only on paper, it would be nice to test our learnings with the app".

Regarding the difficulty of questions, students emphasized the need for balance: "if questions are too easy, we will get bored; if they are too hard, we will give up and won't want to play again". Two of the participants suggested that it could be interesting to offer multiple difficulty levels, such as "easy, normal, hard". However, the other three students raised concerns that this might lead to teasing among peers with different abilities, arguing that "just one medium level would be better so that everyone could play on equal terms". One student proposed a dynamic system: "if the player selects the easy level and keeps getting everything right, the app could automatically suggest moving up to the next level". Another student added "we could have to answer a certain number of questions correctly before advancing to harder ones". These differing opinions reveal that there was no clear consensus among the participants regarding how difficulty levels should be implemented, highlighting the complexity of addressing varied learner profiles within a single app experience.

There was a complementary activity within the focus group, in which students were asked to provide feedback on five visual comparison slides, each displaying two alternative interface designs (A on the left and B on the right). These images were selected based on the visual criteria previously presented (see Figure 26), which were established following an exploratory analysis of UI designs sourced from Behance. The rationale behind image selection is further detailed in the subchapter "Focus Group". This A/B testing exercise aimed to identify participants' design preferences and the interface elements that most resonated with them and why. The image pairs used in this activity are shown in Appendix 2.

The results revealed a strong sensitivity to the perceived age-appropriateness of the interface design. For example, in Slide 1 (Figure 36), all five participants rejected image B describing it as "too childish" because of its use of colors and illustration-style. In contrast, image A was perceived by two students as "too serious", while another mentioned disliking "the bright neon colors". One participant expressed difficulty relating to either option, stating that "none of the images are similar to what I like, one is too childish, and the other is too serious and mature".

Figure 36 - Slide 1 of the A/B testing exercise.

In Slide 2 (Figure 37), there was a clear and unanimous preference for image B, which was described as having a familiar and appealing aesthetic, like Duolingo's interface (see Figure 12). They particularly emphasized the "number of coins" section, which resembled a points or reward system. One participant noted that image B was clearer, better structured and more intuitive than image A. In contrast, all students agreed that image A looked too playful and not adequate for an app whose purpose is also educational, comparing it to the interface of games like Candy Crush.

Figure 37 - Slide 2 of the A/B testing exercise.

In contrast, Slide 3 (Figure 38) generated mixed opinions: four out of the five students found image B too similar to gambling or casino apps, with one student stating that it looked like "they want me to bet money and I won't get anything in return". These students preferred image A, which they described as simpler (considered "perhaps too simple" by one student) and more aligned with educational apps, conveying a sense of comfort and clarity. One participant said that image A "puts you in a comforting space, unlike the other one where too much is going on". Despite this, one student expressed a preference for image B, specifically because of its "casino-like" aesthetic, which they found visually engaging. Additionally, while looking at Slide 3, two students noted a general preference for dark mode interfaces when using apps.

Figure 38 - Slide 3 of the A/B testing exercise.

In Slide 4 (Figure 39), all participants quickly expressed a preference for image A, which they perceived as more closely aligned with "an educational purpose", compared to image B. One of the students explained that "when the background is dark and the app has neon colors, it reminds me of

shooter games", suggesting that the aesthetic of image B evoked associations with non-educational, but rather entertainment or combat-oriented experiences.

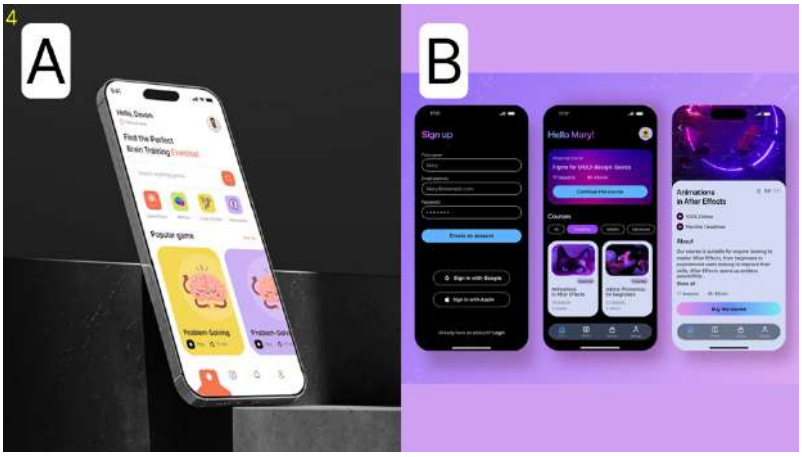


Figure 39 - Slide 4 of the A/B testing exercise.

Similarly to Slide 4, Slide 5 (Figure 40) confirmed a consistent trend, with image A being favored in both cases due to its educational appearance. On Slide 5, image A (from the Orcalit App) was strongly favored, being described as visually mature, while image B was promptly rejected for being "too childish". Students particularly appreciated the avatars, overall app aesthetic, use of color, simplicity and clear organization of image A. Notably, the group unanimously described image A's interface as "perfect" and "very good", offering valuable insight to inform the design direction of Stage 3, which focuses on prototyping a new version of the EduCITY app.

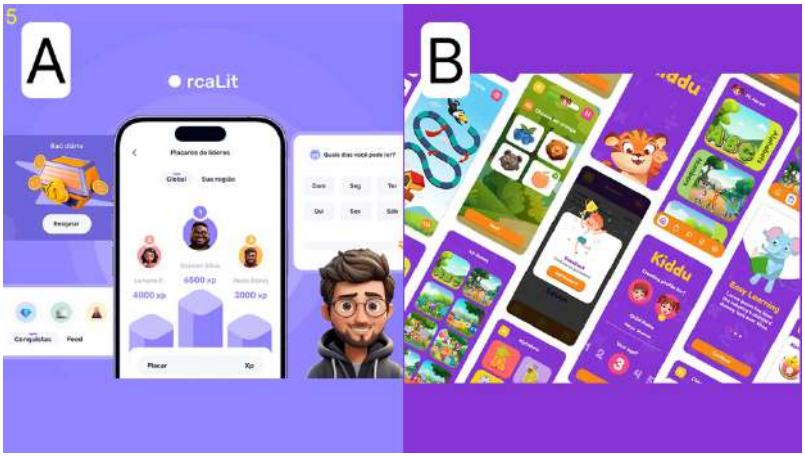


Figure 40 - Slide 5 of the A/B testing exercise.

The observations collected during the A/B exercise reinforce previous findings related to students' expectations for educational apps. Participants consistently valued clarity, visual simplicity, and modern, well-structured interfaces that conveyed an educational purpose. Conversely, they rejected designs perceived as overly childish, visually chaotic, or too closely associated with non-educational contexts, such as gaming or entertainment apps. For instance, UIs with dark backgrounds combined with neon colors were associated with these types of apps, which participants felt deviated from an educational purpose. These insights provide strong guidance for the visual direction to be followed in Stage 3.

Upon using the current version of the EduCITY app, several students reported a discrepancy between their expectations and their actual experience with the app. Specifically, the EduCITY app was perceived as focusing heavily on text (with students complaining about it having too much text on a single screen) and lacking in visual elements. Despite this, students responded positively to the overall concept and found potential educational value in its use.

Concerns were also raised regarding the clarity of the VD elements and interface, such as the AR-triggering button, presented in Figure 41, with three students having difficulty locating it. However, interestingly, while the AR feature initially elicited some hesitation (during the expectations section), students reacted favorably to it after testing it.

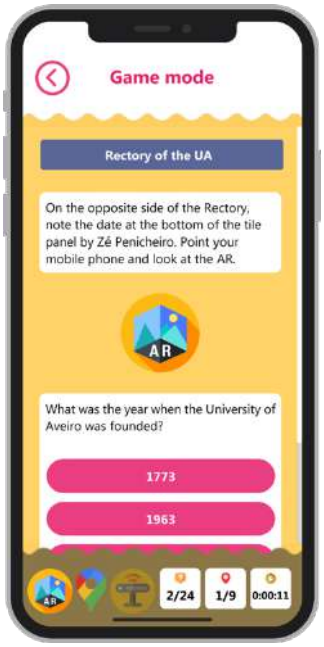


Figure 41 – App screen of the game "EduCITY at the UA campus" with an AR-triggering button.

In the final section of the focus group, participants provided a number of constructive suggestions for improving the app, which can be grouped into the following categories:

- **Gamification and Progression:** Inclusion of levels, in-game currency (such as coins or XP), leaderboards (similar to Kahoot!), and achievement systems such as medals and ranking divisions (similar to Duolingo).

- **Customization:** Investing in avatars and being able to customize them (such as body type, accessories, colors, themes), and adjust game difficulty based on the student's school year and progression throughout the game.

- **Social Functionality:** Implementation of multiplayer rooms or sessions enabling collaborative or competitive gameplay among friends, even when using separate devices.

- **Interface and Feedback Enhancements:** Improvements to the visibility and intuitiveness of buttons, use of color and iconography to draw attention to important

elements (such AR-triggering button), and incorporation of background music and sound feedback.

- **Usability Features:** The ability to close or skip videos, immediate feedback on correct/incorrect answers, and the improvement of the structure of the results screen summarizing performance, using even more metrics.

The contribution of these students was very valuable to evaluate the EduCITY app from their perspective and to follow the PD approach this study committed to, listening to the voices of individuals who the researcher selected as the target audience for the app redesign.

5.1.2. Teacher Interviews

Four expert interviews were conducted: two with teachers and two with UX/UI designers.

Teacher feedback focused on the app's pedagogical potential and some of its usability aspects, providing insights grounded in previous experiences the teachers had already conducted with their students, using the EduCITY app. Highlights of the teachers' feedback can be found in Appendix 11.

When asked about which kind of environments the EduCITY app could be most useful to students, both teachers highlighted its potential for supporting outdoor and field-based learning, although with slightly different emphases. The first teacher to be interviewed (T1) envisioned the app being particularly beneficial during field trips, either organized by the school or visited recreationally by families. According to T1, "mobility and location-based activities could enhance engagement", but using the app in formal school settings would require substantial preparation. To be viable in curricular environments, the games would need to be reusable and aligned with long-term curricular goals – ideally covering content that is unlikely to change, so the game remains relevant for future uses. T1 also suggested that games located in places with an existing pedagogical offer, such as museums or educational institutions, would be more sustainable and easier to integrate into practices.

The second teacher to be interviewed (T2) also saw the app as a valuable resource to promote informal and outdoor learning, especially when linked to fieldwork. However, T2 emphasized that the app should not be used autonomously in school settings. Rather, its use should be guided by the teacher, embedded in structured educational activities. In this view, the app works best as a tool to support site-based learning experiences: "students go, visit, collect information and answer the questions in loco". T2 also valued the structured nature of the information provided by the app, which could enhance the learning experience *in loco*. While individual use was considered possible, T2 stated that it should always be connected to educational objectives, with the possibility of teachers accessing student performance data.

Both teachers noted that students reacted enthusiastically to the EduCITY app, showing strong motivation to engage with the games and answer the questions. According to T2, students were "excited and eager to get the questions right" and recognized the educational potential of the app as they progressed through the content. However, the students' enthusiasm often led to overly hasty behavior, with several usability challenges emerging during the activities. Both teachers reported that students tend to rush through the questions without reading the instructions carefully, sometimes

ignoring key information, such as the number of possible answers. T1 observed that many students "just wanted to click through the buttons", while T2 mentioned that some "focused only in getting first place and ended up not paying attention to the content".

Another recurring issue concerned AR-related features. According to both teachers, students frequently failed to notice the AR button, which was sometimes hidden by long blocks of text, and required intervention from the teachers to realize it was interactive and, indeed, a button. T1 noted that this confusion also occurred during teacher training sessions, suggesting the AR-triggering button lacked visual affordance.

Despite these challenges, both teachers agreed that the app has strong potential to promote outdoor learning and contextualized engagement. T2 emphasized that being physically present at the site of the activity significantly enhanced students' interest, reinforcing the value of location-based educational experiences: "when students see the site and answer questions about what they're looking at directly, it helps make it more interesting".

T1 also highlighted the app's potential, describing it as "an experience that made us reflect and look beyond what would be expected from a simple quiz", adding that "thinking about what is necessary for the app to evolve is in itself a valuable learning outcome". T2 further noted that the app is "a valuable tool because it allows anyone to play games already created and validated by other teachers" which facilitates integration into different classrooms. In fact, this teacher mentioned plans to encourage colleagues to use the EduCITY app with their own students.

Overall, both teachers saw the experience not only as pedagogically promising, but also as an opportunity to reflect on how digital tools can support authentic, location-based learning. Their feedback suggests that the app is engaging for students and encourages teachers to rethink how learning can take place beyond traditional classroom boundaries.

Both teachers expressed their own difficulties with the app and provided detailed suggestions to improve the usability and educational value of the app. A recurring concern for T2 was the lack of user identification features, which made it difficult to assess which students were using which device during the activity. T2 suggested associating an identifier to each device, in compliance with data protection regulations, to allow for better tracking of student performance.

Both teachers agreed with the researcher's recommendation of including a submission button for each question, especially in single-answer formats, to prevent accidental selections from being automatically submitted. T2 also noted that multiple-choice answers should include a "clearer distinction between the question and the rest of the text". Additional suggestions included improved contrast and color schemes.

Regarding the app layout and visual identity, T1 described the interface as "boxy" and proposed making it more dynamic by softening sharp edges and introducing a more diverse color palette to replace the predominant use of pink. T1 also recommended that longer texts be split into sequential segments, allowing users to easily select and review important content. In educational contexts, this technique is known as *chunking*, a cognitive strategy that separates information into smaller, meaningful units (Fountain & Doyle, 2012). By reducing cognitive load and improving the organization of content in memory, chunking facilitates immediate understanding and enhances the ability to

recall or apply the information later on (Fountain & Doyle, 2012). In addition, chunking helps increase text readability and comprehension (Moran, 2016).

Navigation and interaction improvements were also suggested. Both teachers mentioned that the AR-triggering button was often overlooked, similarly to what happened to students in the focus group. Teachers recommended making it more intuitive and visible, possibly by including a short tutorial or guiding message like "click here".

Reaching the end of the interview, both teachers highlighted the importance of maintaining a balance between gamification and clarity, ensuring the experience remains educational, accessible, and contextually appropriate for different learning environments.

5.1.3. UX/UI Designer Interviews

Additionally, the two UX/UI designers interviewed were invited to analyze the current version of the EduCITY app on a screen-by-screen basis. Their feedback, grounded in usability and interface design principles, highlighted a series of recurring issues related to visual hierarchy, readability, aesthetic coherence, and user flow. It is important to note that the designers were asked to adopt a highly critical perspective when reviewing the interfaces, which can be seen, screen by screen, in Appendix 12. This was to ensure rich, detailed feedback by encouraging them to be as observant and selective as possible.

When reviewing the home screen, in Figure 42, both designers identified significant issues related to visual hierarchy and functional clarity.

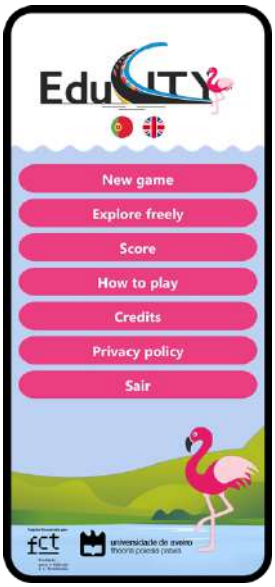


Figure 42 – App's home screen.

Designer 1 (D1) highlighted that the screen felt "overcrowded", with too many buttons competing for attention and not enough spacing between elements. The logo was described as disproportionately large, nearly reaching the screen's edge. Certain buttons, like "Credits", were unclear in purpose. The designer suggested reducing the number of visible buttons by increasing negative space and moving less critical items such as "Score", "Credits", and "Privacy policy" to a

secondary menu or profile area. A tutorial was also recommended to first-time users, with the “How to play” button hidden by default.

Designer 2 (D2) reinforced these observations, noting that all buttons shared the same visual weight, making it difficult for users to distinguish between primary and secondary actions. D2 felt confused when trying to access the list of games, with the button “New game” (*Novo jogo* in Portuguese) being considered unintuitive, as its label suggested starting a single game rather than accessing a list. D2 recommended rewording it to “Game list” (*Lista de jogos* in Portuguese). Similarly to what D1 had already proposed, D2 also suggested that essential buttons (“new game,” “free mode,” “scores”) be more visually prominent, while secondary options like “credits” and “privacy policy” should be less emphasized - or removed from the homepage altogether. A more solid background was also recommended to improve readability.

In addition, both designers raised concerns about the visual structure and clarity of the game list screen, in Figure 43 a), particularly criticizing its overloaded layout and weak visual hierarchy.

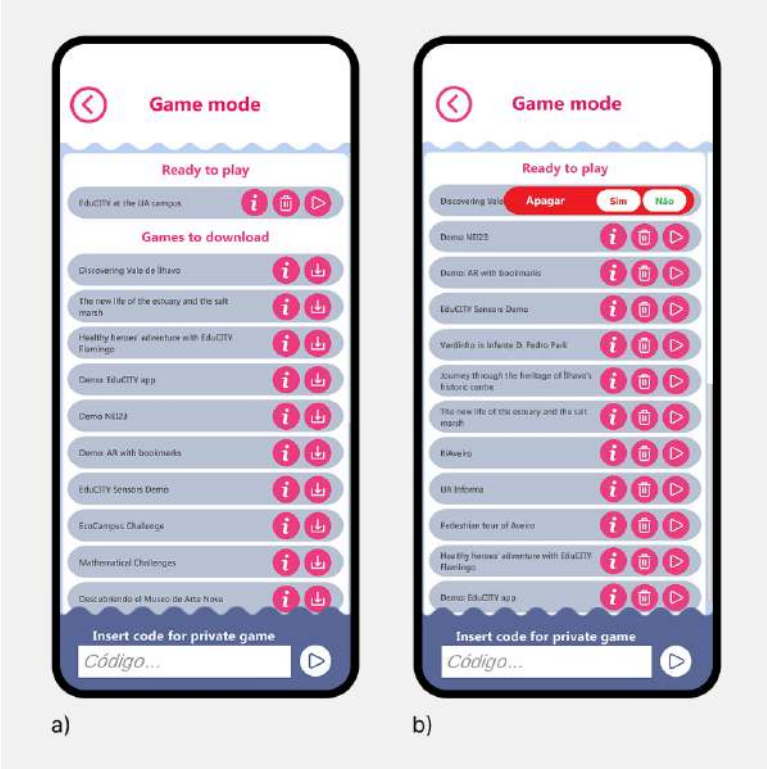


Figure 43 – a) App's game list screen; and b) Game deletion confirmation dialog.

D1 noted that the screen “doesn’t feel like a game screen” but rather a “screen with a lot of dense content” and found the interface visually compressed, pointing out that only displaying the game name was insufficient to inform the user about the content or theme of each game. She recommended using cover images to help differentiate games, following common UI patterns on gaming platforms.

D2 also felt that the interface was cluttered, adding that the cards for each game lacked spacing and that the typography was too small, especially considering that the app is supposed to be used outdoors, where readability is essential. She also questioned the inconsistent visual language across icons, noting that the “info” icon (i) felt out of place alongside the other buttons, like “delete”,

“download” and “play”. D2 also critiqued the design of the delete confirmation dialog, seen in Figure 43 b), stating that having “yes” in red and “no” in green was very confusing. Similarly to other screens, this dialog appears in Portuguese even when the app’s language is set to English.

Both designers found the “insert code” field disproportionately large and visually inconsistent with the rest of the layout. D2 proposed integrating it more naturally into the structure of the screen – as a third category, alongside “Ready to play” and “Games to download”, instead of layering it as an overlay. The designers offered complementary suggestions to improve the game list experience. D1 advocated for transforming the list view into a more visual, card-based layout with game thumbnails, while D2 suggested organizing the content into collapsible dropdown categories or a paginated view to reduce visual load. D2 also recommended establishing a consistent method for confirming game downloads and deletions - either via pop-up or inline gestures like drag-to-delete, but not both. Both agreed on the need for a stronger typographic hierarchy and better alignment of elements within each card. This feedback converges on the idea that this screen must present a more intuitive and engaging interface, that communicates more game information and supports quick, confident user actions.

Regarding the game information screen, illustrated in Figure 44, both designers identified visual inconsistencies and missed opportunities to enrich the user’s understanding of the game.

Figure 44 – App’s game information screen.

D1 mainly focused on alignment-related issues, noting that the icons appeared visually disconnected and were not integrated cohesively with the respective text. She recommended spacing the icons evenly with the text and ensuring consistent sizing across all of them to achieve a more structured layout.

Similarly, D2 also pointed out alignment issues, observing that icons varied in stroke weight and size, which made them appear as though they came from different icon sets. While she acknowledged that the icons, combined with their labels, helped convey meaning, she felt that the label text was too small and not easily legible. More importantly, D2 expressed disappointment with the actual content

of the page, stating that she expected a more detailed description of what the game entails—something closer to a movie-style synopsis, including the locations users would visit or a narrative overview of the game experience. Although she found some of the existing information relevant (such as the game's topic or author), she questioned the value of elements like the "private code" field on this screen, which she felt served little purpose and took up space that could be used more effectively.

The designers' feedback regarding the game information screen suggests that it has the potential to not only provide more relevant information about the game (such as the points of interest) but also spark user interest and anticipation with a captivating game description, bridging usability with narrative engagement.

In relation to the game introduction screen, the designers criticized its heavy use of uninterrupted text, as Figure 45 demonstrates.

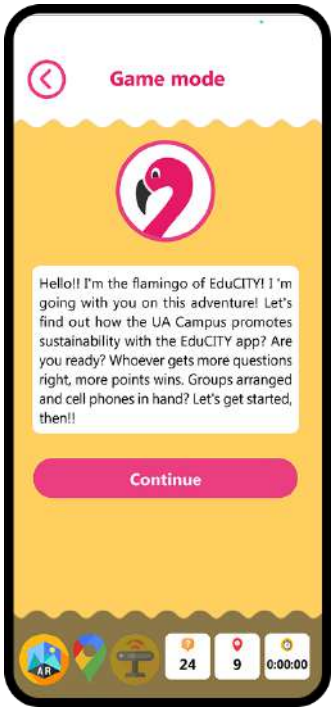


Figure 45 - App's game introduction screen.

Both designers described the introductory text as overly long, dense and visually unappealing, suggesting that users, especially younger ones, would be unlikely to read it fully, a concern that students in the focus group also expressed. D2 commented that today's users, particularly children and teenagers, are accustomed to faster, more interactive formats, and would likely skip over such a large block of text. To fix this issue, D1 proposed applying a chunking approach to the content, where text could be revealed progressively. D2 reinforced this perspective, and recommended transforming the introduction into a short, animated onboarding sequence, broken into smaller steps and possibly designed with icons, motion elements, or story-like transitions, similar to what users expect from platforms like TikTok or Instagram Stories. By replacing the static block of text with segmented chunks, the app could better capture user attention while setting the tone for the gameplay experience ahead.

The designers also expressed dissatisfaction with the bottom navigation bar (Figure 46), questioning its visual consistency and functional relevance.

Figure 46 - App's bottom navigation bar, only visible during gameplay.

D1 had difficulty interpreting the icons, particularly the one representing points of interest, which she did not understand. She also criticized the icon associated with quiz progress, which showed the number of answered questions but did not provide any indication of how many were answered correctly or incorrectly. For her, this missed an opportunity to offer users meaningful and motivating feedback in real time. D2 was confused by the presence of the AR-triggering button in the navigation bar. Her reaction, "What is this? Can I click it?", revealed a lack of affordance and contextual relevance. She questioned why the button was present at all in situations where the AR experience is either unavailable or already triggered by a dedicated button elsewhere on the screen (see Figure 50).

D2 suggested the removal of the bottom navigation bar from this screen, as it disrupted the visual focus and added unnecessary clutter.

Analyzing the app's point of interest screen, illustrated in Figure 47, both designers expressed confusion regarding its purpose and structure, highlighting a lack of contextual clarity and ineffective visual hierarchy.

Figure 47 - Point of interest screen.

Both D1 and D2 noted that they were unsure what the point of interest referred to and struggled to distinguish between the location name (in a blue box) and the point of interest instructions. D1

emphasized the need for more context and suggested incorporating an image of the location or a small map with directions to help users better situate themselves.

D2 pointed out that the flamingo illustration had greater visual prominence than the informational content, stating that “everything above feels unimportant, and what is below is what matters”. To address this, she proposed repositioning the flamingo graphic to give more visual weight to the location’s name and description. D2 also suggested introducing a checklist or animated element showing the various locations the player would visit throughout the game, allowing users to track their journey and progress by marking each completed area.

Although their suggestions differ in form, both designers called for a clearer visual and narrative structure that better supports player orientation.

Regarding the questions screens (Figure 48), designers identified significant usability and VD issues, particularly concerning layout density, text hierarchy, and the handling of response options.

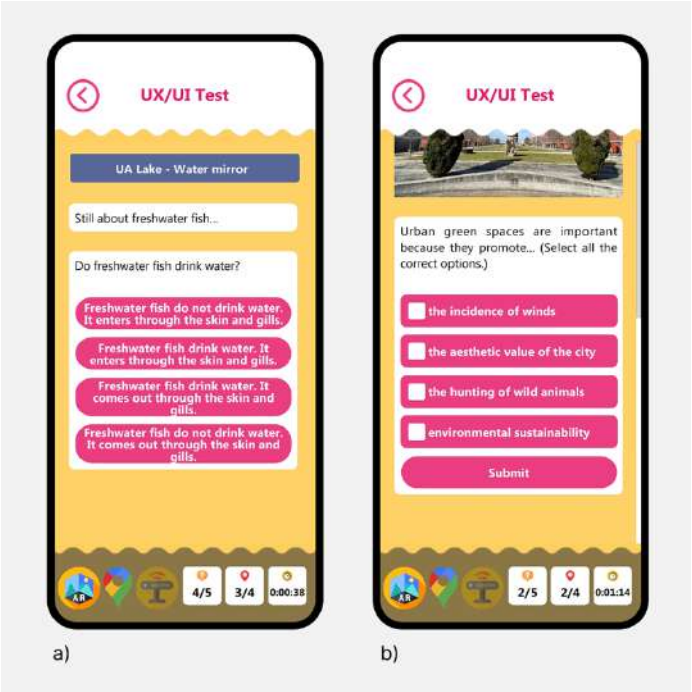


Figure 48 - App's question screens: a) single-option; and b) multiple-option.

D1 pointed out that the screens often contained too much text and that some answer options would become hidden below the bottom bar, something she didn’t initially realize due to the lack of scroll indicators or visual cues. She questioned the relevance of showing the game’s title during gameplay and felt that the top section of the screen took up unnecessary, very valuable space. She also noted that when images were included, there was no affordance to indicate they could be enlarged. D1 suggested reimagining the entire structure in the style of a conversational chat interface, where the question would appear as a speech bubble from the flamingo mascot.

D2 shared many of these concerns. She observed that the introduction and question text were visually indistinguishable, making it hard to distinguish the two. She described the interface as overwhelming, saying there was “too much text, all at once” and, because of that, she struggled to

retain the information. D2 also pointed out that the “point of interest” label (in blue) sometimes appeared more prominently than the question itself, which disrupted focus.

Both designers noted that response buttons, especially when they contained long text (like the one in Figure 48 a)), were described as looking “crushed”, awkwardly proportioned, too similar, making it difficult to distinguish them. D2 flagged something the teachers also pointed out: the absence of a “submit” button in single-choice questions, recommending that this type of question behave consistently with multiple-choice ones to avoid confusion.

Collectively, designers recommended implementing text chunking techniques, increasing spacing between lines, limiting option character length, and applying formatting with bold text or bullet points to enhance clarity. Additionally, they proposed that all response options should be fully visible on the initial screen load or, at the very least, clearly indicate that more content is hidden below. Their feedback underscores the need to reframe question screens to ensure that young users can read, understand, and respond with minimal cognitive load.

The feedback screens following question responses (Figure 49) raised several usability and consistency concerns for both designers.

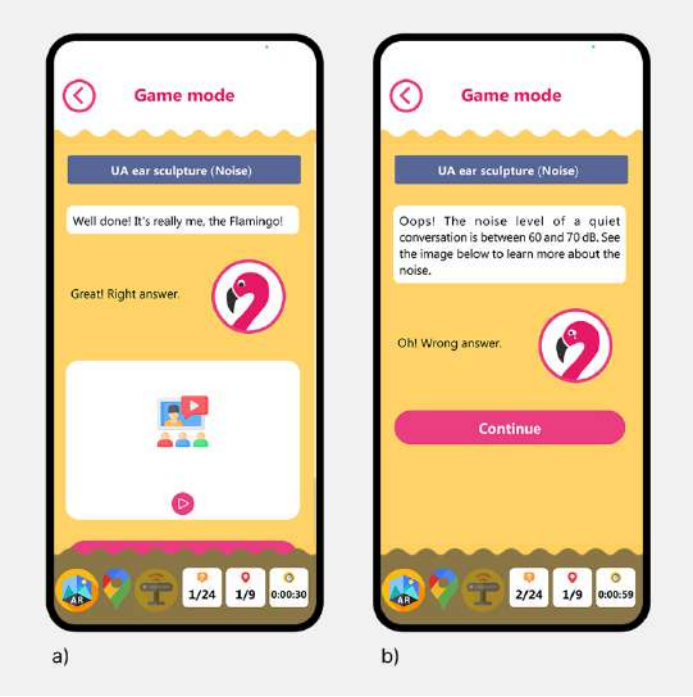


Figure 49 – App’s feedback screens: a) right answer; and b) wrong answer.

Regarding correct answers, D1 suggested removing the need for the user to manually trigger video playback, proposing that the video play automatically instead. She found the interaction less fluid when dependent on the click of a button (Figure 49 a)). D2 pointed out that the bottom navigation bar on this screen (Figure 49 a)) occupied too much vertical space.

As for incorrect answers, D2 criticized the justified text alignment (Figure 49 b)), noting that it made reading more difficult. She recommended aligning the text to the left for improved legibility and proposed displaying the feedback of correctness of the answer (“correct” or “incorrect”) through a speech bubble from the flamingo mascot, helping to create continuity with the conversational tone

suggested earlier. Both designers found the feedback logic and presentation to be problematic. D1 expressed frustration at being reminded that she had chosen the wrong answer twice (both in the feedback of correctness and explanation of the answer), which she considered demotivating and repetitive.

D1 also reported not remembering which option she had selected, as the feedback was shown on a separate screen. To solve this, both designers suggested a feedback method similar to Duolingo's: keeping the response options on screen and using color (e.g., red or green) to highlight the selected choice alongside the feedback, all within the same view. Similarly, D2 also expressed this need for continuity, questioning why the correctness feedback and the explanatory feedback were presented in different visual styles, one inside a card and the other without background, which disrupted the visual coherence. She also found the order of presentation confusing, as the explanation appeared before the feedback of correctness. Instead, she recommended showing the "correct/incorrect" feedback first, followed by the explanation.

Both designers emphasized the importance of immediate and visually cohesive feedback. They recommended removing or repositioning the blue box naming the point of interest, either eliminating it entirely or placing it near the game's title instead. D2 also suggested adding an animation prompt encouraging users to rotate their device before video playback, ensuring better visibility and usability. Their combined feedback points to the need for a unified and less disruptive feedback system, where clarity and emotional impact are carefully considered in order to maintain engagement and avoid user frustration.

Similarly to what happened during the focus group and what teachers reported of their previous experiences with the app, both designers encountered usability issues when interacting with the AR question screen (Figure 50), specifically related to the button responsible for triggering the AR experience.

Figure 50 - App screen with AR-triggering button.

D1 noted that she didn't realize there was a button to trigger AR at all, because it was visually similar in size, shape, and style to the flamingo mascot graphic, which is a non-interactive decorative element. Figure 51 allows for a comparison between the AR-triggering button and the flamingo graphic, a non-interactive element.

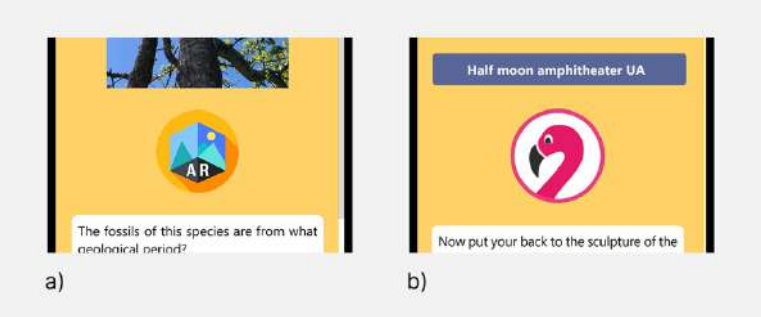


Figure 51 - Comparison between a) the AR-triggering button; and b) the flamingo graphic.

This similarity made it unclear that the element was clickable, leading her to completely overlook the AR-triggering button on her first interaction. D2 had a similar experience, stating that she took a long time to understand that the circle in the center of the screen was a button meant to trigger AR. She repeatedly tapped the bottom navigation bar instead, assuming the interaction might be located there. In her words, the AR button "looked more like an image than an actual button", lacking the affordances typically expected of interactive UI elements.

Both designers' feedback highlights a critical affordance issue: the AR-triggering button does not look like a button. They implicitly recommended visual strategies to improve its recognizability, such as making its shape and look consistent with the rest of the buttons of the app. Their observations suggest that in its current form, the AR experience may go unnoticed or be frustrating to access, particularly for less experienced users. A clearer VD and labeling, possibly with a small icon, could help fix the issue and ensure users understand when and how to interact with this core feature.

In addition, the ARBook screens (Figure 52) were heavily criticized by both designers, who found them confusing, outdated in style, and misaligned with the overall visual and interaction patterns of the app.

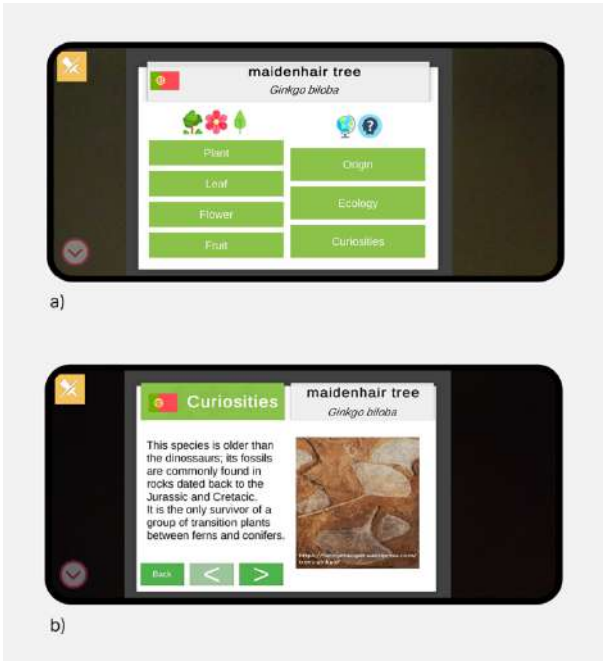


Figure 52 - App's ARBook screens: a) menu overview; and b) page-view.

D1 expressed significant frustration with the navigation flow and interaction model. She found it unclear whether she was supposed to click certain elements and did not notice the “pin” button (yellow square in Figure 52) to fix the AR page in place. The interaction required her to move back and forth frequently between the AR content and the original question, which she described as tedious and cognitively demanding: “I kept having to go back because I forgot what the question was”. She suggested that the AR should launch in a larger, more centered state by default and criticized the current layout, which she considered similar to a misaligned table. D1 also noted that the process of navigating through buttons in AR disrupted the learning flow. As a user who dislikes reading long blocks of text, she felt overwhelmed and disengaged. She recommended that the ARBook interaction be explained in the initial tutorial and emphasized that links should not be embedded in the images themselves.

D2 focused more on interface design and visual presentation. She was confused by the language switcher button, which didn’t clearly indicate the current language state. For instance, when the app is set to English, the icon displays the Portuguese flag, but the designer expected the flag to indicate the current active language, not the one to switch to. She also found the icon distribution in the main ARBook menu awkward (three icons on one side and two on the other) and suggested using a simpler, more balanced layout with only one icon per side.

In terms of aesthetics, D2 described the interface as “flat” and outdated, suggesting the use of rounded corners, shadows, and a generally more modern look to match the visual identity of EduCITY app’s other screens. She also recommended more dynamic visual cues within the AR pages to make navigation and interaction more intuitive and proposed allowing users to change the orientation of the ARBook for better accessibility and immersion.

Together, their feedback highlights that while the ARBook concept is promising, its current execution suffers from navigational friction, low visual appeal, and a lack of clarity in interaction. Their suggestions point towards a more immersive, intuitive, and visually cohesive redesign that better integrates with the rest of the app experience.

Both designers identified some issues with the clarity, structure, and purpose of the results screen (Figure 53), particularly in how performance metrics and feedback were presented.

Figure 53 - App's result screens.

D1 misunderstood the representation of the number of correct and incorrect questions, initially assuming that the value for incorrect answers reflected the total number of questions. She suggested that these values should be displayed in two clearly labeled and separate fields to avoid confusion and provide users with a transparent overview of their performance.

D2 was even critical, calling the correct/incorrect display misleading, stating that “it looks like a fraction”. She was also confused by the points system, which hadn’t been explained at the start of the game: “I played the entire time without knowing there were points”, she noted, adding that she didn’t realize AR interactions also contributed to the score. This lack of upfront explanation made the scoring feel arbitrary.

On a visual level, D2 felt that the results screen should visually stand apart from the rest of the game, clearly signaling the end of the activity. She pointed out that the current layout reused visual elements from earlier screens, making it feel too similar. The low resolution of some elements, such as the image of the number of correct/incorrect questions (see Figure 53), and inconsistent use of icons versus images also drew criticism.

In summary, both designers called for a results screen that is easier to read and understand. Key improvements include separating correct/incorrect counts, clarifying the points’ system, and adapting the interface to reflect the transition from active play to post-game feedback. These adjustments would support user comprehension at the end of a game.

The Free Mode screen (Figure 54) was perceived as confusing and visually underdeveloped by both designers.

Figure 54 - App's free mode screen.

D1 admitted that she didn't understand how the feature worked until the researcher explained it to her, which suggests a serious lack of intuitive design and guidance. She also criticized the logic behind the map pins, questioning why only the locations from previously downloaded games were visible. For D1, this greatly limits the utility and exploratory value of the feature. She recommended that the map should display all available points of interest by default, allowing users to freely explore different locations regardless of which games they had installed.

D2 focused her critique on visual clarity and affordance. She once again noted that the AR-triggering button on the screen did not look like a button at all, lacking any cues that would suggest this was an interactive element. She also found the resolution of the map and its icons to be extremely low, indicating that this degraded the overall visual quality of the experience.

Together, their feedback reinforces the need to redesign Free Mode to be more intuitive, interactive, and visually polished. This includes providing clearer onboarding or instructional cues, ensuring all points of interest are visible, and updating the visual language of the map interface to match the app's design system - particularly in terms of iconography and button clarity.

The designers' evaluations allowed for the identification of inconsistencies in interface structure, insufficient feedback mechanisms, and missed opportunities to create an engaging and age-appropriate design. Their feedback offers a critical foundation for informed redesign decisions that prioritize usability, accessibility, and visual clarity.

5.1.4. Critical Insights for Redesign

The triangulation of data collected from the focus group with students and interviews with teachers and UX/UI designers revealed several perspectives that informed the redesign of the EduCITY app. Numerous patterns emerged from two or more participant groups, allowing for a clear redesign direction. These are listed below:

- **Text Overload and Hierarchy**
  One of the most consistently reported issues was related to text overload and poor hierarchy. Students and designers criticized dense screens with too much text or too many buttons of equal visual weight, which often lead to confusion and disengagement. Similarly, designers described screens as "overcrowded", “flat”, or “compressed”. Teachers also reported students ignored important information due to cognitive overload or unclear layouts. These observations underline the need for stronger hierarchy, prioritizing elements through spacing and chunking of content to improve readability and pacing.

- **Affordance of Interactive Elements**
  All three groups struggled to identify interactive elements, particularly the AR-triggering button. Designers pointed out its similarity to decorative elements (like the flamingo graphic), while students often missed it entirely during app use. This feedback exposes an affordance issue, suggesting the need for interactive elements to follow conventional patterns, using consistent shapes, labels, and icons to convey interactivity clearly.

- **Information Density and Readability**
  Both students and designers struggled with long blocks of uninterrupted text. Students explicitly stated that the app had “too much text on a single screen”, and designers confirmed that young users would likely skip such content. Teachers also reported students missing key instructions due to rushed reading. All groups suggested breaking down long texts into shorter, digestible segments through chunking.

- **Feedback Mechanisms and Motivation**
  Teachers and designers both identified issues with the app’s feedback logic. Teachers noted that some students rushed through questions just to “win”. Designers criticized the delayed, separate feedback after answering questions and proposed integrated, immediate feedback similar to Duolingo, where answer correctness is shown directly on the same screen. Additionally, students suggested using a gamified approach with elements such as medals or XP, and progression systems to keep them motivated. These findings indicate that feedback should be immediate and intuitive to maintain user motivation and engagement.

- **Gamification and Customization**
  Students emphasized the value of gamified features such as levels, leaderboards, and customizable avatars, as long as the design remained appropriate for the educational context. Designers, although less focused on gamification itself, acknowledged that the interface often lacked the visual vibrancy and engagement expected in game-like environments. All groups agreed on the importance of balance: gamification should enhance rather than distract from learning.

- **Alignment between Design and Education Purpose**
  There was a shared expectation between all participant groups that the app should look and feel educational, while still being visually engaging. Designs that resembled commercial games or entertainment apps were often rejected or critiqued by students for being inappropriate in educational contexts. This preference was evident in the A/B testing exercise and reiterated by teachers and designers, who stressed the importance of maintaining a tone that supports learning - through visual maturity, clarity, and purposeful interaction patterns.

- **Usability in Outdoor Contexts**
  Designers and teachers highlighted practical limitations of the app in outdoor settings, such as small fonts and low-contrast buttons. While students did not mention this (as they tested the app indoors), these observations suggest that improved readability and touch-target sizes are necessary to support real-world educational use.

- **AR Experience**
  Although students found the ARBook "cool" and teachers valued its pedagogical potential, designers strongly criticized its interface as outdated, confusing, and visually disconnected from the rest of the app. Navigation lacked clarity, icon layout felt unbalanced, and overall visual presentation was flat. Suggestions included improving iconography, applying visual hierarchy, and providing onboarding to explain the ARBook's function. All groups highlighted the need for better contextual orientation in AR experiences.

While each group brought a different lens, with students as primary users, teachers as pedagogical facilitators, and designers as technical experts, there was alignment on several aspects. Designers' focus on structure and affordance complemented students' frustrations with confusing or overloaded screens. Teachers reported situations that happened with their students that confirmed what students in the focus group and designers felt.

Despite these issues, all groups recognized the app's educational potential, especially in non-formal, outdoor learning contexts. Students described the experience as "fun" and "different from regular classes," and one teacher pointed out: "It provides structured information *in loco* - it's not the same as reading a book or watching a video". Designers also considered the concept strong, particularly if visual consistency, affordance, and usability demands were addressed in future iterations.

When perspectives were different, the PD approach adopted in this study prioritized the students' voice, given their role as primary users. For example, while teachers advocated for highly structured explanations and designers proposed minimalist palettes, students favored a balance between clarity and engagement. In short, students were not only treated as evaluators, but as active co-creators whose insights shaped the direction of the redesign. These decisions reflect the core principle of designing with users, not merely for them, treating students as co-designers.

In the following subchapter, the redesign of the EduCITY app is presented through a screen-by-screen approach, with each design decision further grounded in the feedback provided by students, teachers, and UX/UI designers during Stage 2.

5.2. Prototyping for a Comparative Evaluation

This subchapter presents the process behind the design of a prototype of the EduCITY app, created with insights gathered during the previous stage. The goal was to develop a solution that is better aligned with users' expectations and needs, expressed by students, teachers, and design experts. The prototyping process is detailed in terms of design decisions, iterations, and the resulting interface of the redesigned app. Following this, the subchapter reports on the comparative evaluation between the current version of the app and the new prototype, through user testing with middle school students to assess whether there were improvements in the perceived UX of the prototype, compared to the app.

5.2.1. Redesign Process

Following the analysis of the focus group and the interviews, the (re)design stage of the EduCITY app (Stage 3) was initiated. This stage aimed to address the limitations previously identified and incorporate design improvements that better aligned with their expectations and preferences.

The redesign process began with the creation of lo-fi sketches, as Figure 55 demonstrates.

Figure 55 - Lo-fi sketches drawn to guide the hi-fi prototype.

The lo-fi prototyping allowed for a quick exploration and definition of the interface, structural and functional-wise. Starting with paper-based sketches helped ensure clarity and coherence when transitioning to digital hi-fi prototyping later, in Figma. Once the structure was outlined on all screens needed, the next step was hi-fi prototyping.

The hi-fi prototyping process was carried out on Figma, as previously stated. Due to time constraints, the researcher took advantage of Google's *Material 3* (M3) design system (Google, 2021), which offers a comprehensive set of UI components for Android apps. According to Google, "Material Design is an adaptable system of guidelines, components, and tools that support the best practices of user interface design." (2021). The researcher made use of Figma's M3 Design Kit (Figma), shown in Figure 56, a design file that allowed for the quick use of every component available in this library.

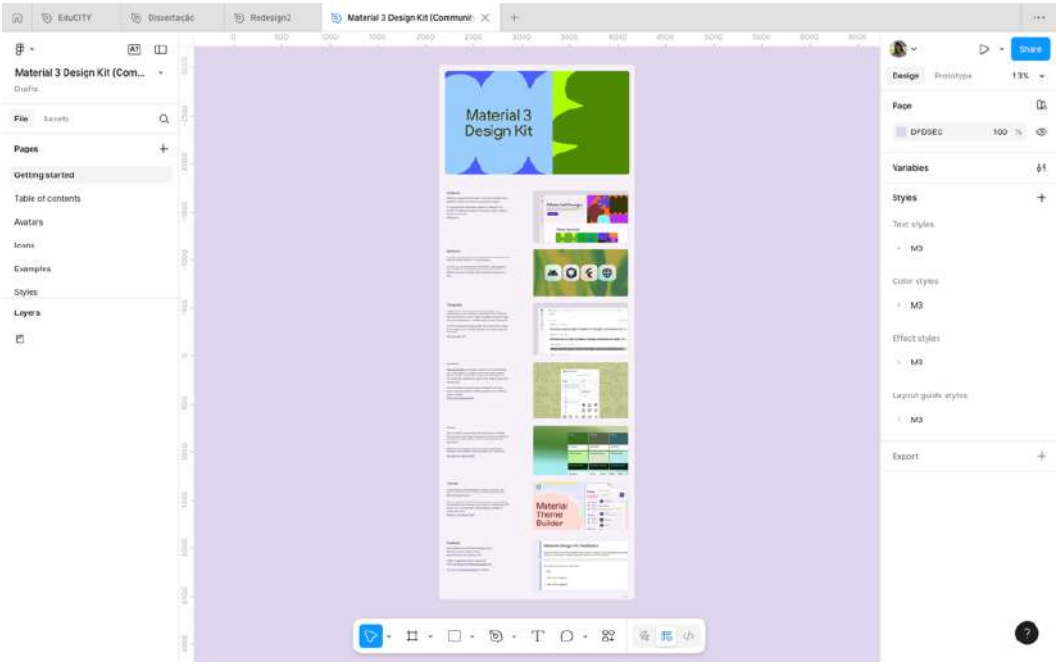


Figure 56 - Material 3 Design Kit file on Figma.

This design system offered ready-made components that ensured visual consistency and the saving of time. The decision to use this specific design system made for Androids was supported by the fact that the researcher already knew the comparative tests would occur on EduCITY's mobile phones, those being Androids, more specifically, Samsung's A22 model.

For this exact reason, the researcher made use of M3's column grid that divides the screen into four vertical columns to guarantee that all screens have a cohesive, well-aligned layout, with an interface that is adaptable to different screen sizes and orientations (K. Gordon, 2022). The grid used in the prototype as well as its elements are presented in Figure 57.

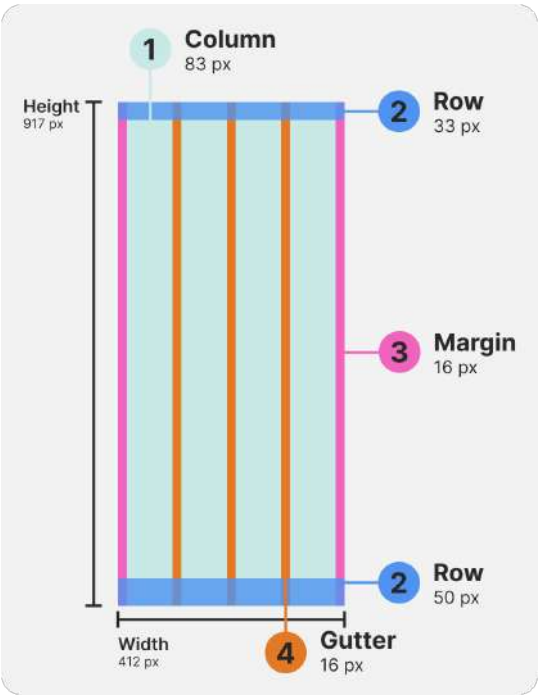


Figure 57 - Elements that make up the grid used by the researcher: (1) columns, (2) rows, (3) margins, and (4) gutters.

The prototype uses a grid of four consistently sized columns (83px) to which all elements will be aligned to and two rows of different heights – one of 33px and the other of 50px that accommodate the space for the fixed elements of the A22, such as the time, network and battery percentage on the top bar and the controls on the bottom bar. The rows ensure that the design elements won't be placed in these positions. The gutters, which are the spaces between columns, are consistently sized (16px) and help users visually separate the different elements on the interface. The margins, on the left and right sides, are the same size as the gutters, and no element should be put over these, unless intentionally, for example, when there is an element with a horizontal scroll.

Besides the grid, the researcher also made use of M3's type styles, guaranteeing a consistent use of typography regarding properties as font, weight, size, line height and letter spacing throughout the layouts on elements such as titles, subtitles, body and labels. Figure 58 demonstrates some of the styles used in the Home Page of the prototype.

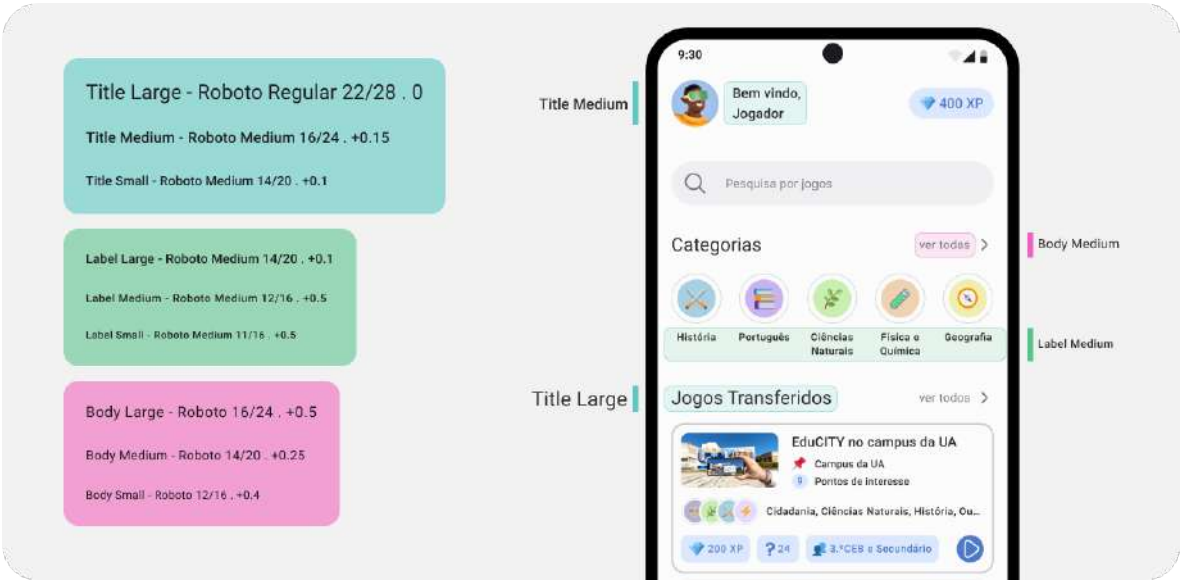


Figure 58 - M3's style roles used in the prototype, particularly in the Home Page.

The prototype's Home Page makes use of 3 type styles from M3, particularly titles, labels and body.

Additionally, the researcher drew strong inspiration from OrcaLit's and Duolingo's interfaces. Figure 59 showcases selected screens and design elements from both apps that were key references during the redesign process.

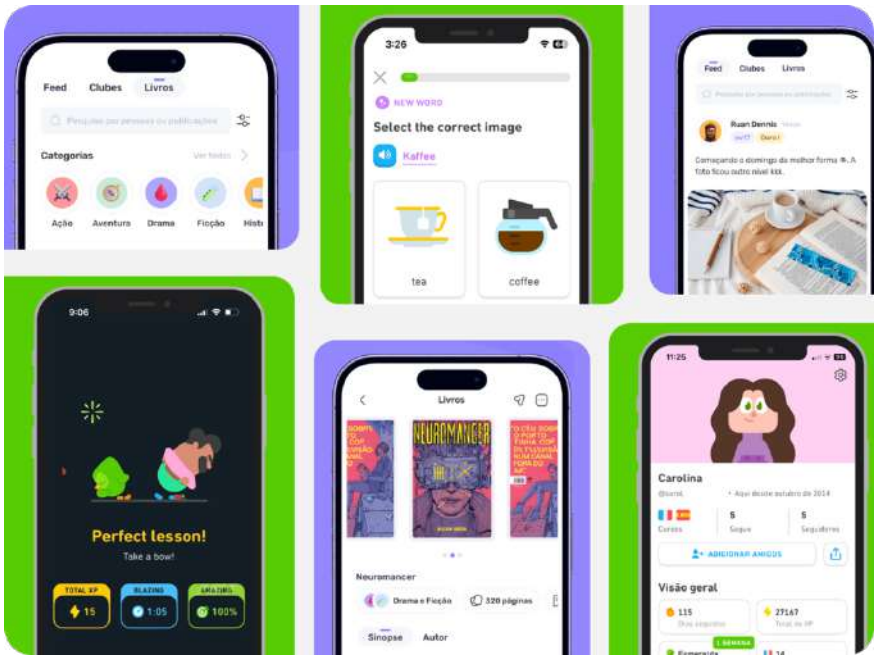


Figure 59 – Screens from OrcaLit (in purple) and Duolingo (in green) that inspired the redesign.

It is worth noting that OrcaLit's interface was described as "perfect" by the participants of the focus group during the A/B exercise, reinforcing its relevance as a source of design inspiration. Regarding Duolingo, particular attention was given to elements such as progress bars, the layout of the profile and results pages, and gamification features, like the XP system.

During the redesign, the app's original, pink-based color scheme was replaced with a more neutral and versatile palette, as illustrated in Figure 60.

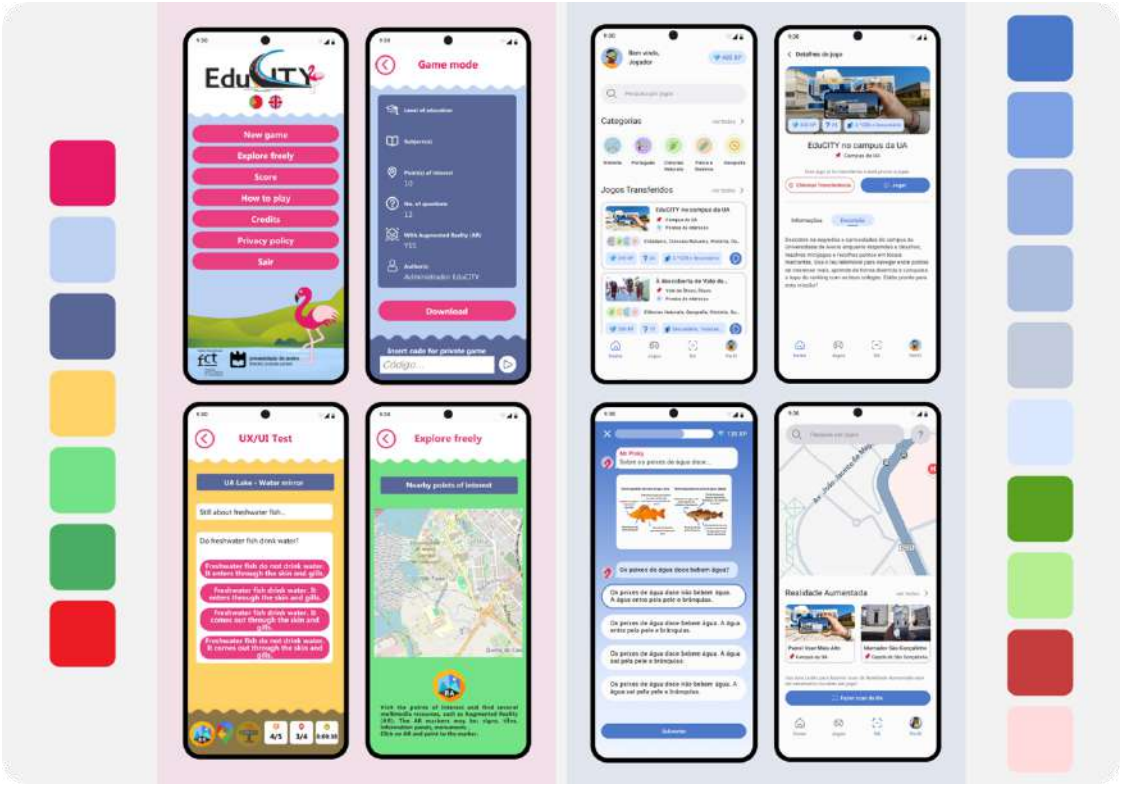


Figure 60 - Color palettes used in the app (on the left) and the prototype (right).

The decision to adopt a simpler color palette was informed by feedback from students and experts. Students in the focus group expressed a preference for cleaner, more “serious” interfaces. UX/UI designers and teachers noted that the original visual style lacked appeal and felt overly simplistic or too text heavy. These impressions guided the adoption of a visual identity that better aligns with contemporary design standards, prioritizing simplicity, improved contrast between elements and, consequently, better accessibility.

One of the biggest changes made to the prototype was the introduction of a bottom navigation bar, shown in Figure 61. This bar allows users to easily and quickly access the main pages the app, those being the home page, the list of games (“Jogos”), the AR scanner (“RA”, which corresponds to the app’s Free Mode) and the profile page (“Perfil”).

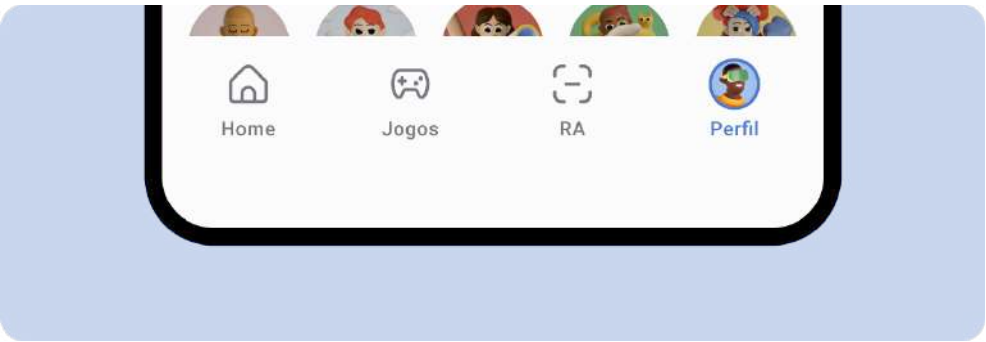


Figure 61 - Prototype's navigation bar.

Additionally, the navigation bar provides users with a clear indication of their current location within the prototype, as the active page is visually highlighted in purple. This design choice aligns with one of Shneiderman’s Eight Golden Rules of Interface Design: “Offer informative feedback”, which was discussed in more detail in the subchapter “User Interface”, on page 13.

This navigation bar appears at the bottom of all screens, except for the gameplay environment, that is, when a user is playing a game. It is intentionally excluded from game screens to avoid occupying valuable screen space and to prevent distractions that could interfere with the true objective of playing the game.

A major focus of the redesign process was the integration of avatars, something that students from the focus group had strongly emphasized, as previously explained in the sub subchapter “Focus Group”. In order to meet this preference, the profile page was created, presented in Figure 62, allowing users to change their profile (avatar) image and unlock new profile pictures as they obtain experience points by playing games, introducing a motivational, gamified layer.

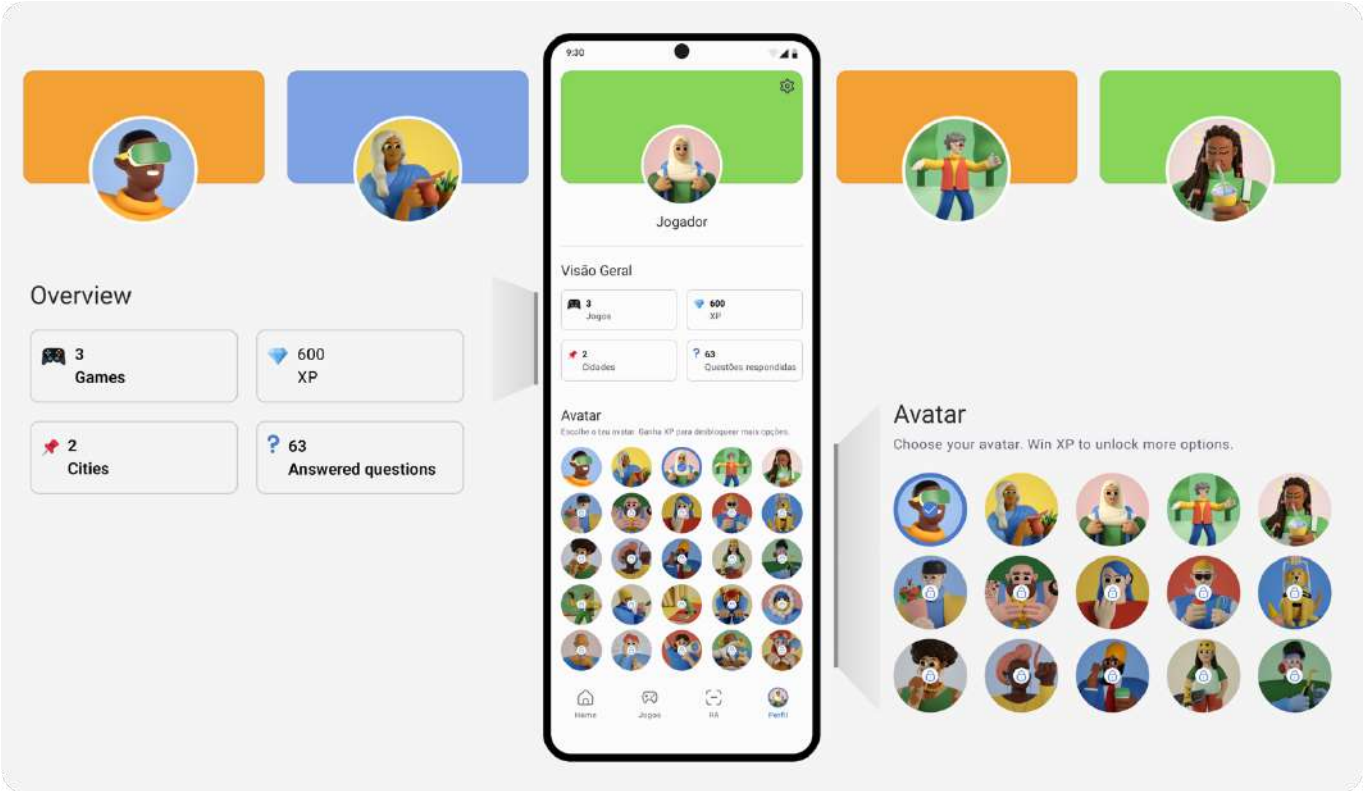


Figure 62 - Prototype's profile page.

All of the avatars used were selected from the M3 Styles (shown in Figure 63), and each one has a background color associated (as Figure 62 demonstrates), changing automatically as the player chooses a particular avatar.

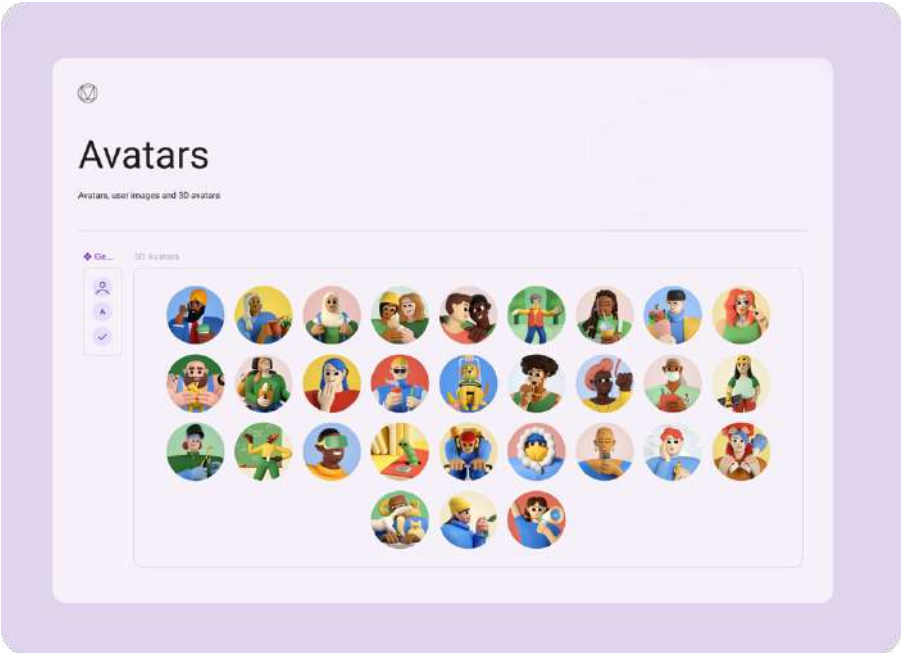


Figure 63 - Avatar styles available on Material 3 (Figma).

The use of avatars was deemed a significant and high-value solution, as it not only satisfied the wish and preference the students felt strongly about during the focus group, but also responded to the need T2 had pointed out of not being able to identify the students on each mobile, as explained in

the subchapter “Teacher Interviews”. Even though the use of avatars doesn’t guarantee the direct identification of every student, at least it facilitates the process as there is a lesser chance of all students choosing the same avatar). At the same time, the use of avatars allows the players to have a more personalized experience, while staying in accordance with the GDPR, not allowing for the direct identification of each player.

The profile page also includes a general overview of user stats, such as the number of games played, total XP, number of cities explored, and total number of questions answered. Access to settings is made on this page, where the field for entering the private code generated for playing test games from the EduCITY platform was added.

The home page underwent a significant transformation: instead of a static menu screen with buttons only (as it is in the current app), the prototype version includes the user’s profile picture, XP amount, a search bar, school subject-based categories (acting as quick, easily available filters), downloaded games and highlighted games (for example, games that the EduCITY team wants to highlight during a certain amount of time). The comparison of the app with the redesigned prototype is illustrated in Figure 64.

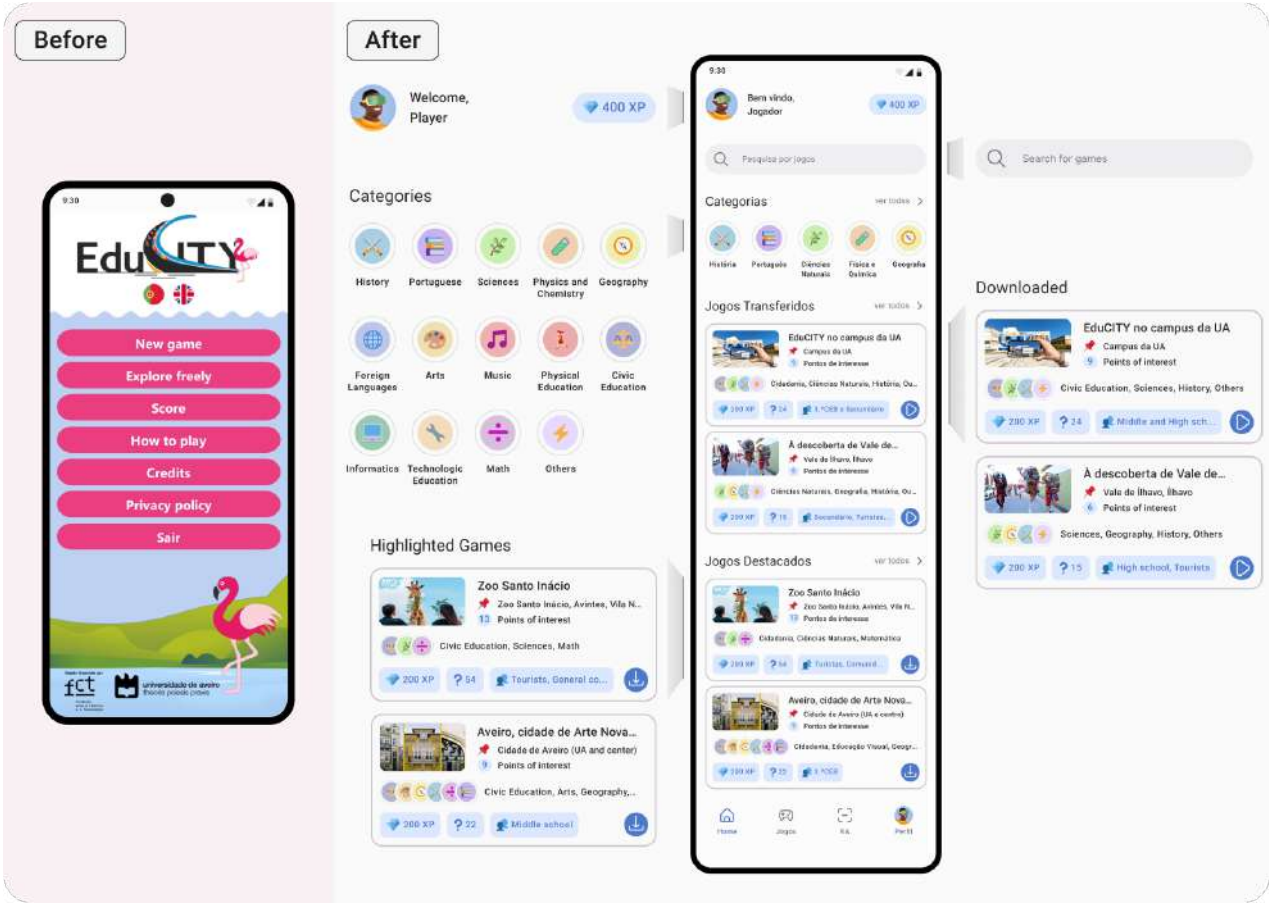


Figure 64 – Comparison between the app (left) and prototype's (right) Home Page screens.

This transformation was guided from the UX/UI experts that considered the home page of the app to be taking few of the potential of the first page users see when they open the app. The prototype version allows the user to easily access the main pages and start playing games directly from the initial

page. Items like “score”, “how to play”, “credits” and “privacy policy” are to be accessed from the profile page on the prototype.

In the list of games screen, similarly to the current EduCITY app, the interface includes only two categories: “Downloaded” and “Available for Download”, along with features such as search, filter and subject-based categories selection. The comparison between the list of games screens of the app and the prototype is illustrated in Figure 65.

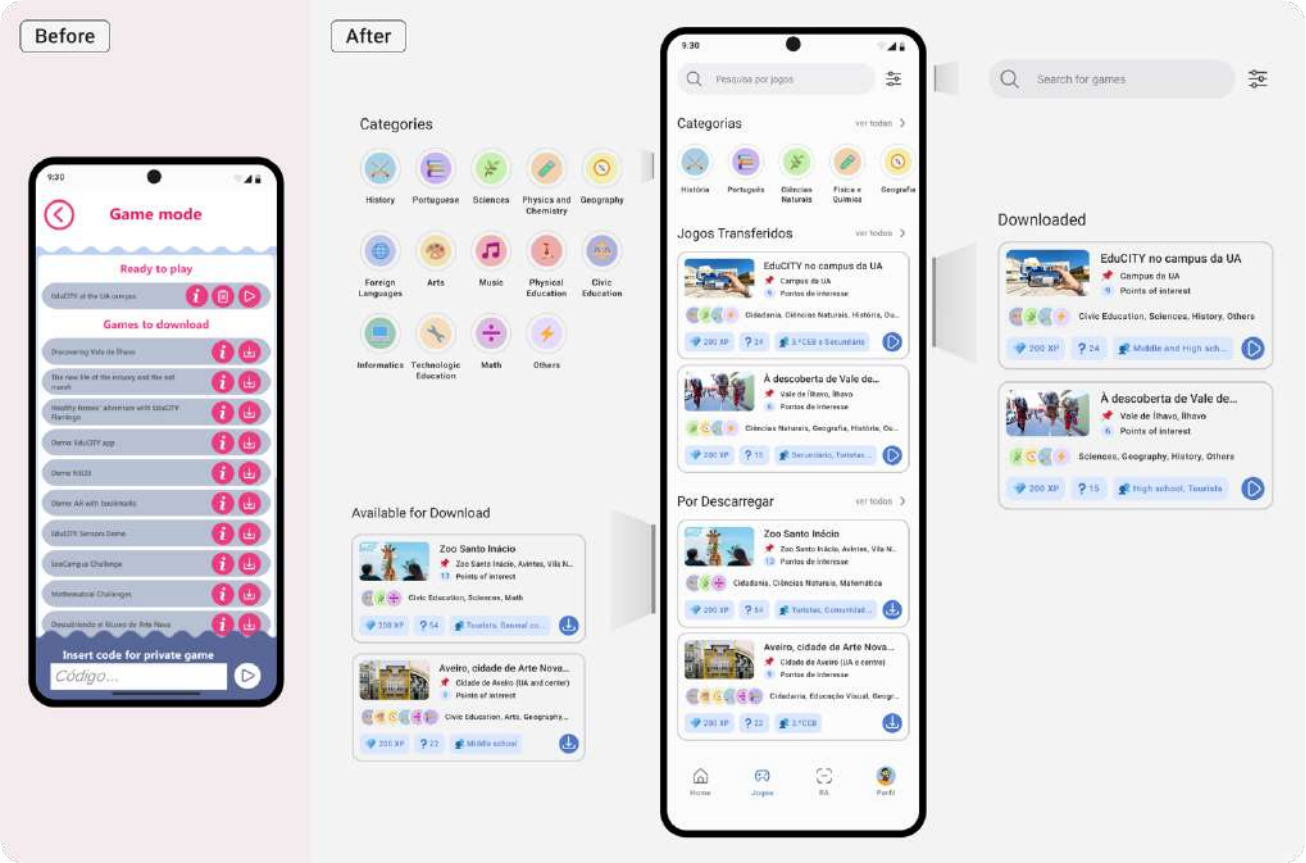


Figure 65 – Comparison between the app (left) and prototype's (right) list of games screens.

In the prototype, each game is displayed as a card that includes the name of the game, an image (thumbnail), general broad location, number of points of interest, subjects, the amount of XP rewarded for playing the game (that is, the maximum XP the player can earn if all questions are answered correctly), and target audience. This change aligns with critiques from UX/UI experts regarding the app version, which only displayed the name of the game. To access any further information, users had to click an “i” button, resulting in extra navigation steps. Additionally, as in the current app, the prototype allows users to directly start a game by clicking the “play” button. This button is only visible if the game has already been downloaded. The comparison between the app’s and the prototype’s game cards is illustrated in Figure 66.

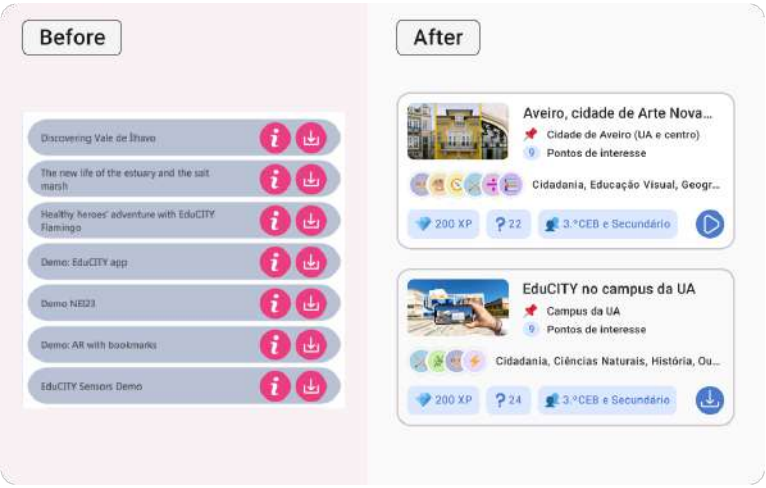


Figure 66 – Comparison between the game cards in the app (left) and in the prototype (right).

By presenting key information upfront and reducing the number of clicks required to access it, the prototype aims to improve usability, support more efficent decision making and reduce cognitive load. By doing this, the prototype applies core usability principles such as Nielsen's "Recognition Rather than Recall" and responds directly to experts' recommendations to improve the app's information hierarchy and visual clarity. Nielsen's list of *10 Usability Heuristics for User Interface Design* has been explained in greater detail previously, on page 7.

However, the prototype also allows the user to access even more detailed information about each game. Similarly to the app, each game has its own info page, now structured into two distinct tabs: "Information" and "Description". This screen includes key elements such as the game's thumbnail, name, maximum XP reward, number of questions, target audience, broad location and action buttons, most of which are present in the quick-view card (see prototype's game card in Figure 66, on the right). These elements remain visible on the screen regardless of which tab is selected. Figure 67 illustrates the actions that can take place in the game-detail screen.

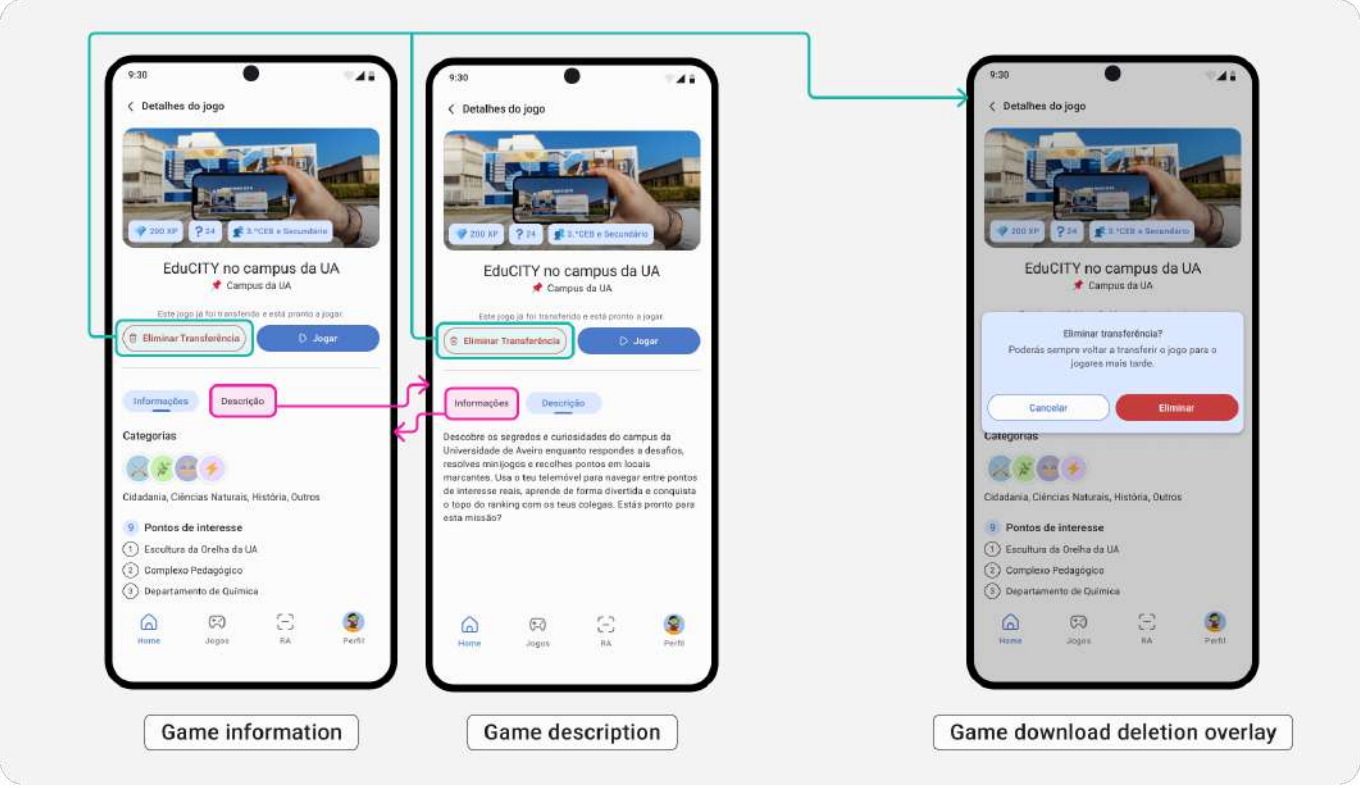


Figure 67 - Game details screens: game information (on the left), game description (in the middle) and game download deletion overlay (on the right).

In the “Information” tab, users can access data related to the subjects covered in the game and the list of specific points of interest, a feature not available in the original version of the app. This design choice aligns with Nielsen’s heuristic of “Visibility of System Status”, allowing users to understand the what the game involves and its route before engaging with it. By listing points of interest, the prototype supports the formation of a clearer mental model and reduces cognitive load at the beginning of the interaction.

In the “Description” tab, also newly introduced, users are presented with a synopsis-like summary, designed to provide a general overview of the game and to motivate them to play.

The interface also includes a download or delete button next to the play button, depending on whether the game has already been download or not. In both cases, confirmation overlays were designed to avoid unintentional actions, shown in Figure 67, on the right. The aligns with Nielsen’s heuristic of “Error Prevention”, as it helps avoid accidental taps that could lead to undesired outcomes. Additionally, the use of visual cues, such as displaying the delete action button in red to signal danger, reinforces the potential risk associated with that action, helping users easily and quickly recognize and reflect before proceeding. This careful visual signaling further contributes to reducing errors and supporting safer decision-making and is aligned with the VD principle of “Contrast”, further developed in the subchapter “User Interface”.

Still regarding the games screen, Filters, a feature pointed out as needed by both experts and students to be able to easily find games, allows users to refine the game-search base on subject, target audience (primary school, middle school, high school, university, tourists and general public) and location (referring to the games’ broad location, not the player’s). The filter screen is illustrated in Figure 68.

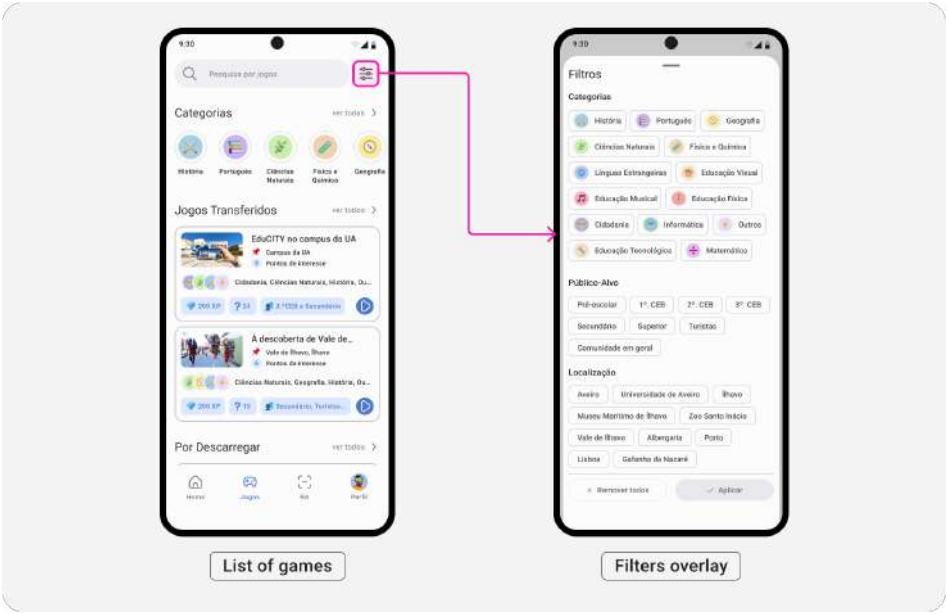


Figure 68 - Games' screen (on the left) and the filters overlay (on the right).

The interaction involved in the filters feature is represented in Figure 68: the user clicks the filter icon and an overlay with the filter categories shows up.

The app's free mode was renamed "RA" (equivalent to AR in Portuguese) on the prototype and placed in the navigation bar to allow for quicker access. The AR page is illustrated in Figure 69, on the left.

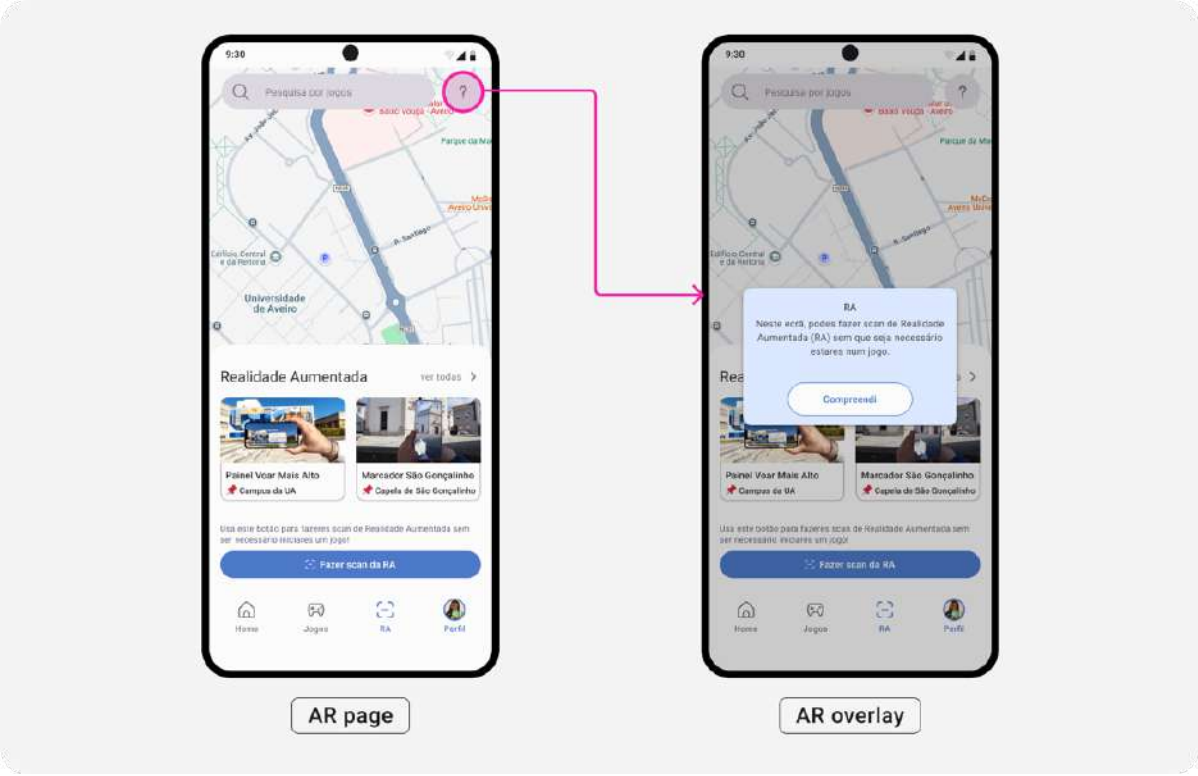


Figure 69 - AR screen (on the left) and the overlay that shows up when clicking the "?" (on the right).

The redesigned page now includes a search bar (allowing users to search and find ARs by location), an interactive map, a suggestion panel (with AR highlights, allowing for a quick view and selection), and an AR scan button with an explanatory text that clarifies its function: “Use this button to scan AR without needing to play a game”. This page also contains a button with a question mark (“?”), for users that might be confused regarding its purpose as that was a difficulty felt by UX/UI experts when using the app for the first time: when this button is clicked, a pop-up shows with the message “On this screen, you can scan Augmented Reality (AR) without needing to play a game”, as Figure 69 (on the right) demonstrates.

The game mechanics have also been reimagined. The game interface of the prototype resembles a chat-based interaction, similar to WhatsApp, where the user responds to messages from EduCITY’s flamingo mascot, *Mr Pinky*. Figure 70 illustrates just this, with the introductory game screen.

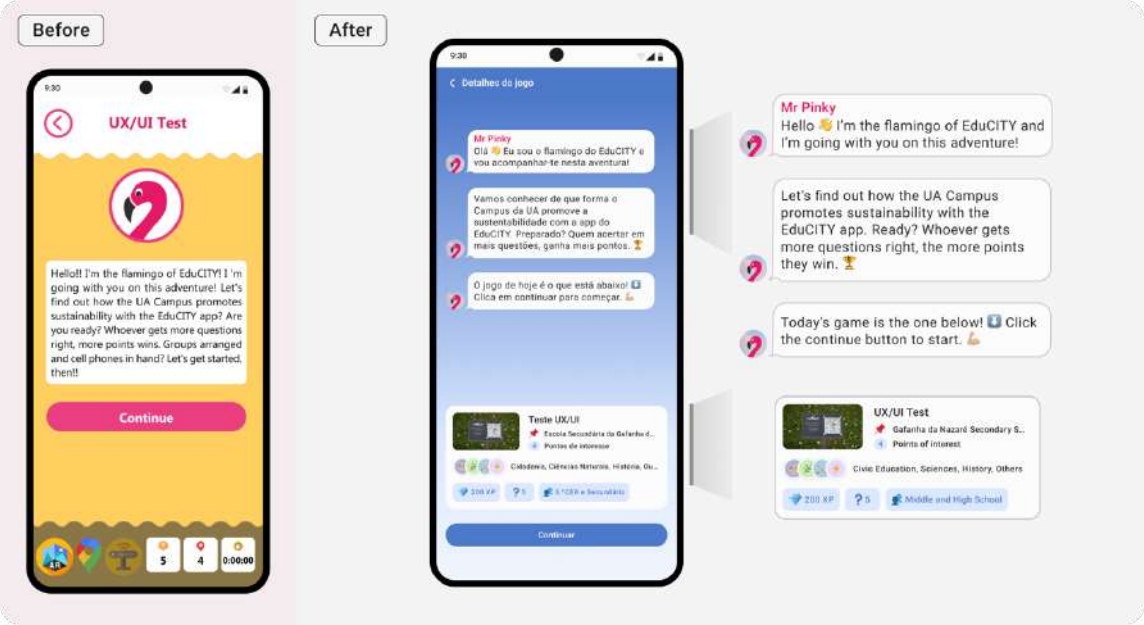


Figure 70 - Comparison between the app (left) and prototype's (right) game introductory screens.

This chat-like interface was a suggestion made by UX/UI expert D1, and it was put into practice because the researcher considered this would be a way of making the interface a bit more interesting to users, after participants of the focus group claimed that “the game can easily become boring”, while delivering an experience they’re already familiar with (chats). Additionally, this mechanic allowed for the improvement of other critiques made by participants during Stage 2: the texts used in the game, which had been unanimously described in the focus group and interviews as “too long” or “having too much information at the same time” were broken into multiple messages – a technique known as *chunking*, previously explained in greater detail in the subchapter “Teacher Interviews”.

Another design decision influenced by the feedback gathered during Stage 2, more specifically the focus group, concerned the tone of voice used throughout the interface. While the original app addressed users using the plural form (“vocês” in Portuguese), the prototype consistently uses the singular (“tu”). This change reflects the students’ preference for playing individually, each on their own device, while still enjoying the experience alongside friends in a shared, competitive setting. Although students valued the social aspect of using the app at the same time as others, they clearly expressed

a desire for a more personal interaction, with each player progressing independently and competing for their own score.

After hearing the UX/UI experts' views on the hierarchy issues regarding the point of interest screens, the researcher reordered elements and made use of some VD principles (previously explained in greater detail in the subchapter "User Interface"), such as the law of proximity, for these screens to be more intuitive and easier to understand. Figure 71 presents two examples of point of interest screens.

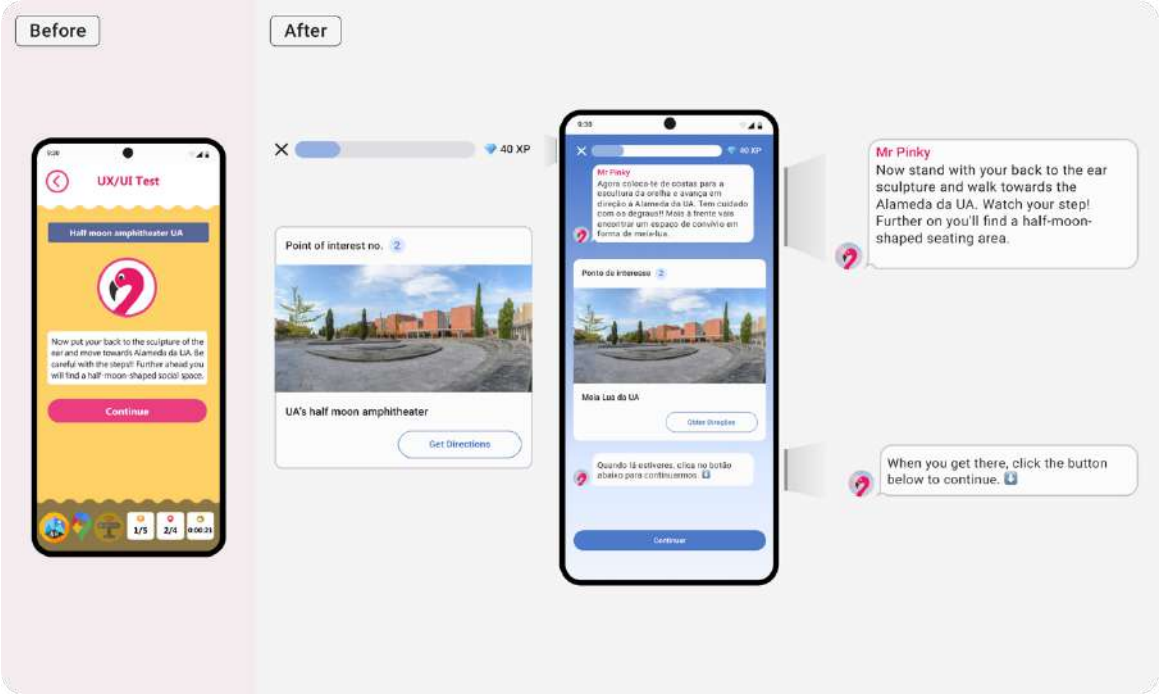


Figure 71 - Point of interest screens.

The chunking of information was also applied to the prototype version of the point of interest screen: the point of interest information is grouped in a card that is numbered to allow for easier understanding, there's an image for easier identification (and possible recall, in cases where the user has already been in the location), a title and a label text that allows the game creator to add detailed information regarding the location or steps needed for the users to get there easily.

Regarding quiz mechanics and interaction, similarly to the app, quiz questions continue to include both single-answer and multiple-answers formats, as Figure 72 demonstrates.

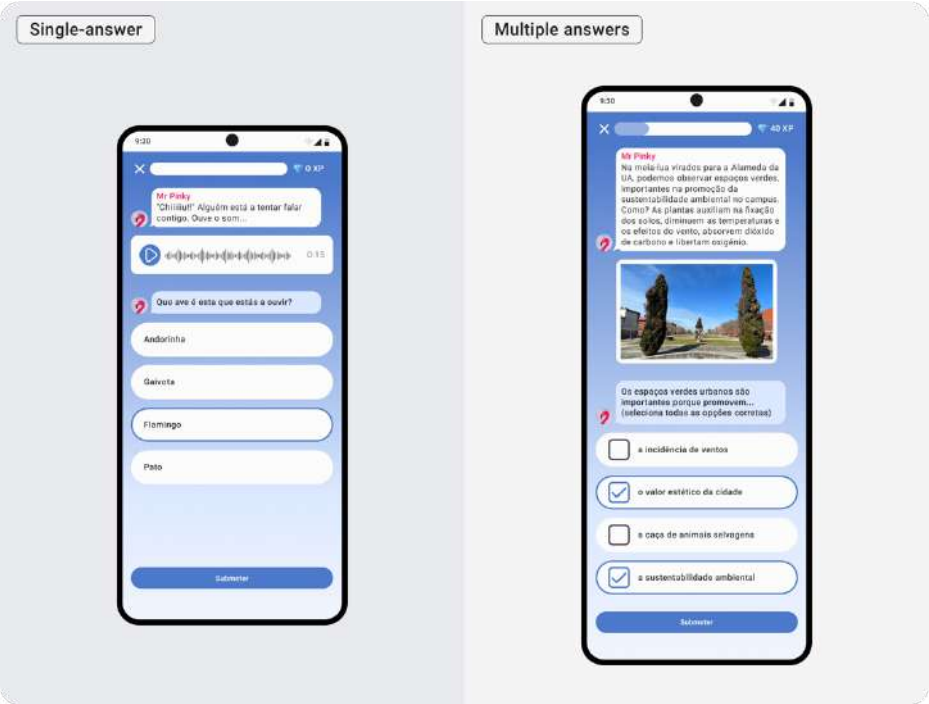


Figure 72 - Different question formats.

One of the major changes made to the gameplay screens was the removal of the duration timer. Figure 73 presents a comparison between a quiz screen from the app (left), which includes a timer at the bottom (in green) and the prototype (right), that has no duration timer.

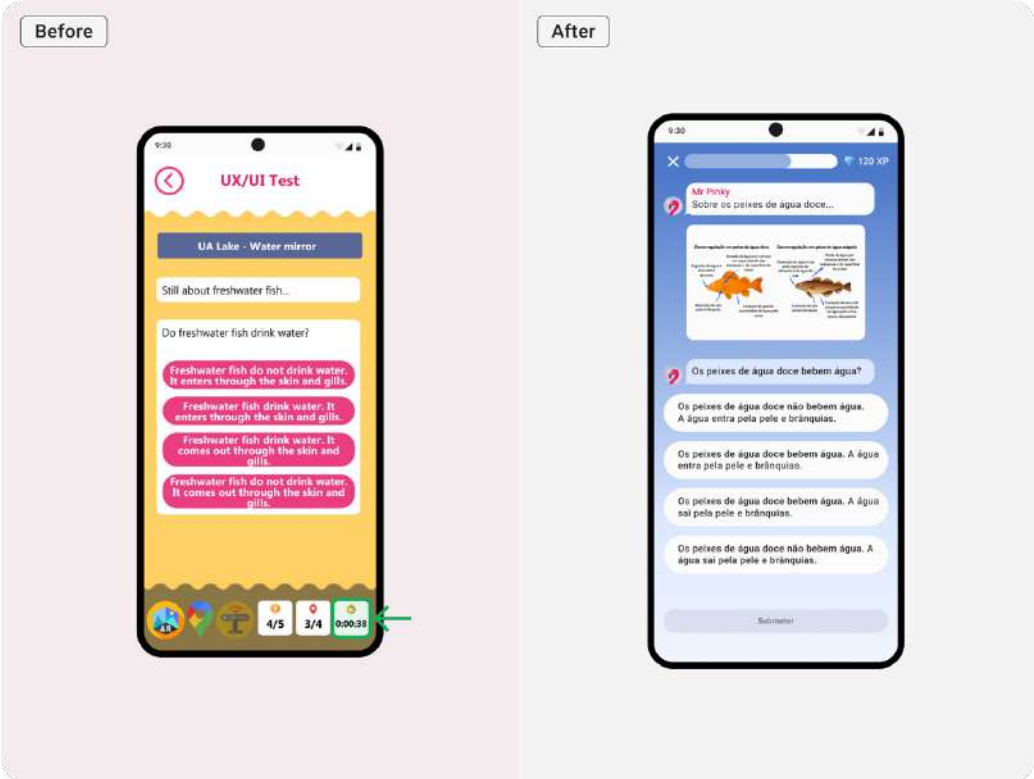


Figure 73 – Comparison between quiz screens of the app (with duration timer, in green) and the prototype (without duration timer).

This decision was based on feedback provided by both teachers, who pointed out that students tend to become overly focused on completing the game as quickly as possible. Rather than engaging

with the content and answering carefully, they tend to fixate on the timer, which, according to teachers, negatively affects their learning experience and response quality.

During gameplay, a progress bar (inspired by Duolingo) gradually fills as users answer questions, and the XP counter increases with each correct response. Figure 74 allows for a comparison between Duolingo's and EduCITY's progress bars.

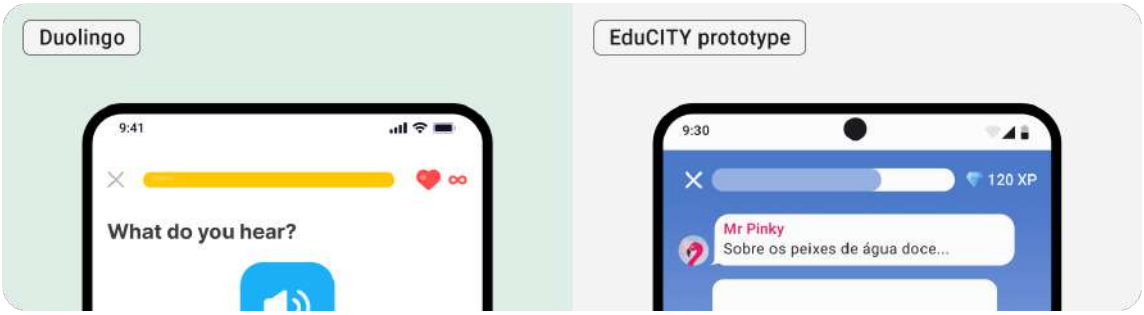


Figure 74 - Comparison of progress bars between Duolingo (on the left) and the prototype (on the right).

In addition, a submission button was also added to every question. In the app, this button only exists on multiple-answers questions, and this caused many users to accidentally select an answer option that was not the intended, to which the system would immediately respond, leading to a feeling of frustration, as teacher T1 pointed out during the interview. To prevent this, there is now a submit button on every quiz-related screen, whether it be single or multiple options. The button is disabled until the player selects an option, as Figure 75 demonstrates.

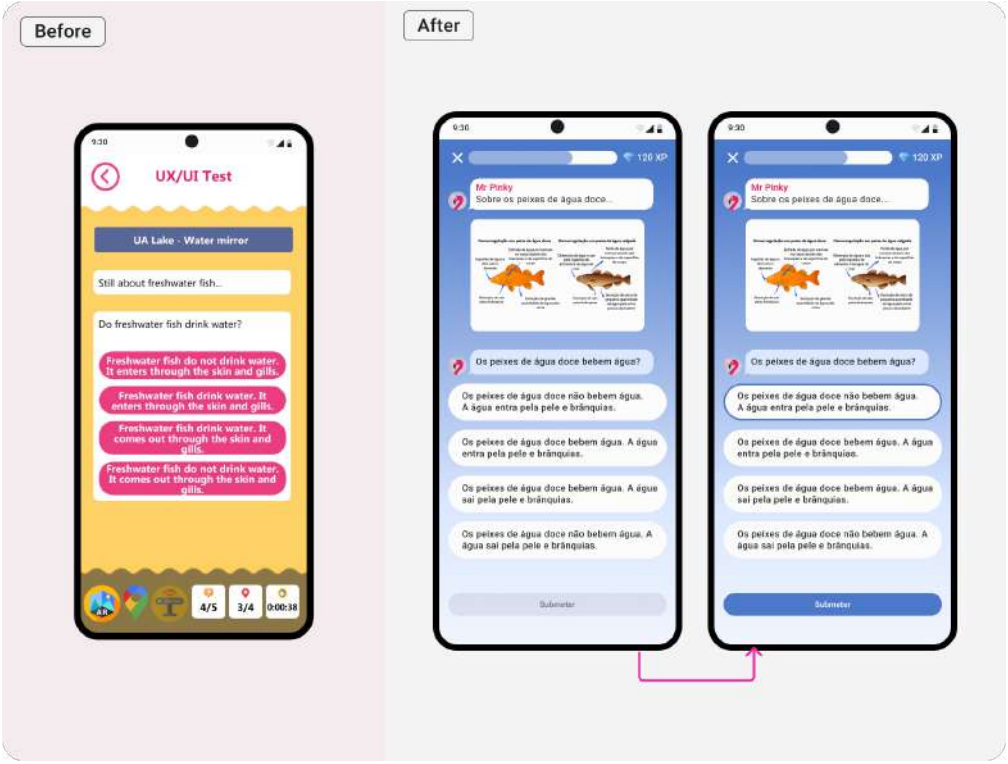


Figure 75 – Comparison between the quiz screen on the app (left) and the prototype (right), with the submit button disabled and active.

This change reflects Nielsen's heuristic of "User Control and Freedom", by giving users more control over their actions, rather than triggering an immediate response. In addition, the submit button

remains disabled until an option is selected, which adheres to key VD principles of affordance and feedback, guiding the user through subtle interface cues and preventing accidental actions.

After submitting an answer, the prototype provides clear visual feedback, with correct answers being highlighted in green and incorrect ones appearing in red, as illustrated in Figure 76.

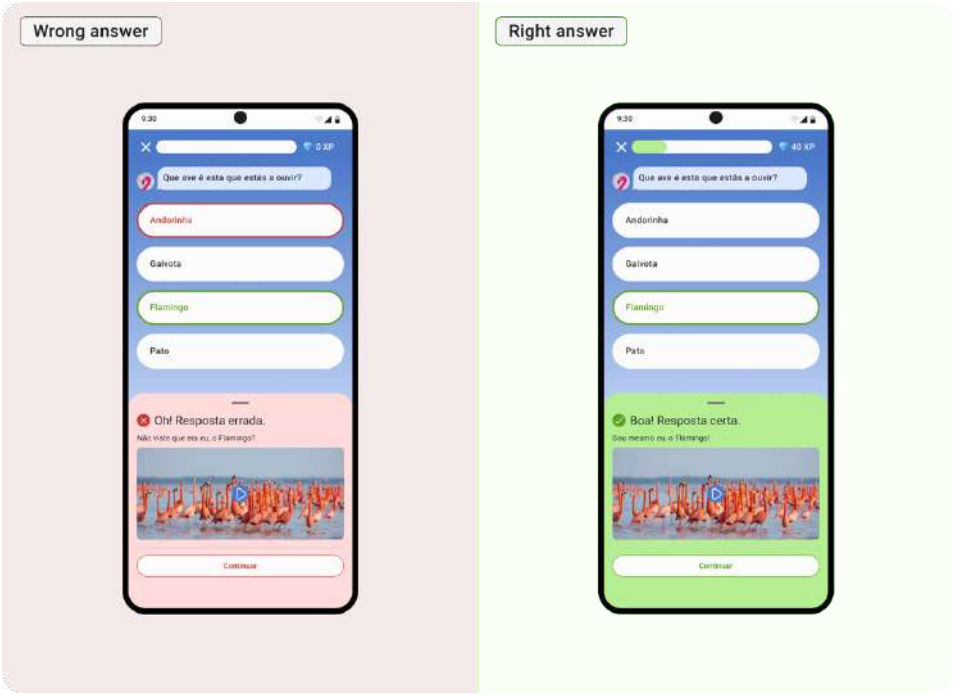


Figure 76 - Visual feedback after submitting answer(s).

In contrast, the current version of the app only displays textual feedback. The prototype provides visual feedback, and it also incorporates sound effects that signal whether the answer is correct or incorrect. Additionally, audio feedback is provided at the end of the game.

By including both visual and audio feedback as well as a submit button, the prototype fosters a more inclusive and accessible user experience. This is particularly important considering that the EduCITY app was conceived to be used in outdoor environments, where screen visibility can be reduced and users are more prone to distractions.

The game results screen, whose app version was appreciated by the participants of the focus group for its organization and purpose, includes more detailed feedback in the prototype. Figure 77 provides a comparison between the EduCITY app and the prototype.

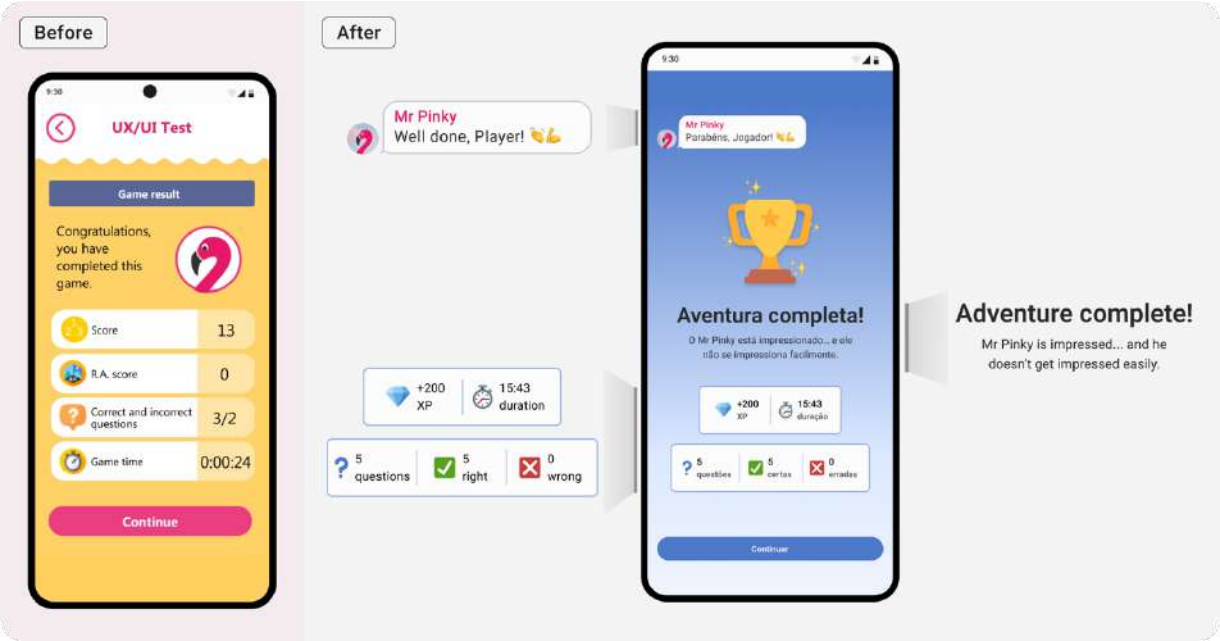


Figure 77 – Comparison of game results screen between the app and the prototype.

The app displayed information on the overall game score, AR score, number of correct answers, number of incorrect answers, and game duration. Notably, the number of correct/incorrect answers was shown in a combined format ("correct/incorrect"), causing it to receive a lot of critiques from the UX/UI experts, as previously mentioned in the subchapter "Teacher Interviews". In response, the prototype presents the total number of questions, separates correct from incorrect answers (allowing for a better readability and intuitiveness) and introduces a motivational message from *Mr Pinky* that reflects the user's performance, as illustrated in Figure 77.

The results screen is aligned with one of Shneiderman's Eight Golden Rules of Interface Design, "Design dialogs to yield closure", by providing users with informative feedback upon completing a task, in this case, a game. This reinforces the users' sense of accomplishment (Shneiderman et al., 2016).

The use of AR caused usability issues during Stage 2, particularly concerning the AR-triggering button. Most participants of the focus group and experts struggled to recognize, locate, or understand the purpose of this button. Figure 78 presents a comparison between the AR-triggering button used in the app (left) and in the prototype (middle and right).

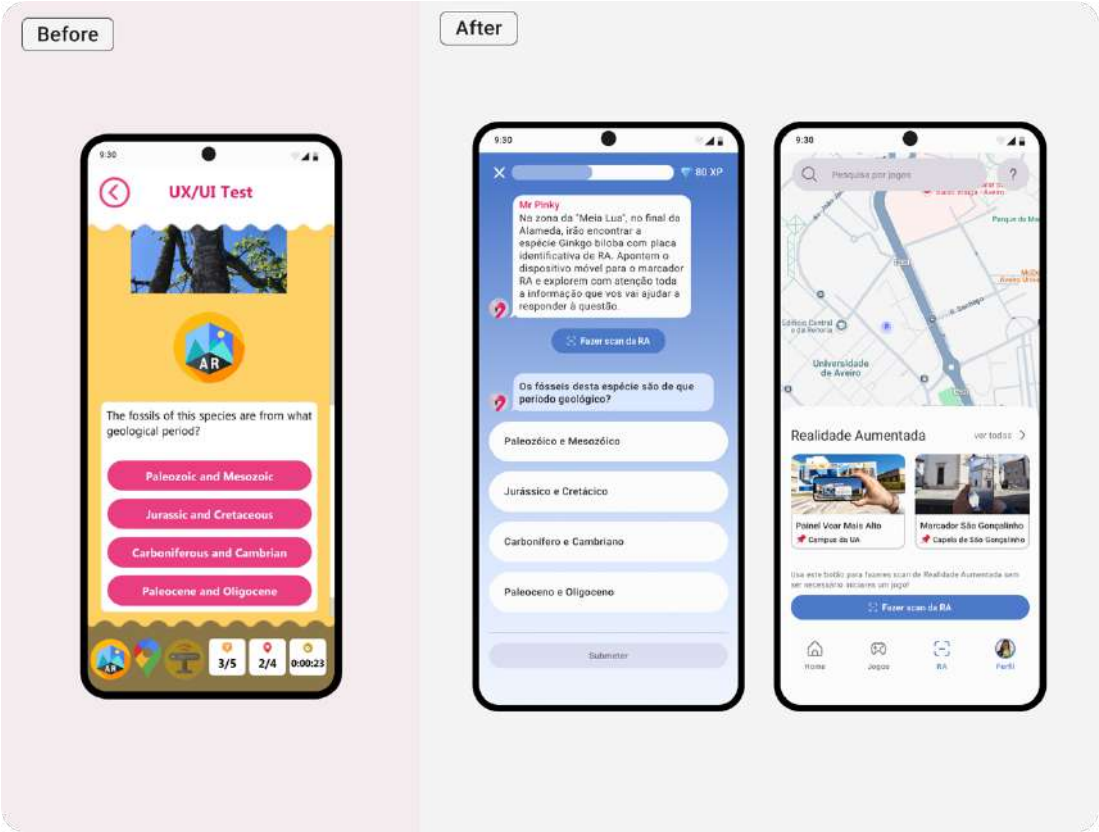


Figure 78 – Comparison of the AR-triggering button between the app (left) and the prototype (right).

These difficulties were mainly due to a lack of visual consistency between the AR-triggering button, which is orange and round, and the rest of the buttons used in the app, which are pink and rectangular, as shown on the left screen of Figure 78. In the prototype, this issue was addressed by redesigning the AR-triggering button to match the visual style of the other interface buttons: blue, rectangular, and with a call-to-action text. In most cases, an icon is also included to further clarify the button's function. This change follows the usability principles of consistency and recognition rather than recall, helping users easily identify the AR-triggering button due to its consistent shape, color, and behavior across the interface.

Once the issues related to the AR-triggering button were addressed, the next step was to tackle the issues regarding the ARBook, which had been described during Stage 2 as "outdated" or "too boxy". Figure 79 shows a comparison between the AR overlay on the camera screen and the ARBook of the app (two screens on the left) and the prototype (two screens on the right).

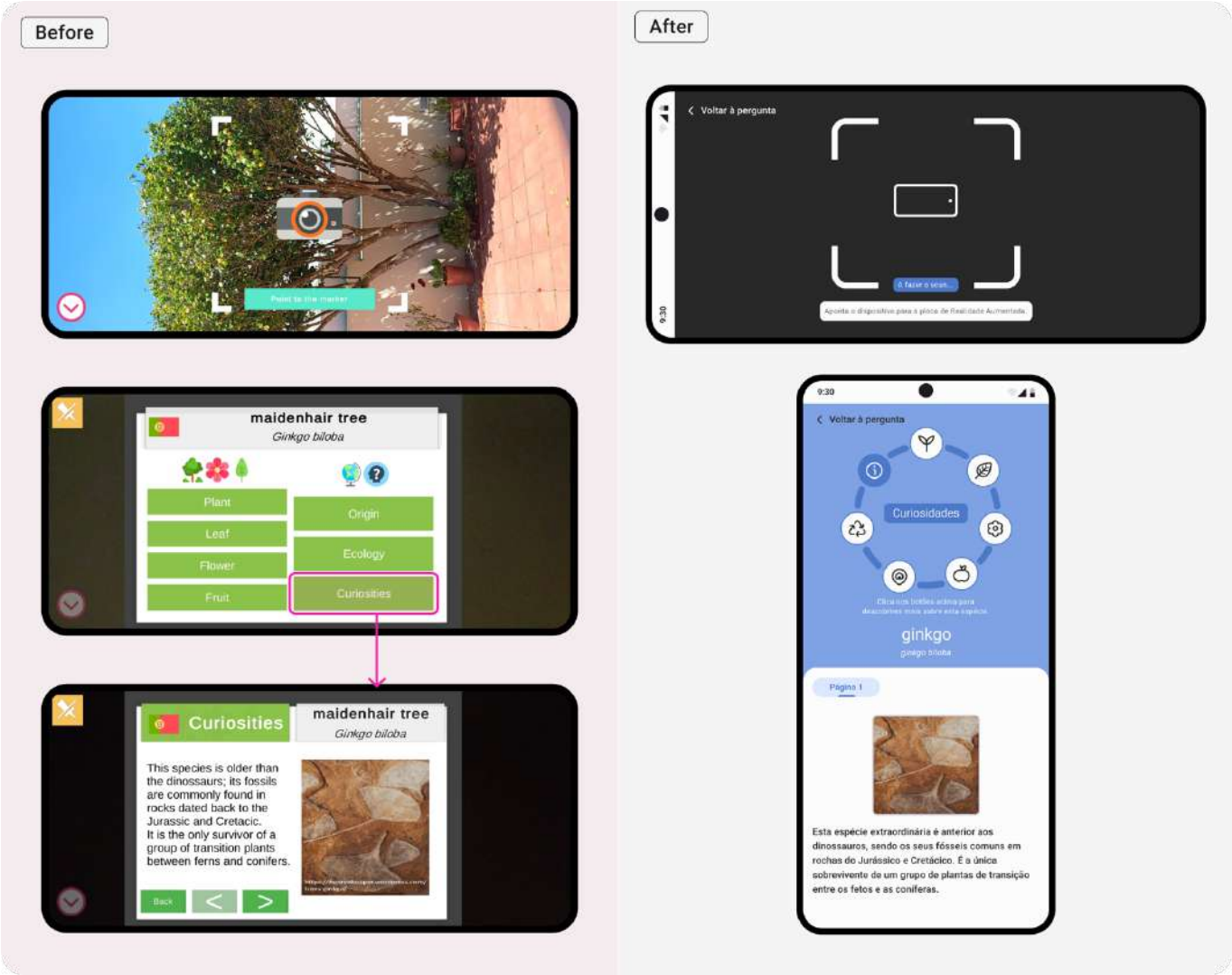


Figure 79 - Comparison between the AR overlay and ARBook in the app (left) and in the prototype (right).

In relation to the AR overlay, this screen didn't raise any concerns or suggestions. However, following the redesign's purpose, the researcher found it necessary to align this screen's visual language to that of the prototype. This involved the applying rounded corners, updating the "back" button to include more contextual information (by adding the label "return to question"), and making the instructional text more explicit (replacing "Point to the marker" with "Point the device to the AR plaque"). A new feedback message ("Scanning...") was also introduced to provide users with clearer system status information during the AR interaction.

Regarding the ARBook itself, significant changes were made to its layout. In the prototype, the ARBook no longer appears "boxy"; instead, there is now a predominance of rounded elements, as illustrated in Figure 80.

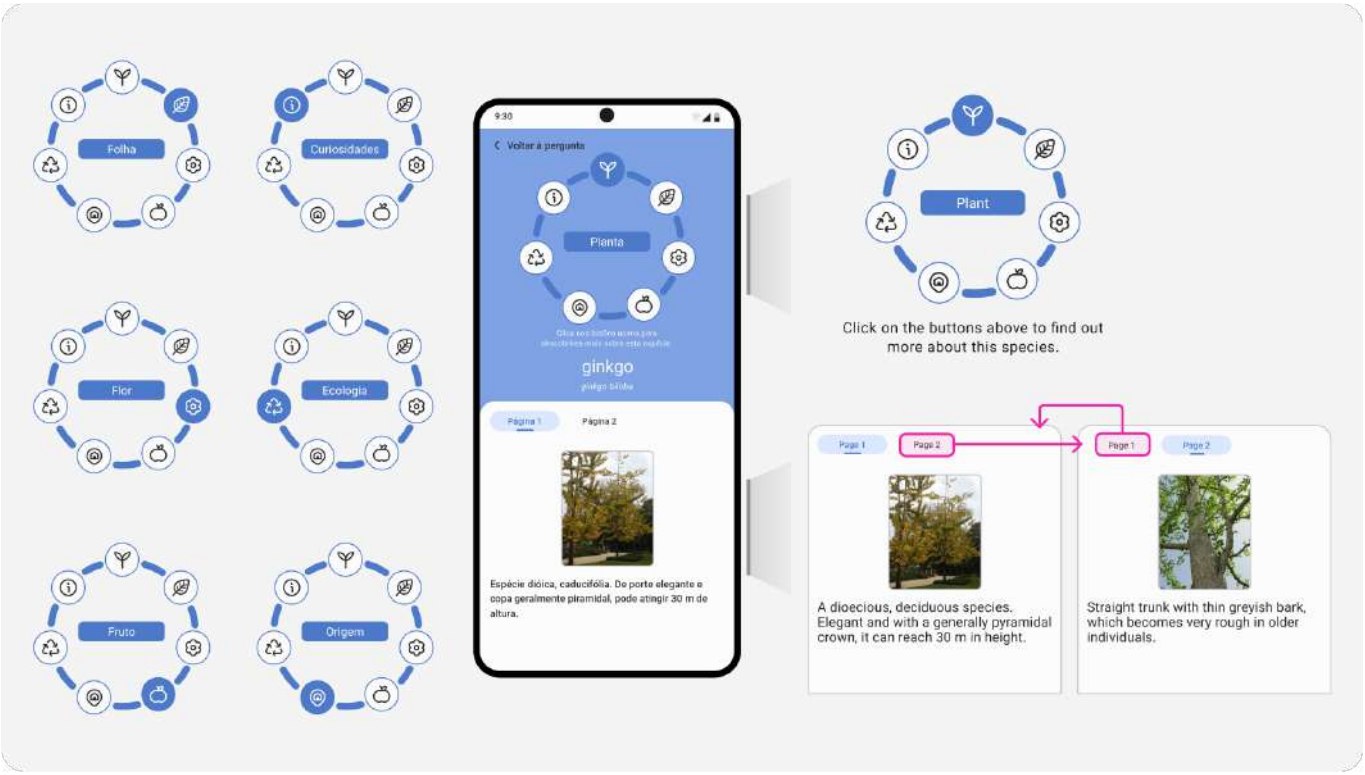


Figure 80 - ARBook layout in the prototype.

Since students described the interaction as “cool” and “interesting” by students, the core interaction model was preserved, with users still having to click and explore the category buttons to access more information about the plant or tree. In the redesigned version, each main category is represented by an icon, and its label is now centered within the circular menu, contributing to a more modern look and feel. There was a conscious effort from the researcher regarding the need to have icons that were consistent between each other and that followed the same visual line, as Figure 81 demonstrates.

Figure 81 - ARBook icons in "default" (top) and "active" state (bottom).

The information associated with each category is divided into one to three pages, similarly to what happens in the app. However, the prototype greatly reduces the number of clicks required to explore the content: instead of being redirected to a new page after selecting a main category, users remain on the same screen, with the main categories always visible and accessible from the top and content displayed at the bottom. This adjustment reduces cognitive load, making access to information easier, faster, and more seamless.

To further support intuitive navigation of the ARBook, a short instructional text was added below the main categories' circular menu, translating "Click on the buttons above to find out more about this species".

Similarly to what happened in the camera AR-overlay, the "back" button of the ARBook screen now includes a text label, in response to difficulties reported by some of the participants of the focus group, who did not understand how to return to the question they were supposed to answer in the first place. This addition is only applied when the ARBook is accessed from a game context. It is not presented when the AR feature is accessed from the bottom navigation bar, as no question needs to be answered in that case.

The prototyping process carried out in Figma required careful attention to interaction flows, especially in the quiz system. The researcher invested significant time thinking of and connecting all possible response combinations to ensure that even though the prototype wasn't a functional one, it could still reflect the logic of the actual gameplay. All of the connections made by the prototype are presented in Figure 82 as blueish lines. These represent the links between frames and define how the user flows through the prototype.

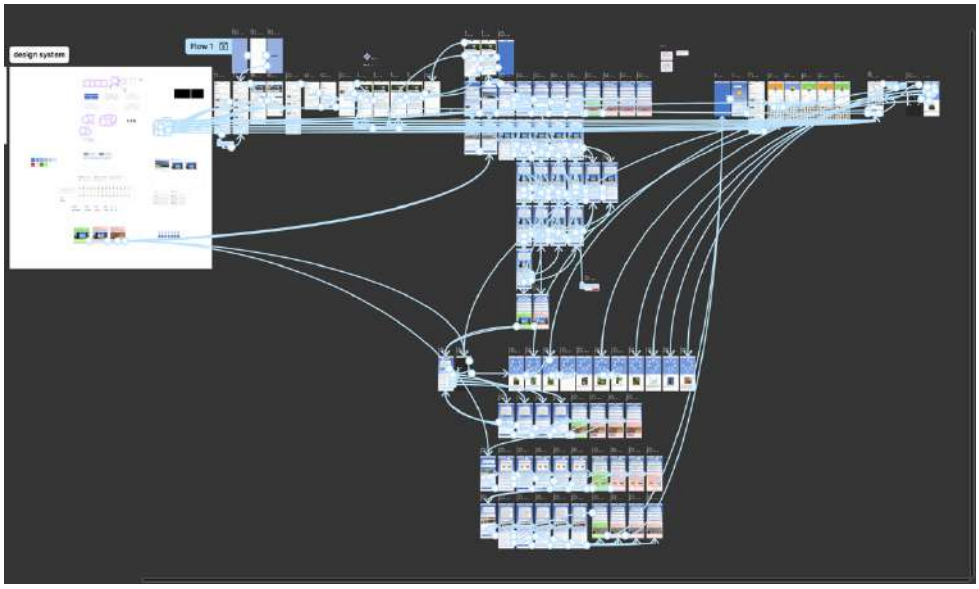


Figure 82 - Screenshot from Figma's file illustrating all of the prototype's connections.

In order to accurately demonstrate how much time and effort it required to make the prototype interactive, 111 frames and over 200 connections were created during Stage 3. This includes extreme cases like selecting one partially correct answer, selecting two with one correct and one incorrect, or three answers with only one being valid. All these possibilities were mapped and connected to guarantee realistic and accurate feedback for each scenario.

In addition to following M3 guidelines, the researcher developed a custom style guide and component system within Figma to ensure visual consistency and fasten the prototyping process, partially demonstrated in Figure 83.

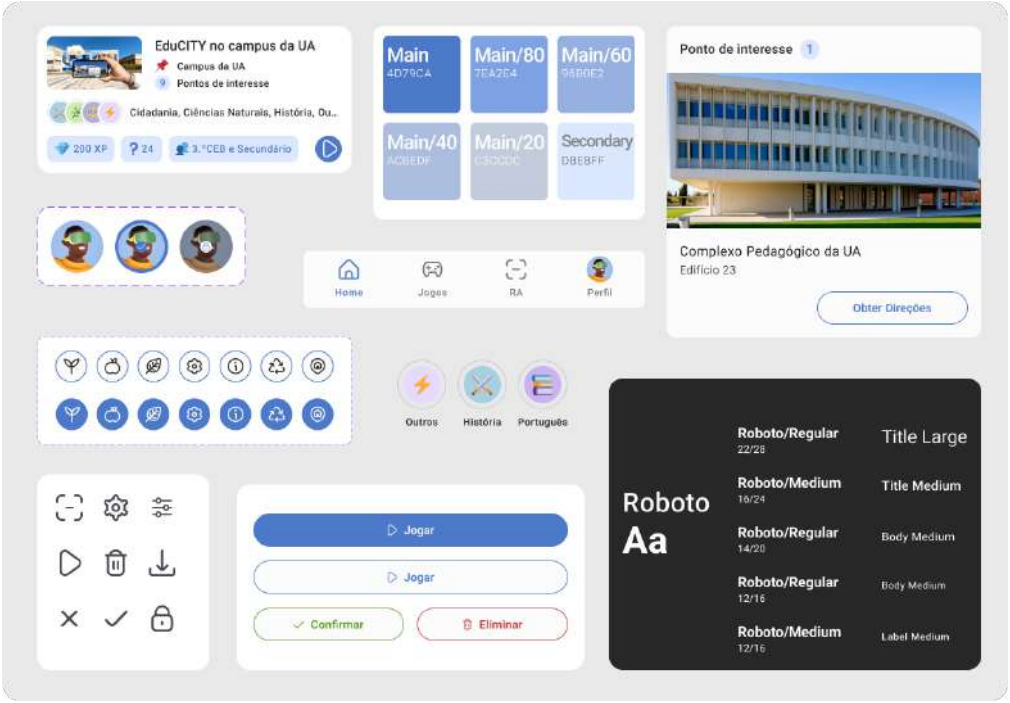


Figure 83 - Style guide made of reusable components designed by the researcher.

This included the creation of reusable elements such as color styles, icon dimensions and behaviors, buttons (with different widths and states, such as primary, secondary and disabled), interactive game cards (with or without the “play” button), the navigation bar (with its expected behavior and appearance, depending on which page the user is on), and both long and short versions of the search bar (depending on whether there is an icon next to it, like the filter icon). As previously demonstrated, filter tag behavior was also prototyped and standardized (white background by default and blue when selected).

In many cases, such as the game cards, components were built using multiple other smaller components, as Figure 84 demonstrates.

Figure 84 - Card component made of other smaller components.

This structure was especially efficient, as updating a single parent component would automatically reflect changes to all child components, including those within more complex, composed components. This avoided the need to manually adjust each element across different screens. By relying on components and component sets, the researcher was able to significantly optimize time and effort. This modular and scalable approach allowed for a more efficient workflow and contributed to maintaining consistency across the entire interface.

The interactive prototype created in Figma can be accessed via this link and the user flow that students were asked to follow is detailed in Appendix 6, specifically on page 162.

5.2.2. Comparative Evaluation

The UX comparative tests were conducted with eight students who answered a post-test questionnaire after using the prototype and after using the app. This questionnaire made use of the AttrakDiff2 scale and had a few open questions. The participants also answered additional comparative questions after completing their last UX test, available in Appendix 13. As previously addressed, the questionnaires employed during the qualitative tests are presented in Appendix 8 and Appendix 9.

The tests were all conducted in the same conditions: in the school outdoor space and they were all carried out the simultaneously. This subchapter presents and discusses the results of the comparative tests for the two groups of participants (P) that were formed: one that started with the prototype (P1 to P4) and one that started with the app (P5 to P8). In addition, there is a comparative analysis of the two.

Before discussing results, it is important to determine the scale's reliability, that can be calculated with the Cronbach's alpha coefficient and the average inter-item correlation, as previously explained in greater detail in the subchapter "Research Stages". To get these measures, the individual responses of all participants to the 21 items of the scale were collected and organized by dimension: PQ, HQ-I and HQ-S. Each participant's ratings were grouped according to these categories, and the internal consistency of the responses was analyzed using Jamovi software (version 2.3.28). Since each dimension contains only 7 items, the average inter-item correlation was also calculated, as recommended by Pallant (2016), to support the interpretation of reliability. In addition, the full table with participants' scores for each AttrakDiff2 item, for the app and prototype versions, is provided in Appendix 14.

In relation to the **Pragmatic Quality (PQ)** dimension, for the **app**'s version, Cronbach's alpha was $\alpha = 0.47$, and the average inter-item correlation was $\bar{r} = 0.21$. Although this alpha is below the commonly accepted threshold of 0.70, such a value can still be considered acceptable for scales with fewer than 10 items (Pallant, 2016). In this case, the $\bar{r}$ value of 0.21 falls within the recommended range of 0.2 to 0.4, indicating a positive relationship between items. For the **prototype** version, however, reliability indicators were weaker, with $\alpha = 0.44$ and $\bar{r} = 0.11$. This lower correlation coefficient suggests a weak relationship between items. Although the analysis software Jamovi recommended reversing item PQ1 in the app and PQ5 in the prototype, a semantic review confirmed that both items were correctly oriented and aligned with the scale direction.

Regarding **Hedonic Quality – Identity (HQ-I),** the **app** version showed excellent internal consistency, with α = 0.95 and r̄ = 0.69. These values reflect strong reliability and very high inter-item correlation, which suggests quite a strong relationship among the items (Pallant, 2016). In contrast, the **prototype** version had a lower alpha (α = 0.68), just below the recommended 0.70 threshold, but this is acceptable considering the short length of the scale. Its inter-item correlation of r̄ = 0.26 lies within the optimal range of 0.2 to 0.4, indicating a positive relationship between items. Despite a suggestion to reverse HQ-I2 in the prototype, this item was also confirmed to be in the correct direction.

The **Hedonic Quality – Stimulation (HQ-S)** dimension presented high reliability in both versions. For the **app**, Cronbach's alpha was α = 0.93, and r̄ = 0.76, well above the recommended range, which also suggests a positive relationship between the seven items (Pallant, 2016). For the **prototype**, internal consistency remained strong (α = 0.83), and the average inter-item correlation dropped to r̄ = 0.48, still indicating a positive relationship above 0.40.

Considering a value of 0.5 or above for Cronbach's alpha to be acceptable in scales with fewer than 10 items (Pallant, 2016), only the PQ dimension fell below the value of 0.50 for both the app and prototype versions. While the app version registered a relatively low alpha α = 0.47, the mean inter-item correlation (r̄ = 0.21) is within the optimal range of 0.2 to 0.4. However, the prototype version seems to have low reliability, with both the alpha (α = 0.44) and inter-item correlation (r̄ = 0.11) falling below the recommended values. Although the low Cronbach's alpha value for the PQ dimension in the prototype version can partly be explained by the reduced number of items in the scale, the very low mean inter-item correlation suggests poor internal consistency. This discrepancy may be explained by technical and contextual issues encountered during testing. Unlike the app, which can be used offline, the prototype required a constant internet connection via Figma. During outdoor testing, limited connectivity led to delays, prototype freezes, and inconsistent feedback across devices - including cases where the prototype became unresponsive or failed to play audio. Furthermore, multiple devices were simultaneously logged into the same Figma session, which may have caused server overload or syncing conflicts. These performance problems likely compromised users' perceptions of efficiency, control and responsiveness - key aspects measured by PQ items - and may have introduced irregularity in how participants rated the construct.

After analyzing the scale's reliability, each dimension and item's mean (M), median (MDN), standard deviation (SD) and interquartile range (IQR) scores were calculated for both versions (App and Prototype). Table 6 presents those values. The table includes all item pairs in Portuguese, the language in which the scale was applied with students, and in English, to ensure clarity and comprehension for the reader of this document.

Table 6 - Descriptive statistics for all items of the AttrakDiff2.

	Version	M	MDN	SD	IQR
Pragmatic Quality (PQ)	**App**	**1.68**	**2**	**1.48**	
	Prototype	**1.59**	**2**	**1.30**	
PQ1 Próxima da tecnologia - Próxima do Homem Technical - Human	App	0.63	0.50	2.07	2.50
	Prototype	0.88	0.00	1.25	2.00
PQ2 Complicada - Simples Complicated - Simple	App	1.38	2.00	2.07	2.25
	Prototype	1.75	2.00	1.17	0.00
PQ3 Não é possível usar – É possível usar	App	2.50	2.50	0.54	1.00

Impractical - Practical	Prototype	2.38	2.00	0.52	1.00
PQ4 Não compreensível - Compreensível Cumbersome - Straightforward	App	1.88	2.00	1.25	1.50
	Prototype	2.50	3.00	0.76	1.00
PQ5 Imprevisível - Previsível Unpredictable - Predictable	App	0.88	0.50	1.36	2.00
	Prototype	0.25	0.00	1.17	1.00
PQ6 Confusa – Bem estruturada Confusing - Clearly structured	App	2.13	2.00	0.84	1.25
	Prototype	2,00	2.00	0.93	0.25
PQ7 Difícil de controlar – Fácil de controlar Unruly - Manageable	App	2.38	2.50	0.74	1.00
	Prototype	1.38	2.00	1.69	1.50
Hedonic Quality-Identity (HQ-I)	**App**	**1.29**	**1**	**1.46**	
	Prototype	**1.57**	**2**	**1.25**	
HQ-I1 Que não estabelece ligação com as pessoas – Que estabelece ligação com as pessoas Isolating - Connective	App	1.50	1.00	1.31	2.25
	Prototype	1.50	1.50	1.51	2.25
HQ-I2 Não profissional - Profissional Unprofessional - Professional	App	1.25	1.00	1.39	1.50
	Prototype	1.50	2.00	1.07	1.25
HQ-I3 Vulgar - Elegante Tacky - Stylish	App	0.88	1.50	1.72	2.25
	Prototype	1.88	2.00	0.99	0.50
HQ-I4 De baixa qualidade – De alta qualidade Cheap - Premium	App	1.13	1.50	1.81	1.75
	Prototype	1.88	2.00	0.84	1.25
HQ-I5 Alienante - Integradora Alienating - Integrating	App	1.38	2.00	1.30	1.25
	Prototype	1.25	1.00	1.04	1.25
HQ-I6 Afasta-me das pessoas – Aproxima-me das pessoas Separates me – Brings me closer	App	0.63	0.00	1.51	2.25
	Prototype	0.50	0.00	1.70	2.25
HQ-I7 Não apresentável - Apresentável Unpresentable - Presentable	App	2.25	3.00	1.04	2.00
	Prototype	2.50	3.00	0.76	1.00
Hedonic Quality-Stimulation (HQ-S)	**App**	**1.07**	**2**	**1.75**	
	Prototype	**1.26**	**1**	**1.02**	
HQ-S1 Convencional - Inventiva Conventional - Inventive	App	1.00	2.00	2.00	3.25
	Prototype	1.38	1.50	1.06	1.25
HQ-S2 Sem imaginação - Criativa Unimaginative - Creative	App	1.63	2.00	1.51	2.25
	Prototype	2.13	2.00	0.64	0.25
HQ-S3 Cautelosa - Ousada Cautious - Bold	App	0.88	0.50	1.36	2.00
	Prototype	0.13	0.00	0.99	0.50
HQ-S4 Conservadora - Inovadora Conservative - Innovative	App	1.00	2.00	1.77	2.25
	Prototype	1.38	1.00	0.92	1.00
HQ-S5 Aborrecida - Cativante Dull - Captivating	App	1.13	1.50	2.17	2.50
	Prototype	1.13	1.50	1.36	2.00
HQ-S6 Pouco exigente - Desafiadora Undemanding - Challenging	App	1.25	2.00	1.98	3.25
	Prototype	0.50	1.00	1.07	1.25
HQ-S7 Comum - Novidade Discouraging - Motivating	App	0.63	1.00	1.85	3.00
	Prototype	0.50	0.50	0.93	1.00

As previously explained, a 7-point scale ranging from –3 to +3 was applied, with 0 being the neutral value. Scores close to 0 were considered moderate or neutral, while higher or lower values indicated more positive or negative perceptions, respectively. All of the dimensions presented positive semantic values, with PQ showing the highest mean scores for both the App and Prototype versions.

To support a more comprehensive interpretation of the AttrakDiff2 results, the analysis includes a word pair diagram. These graphs were based on the mean scores of each item on the app and prototype versions. The findings previously described (all dimensions registering positive values) align

with the results shown in the word pair diagram, in Figure 85, which displays the individual average scores for each word pair, in Portuguese and English.

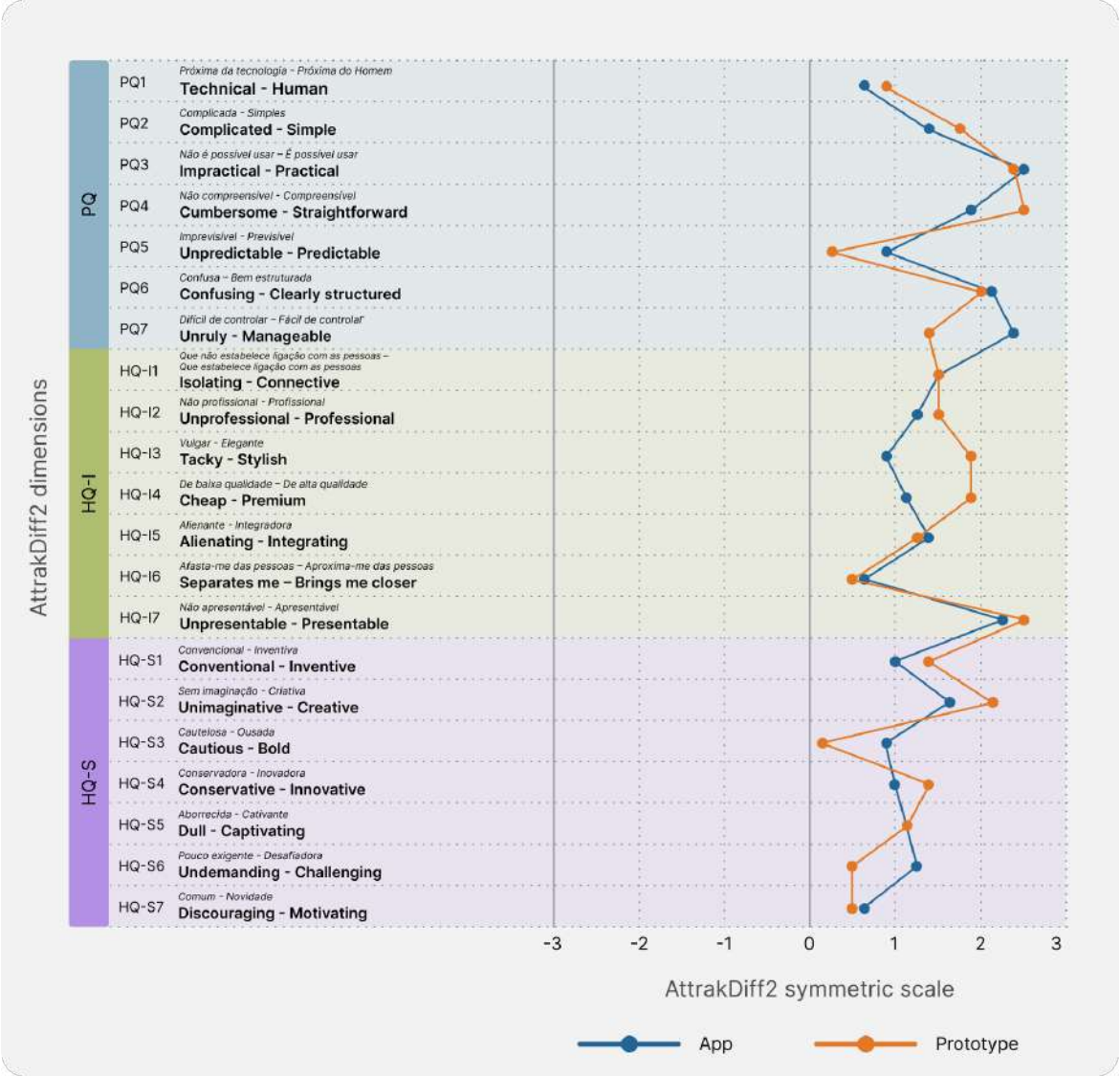


Figure 85 - Description of word pairs (app vs. prototype)

By looking at Figure 85, it is possible to perceive that the overall experience of both versions was perceived by students as positive, since no item had a negative mean score.

The Pragmatic Quality (PQ) dimension results indicate the participants evaluated both versions positively (MDN=2 for the app and the prototype), with a slightly higher mean in the app (1.69 for the app vs 1.58 for the prototype):

- The app was considered practical, clearly structured, and manageable. It was also considered moderately simple and straightforward. However, PQ1 (Technical - Human) received the lowest mean score (M=0.63) among all items, suggesting that users perceived the interface as slightly more human than technical. Although this is a positive result, the relatively low score may indicate that the interface was not strongly perceived as personable or emotionally engaging, but rather neutral in tone.

- The prototype was considered practical, straightforward, and clearly structured. It was also considered moderately simple and manageable. Both PQ1 (Technical - Human) and PQ5 (Unpredictable - Predictable) received low positive scores (M=0.88 and M=0.25), especially PQ5, which shows that participants perceived the prototype as only slightly predictable. These results may reflect issues such as disrupted interaction flow, particularly relevant given the connection instability and prototype lags reported during the tests. Moreover, this notable discrepancy between item scores within the PQ dimension is consistent with the earlier reliability analysis, where the prototype version showed both a low Cronbach's alpha and a weak inter-item correlation. This further suggests that the items may not have been perceived as measuring a single cohesive construct, likely due to uneven user experiences across different aspects of pragmatic interaction.

The Hedonic Quality - Identity (HQ-I) dimension results suggest that participants evaluated both versions positively, with the prototype providing a more favorable perception of the product's identity attributes (MDN=2) compared to the app (MDN=1):

- The app was perceived as presentable and moderately connective, professional, and integrating. Items such as HQ-I3 (Tacky - Stylish), HQ-I4 (Cheap - Premium) and HQ-I6 (Separates me - Brings me closer) received lower scores (M=0.88, M=1.13 and M=0.66, respectively), suggesting that while the app was not seen as unattractive or cheap, it also did not strongly convey a sense of style, premium quality, or emotional connection. These results may reflect a functional but neutral interface that lacked engaging elements capable of fostering a deeper sense of aesthetic appreciation.

- The prototype was perceived as presentable and moderately connective, professional stylish, premium, and integrating. The only item that received a lower score was HQ-I6 (Separates me - Brings me closer), with an even lower score (M=0.50) than the one registered by the app (M= 0.66), even though the difference is small. This also suggests that, despite improvements in perceived style and quality, the prototype may not have significantly strengthened users' emotional connection with the product. It is possible that the technical issues experienced during testing, such as lag and connectivity problems, contributed to this weaker sense of personal attachment or identification.

Regarding the Hedonic Quality – Stimulation (HQ-S) dimension, results also indicate a generally positive evaluation of both versions, with the prototype being perceived as more stimulating (MDN = 2) than the app version (MDN = 1).

- The app was considered moderately creative, captivating, and challenging. Four HQ-I items registered low positive scores, those being HQ-S1(Conventional - Inventive, with M=1.00), HQ-S3 (Cautious - Bold, with M=0.88), HQ-S4 (Conservative - Innovative, with M=1.00) and HQ-S7 (Discouraging - Motivating, with M=0.63). The low positive scores may indicate that although the app was generally well received, it did not strongly convey qualities of inventiveness, boldness, or innovation. Additionally, the relatively low score on HQ-S7 suggests that the app may not have fully succeeded in motivating users or presenting itself as highly engaging or inspiring during use.

- The prototype was considered creative and moderately inventive, innovative, and captivating. Items such as HQ-S6 (Undemanding - Challenging) and HQ-S7 (Discouraging - Motivating) received low positive scores (M=0.50 and M=0.63), but HQ-S3 (Cautious - Bold) clearly stands out, almost having a neutral score (M=0.13). This suggests that while the prototype was perceived as generally stimulating, it may have lacked elements of boldness and challenge and failed to significantly motivate users. The near-neutral value of HQ-S3 doesn't necessarily indicate that participants did not find the interface to be cautious. It simply means that the students didn't find it particularly daring or adventurous, which could imply a design that feels safe, without taking too many risks or being too cautious. However, combined with the modest ratings for challenge (HQ-S6) and motivation (HQ-S7), these results may reflect the usability issues and lags experienced during testing, which could have dampened the sense of stimulation and engagement.

The overall mean score for the app version was M=1.35, while the prototype reached a slightly higher average of M=1.47. These values suggest that despite the serious usability issues regarding wi-fi connection faced during the comparative tests, the prototype's overall experience was perceived more positively. This reinforces the interpretation that the prototype's strengths lie not in technical reliability, but in emotional resonance and visual appeal. Ultimately, the app was seen as more stable from a practical standpoint, but the prototype offered a more engaging and stimulating experience, which is a valuable insight for guiding future design iterations.

Further expanding on the differences between the app and the prototype, that are a few that stand out and deserve careful attention. Most notably, item PQ7 (Unruly - Manageable) shows a full point difference in favor of the app (2.38 vs 1.38), suggesting that it was perceived as easier to control compared to the prototype. Similarly, items such as HQ-S3 (Cautious - Bold) and HQ-S6 (Undemanding - Challenging) also favor the app. As stated previously, these differences are most likely linked to the testing conditions in which the comparative tests took place. These performance issues likely influenced participants' evaluations of control and responsiveness, particularly in items related to manageability, stimulation and challenge.

On the other hand, certain items showed notably higher scores in the prototype. For example, item HQ-I3 (Tacky - Stylish) presented a full-point difference (1.88 vs 0.88), indicating that participants found the prototype more visually refined and aesthetically pleasing. Similarly, items HQ-I2 (Unprofessional- Professional) and HQ-I4 (Cheap - Premium) also received higher ratings in the prototype, suggesting a stronger perception of professionalism and overall design quality. The consistent improvement across multiple Hedonic Identity items (5 improved items out of 7 total items) points to a generally positive reaction to the redesigned visual elements and interface presentation.

Interestingly, PQ4 (Cumbersome – Straightforward) also scored higher in the prototype (2.50 vs 1.88), which may indicate that, despite some technical issues, the redesigned layout and the prototype's interaction might have been perceived as more intuitive. This may reflect the effectiveness of the PD approach used in the redesign, which aimed to simplify navigation and make the app easier to understand.

Additionally, items HQ-I7 (Unpresentable – Presentable) and HQ-S2 (Unimaginative – Creative) also scored higher in the prototype, further reinforcing participants' positive impression of the visual and creative aspects of the redesign. These scores suggest that even with technical constraints, the visual appeal and perceived creativity of the prototype had a meaningful impact on users' hedonic evaluation.

Overall, the results from the AttrakDiff2 support the conclusion that the app version was perceived as pragmatic and functional, particularly in terms of structure and manageability. However, it received lower scores in aspects related to simplicity and clarity. Its identity attributes were only moderately appreciated, especially in terms of style and emotional connection.

The prototype, on the other hand, revealed more varied perceptions across items, showing a lack of internal consistency in the PQ dimension, but stronger overall impressions in the hedonic dimensions. It was perceived as more visually engaging and better at expressing a coherent identity. Furthermore, stimulation scores were generally higher in the prototype, suggesting that it was more successful in evoking interest, excitement, or novelty during the interaction. Despite technical limitations affecting its pragmatic evaluation, the prototype managed to generate a higher emotional and aesthetic response from participants compared to the app, pointing to its potential to promote an even more positive perception of experience when usability issues, such as lack of wi-fi connection, are tackled.

One thing the researcher considered relevant to analyze was whether the order in which the versions were tested had exerted any kind of influence over the students' evaluations. In order to assess this, each of the students' mean scores regarding the app and the prototype were calculated (see Appendix 15). A grouped bar chart, represented in Figure 86, was used to compare participants' overall mean scores across versions. Each pair of bars represents the app and the prototype as tested by a single participant. The pink bars indicate the version tested first, and the turquoise bars represent the second version tested, allowing for a clear visualization of potential order effects.

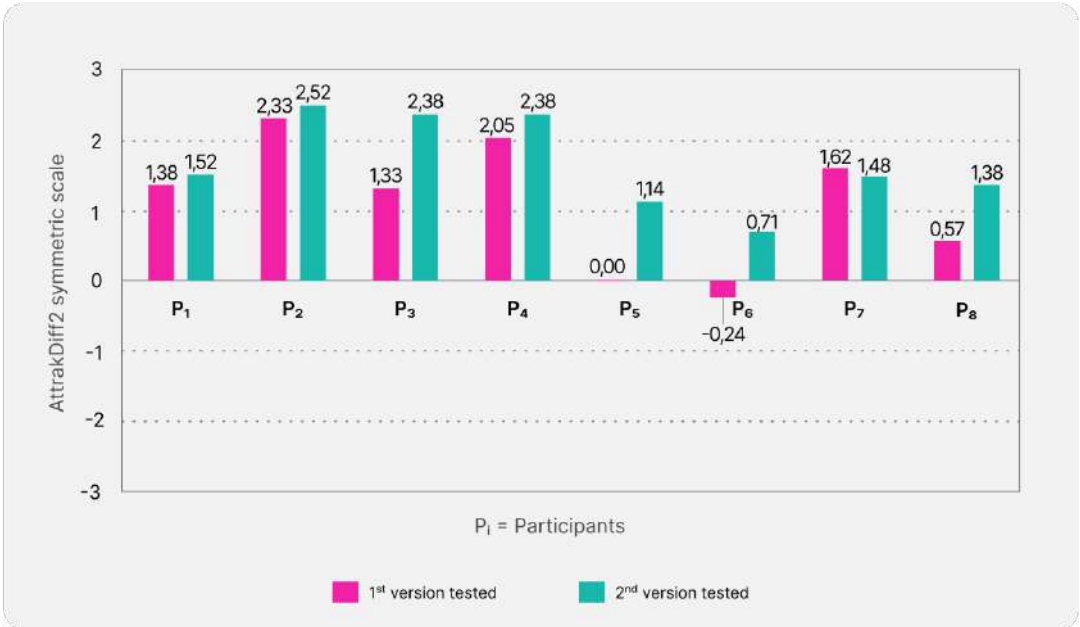


Figure 86 - Comparison of total AttrakDiff2 scores per participant by version tested.

A notable pattern emerged when comparing the total mean scores for each participant across both versions. As Figure 86 demonstrates, seven out of eight participants gave a higher overall score to the second version they tested, regardless of whether it was the app or the prototype. This may suggest the presence of a learning or familiarization effect, where the second evaluation benefited from increased familiarity with the test, criteria, or evaluation process. Rather than reflecting a preference for one version over the other, this pattern highlights the potential influence of test order in UX comparative studies, a phenomenon also known as a *carryover effect*.

P7 was the only participant who did not follow this trend. In this case, the participant rated the version tested first, the app, more favorably (M = 1.62) than the prototype (M = 1.48). A closer look at the scores P7 attributed to each item (see Appendix 14) shows that the participant assigned slightly lower values to the prototype in several items, such as PQ7, HQ-I2, HQ-I4, HQ-I5. However, on item HQ-S7 (Discouraging - Motivating), P7 gave the prototype a score of 2 and a negative score of -1 to the app: this is the only item where P7 attributed a 3-point difference between versions. Although the difference in overall means is not drastic, this exception reinforces the importance of accounting for individual variation and highlights the limitations of relying solely on quantitative measures to understand user perception.

In light of these findings, particularly the potential influence of test order and the subtle individual nuances revealed in cases like P7, the qualitative data collected during the comparative tests becomes especially valuable. Besides the AttrakDiff2 scale, participants were asked to answer a set of after each UX test, providing space for them to express their thoughts, preferences, and experiences in their own words. These responses were transcribed by the researcher (see Appendix 16) and an inductive qualitative analysis was conducted using NVivo 15, a qualitative data analysis software.

The inductive approach required the researcher to carefully read all responses and identify meaning units in the text, which were then grouped into subcategories (D. R. Thomas, 2006). The upper-level categories correspond to the questions included in the questionnaires (D. R. Thomas, 2006). This process allowed the researcher to define four core themes, those being “Favorite features”, “Suggested changes”, “Learning in a fun way” and “Direct comparison of versions”, to which the categories and subcategories are linked.

Table 7 presents the results of the inductive qualitative analysis conducted using NVivo 15. It is organized around four core themes derived from open-ended questions answered by students during comparative UX testing: (1) what students liked most in the prototype, (2) what they would change in the prototype, (3) reasons why the prototype helps learning in a fun way, and (4) what students liked most in the app. Each theme includes categories and subcategories that reflect the content of students’ responses, as well as the number of coding references per subcategory. To illustrate each subcategory, a representative excerpt from the students' answers is also provided. All content has been translated into English to ensure readability and comprehension from non-Portuguese readers.

Table 7 - Overview of core themes, categories, subcategories, and example responses from students' open-ended answers.

Theme	Category	Subcategory	Comment Frequency	Pertinent Representative Comment
Favorite features about each version	What students liked most in the prototype	Visual Design (colors, look, structure)	6	"It's beautiful and organized"
		Avatars	2	"I liked the avatars and being able to choose the one I wanted."
		Usability	2	"Easiness of use that helps people."
	What students liked most in the app	Visual Design (look, structure)	5	"The colors were vibrant"
		Flamingo	1	"The flamingo would comment my answers"
		Learning	1	"I got to know more"
		Nothing	1	"I didn't like anything"
Suggested changes to each version	What students would change in the prototype	Nothing	5	"I wouldn't change a thing"
		Speed	3	"I would like the prototype to be faster"
		Visual Design (colors)	1	"I would like the prototype to have more vibrant colors"
	What students would change in the app	Visual Design (colors and look)	5	"I would make it more attractive"
		Nothing	2	"I wouldn't change anything"
		Gamification	1	"I would add a sort of points system"
		Sound Feedback	1	"I would like it to have more sound"
		Usability	1	"I would place an 'x' to be able to close videos"
Learning in a fun way in both versions	Reasons the prototype helps learn in a fun way	Fun and Motivation	5	"It makes you want to play again"
		Collaboration	1	"We get to play with friends"
		Games	1	"I like playing games"
		Learning something new	1	"There were things I didn't know and got to learn"
		Relaxation	1	"It is relaxing"
	Reasons the app helps learn in a fun way	Fun	3	"It's a game you don't get tired of"
		None	2	"I don't find the app captivating or appealing"
		Question's Structure	1	"The questions have a nice structure"
Direct comparison of versions	What students preferred in the prototype, compared to the app	Visual Design (look and structure)	4	"The prototype is prettier"
		Avatars	3	"I could change the profile picture in the prototype"
		AR	2	"The beauty of the AR. It was more eye-catching than the app"

		Sound feedback	2	"I liked the sounds"
		Usability	2	"The prototype is very intuitive"
		Everything	1	"I preferred everything in the prototype"
	What students preferred in the app, compared to the prototype	Speed	3	"The app responded better and wouldn't stop working"
		Nothing	2	"Nothing was better in the app"
		Not sure	1	"I don't know"
		Visual Design (colors)	1	"The app had a bigger variety of colors"
	The version that would allow to learn in a more fun way	Prototype	6	"The prototype. It's easier to use and makes you want to keep playing"
		App	1	"The app, because it is less slow"
		Both	1	"I would have fun playing in both versions"

Table 7 illustrates the importance of not relying solely on quantitative measures but rather adopting a mixed-method approach, as recommended by the DBR framework (Anderson & Shattuck, 2012). Thanks to the inclusion of qualitative data, a much more detailed and nuanced understanding of the participants' perception of experience is allowed. For instance, although the prototype achieved only a slightly higher overall mean score than the app on the AttrakDiff2 scale (M=1.35 vs. M=1.47), the qualitative analysis revealed that six out of the eight students believed the prototype would help them to learn in a more enjoyable way. One of the remaining two students expressed interest in using both versions to learn in a fun way. The only participant who explicitly preferred the app (P3) justified their preference based on the performance issues observed in the prototype, stating that the app was "less slow". This indicates that P3's perception of experience is directly influenced by the product's functioning and performance, unlike the rest of the participants, who favored the prototype despite its performance issues.

Interestingly, when asked about potential improvements in the app, one participant (P5) suggested adding "a sort of points system", even though the app already has one. This was most likely due to a similar issue encountered by UX/UI designer D2 during Stage 2 of the study. D2 reported playing the entirety of the game without realizing any kind of point system, due to the app's lack of feedback. She only became aware of the scoring mechanism upon reaching the final results screen, where the accumulated points are displayed. It is likely that P5 also overlooked this feature, suggesting a failure of the app in communicating system status. This aligns with Nielsen's heuristic "visibility of system status", which emphasizes the importance of keeping users informed about what is going on through appropriate and timely feedback (Nielsen, 1994b). Nielsen's *10 Usability Heuristics for User Interface Design* have been explained in greater detail previously, on page 7.

Figure 87 presents a Treemap generated in NVivo 15 that allows for a visual comparison of the frequency of coded references across all categories and subcategories from the open-ended questionnaire responses. Each color-coded block represents a core category (e.g., "What students liked most in the prototype", "What students would change in the app"), while the size of each inner block reflects the number of references assigned to its respective subcategory. The larger the area, the more frequently that subcategory was mentioned by participants.

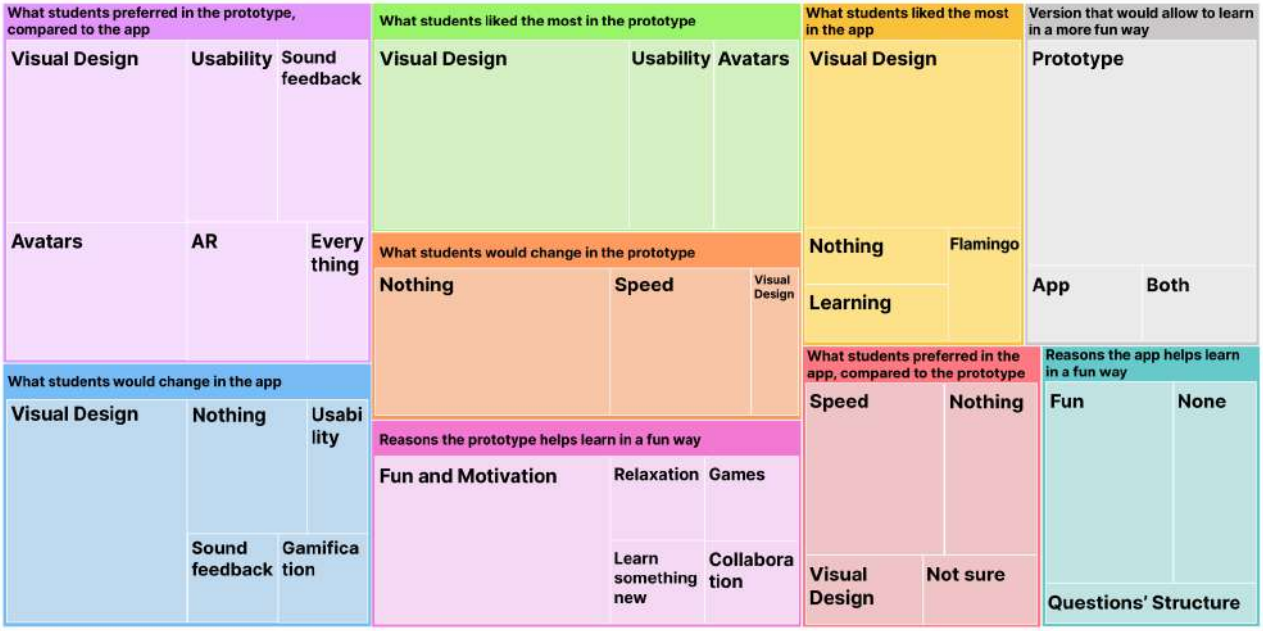


Figure 87 - Treemap generated with NVivo 15.

From looking and interpreting Figure 87, a few insights emerge that are worth noting. As a first insight, in "What students liked most in the prototype" (in green), there is a clear predominance of responses related to Visual Design, followed by mentions of Usability and Avatars. These subcategories reflect the aspects that stood out the most to participants when interacting with the prototype.

Regarding "What students would change in the prototype" (in orange) reveals Speed as the most cited issue, although a larger portion of students stated they would change “Nothing”, which might indicate that: participants either did not perceive clear flaws; they chose not to suggest improvements regarding the prototype; there was a level of disengagement; or difficulty articulating thoughts and opinions, especially considering only one out of the five responses reading “nothing” had additional feedback.

Within "What students preferred in the prototype, compared to the app" (in purple), Visual Design clearly dominates the category, followed by Avatars, Usability, Sound Feedback and AR. One participant (P3) also stated they preferred “Everything” about the prototype. In contrast to the previously discussed category, this time participants were able to express their preferences more clearly, providing concrete examples. The fact that P3 was the only student to claim they preferred “everything” about the prototype when compared to the app and yet still chose the app when asked which version would better support learning in a fun way, provides strong evidence that, for this student, system performance is a decisive factor in their perception of a positive experience. The AttrakDiff2 scores attributed by P3 further reinforce this interpretation, while the prototype received an overall mean score of 1.33, the app scored significantly higher at 2.38, with the student assigning the maximum score (3) to 12 out of the 21 items (see Appendix 14).

Regarding the app, this version received less enthusiastic feedback. In “What students liked the most in the app” (in yellow), Visual Design is again the most liked feature (similarly to the prototype) and other subcategories emerge, like Flamingo and Learning. One participant (P6) claimed to like “nothing” in the app version.

Under "What students would change in the app" (in blue, on the left), Visual Design again dominates, alongside Usability, Sound Feedback, and even Gamification, indicating multiple areas for improvement. However, two participants (P3 and P4) claimed to want to change “nothing” in the app. P3’s expressed opinion in this category is in line with what has already been analyzed regarding this participant’s perception of experience.

Within “What students preferred in the app, compared to the prototype” (in red), there is a clear domination of responses related to the Speed of the version, which is in line with the connection issues faced by the prototype. There was one response related to the app’s bigger mixture of colors (Visual Design) and other claiming not to be sure about what was better in the app. Interestingly, two participants (P4 and P6) claimed that “nothing” was better in the app:

- In regard to P4, even though this participant claimed not to want to change anything in the app, when asked about what was better in the app than the prototype, the answer was “nothing”, showing that even though this participant wouldn’t change a thing about the app, they still favored the prototype. However, P4’s overall mean score on the AttrakDiff2 scale was higher in the app than the prototype (2.05 vs. 2.38).

- P6 was the participant that claimed not to like “anything” in the app, which is coherent with what they answered in this category related to preference. In line with this, P6’s overall mean score attributed to the app using the AttrakDiff2 scale was -0.24, confirming a negative perception of experience towards the app.

When it comes to reasons why the prototype helps learn in a fun way (in pink), the most frequent theme is Fun and Motivation, related to the participants enjoying the use of technology to learn, similarly to what was mentioned by other students during the focus group. Other subcategories such as Relaxation, Games, Learning something new, and Collaboration (with one participant claiming to appreciate having the chance to play with their colleagues) were also mentioned.

For the app’s reasons (in turquoise, on the right), the keyword Fun appears once again, but so does None, suggesting limited engagement, with one participant (P5) claiming that if they don’t find the app “captivating or appealing”, then it won’t be able to provide a fun learning experience. This means that P5’s perception of experience is highly anchored on the product’s visual appeal. This participant’s AttrakDiff2 results are in line with their previous comment, considering P5 attributed an overall mean score of 0 to the app version.

Regarding which version would allow for more fun learning (grey), the prototype clearly dominates over the app, with only one student preferring the app and another undecided, as previously explained.

These results raise the question: what aspects of the prototype made it feel more enjoyable or engaging than the app? By taking a closer look at Table 7 and Figure 87, it is clear that the prototype stood out mainly for its interface improvements and visual elements. Terms like “colors”, “organized” and “intuitive” were frequent, indicating that the redesign was perceived as more eye-appealing, structured and user-friendly. Two participants mentioned the AR feature directly, and it was in a clear positive light. One participant (P5) explicitly praised “the beauty of the AR”, highlighting the aesthetic appeal of the AR elements and stating that it made the prototype “more appealing than the app”.

Although AR was not frequently referenced, this grand remark suggests that when noticed, it contributed to the perceived innovation and visual attractiveness of the prototype.

In addition, the avatar system emerged as a consistently positive element. Five references were made in relation to them. The students claimed that they “really liked the avatars” and the ability to “choose others”, showing appreciation for customization. These features align well with hedonic and identity-driven aspects of user experience, reinforcing the idea that customization can enhance the connection users feel with interfaces, as well as their perception of experience. These results only demonstrate the effect that following a PD approach can have in significantly improving a product and providing users with features they actually appreciate: the avatars feature is one that only the prototype contains and that emerged thanks from talking to students, teachers and designers, listening to their needs and preferences, placing them as co-designers in the process.

Participants also frequently mentioned “easiness of use” and “interactivity”, which suggests that despite the technical limitations faced by the prototype, it still was able to convey an improved interaction experience. The prominence of “I really liked it” and other positive answers towards the prototype indicate a favorable emotional reaction, even with some usability issues during testing.

However, despite the positive feedback regarding the prototype’s experience, several participants also explicitly mentioned its “slow performance” as a major drawback. Words such as “slow” and several comments referring to waiting times or delays in response suggest that this issue had a noticeable impact on the overall experience. Unlike the app, which supports offline gameplay after downloading the content, the prototype requires a constant internet connection. This dependency, combined with unstable wi-fi conditions in the school playground where the tests took place, significantly affected usability and, the overall test results, as the qualitative analysis demonstrated. These technical shortcomings undermined some of the perceived benefits of the new design, highlighting the importance of system reliability and responsiveness in outdoor educational tools.

Interestingly, despite all the difficulties the prototype faced, one participant (P8) described the prototype as being “relaxing”. In contrast to P3’s perception of experience, system performance doesn’t seem to affect P8’s. Even though P8 commented on the prototype’s slow behavior (“the app responded better and wouldn’t stop working”), when asked which version was better to learn in a fun way, P8 chose the prototype, thanks to it “being much prettier and better organized”. This means P8 especially values VD elements when it comes to their experience perception.

Another interesting insight is the fact that one participant, as previously described, mentioned the lack of a point system in the app. However, none of the eight participants referred to the XP system implemented in the prototype, which is visible on the prototype’s home screen, user profile and throughout the entire quiz environment. This might suggest that this gamification feature did not stand out to users or failed to be perceived as meaningful or integrated part of the gameplay experience. It could indicate an insufficient feedback mechanism that highlights user progress and rewards. This may reflect a weakness in "visibility of system status" heuristic, as users were not made sufficiently aware of the implications their actions had in the system. Therefore, even though the feature was present, its perceived absence might point to an experience gap that may require greater emphasis, better placement, or a more dynamic reinforcement, achievable with animations, pop-ups, or even sound feedback to enhance its change of status during interaction.

In sum, while the app was praised for its content and speed, the prototype was seen as more visually engaging and intuitive. These distinctions reflect how participants weighed different aspects of the user experience that significantly shaped their perceptions.

The analysis conducted on the data collected during Stage 4 of the study, Comparative Evaluation, allows for a deep understanding of elements that significantly shaped each participant's perceptions of experience. These perceptions, regarding both the app and prototype versions, along with all the findings, insights and knowledge the researcher came to gather for the duration of this study are presented in the next chapter, along with conclusions, some considerations and recommendations for future work.

6. Insights and Key Contributions

This chapter reflects on the present study's contributions and its practical outcome - a hi-fi redesigned prototype – developed through an iterative and participatory process involving students, teachers, and UX/UI experts.

Rather than a polished final product, this prototype should be considered a research-grounded design experiment: a concrete articulation of insights gathered throughout the study, which tests a new proposal for the EduCITY app. This proposal, grounded in empirical evidence and collaborative input, supports a reconfiguration of the original app and informs the development of a potential second version, that is, EduCITY 2.0.

EduCITY 2.0 is not just an updated version of the app. Rather, it is a product of co-creation, where the voices of students, teachers, and UX/UI experts are not only heard, but actively shape the outcome. It represents a conceptual shift from a highly function-driven product to a user-centered and experience-oriented tool, built around the actual needs, expectations, preferences, and motivations of its audience. As such, the prototype marks a turning point in the EduCITY project – one that acts as a bridge between the model underlying the EduCITY project and a revised vision that values quality of experience brought through design as much as educational content.

There are a few considerations from this journey that are worth making and reflecting on. For example, despite being hi-fi, the prototype was not fully functional. Due to time constraints and the predefined flow students were asked to follow, not all designed elements were clickable or functional, such as filters, "see all" links or multimedia resources (audio and video) during the quiz. These limitations in interaction, although common in prototyping, combined with external constraints during testing (like the lack of wi-fi connection), severely restricted the prototype's performance. Such conditions may have significantly influenced its evaluation, particularly considering that middle school students are likely unfamiliar with this sort of interaction, where products are only partially functional.

However, even with these shortcomings, the prototype was frequently rated more positively than the fully functional version of the app, with a working database and no dependency on an internet connection, except for downloading games. This finding alone demonstrates the power of PD: when users and their needs are placed at the center of the design process, even a prototype with limitations can offer a more meaningful and satisfying experience than a complete product developed without engaging users in its design, testing, and iterative improvement stages. As described by students, the prototype, co-designed with input from UX/UI experts, teachers, and most importantly, students, felt more "intuitive", "engaging", and aligned with their expectations.

As such, this outcome not only confirms the prototype's value as a proof of concept but also offers a grounded response to the research question that guided this study: **"How can a participatory design process influence middle school students' perception of the user experience when using the EduCITY app?".** The findings suggest that involving students, alongside teachers and UX/UI experts, throughout different stages of the design process contributed to a product that better reflected students' expectations, preferences, and motivations. This was evident in how the prototype, despite its limited functionality, was still often considered to provide a more positive perception of experience than the fully functional app. Students described the redesigned version as

more intuitive, engaging, and visually appealing - qualities directly linked to the participatory contributions gathered during the study.

In this sense, the PD process influenced students' perception of UX by enabling the design of a version that resonated more strongly with their needs and preferences, even when technical performance was constrained. This highlights the potential of participatory methods not only to improve usability but also to enhance emotional engagement and perceived value in educational technologies.

Ultimately, in educational apps like EduCITY, it is not just about what the product does; it is especially about how it makes users feel. These insights are fundamental for guiding future development. Ensuring that players feel satisfied, curious, challenged, and supported by the interface and game structure will be key to making students want to keep playing and learning through EduCITY 2.0.

6.1. Revisiting the Method

Beyond the empirical results and symbolic milestones discussed previously, it is also important to reflect on the methodological rigor of this study. Drawing on the key characteristics of a quality DBR study outlined by Anderson & Shattuck (2012) and detailed in the subchapter "Design-Based Research", this study can be considered to meet those standards. In the following paragraphs, each criterion is examined in the light of this study's particular context, demonstrating that a high quality DBR approach was appropriately applied.

Firstly, "being situated in real educational contexts". This study was conducted in a real-world school setting, involving middle school students and teachers interacting with the EduCITY app. The testing, and evaluation phases took place in authentic educational environments, ensuring contextual relevance and external validity of the findings.

Secondly, this study meets the criterion of "focusing on the design and testing of a significant intervention". In this case, the intervention - a redesigned prototype of the EduCITY app - was informed by an in-depth review of relevant literature and shaped by direct user and expert feedback during interaction with the current version of the app. The primary objective of the redesign was to enhance students' perception of user experience in outdoor educational activities. The design process was carefully documented and deliberately tailored to real user needs, with particular attention paid to the constraints and challenges faced throughout. This level of documentation supports the evaluation of the intervention's feasibility and transferability to similar educational contexts, which is a key aspect of quality in DBR studies, as emphasized by Anderson & Shattuck (2012).

Thirdly, adopt "mixed research methods". Quantitative data (from the AttrakDiff2 scale) was combined with qualitative insights (from interviews, focus groups, and open-ended responses gathered during the comparative UX tests). This combination allowed for a more comprehensive understanding of users' perceptions of their experience and the effects of the intervention. By drawing on both qualitative and quantitative data, the study achieved more nuanced and layered findings, which not only complemented each other but also supported the development of well-grounded conclusions. This methodological complementarity is essential in DBR, as it allows researchers to

explore complex realities using the methods that best fit their specific aims (Anderson & Shattuck, 2012; Cumming, 2015).

Fourthly, a DBR quality study is supposed to “involve multiple iterations”. In this study, iteration was understood not as a fixed cycle with repeated interactions in a closed loop, but as a process of progressive refinement grounded in feedback from diverse sources and applied at successive stages. Initial conceptual redesigns were informed by literature and expert interviews. These evolved into a refined prototype shaped by student and expert feedback; and this prototype was later tested and validated through comparative testing with a new student sample. Although each participant group was consulted only once, their contributions informed different design stages, reflecting an iterative process that unfolded through varied data sources and incremental improvements.

This study was also based on “collaborative partnerships”. Following a PD approach, UX/UI experts contributed to the evaluation and improvement of the app’s interface and usability, teachers helped contextualize educational content and students participated in both co-design discussions and prototype testing. This participatory model reflects DBR’s collaborative ethos and strengthened the relevance of the intervention.

In addition, the study led to the emergence of “design principles”. As part of the research process, design guidelines not only guided but also emerged from the analysis of literature, empirical data and user feedback. These context-aware design principles, such as clarity in interface feedback, visibility of progress, system status and intuitive navigation in outdoor contexts, contributed to the refinement of EduCITY and are meant to contribute to the wider field of mobile learning app design.

This study is different from action research in the sense that it was not conducted by a teacher, but a researcher focusing on the design of an improved experience. Simultaneously, this study pursued the dual focus typical of DBR, solving practical design issues and contributing to theoretical insights about UX in mobile learning apps.

Last but not least, this study demonstrated “practical impact on practice”. The redesigned prototype (EduCITY 2.0) represents a concrete outcome of the research process, offering actionable improvements to its user interface and user experience. The study's outcomes are expected to inform future iterations of the app and contribute to more engaging and pedagogically effective mobile learning tools.

By fulfilling these criteria, this study marks a new chapter for EduCITY - EduCITY 2.0 - and it stands as a concrete example of how DBR and PD approaches can be used to meaningfully improve both design outcomes and overall user experience in educational technology.

6.2. Revisiting EduCITY

After revisiting the study's method, this section reflects the EduCITY project itself and what EduCITY 2.0 truly represents.

To do so, it is necessary to critically examine the holistic model of EduPARK - the project that originated EduCITY - and its set of Supporting Pillars (shown in Figure 88), which constitute "guidelines for future strategy development" (Pombo & Marques, 2019a, p. 26).

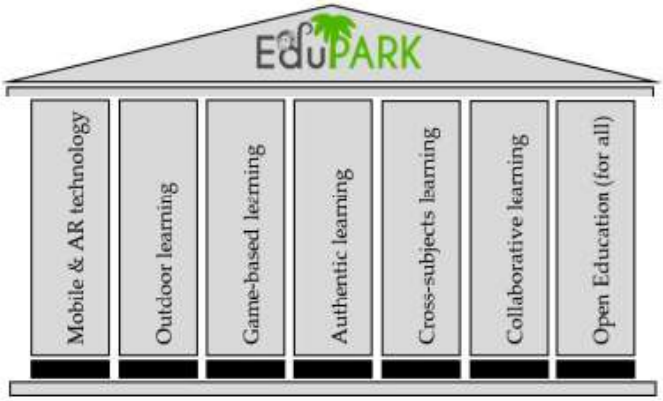


Figure 88 - Seven pillars of the EduPARK project (Pombo & Marques, 2019a, p. 27).

These pillars are likewise foundational to EduCITY, as it builds upon the same guiding principles. This reflection draws on empirical insights collected throughout the present study, including literature review, interviews with UX/UI experts and teachers, focus groups with students, and comparative user testing, to evaluate the relevance of each pillar in the current context, propose potential adaptations, and suggest new conceptual directions for the future development of not just EduCITY, but also other projects that share similar characteristics.

EduPARK's seven Supporting Pillars are presented and discussed in the light of this study's context and findings below:

Pillar 1: Mobile & AR technology. All participant groups (students, teachers, and designers) acknowledged the educational potential of both the current app and the redesigned prototype. Students challenged traditional education formats and suggested a more hybrid approach in which subject content is followed by technology-supported exploration. Teachers supported this vision, emphasizing the potential of mobile and AR technologies to support meaningful, situated learning. Despite limitations in the prototype's AR features, students expressed enthusiasm for interactive elements and desired even more immersive experiences in the app. The addition of new features in the prototype, such as visual and sound feedback and reward systems, further demonstrates the expanding potential of mobile technologies in educational settings.

Pillar 2: Outdoor learning. Students strongly associated outdoor learning with enjoyment and novelty. According to the teachers interviewed and what the students in the focus group conveyed, the opportunity to leave the classroom and engage with content outdoors increases motivation and engagement. Unlike EduPARK, which was limited to a specific space, EduCITY was designed for urban environments and can be used in any city of the world. This flexibility supports formal (e.g., classroom), informal (e.g., leisure-time learning) and non-formal (e.g., museum or school field trip)

educational contexts, as suggested by teachers. This flexibility suggests a shift from a strict emphasis on outdoor settings to a broader framework of contextual learning enabled by EduCITY.

Pillar 3: Game-based learning. GBL plays a particularly significant role in this study. Students repeatedly expressed a desire for features that allow for a stronger gamification of the app, which led to the integration of features like XP points and avatar unlocking (with XP acting as a currency) in the prototype. Nevertheless, there is still significant potential for further development of gamification in EduCITY. Students suggested and were receptive to additional features such as badges, different types of games (beyond quizzes), and even a lives system. Moreover, progression mechanisms, where users advance through levels or earn rewards over time, should also be explored and tested to determine their impact on students' perception of experience. These suggestions are in line with research indicating that game mechanics can significantly enhance engagement and learning when thoughtfully implemented (Kapp, 2012).

Pillar 4: Authentic learning. Teachers emphasized that experiencing learning content *in loco* and in real learning contexts, particularly when enhanced with interactivity and features such as AR, is far more impactful than passively reading the same content in a textbook. The possibility of directly observing phenomena and immediately interacting with contextualized information seems to foster a deeper and more memorable learning process (Pombo & Marques, 2019a).

Pillar 5: Cross-subjects learning. The potential to create cross-disciplinary connections was considered an added value by teachers, enabling the connection of different concepts across disciplines. At the same time, the app's flexible structure supports both interdisciplinary and single-subject learning, depending on the pedagogical goals. This adaptability makes the app suitable for a wide range of curricula and learning contexts.

Pillar 6: Collaborative learning. This pillar recommends using the app in group settings, with intra-group collaboration and inter-group competition to foster engagement. However, this study revealed that most students preferred to play individually, at the same time as others, competing against each other. In contrast, teachers favored group dynamics, although one of them acknowledged that collaboration could naturally emerge even in the individual gameplay students claimed to prefer. To accommodate different preferences, the app should (and indeed does) support both individual and group modes, even though no specific strategies have yet been defined for each mode, thus promoting player autonomy and contextual adaptability.

Pillar 7: Open Education (for all). In this study, the prototype was co-designed specifically for and with middle school students (3rd cycle) in mind. However, the app's structure and content allow for broader applicability: from primary school students to senior users. While this inclusiveness is admirable, it raises important considerations regarding accessibility and usability. Designing for a broad audience requires ensuring that interface elements and content are adaptable to diverse needs, abilities, and levels of digital literacy.

More than a technological update, EduCITY 2.0 emerges from pedagogical and experiential rethinking. It reflects a model that places user experience, particularly students' needs and expectations, at the center of educational technology design. The insights gathered from participants throughout this study highlight the need to move beyond functionality and content delivery and towards engagement, playfulness, adaptability, and emotional connection. EduCITY 2.0 embodies

this transition and sets the tone for a new generation of learning tools that are not only educational but enjoyable and intuitive.

Considering these findings and the evolving nature of EduCITY 2.0, an additional Supporting Pillar is proposed. This pillar aims to aggregate the emergent themes identified in the study and further articulates the conceptual and practical identity of the new EduCITY 2.0, while also serving as guidelines for the design of similar educational technologies.

Pillar 8: User-Centered. The PD and UCD approaches adopted in this study demonstrate that integrating user feedback, in this case from students, teachers, and UX/UI experts, is essential to ensuring that the app meets user expectations, improves usability, and fosters a more positive perception of the user experience. The concept of being *User-Centered*, as opposed to *User-Centered Design*, allows this pillar to transcend design and inform the overall logic of the project. It encompasses planning, development, and adaptation of the app to diverse usage contexts, making it reflective of the needs of different user profiles and learning settings.

Although the original EduPARK pillars provide a strong foundation, the empirical findings from this study indicate a need for a more flexible and user-driven model. Revisiting these pillars considering contemporary mobile learning practices is essential not only for the future development of EduCITY, but also for similar educational projects or products aiming to meet the real needs and expectations of their users. The revised set of pillars, emerging from this study, is presented in Figure 89.

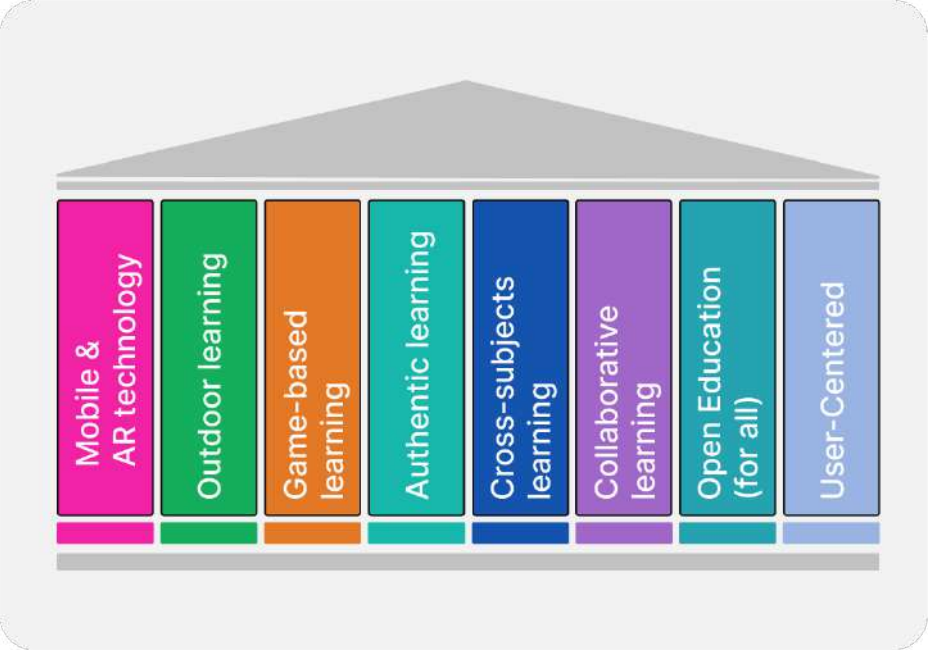


Figure 89 - Proposal for the Supporting Pillars of EduCITY 2.0.

To summarize, the study contributes with:

- A revised prototype for the EduCITY app based on participatory input (EduCITY 2.0);
- Evidence that a PD approach improves perceived UX, even with non-fully functional prototypes, but using scenarios with a rigorous representation of UX and UI characteristics;
- Insights into how student preferences and expectations can reshape educational technology;
- A practical demonstration of how DBR and user-centered methodologies can and should coexist, reinforcing each other in educational innovation.
- A critical reassessment of EduPARK's Supporting Pillars, resulting in one new pillar, User-Centered, that reflects the evolving priorities of educational technology design.

CONCLUSIONS

This study explored whether following a PD approach could improve students' perception of user experience when interacting with the EduCITY app, particularly in outdoor educational contexts. By involving end-users and experts throughout the design process, a hi-fi prototype was designed and tested with students, against the current app version. Despite the limitations encountered, the findings reveal that even a non-fully functional prototype, co-designed with its target users, can offer a more satisfying and engaging experience than a completely developed and functional product designed without their input.

Through the mixed-methods evaluation, students showed a clear preference for the prototype in terms of visual appeal, organization, and interface intuitiveness. This highlights the value of placing users at the center of the design process and listening to their expectations, preferences, and frustrations.

Limitations

As with any research, this study also presents limitations. The difficulties faced throughout the duration of the study are outlined below, as they help contextualize the findings and demonstrate opportunities for future improvement.

During Stage 1 (Literature Review), the researcher found it especially difficult to filter and select the most relevant contributions because of the extensive theoretical information there is of multiple themes related to UX/UI design. Another difficulty is related to the fact that foundational figures in interaction design, such as Norman and Nielsen, are underrepresented in scientific databases, often leading to reliance on blog-style content from sources like NN/g and IxDF. While these sources are widely referenced and respected within the UX community, their informal nature may compromise the development of a literature review supported by more traditional, peer-reviewed academic evidence.

Another limitation of the study is the fact that students from the focus group, just like the UX/UI experts, didn't test the app in real contexts of use conditions. The fact that both these groups got familiar with the EduCITY app indoors may have limited the extent and contextual relevance of their feedback. In addition, the study might have highly benefited if feedback from EduCITY project members had been gathered in a more formal manner, probably via focus group or interviews. This feedback was collected in an informal way throughout Stages 1 and 2 of the study, during conversations or team meetings.

Due to time constraints, only one high-fidelity version of the prototype was developed and tested. While this study followed an iterative logic through successive refinement phases involving literature review, expert feedback, student focus groups and comparative testing, the opportunity to conduct additional full cycles of redesign and testing with new user samples was limited. More iterations would have allowed for deeper refinement and enhanced alignment with DBR's vision of ongoing, cyclical development.

Another limitation related to the comparative tests is the fact that there is only one Portuguese version of the AttrakDiff2 scale: the one translated by Carneiro (2018). There is the possibility that this

scale is not fully adapted to the vocabulary and cognitive style of middle school students, which may have also compromised their interpretation of the scale.

Perhaps the most significant was the requirement for an internet connection for the prototype to fully function, which may have significantly influenced students' perception of usability, especially when connection was unstable.

Last but not least, the sample size of the study was quite limited: the focus group included only five participants and the comparative UX tests involved eight. All students came from the same school and were in the same grade (8th grade), which significantly limits the broader applicability of the findings.

It would have been interesting to conduct the study with a larger and more diverse student group, especially in the comparative testing stage, in order to get a more comprehensive understanding of students' opinions and perceptions of experience when using both versions. Nevertheless, although the population sample was relatively small, not allowing for findings to be generalized, the diversity of individual preferences still varied greatly: while some participants prioritized VD, others were much more sensitive to technical performance, which was a factor that strongly influenced their perception of user experience when engaging with the prototype.

Achievement of Objectives

In the initial stage of this study, four specific objectives were defined, resulting in the development of a construct capable of addressing the research question. Each of those objectives and the degree to which they were met is summarized below:

1. **To conduct comparative UX testing between a redesigned prototype and the current app version, evaluating the user experience, particularly in outdoor educational contexts.** Comparative UX testing was successfully conducted using both quantitative (AttrakDiff2) and qualitative methods. Students tested both versions in real and simulated outdoor scenarios.

2. **To improve the app's user experience and user interface design, based on the expectations of students and opinions of experts and teachers.** Improving the app's UX/UI based on user and expert feedback was accomplished through a carefully documented design process that informed the redesigned prototype.

3. **To develop a high-fidelity prototype as a proposal for the EduCITY app, that reflects insights from expert reviews and end-users' perceptions.** Developing a high-fidelity prototype was achieved, even though there was only one iteration. The prototype reflected feedback gathered during Stage 2 from students, teachers, and UX/UI experts.

4. **To apply participatory research based on design methodologies related to the UX/UI improvement process, including focus groups with end-users, interviews with experts and teachers, and comparison of scenarios.** Applying participatory research methods was a central component of this study. Despite sample limitations, interviews with UX/UI

designers and teachers and focus groups with students provided valuable insights to design a prototype in which comparative tests were then conducted with other students.

Future Work

As Anderson and Shattuck (2012) note, DBR interventions are hardly ever "complete", but rather open to ongoing refinement. In this sense, several opportunities for future work arise.

For example, it would be relevant to conduct further iterations of the prototype, incorporating more user testing and expanding the student sample across different schools, regions and age groups. This broader testing of the prototype would also allow to understand whether key features of the prototype, such as the XP system, are overlooked due to UI issues, low engagement, unclear design or other reasons.

To accommodate different preferences and learning contexts, future iterations should also explore more defined strategies of individual and group play modes. Although the current version of EduCITY supports both modes, no specific interaction or reward strategies (such as badges for playing in group or individually) have yet been developed to address their unique dynamics, which could further enhance player autonomy.

It would also be interesting to broaden the prototype's functionality by including all the pages and features the app contains, such as the private game code, the privacy policy or even a second language (English). In addition, the previous suggested further iterations would allow for the creation and design of other features also suggested during Stage 2, such as the settings page and an onboarding for the first-time users and higher adaptability to different contexts.

Similarly, it is crucial to design for inclusion, ensuring that interface elements and content can be adapted to different levels of digital literacy, visual comfort, and user familiarity with mobile technology. This is particularly relevant when aiming to reach diverse school populations, including younger students or those with less frequent access to digital tools.

There is also a huge potential for this app to diversify its gamification elements. EduCITY 2.0 could have more complex systems like limited lives, badges, in-app customization (for example, avatars with unlockable accessories just like suggested by the students in the focus group) and alternative game mechanics that go beyond the quiz, such as puzzles or games of association.

There is also space for the refinement of existing features. For example, the "Get directions" button on the point of interest screen could open an in-app map feature using a maps API, that would easily and effortlessly guide the users to the desired location.

Given all this, future iterations of EduCITY 2.0 should not only improve existing elements but also embrace the creative and playful potential revealed through user feedback. The aim should remain clear: to evolve EduCITY into an ever-more intuitive, engaging, and meaningful learning platform that provides positive and meaningful experiences to their users.

Lastly, it is worth noting that future projects of a similar nature, such as the upcoming Edu4HEALTH, which builds directly on the foundations laid by EduCITY, can benefit from many of the guidelines, design directions, and user insights generated through this study. In that sense, the work done in this study can contribute to a broader ecosystem of mobile learning tools that blend location-based experiences with playful, user-centered design.

Personal Reflection

This section adopts a more personal stance and, therefore, I chose to write it in the first person. While academic writing often requires distance from the thinker, reflecting on a year-long process of research and transformation feels more real if I use my personal tone.

Engaging in this research project was both a challenge and a privilege. While I began with a clear academic purpose, which was to understand whether PD could improve students' perception of user experience of an educational app, the process soon revealed itself as much more than the pursuit of answers. It became a journey of learning, not only about users and design, but about myself: a designer by vocation, facing the unfamiliar role of a novice researcher.

Compared to the shorter reports I had produced throughout my academic training, this dissertation represented a major shift in intellectual depth, responsibility, and especially autonomy. I was no longer just documenting or presenting design decisions: I had to justify, test, reflect, and engage with knowledge critically and continuously through a long period of time. This process demanded a deeper engagement with theory, a much more rigorous approach to planning and evaluating design choices, and an ongoing commitment to intellectual honesty. It was not only a design exercise, but a sustained research effort, requiring me to adopt a mindset of inquiry and precision that went far beyond what I had previously experienced.

One of the most valuable aspects of this experience was the opportunity to listen - truly listen - to students, teachers, and design experts. Their perspectives shaped each step of the process, from critique to concept, from lo-fi ideas to a hi-fi prototype. At times, this meant letting go of my own assumptions or aesthetic preferences in favor of what made sense to them: a shift that embodies the very essence of PD.

I also came to appreciate the iterative nature of DBR, not just as a methodology, but as a mindset - one that I will carry forward. No design is ever the last, no prototype is ever truly complete, and there is nothing wrong with that. Actually, there is strength in that imperfection: there's always space to improve and evolve, especially with the help of users.

Throughout this journey, I relied on a variety of tools. One of the most impactful was Artificial Intelligence (AI). When I decided to embark on this journey of writing my entire dissertation in English as a non-native English speaker, I knew it was going to be a challenge. Even though I feel very comfortable with English, academic writing can be much more demanding. In this context, AI played the role of a translator and language enhancer, helping me to refine vocabulary, improve sentence flow, and ensure clarity, especially in more technical sections. However, AI became much more than that. It acted as the kind of partner with which I could articulate and test ideas. I would first formulate my own thoughts, write them down and only then use AI to explore alternative phrasings, always keeping a very critical mindset. This process sharpened my analytical and writing skills, allowing me

to express myself more clearly while remaining in full control of the message being conveyed. Rather than replacing my thinking, AI supported and strengthened it.

The constraints I found, such as limited time, small sample sizes, and technical barriers, became part of the process rather than obstacles to it. These limitations taught me to be flexible, prioritize, and above all, stay grounded in the needs and realities of the users, instead of my own. This flexibility and constant need for adaptability was particularly tested during a demanding 3-month period in which I was simultaneously working on this dissertation, doing the entire editorial design of the book *Lessons Learned - EduCITY* (Pombo et al., 2025), and fulfilling my other duties as a research fellow in the EduCITY project. Managing multiple responsibilities wasn't easy and it required tremendous discipline and planning, but it also gave me confidence in my ability to deliver quality work under pressure and maintain a sense of purpose and perseverance throughout.

To better assess and articulate the skills I worked on and developed during this study, I chose to refer to the Researcher Development Framework (RDF) (Vitae, 2010). RDF, demonstrated in Figure 90, is a framework created in the UK for researchers to evaluate themselves and identify areas in which they want to develop further and it is organized into four domains, those being: A) Knowledge and Intellectual abilities; B) Personal effectiveness; C) Research governance and organisation; and D) Engagement, influence and impact.

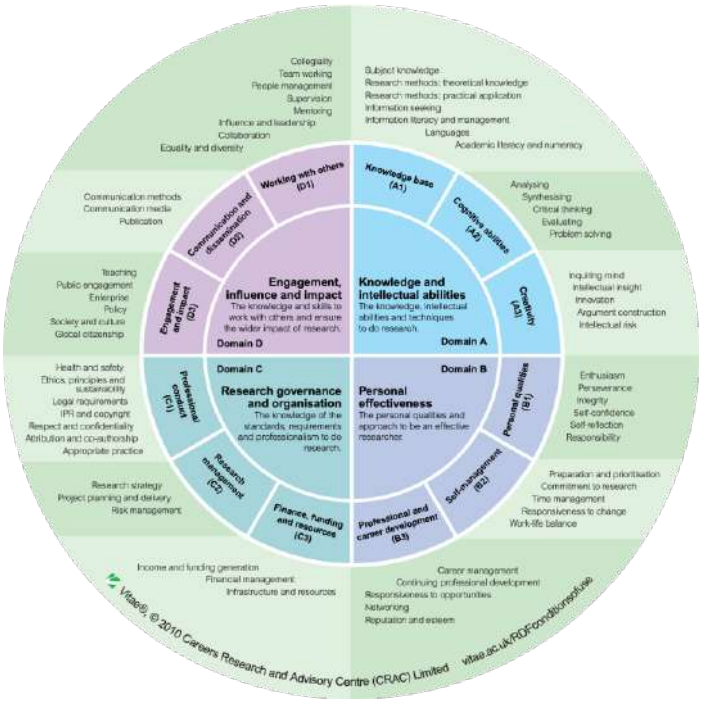


Figure 90 - Vitae's Researcher Development Framework.

In relation to domain A, I consider having significantly deepened my theoretical and methodological knowledge, especially in areas such as UX, PD, mixed methods of research and educational technology. Analyzing data from both qualitative and quantitative sources challenged me to think critically and to see patterns, synthesize diverse perspectives, and apply abstract concepts to concrete design decisions. The iterative nature of the study, combined with the need to triangulate feedback from students, teachers and experts, pushed me to improve not just my research techniques, but also my capacity for analytical reasoning and intellectual adaptability. These developments reflect a strong progression within the RDF's domain A.

Domain B was undoubtedly one of the most transformative. Balancing the demands of this dissertation with a full-time research scholarship and a simultaneous editorial project required a high level of self-management, prioritization and emotional resilience. I became more reflective and aware of my own working patterns, learning how to work under pressure while maintaining quality and motivation. I also strengthened my ability to receive and integrate feedback, both technical and conceptual, which played a crucial role in developing the final version of the prototype and the written dissertation. This journey helped me grow personally, fostering a stronger sense of confidence, perseverance, and responsibility.

Regarding domain C, to conduct this study required navigating several practical and ethical aspects of research. From preparing Informed Consent Authorization Forms, to ensuring data protection and respecting participants' confidentiality, I became much more aware of the responsibilities involved in conducting human-centered research. I also planned and organized complex research stages involving interviews, focus groups and A/B tests, each with its own logistics and dependencies, conducting the focus group and interviews by myself. Managing timelines, documentation, recruitment and testing simultaneously was a real challenge, but one that allowed me to improve my project management and organizational skills considerably.

Finally, domain D. At the heart of this dissertation was the intention to design with and for users. This meant engaging actively and empathetically with students, teachers and experts, listening to their input, and translating it into meaningful design decisions. I refined my communication skills in various settings, from writing emails and conducting interviews to facilitating focus groups and analyzing open-ended feedback. Working closely with the EduCITY team, I continued with my tasks of producing and designing content for EduCITY's social accounts. This domain came alive through the collaborative and applied nature of the study, reinforcing my belief that research becomes truly impactful when it really involves the people it seeks to serve.

This dissertation was, in many ways, a test of balance: between theory and practice, between structure and creativity, between academic rigor and user empathy, and between the designer and researcher that I now am. Looking back, I recognize that every interview conducted, every screen designed, and every piece of feedback received added something meaningful, even if small, to what I now call this new era of EduCITY, EduCITY 2.0.

While this may mark the end of both this study's and my own academic chapter, it reinforces my belief that involving users meaningfully in the design of - in this case, educational - technology is not just beneficial, but essential. I carry with me all that I've learned throughout this process, and I hope to apply these lessons in future projects where design serves real people and real needs. I sincerely hope that the insights gained in this study will serve as a starting point for further iterations, deeper collaboration, and better user experiences for learners everywhere.

It is important to acknowledge the people, opportunities, and contexts that played a key role in making this research journey possible and deeply meaningful.

This dissertation was developed within the scope of the EduCITY project, where I was selected for two consecutive research grants. These grants allowed me to be actively involved in the project and its activities. Being part of this special team, one that met weekly and supported each other not only as colleagues but also as friends, made the entire journey lighter, more joyful, and genuinely

collaborative. I am especially grateful for the encouragement, support, and trust shown by each member throughout every phase of the work.

I also want to express my heartfelt gratitude to my supervising team. Their guidance, feedback, and availability were fundamental throughout the process, especially during the last months, when we met very frequently. Their willingness to help, always with an exceptional balance between rigor and generosity, made a significant difference and pushed me to do my best work.

As I look back, I can clearly see how every stage of my academic path has shaped the (now) researcher and designer I've become. From the solid foundations built during my undergraduate studies in New Communication Technologies at the University of Aveiro, each step added something unique to the way I think and work. The many projects I developed along the way, particularly those that challenged me to reflect, test, and iterate, laid the groundwork for my growing interest in the UX/UI design field. The master's degree did not just refine that interest; it expanded it, pushing me to combine creativity with method, empathy with rigor, and design with research. This dissertation is, in many ways, the result of all those experiences converging into one meaningful project.

References

Ahlin, E. (2019). Semi-Structured Interviews With Expert Practitioners: Their Validity and Significant Contribution to Translational Research. SAGE Publications Ltd. https://doi.org/10.4135/9781526466037

Akintayo, O. T., Eden, C. A., Ayeni, O. O., & Onyebuchi, N. C. (2024). Evaluating the impact of educational technology on learning outcomes in the higher education sector: a systematic review. International Journal of Management & Entrepreneurship Research, 6(5), 1395–1422. https://doi.org/10.51594/ijmer.v6i5.1091

Akram, H., Abdelrady, A. H., Al-Adwan, A. S., & Ramzan, M. (2022). Teachers' Perceptions of Technology Integration in Teaching-Learning Practices: A Systematic Review. Frontiers in Psychology, 13. https://doi.org/10.3389/fpsyg.2022.920317

Alhebaishi, S., & Stone, R. (2024). Augmented Reality in Education: Revolutionizing Teaching and Learning Practices – State-of-the-Art. International Journal of Advanced Computer Science and Applications, 15(11). https://doi.org/10.14569/IJACSA.2024.0151103

An, F., Xi, L., & Yu, J. (2024). The relationship between technology acceptance and self-regulated learning: the mediation roles of intrinsic motivation and learning engagement. Education and Information Technologies, 29(3), 2605–2623. https://doi.org/10.1007/s10639-023-11959-3

Anderson, T., & Shattuck, J. (2012). Design-Based Research. Educational Researcher, 41(1), 16–25. https://doi.org/10.3102/0013189X11428813

Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S., & MacIntyre, B. (2001). Recent advances in augmented reality. IEEE Computer Graphics and Applications, 21(6), 34–47. https://doi.org/10.1109/38.963459

Babbie, E. (2010). The Practice of Social Research (E. Mitchell, N. Albert, & J. Chell, Eds.; Thirteenth).

Barab, S., & Squire, K. (2004). Design-Based Research: Putting a Stake in the Ground. Journal of the Learning Sciences, 13(1), 1–14. https://doi.org/10.1207/s15327809jls1301_1

Brown, A. L. (1992). Design Experiments: Theoretical and Methodological Challenges in Creating Complex Interventions in Classroom Settings. Journal of the Learning Sciences, 2(2), 141–178. https://doi.org/10.1207/s15327809jls0202_2

Burkett, I. (2012). An Introduction to Co-design. Sydney: Knode, 12.

Carneiro, L. T. (2018). O impacto do design da cadeira de rodas na experiência de utilização e na perceção do estigma. Universidade de Lisboa.

Cesário, V., & Nisi, V. (2023). Designing mobile museum experiences for teenagers. Museum Management and Curatorship, 38(3), 272–292. https://doi.org/10.1080/09647775.2022.2111329

Coombs, P. H., & Ahmed, M. (1974). Attacking Rural Poverty: How Nonformal Education Can Help.

Cooper, A., Reimann, R., Cronin, D., Noessel, C., Csizmadi, J., & Lemoine, D. (2014). About Face: The Essentials of Interaction Design (4th ed.). Wiley.

Creswell, J. W. (2007). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. SAGE.

Cumming, A. (2015). Design in four diagnostic language assessments. Language Testing, 32(3), 407–416. https://doi.org/10.1177/0265532214559115

Czerkawski, B., & Berti, M. (2021). Learning experience design for augmented reality. Research in Learning Technology, 29. https://doi.org/10.25304/rlt.v29.2429

de Villiers, M. R. (Ruth), & Harpur, P. A. (2013). Design-based research - the educational technology variant of design research. Proceedings of the South African Institute for Computer Scientists and Information Technologists Conference, 252–261. https://doi.org/10.1145/2513456.2513471

Denzin, N. K., & Lincoln, Y. S. (Eds.). (2011). The SAGE Handbook of Qualitative Research (4th ed.). SAGE.

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness. Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments, 9–15. https://doi.org/10.1145/2181037.2181040

Di Fuccio, R., Kic-Drgas, J., & Woźniak, J. (2024). Co-created augmented reality app and its impact on the effectiveness of learning a foreign language and on cultural knowledge. Smart Learning Environments, 11(1). https://doi.org/10.1186/s40561-024-00304-x

Dirin, A., & Laine, T. H. (2018). User Experience in Mobile Augmented Reality: Emotions, Challenges, Opportunities and Best Practices. Computers, 7(2), 33. https://doi.org/10.3390/computers7020033

Eraut, M. (2004). Informal learning in the workplace. Studies in Continuing Education, 26(2), 247–273. https://doi.org/10.1080/158037042000225245

Figma. (n.d.). Material 3 Design Kit. Retrieved May 11, 2025, from https://www.figma.com/community/file/1035203688168086460

Fountain, S. B., & Doyle, K. E. (2012). Learning by Chunking. In Encyclopedia of the Sciences of Learning (pp. 1814–1817). Springer US. https://doi.org/10.1007/978-1-4419-1428-6_1042

Garcia, M. B. (2020). Augmented reality in history education: An immersive storytelling of American colonisation period in the Philippines. International Journal of Learning Technology, 15(3), 234–254. https://doi.org/10.1504/IJLT.2020.112170

Garrett, J. J. (2010). The Elements of User Experience: User-Centered Design for the Web and Beyond (2nd ed.). New Riders Publishing.

Giacobone, G. A., Pollini, A., Urquiza, D., & Chouta, K. (2024). Participatory design methods for sustainable interaction design: co-designing digital experiences for sustainability education. Universal Access in the Information Society. https://doi.org/10.1007/s10209-024-01092-4

Google. (2021). Material Design. https://m3.material.io/

Gordon, E., Schirra, S., & Hollander, J. (2011). Immersive Planning: A Conceptual Model for Designing Public Participation with New Technologies. Environment and Planning B: Planning and Design, 38(3), 505–519. https://doi.org/10.1068/b37013

Gordon, K. (2020, March 1). 5 Principles of Visual Design in UX. Nielsen Norman Group. https://www.nngroup.com/articles/principles-visual-design/

Gordon, K. (2022, July 17). Using Grids in Interface Designs. Nielsen Norman Group. https://www.nngroup.com/articles/using-grids-in-interface-designs/

Grudin, J., & Pruitt, J. (2002). Personas, Participatory Design and Product Development: An Infrastructure for Engagement. In T. Binder, J. Gregory, & I. Wagner (Eds.), PDC 2002 Conference Proceedings (pp. 144–152). CPSR.

Hartson, R., & Pyla, P. S. (2012). The UX Book. Elsevier. https://doi.org/10.1016/C2010-0-66326-7

Hassenzahl, M. (2003). The Thing and I: Understanding the Relationship Between User and Product (pp. 31–42). https://doi.org/10.1007/1-4020-2967-5_4

Hassenzahl, M., Burmester, M., & Koller, F. (2003). AttrakDiff: Ein Fragebogen zur Messung wahrgenommener hedonischer und pragmatischer Qualität (pp. 187–196). https://doi.org/10.1007/978-3-322-80058-9_19

Hassenzahl, M., Wiklund-Engblom, A., Bengs, A., Hägglund, S., & Diefenbach, S. (2015). Experience-Oriented and Product-Oriented Evaluation: Psychological Need Fulfillment, Positive Affect, and Product Perception. International Journal of Human-Computer Interaction, 31(8), 530–544. https://doi.org/10.1080/10447318.2015.1064664

Howard, J., McDonald, B., Philips, T., Krzywinska, T., Speakman, J., Brown, D., Mitchell, A., & Parker, A. (2022). The Kerdroya Postmortem: Navigating the Labyrinth of Co-creative Design and Collective Vision. ACM International Conference Proceeding Series. https://doi.org/10.1145/3555858.3563277

Interaction Design Foundation - IxDF. (2016a, June 1). What is User Experience (UX) Design? Interaction Design Foundation - IxDF. https://www.interaction-design.org/literature/topics/ux-design

Interaction Design Foundation - IxDF. (2016b, June 2). What is User Interface (UI) Design? Interaction Design Foundation - IxDF. https://www.interaction-design.org/literature/topics/ui-design

Interaction Design Foundation - IxDF. (2016c, June 5). What is User Centered Design (UCD)? Interaction Design Foundation - IxDF. https://www.interaction-design.org/literature/topics/user-centered-design

Interaction Design Foundation - IxDF. (2016d, June 5). What is Visual Design? Interaction Design Foundation - IxDF. https://www.interaction-design.org/literature/topics/visual-design

Interaction Design Foundation - IxDF. (2023, March 17). What is Participatory Design? https://www.interaction-design.org/literature/topics/participatory-design?

International Organization for Standardization (ISO). (2019). ISO 9241-210:2019 - Ergonomics of human-system interaction — Part 210: Human-centred design for interactive systems.

Johnson, J. L., Adkins, D., & Chauvin, S. (2020). A Review of the Quality Indicators of Rigor in Qualitative Research. American Journal of Pharmaceutical Education, 84(1), 7120. https://doi.org/10.5688/ajpe7120

Johnson, M., & Majewska, D. (2022). Formal, non-formal, and informal learning: What are they, and how can we research them?

Kapp, K. M. (2012). The Gamification of Learning and Instruction: Game-based Methods and Strategies for Training and Education. John Wiley & Sons.

Kim, A. J. (2011, January 26). Gamification 101: Design the Player Journey. Slideshare. https://pt.slideshare.net/slideshow/gamification-101-design-the-player-journey/6713590

Kim, G. J. (2015). Human-Computer Interaction: Fundamentals and Practice. Taylor & Francis Group, LLC.

Korn, M. (2013). Situating Engagement: Ubiquitous Infrastructures for In-Situ Civic Engagement. Aahus Universitet.

Koutsabasis, P., Partheniadis, K., Gardeli, A., Vogiatzidakis, P., Nikolakopoulou, V., Chatzigrigoriou, P., Vosinakis, S., & Filippidou, D. E. (2022). Co-Designing the User Experience of Location-Based Games for a Network of Museums: Involving Cultural Heritage Professionals and Local Communities. Multimodal Technologies and Interaction, 6(5). https://doi.org/10.3390/mti6050036

Krueger, R. A., & Casey, M. A. (2000). Focus Groups: A Practical Guide for Applied Research (3rd ed.). Sage Publications.

Krueger, R. A., & Casey, M. A. (2009). Focus Groups: A Practical Guide for Applied Research (4th ed.). SAGE Publications.

Labrie, A., & Cheng, J. (2020). Adapting Usability Heuristics to the Context of Mobile Augmented Reality. Adjunct Publication of the 33rd Annual ACM Symposium on User Interface Software and Technology, 4–6. https://doi.org/10.1145/3379350.3416167

Laine, T. H. (2018). Mobile Educational Augmented Reality Games: A Systematic Literature Review and Two Case Studies. Computers 2018, Vol. 7, Page 19, 7(1), 19. https://doi.org/10.3390/COMPUTERS7010019

Lallemand, C., Koenig, V., Gronier, G., & Martin, R. (2015). Création et validation d'une version française du questionnaire AttrakDiff pour l'évaluation de l'expérience utilisateur des systèmes interactifs. European Review of Applied Psychology, 65(5), 239–252. https://doi.org/10.1016/j.erap.2015.08.002

Lincoln, Y. S., & Guba, E. G. (1985). Naturalistic Inquiry (E. G. Guba, Ed.). SAGE.

Lowdermilk, T. (2013). User-Centered Design: A Developer's Guide to Building User-Friendly Applications (M. Treseler, Ed.; 1st ed.). O'Reilly Media, Inc. www.it-ebooks.info

Lupton, E., & Phillips, J. C. (2015). Graphic Design: The New Basics (2nd ed.). Princeton Architectural Press.

Mackay, W. E., Leiva, G., Battut, A., & Beaudouin-Lafon, M. (2024). VideoClipper: Rapid Prototyping with the "Editing-in-the-Camera" Method. Conference on Human Factors in Computing Systems - Proceedings. https://doi.org/10.1145/3613904.3642458

Malamsha, M. P., Sauli, E., & Luhanga, E. T. (2021). Development and validation of a mobile game for culturally sensitive child sexual abuse prevention education in Tanzania: Mixed methods study. JMIR Serious Games, 9(4). https://doi.org/10.2196/30350

Marques, M. M., & Pombo, L. (2020). Game-Based Mobile Learning with Augmented Reality: Are Teachers Ready to Adopt It? (pp. 207–218). https://doi.org/10.1007/978-981-13-9652-6_19

Marques, M. M., & Pombo, L. (2023). User Experience of a Mobile App in a City Tour Game for International Doctoral Students. Education Sciences, 13(12), 1221. https://doi.org/10.3390/educsci13121221

Mercier, J., Chabloz, N., Dozot, G., Ertz, O., Bocher, E., & Rappo, D. (2023). BiodivAR: A Cartographic Authoring Tool for the Visualization of Geolocated Media in Augmented Reality. ISPRS International Journal of Geo-Information, 12(2). https://doi.org/10.3390/ijgi12020061

Miya, T. K., & Govender, I. (2022). UX/UI design of online learning platforms and their impact on learning: A review. International Journal of Research in Business and Social Science (2147- 4478), 11(10), 316–327. https://doi.org/10.20525/ijrbs.v11i10.2236

Moran, K. (2016, March 20). How Chunking Helps Content Processing. Nielsen Norman Group. https://www.nngroup.com/articles/chunking/

Morville, P. (2004, June 21). User Experience Design. Semantic Studios. https://semanticstudios.com/user_experience_design/

Mosbak, L.-D., & Bjorner, T. (2022). An Augmented Reality Training Application for Service and Maintenance of a Medical Analyzer: A UX Approach to Usefulness and User Satisfaction. Proceedings of 2022 8th International Conference of the Immersive Learning Research Network, iLRN 2022. https://doi.org/10.23919/iLRN55037.2022.9815890

Muller, M. J., & Kuhn, S. (1993). Participatory design. Communications of the ACM, 36(6), 24–28. https://doi.org/10.1145/153571.255960

Nielsen, J. (1993). Usability Engineering (M. Kaufmann, Ed.). Academic Press.

Nielsen, J. (1994a). Heuristic evaluation. In J. Nielsen & R. L. Mack (Eds.), Usability Inspection Methods (pp. 25–62). John Wiley & Sons, Inc.

Nielsen, J. (1994b, April 24). 10 Usability Heuristics for User Interface Design. Nielsen Norman Group.

Norman, D. (2014). The Design of Everyday Things: Revised and Expanded Edition. The MIT Press.

Norman, D. A., & Draper, S. W. (Eds.). (1986). User Centered System Design: New Perspectives on Human-computer Interaction. Lawrence Erlbaum Associates. https://books.google.pt/books?id=IR9FAAAAYAAJ

Norman, D., & Nielsen, J. (1998, August 8). The Definition of User Experience (UX). Nielsen Norman Group. https://www.nngroup.com/articles/definition-user-experience/

Ntagiantas, A., Konstantakis, M., Aliprantis, J., Manousos, D., Koumakis, L., & Caridakis, G. (2022). An Augmented Reality Children's Book Edutainment through Participatory Content Creation and Promotion Based on the Pastoral Life of Psiloritis. Applied Sciences (Switzerland), 12(3). https://doi.org/10.3390/app12031339

NVivo 15. (n.d.). Lumivero. Retrieved May 22, 2025, from https://lumivero.com/products/nvivo/

O'Connor, A., Tai, A., Brinn, M., Hoang, A. N. T. H., Cataldi, D., & Carson-Chahhoud, K. (2023). The Acceptability of Using Augmented Reality as a Mechanism to Engage Children in Asthma Inhaler Technique Training: Qualitative Interview Study With Deductive Thematic Analysis. JMIR Pediatrics and Parenting, 6. https://doi.org/10.2196/40231

Ørngreen, R. (2015). Reflections on Design-Based Research (pp. 20–38). https://doi.org/10.1007/978-3-319-27048-7_2

Paixão, F., & Jorge, F. (2014). Relação entre espaços de educação formais e não formais: uma estratégia na formação de professores para o ensino básico (pp. 359–369). Aveiro: UA Editora.

Pallant, J. (2016). SPSS Survival Manual: A Step by Step Guide to Data Analysis Using IBM SPSS (6th ed.). Routledge. https://doi.org/https://doi.org/10.4324/9781003117407

Papakostas, C., Troussas, C., Krouska, A., & Sgouropoulou, C. (2023). Exploring Users' Behavioral Intention to Adopt Mobile Augmented Reality in Education through an Extended Technology Acceptance Model. International Journal of Human–Computer Interaction, 39(6), 1294–1302. https://doi.org/10.1080/10447318.2022.2062551

Pombo, L., Ferreira-Santos, J., Draghi, J., Lopes, L., Marques, M. M., Lopes, M., Sá Beça, P., Rodrigues, R., Tavares, R., Pinho, R., Ribeiro, S., Rodrigues, S., & Carlos, V. (2022). Aveiro, cidade sustentável: EduCITY (1st ed.). UA Editora.

Pombo, L., M. Marques, M., Ferreira-Santos, J., Rodrigues, R., Sousa, B., & Baptista, C. (2025). Lessons Learned - EduCITY (1st ed., Vol. 1). Universidade de Aveiro. https://doi.org/https://doi.org/10.48528/z27p-jc51

Pombo, L., & Marques, M. M. (2019a). An App that Changes Mentalities about Mobile Learning—The EduPARK Augmented Reality Activity. Computers, 8(2), 37. https://doi.org/10.3390/computers8020037

Pombo, L., & Marques, M. M. (2019b). Improving students' learning with a mobile augmented reality approach – the EduPARK game. Interactive Technology and Smart Education, 16(4), 392–406. https://doi.org/10.1108/ITSE-06-2019-0032

Pombo, L., & Marques, M. M. (2023). EduCITY as a smart learning city environment towards education for sustainability - work in progress. In T. Bastiaens (Ed.), EdMedia + Innovate Learning (pp. 133–139). Association for the Advancement of Computing in Education (AACE). https://www.learntechlib.org/primary/p/222493/

Pombo, L., Marques, M. M., & Oliveira, S. (2019). Lessons Learned - EduPARK. UA Editora.

Pombo, L., & Rodrigues, R. (2024). Mobile augmented reality games for authentic science learning: perspectives of students (future teachers) on the EduCITY activity. 3145–3154. https://doi.org/10.21125/inted.2024.0845

Pombo, L., Rodrigues, R., & Sousa, B. (2024). EduCITY activity as best practice on education for sustainable development - a case study with higher education students (future teachers). 2964–2974. https://doi.org/10.21125/edulearn.2024.0793

Pope, M. L. (1982). Personal Construction of Formal Knowledge.

Poulin, R. (2018). The Language of Graphic Design. Quarto Publishing Group USA, Inc.

Raghavan, R. (2022, November 22). Difference between UCD and UX (User-Centered Design Vs User Experience). Acodez. https://acodez.in/ucd-ux-designs/#What_Is_User-Centered_Design_UCD

Rauschenberger, M., Schrepp, M., Perez-Cota, M., Olschner, S., & Thomaschewski, J. (2013). Efficient Measurement of the User Experience of Interactive Products. How to use the User Experience Questionnaire (UEQ).Example: Spanish Language Version. International Journal of Interactive Multimedia and Artificial Intelligence, 2(1), 39. https://doi.org/10.9781/ijimai.2013.215

Rebelo, F., Noriega, P., Duarte, E., & Soares, M. (2012). Using Virtual Reality to Assess User Experience. Human Factors: The Journal of the Human Factors and Ergonomics Society, 54(6), 964–982. https://doi.org/10.1177/0018720812465006

Reiersølmoen, M., Gianni, F., & Divitini, M. (2018). DELTA: Promoting young people participation in urban planning. Smart Innovation, Systems and Technologies, 80, 77–89. https://doi.org/10.1007/978-3-319-61322-2_8

Robertson, T., & Simonsen, J. (2012). Challenges and Opportunities in Contemporary Participatory Design. Design Issues, 28(3), 3–9. https://doi.org/10.1162/DESI_a_00157

Rodrigues, R., & Pombo, L. (2024). The Potential of a Mobile Augmented Reality Game in Education for Sustainability: Report and Analysis of an Activity with the EduCITY App. Sustainability, 16(21), 9357. https://doi.org/10.3390/su16219357

Salehudin, M., Zurqoni, Z., Robingatin, R., Syobah, Sy. N., Janah, F., Rorimpandey, W. H. F., & Subakti, H. (2023). Mobile Learning With Discord Application as Creative Teaching. TEM Journal, 1697–1705. https://doi.org/10.18421/TEM123-51

Scholes, L., Jones, C., Stieler-Hunt, C., & Rolfe, B. (2014). Serious games for learning: games-based child sexual abuse prevention in schools. International Journal of Inclusive Education, 18(9), 934–956. https://doi.org/10.1080/13603116.2013.860195

Schuler, D., & Namioka, A. (Eds.). (1993). Participatory Design: Principles and Practices. Lawrence Erlbaum Associates.

Schutz, A. (1967). The Phenomenology of the Social World. Northwestern University Press.

Shneiderman, B., Jacobs, S. M., Cohen, M. S., Diakopoulos, N., Elmqvist, N., & Plaisant, C. (2016). Designing the User Interface: Strategies for Effective Human-Computer Interaction (6th ed.). Pearson.

Skydsgaard, M. A., Møller Andersen, H., & King, H. (2016). Designing museum exhibits that facilitate visitor reflection and discussion. Museum Management and Curatorship, 31(1), 48–68. https://doi.org/10.1080/09647775.2015.1117237

Sousa, B., Marques, M. M., & Pombo, L. (2024). EduCITY app user experience: school students' perspective. 3392–3401. https://doi.org/10.21125/edulearn.2024.0882

Suryani, S., Nurdiansah, N., Faizal, F., Nirwana, N., Johanis, A. R., Marsa, M., & Pratama, A. Y. (2023). UI/UX Design Of Mobile-Based Pharmacy Application Using Design Thinking Method. Journal of Computer Networks, Architecture and High Performance Computing, 5(2), 714–723. https://doi.org/10.47709/cnahpc.v5i2.2811

TAŞ, S., & YAVUZ, A. (2023). Developing and Reviewing a Mobile Application for a 7th Grade Mathematics Course. Journal of Computer and Education Research, 11(21), 1–19. https://doi.org/10.18009/jcer.1194818

Thomas, C. G. (2015). Research Methodology and Scientific Writing. ANE Books.

Thomas, D. R. (2006). A General Inductive Approach for Analyzing Qualitative Evaluation Data. American Journal of Evaluation, 27(2), 237–246. https://doi.org/10.1177/1098214005283748

Trischler, J., Dietrich, T., & Rundle-Thiele, S. (2019). Co-design: from expert- to user-driven ideas in public service design. Public Management Review, 21(11), 1595–1619. https://doi.org/10.1080/14719037.2019.1619810

UXPin. (2024, August 5). UX Honeycomb – 7-Factor Design Framework for Great User Experience. UXPin. https://www.uxpin.com/studio/blog/ux-honeycomb-definition-and-use/

Vieira, D., Providência, B., & Carvalho, H. (2023). Design of a smart garment for fencing: measuring attractiveness using the AttrakDiff Mini method. Human-Intelligent Systems Integration, 5(1–2), 1–9. https://doi.org/10.1007/s42454-023-00047-z

Vitae. (2010). Research Development Framework.

Wong, E. (2025, February 27). Shneiderman's Eight Golden Rules Will Help You Design Better Interfaces. Interaction Design Foundation - IxDF. https://www.interaction-design.org/literature/article/shneiderman-s-eight-golden-rules-will-help-you-design-better-interfaces

Appendices

Appendix 1 - Focus Group Guide

Guião e Planeamento do Focus Group com estudantes

Informações:

- Sobre o projeto de investigação – O foco desta investigação é o redesign da app **EduCITY**, uma app educativa com georreferenciação que utiliza jogos em estilo *quizz* para levar os utilizadores a explorar percursos pela cidade, como num *peddypaper*. O objetivo principal é avaliar a experiência do utilizador e explorar como um processo de design participativo pode contribuir para uma melhor UX.

- Data, local e duração da sessão – A sessão será realizada em **(local)** no dia **(data)**, com uma duração estimada de **60 a 90 minutos**;

- Participantes - O grupo é composto por cinco estudantes do 3º ciclo;

- Objetivo do *Focus Group* - Recolher insights sobre as expectativas dos participantes em relação a uma app educativa como o **EduCITY**, comparar essas expectativas com a versão atual da app, e identificar falhas e melhorias necessárias para otimizar a experiência do utilizador da app EduCITY.

Etapas:

1) Apresentação e Introdução (Moderadora) - **10 min**
Objetivo: Legitimar o debate e motivar os participantes.

Fases/Tarefas:

a) Dar as boas-vindas aos participantes;
b) Informar os participantes sobre os objetivos do trabalho de investigação e do grupo focal;

c) Pedir que cada participante leia e assine o Consentimento Informado (RGPD):
   - **"Antes de começarmos, precisamos de tratar de uma parte importante: o consentimento informado."**
   - "Este documento explica o que vamos fazer hoje e como os vossos dados vão ser usados. Quero lembrar-vos que tudo o que partilharem será confidencial e apenas usado para fins deste estudo."
   - "A participação é completamente voluntária, e se, a qualquer momento, quiserem parar ou não responder a alguma questão, podem fazê-lo sem problema."
   - "Por favor, leiam o documento com atenção e assinem aqui. Se tiverem alguma dúvida, perguntem-me antes de assinarem. Estou aqui para ajudar!"

d) Consultar os participantes, novamente, sobre a gravação das discussões, assegurando a sua não divulgação, uma vez que servirá apenas para análise dos dados com a devida autorização dos participantes;
e) Assegurar o anonimato das opiniões;
f) Destacar a importância de todos os participantes no debate e explicar porque foram convidados a participar;
g) Destacar que não existem respostas certas ou erradas;
h) Explicar as regras de funcionamento do grupo:
   - Só fala uma pessoa de cada vez;
   - Evitar discussões paralelas para garantir que todos possam participar;
   - Não me levem a mal, mas vou ter uma intervenção para distribuir o tempo de forma mais equitativa possível;

- Manter a atenção e a discussão na temática em questão.
- Devem colocar o telemóvel em silêncio;
- Caso precisem de sair, voltem assim que possam.

i) Explicar que aquilo que se pretende é uma conversa. Caso alguém diga algo interessante e a que outro participante queira dar seguimento, deve fazê-lo.

j) Pedir aos participantes para se apresentarem (1º nome) e dizerem o que gostam de fazer no seu tempo livre (***ice breaker***).

2) Exercício de Criação/Imaginação de um Cenário (Moderadora e Participantes) - **15 min**
Objetivo: Explorar as **expectativas** dos participantes em relação a uma app educativa como o **EduCITY**, sem influência da versão atual da app.

Fases/Tarefas:

a) **Exercício de Imaginação do Cenário** - Antes de apresentar a versão atual da app, pedir aos participantes para **imaginar um cenário:**
   - "Imaginem que estão numa cidade ou num lugar ao ar livre, como um parque ou uma zona histórica. Há uma app no vosso telemóvel com jogos, em estilo quizz, para descobrirem e aprenderem coisas novas enquanto exploram o espaço. É como um jogo interativo, parecido com um *peddypaper* ou uma caça ao tesouro, onde vocês ganham pontos à medida que aprendem/acertam nas respostas. Podem fazer estas atividades sozinhos, com amigos ou até com o vosso professor numa aula diferente, fora da sala. Agora pensem: o que gostavam que esta app tivesse? Como acham que poderia tornar a aprendizagem mais divertida e interessante?"

   Perguntar o que os participantes esperam desta app em termos de funcionalidades, usabilidade, e de que forma é que esta pode apoiar a aprendizagem fora da sala de aula (ver questões abaixo): "Não tenham medo de imaginar coisas novas! A ideia é pensarmos juntos em como fazer desta app algo mesmo fixe para vocês." – não fazer logo perguntas

b) **Discussão sobre Expectativas** – Guião da conversa que eu gostaria que acontecesse, para estimular a conversa - Explorar as **expectativas dos participantes** em relação à app, com perguntas como:
   - "Se esta app fosse feita à vossa medida, o que gostavam que ela tivesse? Que tipo de coisas acham que ela devia fazer?"
   - "Como é que acham que esta app vos poderia ajudar a aprender fora da sala de aula?"
   - "Preferiam jogar este tipo de jogo sozinhos, com os amigos, ou durante uma aula com o professor?"
   - "Que funcionalidades acham mais fixes ou úteis? Quando falamos em funcionalidades, estamos a falar de coisas que a app consegue fazer. Por exemplo, podem ser jogos ou quizzes, a possibilidade de ver mapas, receber pistas para encontrar lugares, ganhar pontos ou prémios, ou até tirar fotos e partilhar com os amigos. Agora imaginem que vocês estão a criar esta app. Que coisas acham que ela devia conseguir fazer para ser mais interessante ou útil para vocês?" (Incentivá-los a ir para lá dos exemplos: puxar por eles para dizerem mais)
   - "Já usaram apps ou jogos no telemóvel que acharam confusas ou difíceis de usar? O que torna uma app fácil e fixe de usar?"
   - "O que é que vocês acham que deviam aprender com uma app destas? (Aprender sobre monumentos? Sobre a história? Ou até sobre outras coisas?)"
   - "Faz sentido usarem uma aplicação destas para aprenderem coisas novas?"

- “Acham que utilizariam uma app destas na escola ou em visitas de estudo? E em casa, com a família ou amigos?”
- “Se esta app fosse usada na escola, como é que acham que podia ajudar? Acham que seria mais fixe do que as aulas normais? Porquê?”
- “Se a app vos desse desafios mais difíceis ou perguntas sobre coisas que ainda não sabem, acham que seria divertido ou desmotivante?”

c) **Testes A/B** – Depois de discutir algumas das expectativas com os alunos, mostrar imagens A/B para perceber qual o estilo visual com que os alunos mais se identificam/mais associam a este tipo de app:
- “Agora vou mostrar-vos alguns pares de imagens, A e B, e quero que vocês me digam do que gostam mais em cada uma, do que não gostam e porquê. Estou a falar das cores, da estrutura, da organização, dos desenhos... qualquer coisa, na verdade! Contem-me tudo!”.

3) Apresentação da app atual e comparação com expectativas (Moderadora e Participantes) - **20 min**
Objetivo: Comparar as **expectativas dos participantes** (levantadas na Etapa 2) com a **versão atual da app** e obter feedback sobre as diferenças, correções e melhorias necessárias.

Fases/Tarefas:

a) **Apresentação da app atual e contextualização**
- **Distribuição de telemóveis do projeto EduCITY**
- **Introdução ao propósito da app:**
  “A EduCITY é uma aplicação educativa que pretende ajudar os utilizadores a aprenderem enquanto exploram o espaço à sua volta, utilizando percursos georreferenciados e jogos interativos. Hoje, vamos usá-la para fazer de conta que estamos no exterior e descobrir como funciona!”

- **Cenário para contextualizar os participantes:**
  "Vamos imaginar que vocês estão a explorar a cidade de Aveiro com a app EduCITY. Escolhem um jogo que tem um determinado percurso e a app dá-vos desafios como responder a perguntas que vos ensinam algo sobre a história, os monumentos, ou até sobre a natureza ao vosso redor."

- **Demonstração breve das funcionalidades (sem explicações detalhadas para reações espontâneas):**
  1. Interface inicial: "Aqui escolhem o jogo que querem jogar."
  2. Lista de jogos: “Neste ecrã podem ver todos os jogos que existem na app e descarregar os que quiserem jogar.”
  3. Pedir que explorem a interface e verbalizem o que acham que cada botão faz.

  “Agora, vamos experimentar a app aqui na sala. Sempre que estão a jogar, o flamingo vai-vos dizendo para que local têm de se dirigir para poderem responder às perguntas. Hoje vamos fingir que cada mesa corresponde a um local diferente, ok?” (colocar papéis com o nome de cada local em cima da mesa respetiva)

  “Conseguem descarregar o jogo EduCITY no Campus da UA? (dar alguns segundos para que todos descarreguem o jogo) Podem começar a jogar”

b) **Teste prático da app na sala**

- **Explicar o funcionamento geral** - "Agora vamos jogar! O flamingo da app vai indicar-vos para onde devem ir para responder às perguntas. Sigam as instruções e vejam o que conseguem descobrir!"

- **Observar a interação com os seguintes elementos-chave do jogo:**
  1. Áudio do flamingo – Como sabem que há um som para ouvir?
  2. Pergunta com várias respostas certas – Observar se percebem o formato da questão.
  3. AR Book Ginkgo Biloba – Observar se tentam explorar a Realidade Aumentada.
  4. Exploração de imagem – "O que podem fazer com esta imagem?" (Observar se dão zoom, exploram a navegação, etc.)
  5. AR Book Cipreste-dos-cemitérios – "Como ativam esta funcionalidade?" (Observar se percebem o botão de RA.)
  6. Vídeo da cantina UA – "Como podem ver este vídeo?"
  7. Ecrã de resultados – Observar reações ao feedback final.

- **Destaque das limitações atuais e interação com os participantes:**
  - Mencionar (de forma leve) algumas áreas que podem ser melhoradas: *"Este é o nosso ponto de partida*! Sabemos que esta app ainda pode melhorar - pode ficar mais bonita, ter coisas mais fixes para fazer e ser mais fácil de usar. Quero ouvir as vossas ideias: o que acham que está bem, o que pode ser melhorado, e como posso torná-la mais interessante para vocês."

  - Se necessário, explicar algumas **funcionalidades:**

    Quizzes: "Em cada local, aparece pelo menos uma pergunta para responderem. Por exemplo, pode perguntar algo sobre o monumento que estão a ver."

    Realidade Aumentada: "O jogo permite que vocês explorem conteúdos em Realidade Aumentada para vos ajudar a responder às perguntas que surgem."

    Recompensas ou feedback: "Depois de responderem, a app dá-vos feedback – certo ou errado – se responderem corretamente, podem ganhar pontos."

c) **Comparação com expectativas** – Pedir aos participantes para compararem as funcionalidades e o design da app atual com as expectativas que expressaram anteriormente, no cenário imaginado:

- "Vocês lembram-se de como imaginaram uma app para aprender ao ar livre? Agora vamos comparar isso com a EduCITY".

- Se necessário, dizer: "Se há algo que não gostaram, não faz mal. Estamos aqui para melhorar a app e a vossa opinião é essencial."

- Focar discussão no futuro - Possíveis questões a serem abordadas:
  - "Quando exploraram a app, encontraram algo que acham que corresponde ao que imaginaram?"
  - "O que gostaram mais?"
  - "Houve algo que vos confundiu ou que acham que devia ser mais claro?"
  - "Se pudessem mudar alguma coisa, o que seria?"
  - "Existe alguma coisa que pensavam que estaria na app, mas não está?"
  - "É fácil de entender o que devem fazer quando estão a jogar ou não? O que acham que podia ser melhorado?"

"Agora que já discutimos o que funciona e o que não funciona na app, vamos pensar juntos em como a podemos melhorar."

d) **Discussão de melhorias:** Promover uma discussão sobre como a app atual pode ser **ajustada** ou **melhorada** para se alinhar melhor com as expectativas dos participantes. (Ex: sugestões de novas funcionalidades, ajustes no design, ou melhorias na usabilidade.)

- **Possíveis perguntas:**
  - "Como acham que poderíamos melhorar isto? Se pudessem tornar este jogo ainda melhor, o que fariam?"
  - "O que é que poderíamos acrescentar à app para a tornar mais útil ou divertida?"
  - "Se pudessem mudar o aspeto da app, o que fariam? O que acham das cores?"
  - "Acharam fácil de usar ou algumas partes foram complicadas?"
  - "Gostavam de ver mais desafios diferentes?"
  - "Se pudessem escolher, preferiam mais vídeos, mais perguntas ou mais realidade aumentada?"

- **Exemplos de melhorias:**
  - "Por exemplo, acham que seria útil ter notificações ou prémios para completar desafios?"
  - "Acham que os quizzes deviam ser mais variados?"

Durante a sessão de *focus group*, a moderadora – que, neste caso, será a investigadora – terá como responsabilidades principais:

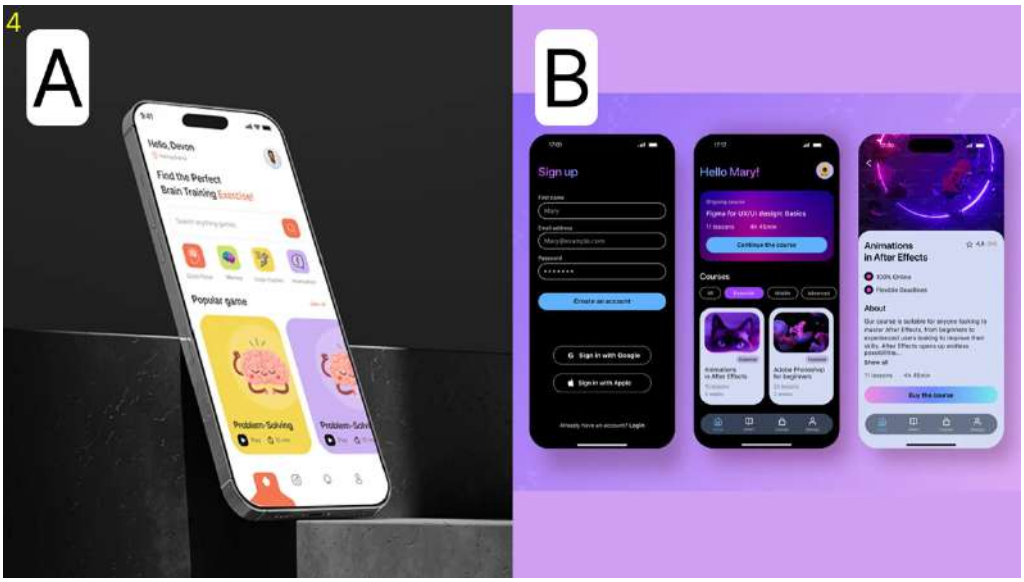
- Explicar o objetivo do projeto de investigação, quais os resultados esperados e o impacto que os dados a obter com o *focus group* terão no resultado (redesign da app);
- Facilitar a discussão, mantendo a sua organização e intervindo quando necessário;
- Incentivar a intervenção de todos os participantes, garantindo que todos têm a oportunidade de expressar as suas ideias;
- Manter a análise em profundidade, não permitindo o avanço para as próximas etapas enquanto os participantes não tiverem explorado completamente cada fase.

4) Conclusão da Sessão:

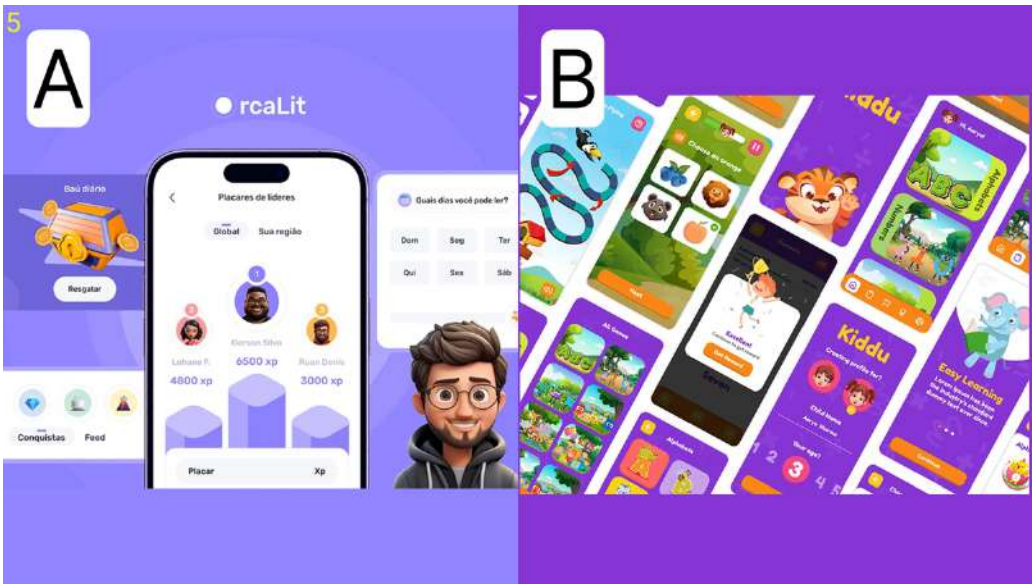
No final da sessão, a moderadora deve:

- Agradecer aos participantes pelo seu tempo, colaboração e pelas **contribuições valiosas** para o desenvolvimento da app EduCITY.
- Reforçar a importância das suas opiniões no processo de **melhoria contínua** da app, destacando como as sugestões dos alunos ajudarão no redesign.

Appendix 2 - Image Pairs used in the A/B Test


4
A
B
Hello, Devon
Find the Perfect Brain Training Exercise
Popular game
Problem-Solving
Sign up
Hello Mary!
Courses
Animations in After Effects


3
A
B
Johnathen S.
Pick up where you left...
Advanced Spanish
Languages to learn
Spanish
Profile
Johnathen S.
Bronze
Badges
Welcome bonus up to
WINNERS LIVE FEED
Casino
XMAS DROP
Providers


5
A
B
rcaLit
Placares de líderes
Global
Sua região
6500 xp
4800 xp
3000 xp
Resgatar
Conquistas
Feed
Placar
Xp
Kiddu
Easy Learning

Appendix 3 - Informed Consent Authorization Form used for Participants of the Focus Group

Consentimento Informado para Focus Group

PARTICIPAÇÃO NO FOCUS GROUP

Informação ao **Participante e Encarregado de Educação** e Consentimento Informado

Este documento é dirigido aos Encarregados de Educação dos participantes do Focus Group. Mais se indica que, sem o consentimento do Encarregado de Educação para recolha e tratamento dos dados, não será permitida a participação do seu educando no estudo.

Por favor, leia com atenção a seguinte informação.

1. QUAIS OS OBJETIVOS DO ESTUDO?

Este estudo pretende:

1) Realizar testes comparativos de UX entre um protótipo (correspondente ao redesign da app) e a versão atual da app, avaliando a experiência de utilizador, especialmente em contextos educativos *outdoor*.

2) Melhorar a experiência de utilizador e o design da interface da app com base nas expectativas de especialistas, professores e alunos.

3) Desenvolver um protótipo não funcional como proposta de redesign para a app EduCITY, que reflita os insights das análises dos especialistas e das perceções dos utilizadores.

4) Aplicar uma investigação participativa baseada em metodologias de design relacionadas com o processo de melhoria de UX/UI, incluindo grupos focais com utilizadores finais, entrevistas com especialistas e professores, e comparação de cenários.

Adicionalmente, pretende responder à questão de investigação **"Podem as técnicas de design participativo, num processo de investigação, melhorar a perceção que estudantes do 3º ciclo têm da experiência de utilização da aplicação EduCITY?"**, tendo como objeto de estudo a **aplicação EduCITY** (https://educity.web.ua.pt/app.php).

2. QUEM ESTÁ A REALIZAR O ESTUDO?

O presente estudo está a decorrer no âmbito do projeto de Mestrado em Comunicação e Tecnologias Web de **Carolina Miguel Vidal Ferreira Baptista** (Universidade de Aveiro, Departamento de Comunicação e Arte). Este trabalho conta com a orientação do **Doutor Óscar Mealha** (Universidade de Aveiro, Departamento de Comunicação e Arte) e coorientação da **Doutora Lúcia Pombo** (Universidade de Aveiro, Departamento de Educação e Psicologia).

3. A QUEM SE DIRIGE O ESTUDO?

Para a concretização do presente estudo, pretende-se e solicita-se a participação de:

- Estudantes do 3º ciclo;
- Que saibam ler e compreender a língua portuguesa;
- Que sejam capazes de utilizar tecnologias.

4. EM QUE CONSISTE O ESTUDO?

O presente estudo assenta na realização de um *focus group* (grupo focal), no qual será solicitado ao seu educando que:

1) Imagine um cenário ideal para a utilização de uma aplicação, considerando funcionalidades e características que seriam essenciais numa aplicação educativa como a **EduCITY** (https://educity.web.ua.pt/app.php);
2) Utilize a app EduCITY;
3) Identifique falhas e melhorias na versão atual da aplicação EduCITY;
4) Compare as expectativas com a versão atual da aplicação EduCITY.

O objetivo deste *focus group* é permitir que os estudantes, com base nas suas experiências e necessidades, contribuam com ideias sobre possíveis funcionalidades para uma app educativa como a EduCITY e discutam acerca dos pontos fortes, falhas e sugerir melhorias.

O *focus group* será realizado presencialmente, recorrendo a uma sala na **escola**, depois de agilizado prévio agendamento, sendo expectável uma duração de **60 a 90 minutos**.

Nenhum participante usará o seu dispositivo móvel, uma vez que será a investigadora a facultar os aparelhos, com a app EduCITY já instalada. A app EduCITY não pede o nome do(s) utilizador(es) e não tem login/registo.

A informação será recolhida através de uma grelha de observação e, para facilitar a transcrição e posterior análise da informação, o *focus group* será gravado por recurso a gravador de vídeo e/ou áudio.

5. QUAIS AS CONDIÇÕES DE PARTICIPAÇÃO?

A participação do seu educando neste estudo/*focus group* é totalmente **voluntária**, tendo direito a não querer participar. Se concordar que o seu educando participe, este poderá desistir em qualquer momento, sem prejuízo. Caso queira desistir, a meio ou no final do *focus group*, bastará ao seu educando dar indicação ao moderador dessa sua vontade, terminando este toda a recolha de dados que esteja a realizar e apagando de imediato os conteúdos recolhidos até àquele momento. Não estão previstas quaisquer contrapartidas associadas à participação do seu educando.

6. QUAIS OS POTENCIAIS RISCOS E BENEFÍCIOS ASSOCIADOS À PARTICIPAÇÃO DO SEU EDUCANDO?

Não se antecipam quaisquer riscos ou benefícios diretamente associados à participação do seu educando, no entanto, ao participar, estará a contribuir para a melhoria do conhecimento e desenvolvimento global da sociedade, assim indiretamente contribuindo também para o seu educando.

7. QUEM SÃO OS RESPONSÁVEIS PELO TRATAMENTO DA INFORMAÇÃO?

A responsável pelo tratamento dos dados é a Mestranda Carolina Baptista, contactável pelo email carolina.baptista@ua.pt.

8. COMO SERÃO TRATADOS OS DADOS DO SEU EDUCANDO?

Toda a informação recolhida ao longo deste estudo será tratada de forma confidencial e armazenada em local seguro, com acesso controlado e garantias de reposição em caso de falha.

Apenas a responsável acima identificada (ponto 7) terá acesso aos dados que podem identificar o seu educando. Todos os restantes elementos da equipa de investigação do projeto poderão ter acesso à informação depois de anonimizada.

Os dados pessoais não irão ser comunicados a nenhuma entidade externa nem há possibilidade de serem transferidos para países terceiros.

Não serão tornados públicos, de nenhuma forma, quaisquer dados/resultados que permitam a identificação do seu educando.

De forma a facilitar a análise da informação, a investigadora procederá ao registo de notas e gravação de áudio e vídeo. Na análise da informação, o nome do seu educando será substituído por um código, de forma que não seja possível a sua identificação.

A investigadora procederá à transcrição do *focus group* em formato anónimo no mais curto espaço de tempo possível, previsivelmente **2 a 4 semanas** após a sua realização, sendo, nesse momento, apagados os conteúdos previamente gravados que contenham informação pessoal relativa à pessoa do seu educando.

Os dados anonimizados e os resultados do estudo podem ser partilhados com revistas internacionais ao abrigo do movimento *opendata* e apresentados publicamente em congressos científicos e outras publicações.

Este estudo teve a aprovação do Encarregado de Proteção de Dados da Universidade de Aveiro, dando cumprimento ao Regulamento Geral de Proteção de Dados (RGPD), garantindo a segurança e confidencialidade de todos os dados facultados pelos participantes, em todas as fases do processo.

9. QUAIS OS SEUS DIREITOS E COMO PODE EXERCÊ-LOS?

Ao aceitar que o seu educando participe neste estudo e na qualidade de titular dos dados pessoais do seu educando, informa-se ainda que terá direito, enquanto aplicável (enquanto os dados pessoais do seu educando, incluindo gravações, não forem apagados), a:

a. Aceder aos seus dados do seu educando e a receber informação sobre o processamento dos seus dados pessoais;
b. retificar quaisquer imprecisões sobre os seus dados pessoais durante o período de recolha ou de tratamento dos mesmos;
c. solicitar o apagamento dos seus dados pessoais;

Tal solicitação deve ser dirigida, por email, ao Responsável pelo tratamento de dados acima identificado (ponto 7), que deverá agir de acordo com as suas pretensões.

10. COMO SABER MAIS INFORMAÇÃO?

Caso deseje obter informações adicionais ou esclarecer qualquer dúvida sobre este estudo, poderá contactar o responsável pelo tratamento identificado no ponto 7.

Também, e se assim o entender, pode apresentar dúvidas ou colocar questões ao Encarregado de Proteção de Dados da Universidade de Aveiro, pelo email epd@ua.pt, ou através de carta dirigida ao Encarregado de Proteção de Dados, Universidade de Aveiro, Edifício da Antiga Reitoria, piso 4, Campus de Santiago, 3810-193, Aveiro.

Poderá ainda, e a qualquer momento, apresentar uma reclamação perante a autoridade responsável - Comissão Nacional de Proteção de Dados (CNPD), se entender que os seus direitos sobre os seus dados pessoais foram infringidos.

11. DECLARAÇÃO DE CONSENTIMENTO INFORMADO

Para que possa tratar os dados do seu educando, necessito do seu consentimento, que deve ser livre, explícito, inequívoco e informado. Nestes termos e presente toda a informação supra, muito agradeço que proceda à escolha da opção que melhor entenda:

☐ **Declaro, ao abrigo do RGPD e da LPDP, que dou o meu consentimento para a recolha e tratamento dos dados pessoais do meu educando, necessário à execução do projeto identificado.**

☐ **Declaro, ao abrigo do RGPD e da LPDP, que não dou o meu consentimento para a recolha e tratamento dos dados pessoais do meu educando.**

O presente formulário é assinado no dia: ____/_____/_____ em _____ (indicar o local em que assina o formulário)

_____

(Assinatura do Responsável pela Recolha dos dados, conforme documento de identificação)

_____

(Assinatura do Encarregado de Educação, conforme documento de identificação)

_____

(Assinatura do Participante, Titular dos dados, conforme documento de identificação)

Agradeço a sua atenção.

Appendix 4 - Semi-structured Interview Guide

Guião e Planeamento da Entrevista Semiestruturada com professores e peritos

Informações:

- Sobre o projeto de investigação – O foco desta investigação é o redesign da app **EduCITY**, uma app educativa com georreferenciação que utiliza jogos em estilo quiz para levar os utilizadores a explorar percursos pela cidade, como num *peddypaper*. O objetivo principal é avaliar a experiência do utilizador e explorar como um processo de design participativo pode contribuir para uma melhor UX.

- Data, local e duração da sessão – A sessão será realizada em **(local)** no dia **(data)**, com uma duração estimada de **40 a 50 minutos**;

- Participantes - Peritos em UX/UI design ou professores dos ensinos básico ou secundário;

- Objetivo da entrevista - Permitir que os participantes contribuam, com base na sua **experiência**, com ideias, sugestões de funcionalidades, propostas de melhorias e análises críticas sobre a app EduCITY, para enriquecer o redesign e alinhar o desenvolvimento da app às necessidades reais dos utilizadores.

Etapas:

1) Apresentação e Introdução (Entrevistadora) - **10 min**
Objetivo: Criar um ambiente confortável e introduzir o propósito da investigação e da entrevista.

Fases/Tarefas:

a) Dar as boas-vindas ao participante;
b) Informar o participante dos objetivos do trabalho de investigação e da entrevista;

c) Confirmar que o participante leu e assinou o Consentimento Informado (RGPD):
   - "Antes de começarmos, gostaria de tratar de uma parte essencial: o consentimento informado."
   - "Este documento detalha o propósito desta entrevista, o que será feito hoje e como os seus dados serão utilizados. É importante lembrar que toda a informação partilhada será tratada de forma confidencial e apenas usada para fins deste estudo."
   - "A sua participação é completamente voluntária. Caso queira interromper a entrevista a qualquer momento ou optar por não responder a alguma pergunta, sinta-se à vontade para o fazer, sem qualquer problema."
   - "Por favor, leia o documento com atenção e assine aqui. Caso tenha alguma dúvida, fico à disposição para esclarecê-la antes de procedermos."

d) Consultar o participante sobre a gravação das discussões, assegurando a sua não divulgação, uma vez que servirá apenas para análise dos dados com a devida autorização do participante;
e) Assegurar o anonimato das opiniões;
f) Destacar a importância do contributo do participante e explicar por que foi convidado a participar;
g) Destacar que não existem respostas certas ou erradas;
h) ***Ice breaker:*** Fazer uma pergunta simples para quebrar o gelo, como "Se pudesse descrever a app educativa ideal com uma palavra, qual seria e porquê?" (experts) ou "Do que já conhece da app EduCITY, se a pudesse tornar na app ideal, o que acrescentaria?" (professores).

2) Apresentação da app atual e análise crítica – **25 min**
Objetivo: Obter feedback sobre a versão atual da app EduCITY, identificar problemas e explorar melhorias necessárias ao redesign.

Fases/Tarefas:

a) **Apresentação da app atual**:

- Apresentar a versão atual da app EduCITY (chamar-lhe um "ponto de partida"), destacando os seus principais recursos e funcionalidades.
- Explicar brevemente como a app funciona, para contextualizar o participante:
  - "Agora vou apresentar a versão atual da app EduCITY, que será o nosso ponto de partida para esta análise."
  - "Esta app foi concebida como uma ferramenta educativa que utiliza georreferenciação e jogos em estilo quiz para promover a exploração e aprendizagem ao ar livre. A ideia principal é que alunos e professores possam utilizar a app para explorar percursos educativos em espaços urbanos, como se fosse um peddypaper."
  - "A app permite criar itinerários personalizados, onde os utilizadores têm de responder a questões relacionadas com os locais que visitam, promovendo uma aprendizagem mais ativa e contextualizada. O objetivo é aliar tecnologia e educação, tornando as aprendizagens mais envolventes, especialmente fora da sala de aula."

  - Além disso, a app inclui algumas **funcionalidades-chave**, que iremos explorar através de um cenário de uso - "Agora, imagine que é um aluno a participar numa atividade com a app EduCITY. Vamos descarregar e jogar ao jogo "EduCITY no campus da UA". Pedia-lhe que fosse dando a sua opinião à medida que interage com a app."

    i. Áudio do flamingo – Como sabe que há um som para ouvir?
    ii. Pergunta com várias respostas certas – Como interpreta o formato da questão?
    iii. AR Book Ginkgo Biloba – O que faz quando encontra esta funcionalidade? Tenta explorá-la?
    iv. Exploração de imagem – O que pode fazer com esta imagem? (Verificar se amplia, explora a navegação, etc.)
    v. AR Book Cipreste-dos-cemitérios – Como ativa esta funcionalidade? (Observar se percebe o botão de RA.)
    vi. Vídeo da cantina UA – Como pode ver este vídeo?
    vii. Ecrã de resultados – Qual a sua reação ao feedback final?

  - "A partir desta exploração, gostava de conhecer a sua opinião sobre a app e como acha que podemos melhorar. O que achou intuitivo? O que gerou dúvidas? Como acha que a app pode ser melhorada?"

b) **Análise crítica** – Pedir ao participante para avaliar a app, considerando os seguintes aspetos:

- Para **professores**:
  - "Em que contextos imagina que esta app poderia ser mais útil para os alunos? Durante aulas ao ar livre, visitas de estudo, atividades autónomas, ou outras situações?"
  - "De que forma a app poderia ser integrada numa aula tradicional ou numa visita de estudo?"
  - "Na sua opinião, é fácil para um professor utilizar a app com os alunos durante uma aula ou atividade? Porquê?"
  - "Que desafios vê na utilização da app como ferramenta pedagógica?"
  - "Que melhorias ou adaptações poderiam facilitar a integração da app nas suas práticas de ensino?"
  - "Que tipo de conteúdos ou desafios considera mais relevantes para os alunos? Acha que a app deveria focar-se mais em conteúdos informativos, jogos, exploração do espaço físico ou outro tipo de abordagem?"

- "Acha que os alunos aprenderiam melhor utilizando esta app individualmente ou em grupo? Como poderia ser trabalhada a colaboração entre os alunos?"
- "De que forma é que esta app pode apoiar ou dificultar o ensino ao ar livre?"
- "Acha que esta app pode ajudar a atingir os objetivos pedagógicos em ambientes fora da sala de aula/escola? Porquê?"
- "Quais seriam os principais incentivos para os professores utilizarem esta app nas suas aulas?"
- "Como imagina que os alunos utilizariam a app no dia a dia? Acha que a utilizariam apenas em contexto escolar ou também em casa, com a família ou amigos?"

- Para **peritos em UX/UI**:
  - "Como avalia a usabilidade geral da app e a sua navegação? Existem barreiras que possam dificultar a interação dos utilizadores?"
  - "Os elementos de design (layout, tipografia, ícones, cores) são consistentes e intuitivos para os utilizadores finais? Que aspetos poderiam ser melhorados?
  - "Os fluxos de navegação da app são claros e eficientes? Há alguma funcionalidade ou percurso do utilizador que possa causar confusão ou frustração?"
  - Que oportunidades vê para melhorar a experiência da app, considerando boas práticas de UX/UI? Existem padrões ou estratégias que poderiam ser aplicados para tornar a interface mais apelativa e funcional?

c) **Discussão de melhorias:** Pedir sugestões concretas para melhorar usabilidade, funcionalidade ou design da app:
- "Que **funcionalidades** sente que faltam na app?" (Para os professores: Quando falamos em funcionalidades, estamos a falar de coisas que a app consegue fazer. Por exemplo, podem ser jogos ou quizzes, a possibilidade de ver mapas, receber pistas para encontrar lugares, ganhar pontos ou prémios, ou até tirar fotos e partilhar com os amigos)
- "Há algum aspeto da interface ou da experiência de interação com a app que poderia ser mais claro ou intuitivo?"
- "Que alterações sugeriria para alinhar a app às necessidades dos alunos?"

3) Conclusão da Sessão – **5 min**
Objetivo: Encerrar a sessão, agradecendo ao participante e reforçando a relevância do seu contributo.

Tarefas:
- Agradecer ao participante pelo tempo e colaboração.
- Reforçar a importância das suas opiniões e como estas serão utilizadas para melhorar a app EduCITY.
- Perguntar se o participante tem alguma questão ou comentário final.

Appendix 5 - Informed Consent Authorization Form used for Experts in the Interviews

Consentimento Informado para Entrevista Semiestruturada

PARTICIPAÇÃO NA ENTREVISTA
INFORMAÇÃO AO PARTICIPANTE E CONSENTIMENTO INFORMADO

Por favor, antes de iniciar a sua participação, leia com atenção a seguinte informação.

1. QUAIS OS OBJETIVOS DO ESTUDO?

Este estudo pretende:

1) Realizar testes comparativos de UX entre um protótipo (correspondente ao redesign da app) e a versão atual da app, avaliando a experiência de utilizador, especialmente em contextos educativos *outdoor*.

2) Melhorar a experiência de utilizador e o design da interface da app com base nas expectativas de especialistas, professores e alunos.

3) Desenvolver um protótipo não funcional como proposta de redesign para a app EduCITY, que reflita os insights das análises dos especialistas e das perceções dos utilizadores.

4) Aplicar uma investigação participativa baseada em metodologias de design relacionadas com o processo de melhoria de UX/UI, incluindo grupos focais com utilizadores finais, entrevistas com especialistas e professores, e comparação de cenários.

Adicionalmente, pretende responder à questão de investigação **"Podem as técnicas de design participativo, num processo de investigação, melhorar a perceção que estudantes do 3º ciclo têm da experiência de utilização da aplicação EduCITY?"**, tendo como objeto de estudo a **aplicação EduCITY** (https://educity.web.ua.pt/app.php).

2. QUEM ESTÁ A REALIZAR O ESTUDO?

O presente estudo está a decorrer no âmbito do projeto de Mestrado em Comunicação e Tecnologias Web de **Carolina Miguel Vidal Ferreira Baptista** (Universidade de Aveiro). Este trabalho conta com a orientação do **Doutor Óscar Mealha** (Universidade de Aveiro, Departamento de Comunicação e Arte) e coorientação da **Doutora Lúcia Pombo** (Universidade de Aveiro, Departamento de Educação e Psicologia).

3. A QUEM SE DIRIGE O ESTUDO?

Para a concretização do presente estudo, pretende-se e solicita-se a participação de:
- Peritos na área de User Experience (UX) e/ou User Interface (UI) Design; ou
- Professores do Ensino Básico ou Secundário;
- Que saibam ler e compreender as línguas portuguesa e inglesa.

4. EM QUE CONSISTE O ESTUDO?

O presente estudo assenta na realização de uma entrevista, na qual Lhe será solicitado que responda a um conjunto de questões que têm por objetivo:
1) Recolher dados relativos à sua opinião de utilização da aplicação EduCITY;
2) Encontrar e definir problemas que afetem a usabilidade e experiência do utilizador na aplicação EduCITY (https://educity.web.ua.pt/app.php);

A entrevista será realizada presencialmente ou à distância, recorrendo a uma sala no Departamento de Comunicação e Arte da Universidade de Aveiro ou à plataforma Zoom, depois de agilizado prévio agendamento, sendo expectável uma duração de **50 minutos.**

A informação será recolhida através de uma grelha de observação e, para facilitar a transcrição e posterior análise da informação, a entrevista será gravada por recurso a gravador de vídeo e/ou áudio.

5. QUAIS AS CONDIÇÕES DE PARTICIPAÇÃO?

A sua participação nesta entrevista é totalmente **voluntária**, tendo direito a não querer participar. Se concordar em participar, poderá desistir em qualquer momento, sem prejuízo para si. Caso queira desistir, a meio ou no final da entrevista, bastará dar indicação à entrevistadora dessa sua vontade, terminando esta toda a recolha de dados que esteja a realizar e apagando de imediato os conteúdos recolhidos até àquele momento.

Não estão previstas quaisquer contrapartidas associadas à sua participação.

6. QUAIS OS POTENCIAIS RISCOS E BENEFÍCIOS ASSOCIADOS À SUA PARTICIPAÇÃO?

Não se antecipa quaisquer riscos ou benefícios diretamente associados à sua participação, no entanto, ao participar, estará a contribuir para a melhoria do conhecimento e desenvolvimento global da sociedade, assim indiretamente contribuindo também para si.

7. QUEM SÃO OS RESPONSÁVEIS PELO TRATAMENTO DA INFORMAÇÃO?

A responsável pelo tratamento dos dados é a Mestranda Carolina Baptista, contactável pelo email carolina.baptista@ua.pt.

8. COMO SERÃO TRATADOS OS SEUS DADOS?

Toda a informação recolhida ao longo deste estudo será tratada de forma confidencial e armazenada em local seguro, com acesso controlado e garantias de reposição em caso de falha.

Apenas a responsável acima identificada (ponto 7) terá acesso aos dados que o podem identificar. Todos os restantes elementos da equipa de investigação do projeto poderão ter acesso à informação depois de anonimizada.

Os dados pessoais não irão ser comunicados a nenhuma entidade externa nem há possibilidade de serem transferidos para países terceiros. Não serão tornados públicos, de nenhuma forma, quaisquer dados/resultados que permitam a sua identificação.

De forma a facilitar a análise da informação, a investigadora procederá ao registo de notas e gravação de áudio e vídeo. Na análise da informação, o seu nome será substituído por um código, de forma a que não seja possível a sua identificação.

A investigadora procederá à transcrição da entrevista em formato anónimo. Com o término do período de análise de dados, previsivelmente maio de 2025, todos os conteúdos previamente gravados que contenham informação pessoal relativa à sua pessoa serão apagados.

Adicionalmente, a investigadora procederá, também, ao envio de um memorando com os pontos mais pertinentes daquilo que foi a entrevista, visando a validação dos mesmos por parte do entrevistado.

Os dados anonimizados e os resultados do estudo podem ser partilhados com revistas internacionais ao abrigo do movimento *opendata* e apresentados publicamente em congressos científicos e outras publicações.

Este estudo teve a aprovação do Encarregado de Proteção de Dados, dando cumprimento ao Regulamento Geral de Proteção de Dados (RGPD), garantindo a segurança e confidencialidade de todos os dados facultados pelos participantes, em todas as fases do processo.

9. QUAIS OS SEUS DIREITOS E COMO PODE EXERCÊ-LOS?

Ao aceitar participar neste estudo e na qualidade de titular dos seus dados pessoais, informa-se ainda que terá direito, enquanto aplicável (enquanto os seus dados pessoais, incluindo gravações, não forem apagados), a:

a. Aceder aos seus dados e a receber informação sobre o processamento dos seus dados pessoais;
b. retificar quaisquer imprecisões sobre os seus dados pessoais durante o período de recolha ou de tratamento dos mesmos;
c. solicitar o apagamento dos seus dados pessoais;

Tal solicitação deve ser dirigida, por email, ao Responsável pelo tratamento de dados acima identificado (ponto 7), que deverá agir de acordo com as suas pretensões.

10. COMO SABER MAIS INFORMAÇÃO?

Caso deseje obter informações adicionais ou esclarecer qualquer dúvida sobre este estudo, poderá contactar a responsável pelo tratamento identificada no ponto 7.

Também, e se assim o entender, pode apresentar dúvidas ou colocar questões ao Encarregado de Proteção de Dados da Universidade de Aveiro, pelo email epd@ua.pt, ou através de carta dirigida ao Encarregado de Proteção de Dados, Universidade de Aveiro, Edifício da Antiga Reitoria, piso 4, Campus de Santiago, 3810-193, Aveiro.

Poderá ainda, e a qualquer momento, apresentar uma reclamação perante a autoridade responsável - Comissão Nacional de Proteção de Dados (CNPD), se entender que os seus direitos sobre os seus dados pessoais foram infringidos.

11. DECLARAÇÃO DE CONSENTIMENTO INFORMADO

Para que possa tratar os seus dados, necessito do seu consentimento, que deve ser livre, explícito, inequívoco e informado. Nestes termos e presente toda a informação supra, muito agradeço que proceda à escolha da opção que melhor entenda:

☐ **Declaro, ao abrigo do RGPD e da LPDP, que dou o meu consentimento para a recolha e tratamento dos meus dados pessoais, necessário à execução do projeto identificado.**

☐ **Declaro, ao abrigo do RGPD e da LPDP, que não dou o meu consentimento para a recolha e tratamento dos meus dados pessoais.**

O presente formulário é assinado no dia: ____/____/_____ em _____ (indicar o local em que assina o formulário)

_____

(Assinatura do Responsável pela Recolha dos dados, conforme documento de identificação)

_____

(Assinatura do Participante, Titular dos dados, conforme documento de identificação)

Agradeço a sua participação.

Appendix 6 - Comparative UX Tests Guide

Guião e Planeamento de Teste Comparativo com estudantes

VERSÃO QUE COMEÇA PELA APP ATUAL

(para o grupo que comece pelo protótipo, basta trocar ordem das etapas 3 e 4)

Informações:

- Sobre o projeto de investigação – O foco desta investigação é o redesign da app **EduCITY**, uma app educativa com georreferenciação que utiliza jogos em estilo quiz para levar os utilizadores a explorar percursos pela cidade, como num *peddypaper*. O objetivo principal é avaliar a experiência do utilizador e explorar como um processo de design participativo pode contribuir para uma melhor UX.

- Data, local e duração da sessão – A sessão será realizada em **(local)** no dia **(data)**, com uma duração estimada de **50 a 60 minutos**;

- Participantes - O grupo é composto por oito estudantes do 3º ciclo;

- Objetivo do teste comparativo - Avaliar e comparar duas versões da aplicação EduCITY: a versão atual e um protótipo redesenhado. O objetivo é compreender como cada versão influencia a perceção da experiência de utilizador dos estudantes, recolhendo opiniões, propostas de melhoria e análises críticas dos participantes com base nas tarefas realizadas durante o teste.

Etapas:

1) Introdução (Entrevistadora) - **5 min**

Apresentação da investigadora: "Olá, o meu nome é Carolina e sou investigadora da Universidade de Aveiro no âmbito da minha dissertação de mestrado. Obrigada por estarem aqui hoje!"

Objetivo do teste: "O objetivo deste teste é avaliar duas versões da aplicação EduCITY: a versão atual e um protótipo redesenhado. Estou interessada na vossa opinião sobre a experiência de utilização de ambas as versões As vossas opiniões e feedback são muito importantes para melhorar a app, tornando-a mais útil, interessante e fácil de usar para alunos como vocês."

Estrutura da sessão: "Vamos usar estes telemóveis! Metade vai começar por realizar tarefas na app atual e, depois, vão fazer as mesmas tarefas no protótipo redesenhado. A outra metade vai fazer o oposto: começam pelo protótipo e depois vão para a app atual. Durante o teste, podem e devem fazer perguntas ou partilhar o que estão a sentir! No final de cada uso, vão preencher um pequeno questionário sobre a vossa experiência."

Regras e orientações:

- "Não se esqueçam! Não há respostas certas ou erradas. Quero saber como vocês realmente se sentem e o que acham. Sintam-se à vontade para partilhar qualquer comentário. Se, em algum momento, não se sentirem confortáveis, podem sair da sessão sem qualquer problema."

2) Assinatura do consentimento informado e criação dos grupos – **10 min**

- "**Antes de começarmos**, precisamos de tratar de uma parte importante: o consentimento informado. Este documento explica o que vamos fazer hoje e como os vossos dados vão ser

usados. Quero lembrar-vos que tudo o que partilharem será confidencial e apenas usado para fins deste estudo."

- "A participação é completamente voluntária, e se, a qualquer momento, quiserem parar ou não responder a alguma questão, podem fazê-lo sem problema. Por favor, leiam o documento com atenção e, se concordarem, assinem aqui. Se tiverem alguma dúvida, perguntem-me antes de assinarem. Estou aqui para ajudar!"

- Dividam-se em dois grupos de quatro elementos, por favor! Um começa com a testar a app e outro começa a testar o protótipo. Depois trocam!

3) Teste da **app** atual – **20 min**
Instruções Gerais: "Estes alunos vão começar com a versão atual da app. Vou pedir-vos para realizarem algumas tarefas consoante a história que vos vou contar agora."

- **Cenário** de uso: "Imaginem que a vossa turma está a participar numa atividade ao ar livre organizada por um professor vosso, e a app EduCITY vai ser usada para explorar o campus da Universidade de Aveiro de uma forma interativa. O objetivo é completar um jogo "EduCITY no Campus da UA" e descobrir mais sobre os espaços ao vosso redor enquanto respondem a perguntas. Quem acertar mais respostas, ganha!"

- **Tarefas a realizar**:
  - Abrir a app
  - Ver lista de jogos
  - Ver informações sobre o jogo "Teste UX/UI"
  - Descarregar jogo
  - Iniciar jogo
  - Responder às questões
  - Explorar recursos multimédia
  - Fazer scan da RA
  - Explorar ARBook
  - Terminar o jogo
  - Verificar as métricas do jogo
  - Testar modo livre

- **Interação durante o teste:**
  - Pedir aos participantes que falem em voz alta sobre o que estão a pensar ou sentir enquanto realizam as tarefas (método *think-aloud*).

  - Fazer perguntas exploratórias, se necessário:
    - "Conseguiste realizar as tarefas facilmente? Porquê?"
    - "O que é que te deixou confuso(a) ou foi difícil de entender?"
    - "O que mais gostaste?"

- **Questionário pós teste** (10 min):
  - Distribuir o questionário pós-teste com a escala AttrakDiff2.
  - Garantir que os participantes compreendem como preencher o questionário.
  - Garantir recolha de feedback adicional com as perguntas abertas.

4) Teste do **protótipo** – 20 min

Introdução ao protótipo: "Agora, vamos passar ao protótipo redesenhado. As tarefas serão semelhantes às da app atual (vai ter mais algumas), mas quero que se concentrem em notar diferenças e partilhar as vossas impressões."

- **Tarefas a realizar**:
  - Iniciar protótipo (ir para a página "Home")
  - Ver informação sobre o jogo "EduCITY no campus da UA"
  - Ver descrição do jogo "EduCITY no campus da UA"
  - Ver lista de jogos (página "Jogos")
  - Aplicar filtros "3.º CEB" e "Gafanha da Nazaré"
  - Selecionar jogo "Teste UX/UI"
  - Jogar (é necessário que participantes transfiram o jogo primeiro)
  - Iniciar jogo
  - Responder às questões
  - Ver recursos multimédia (não funcionais)
  - Fazer scan da RA
  - Explorar ARBook
  - Terminar o jogo
  - Verificar a métricas do jogo
  - Alterar foto de perfil (avatar – ir para página "Perfil")
  - Mudar avatar para a 5ª foto
  - Ver informações sobre o seu perfil (pontos, jogos, cidades)
  - Ver página "RA" (página "Modo Livre" na app) e explicar o que pode fazer nessa página

- **Interação durante o teste:**
  - Continuar a utilizar método *think-aloud*.
  - Perguntas exploratórias, se necessário:
    - "O que achaste desta versão, em comparação com a anterior?"
    - "O que é que te agradou ou desiludiu mais nesta versão?"

- **Questionário pós teste** (10 min):
  - Distribuir o questionário pós-teste com a escala AttrakDiff2 para protótipo **e perguntas comparativas**.
  - Garantir que os participantes compreendem como preencher o questionário.
  - Garantir recolha de feedback adicional com as perguntas abertas e comparativas.

5) **Conclusão** da Sessão – 5 min

Objetivo: Encerrar a sessão, agradecendo ao participante e reforçando a relevância do seu contributo.

Comentários Finais:

- "Alguém tem mais alguma coisa que gostasse de partilhar? Pode fazê-lo agora! Se, mais tarde, se lembrarem de alguma coisa importante, podem entrar em contacto comigo pelo email que está no formulário de consentimento ou pedir ao/à professor(a) para falar comigo."

Appendix 7 - Informed Consent Authorization Form used for Participants of the Comparative UX Tests

Consentimento Informado para Teste Comparativo

PARTICIPAÇÃO NO TESTE COMPARATIVO

Informação ao **Participante e Encarregado de Educação** e Consentimento Informado

Este documento é dirigido aos Encarregados de Educação dos participantes do Teste Comparativo. Mais se indica que, sem o consentimento do Encarregado de Educação para recolha e tratamento dos dados, não será permitida a participação do seu educando no estudo.

Por favor, leia com atenção a seguinte informação.

1. QUAIS OS OBJETIVOS DO ESTUDO?

Este estudo pretende:

1) Realizar testes comparativos de UX entre um protótipo (correspondente ao redesign da app) e a versão atual da app, avaliando a experiência de utilizador, especialmente em contextos educativos *outdoor*.

2) Melhorar a experiência de utilizador e o design da interface da app com base nas expectativas de especialistas, professores e alunos.

3) Desenvolver um protótipo não funcional como proposta de redesign para a app EduCITY, que reflita os insights das análises dos especialistas e das perceções dos utilizadores.

4) Aplicar uma investigação participativa baseada em metodologias de design relacionadas com o processo de melhoria de UX/UI, incluindo grupos focais com utilizadores finais, entrevistas com especialistas e professores, e comparação de cenários.

Adicionalmente, pretende responder à questão de investigação **"Podem as técnicas de design participativo, num processo de investigação, melhorar a perceção que estudantes do 3º ciclo têm da experiência de utilização da aplicação EduCITY?"**, tendo como objeto de estudo a **aplicação EduCITY** (https://educity.web.ua.pt/app.php).

2. QUEM ESTÁ A REALIZAR O ESTUDO?

O presente estudo está a decorrer no âmbito do projeto de Mestrado em Comunicação e Tecnologias Web de **Carolina Miguel Vidal Ferreira Baptista** (Universidade de Aveiro, Departamento de Comunicação e Arte). Este trabalho conta com a orientação do **Doutor Óscar Mealha** (Universidade de Aveiro, Departamento de Comunicação e Arte) e coorientação da **Doutora Lúcia Pombo** (Universidade de Aveiro, Departamento de Educação e Psicologia).

3. A QUEM SE DIRIGE O ESTUDO?

Para a concretização do presente estudo, pretende-se e solicita-se a participação de:

- Estudantes do 3º ciclo;
- Que saibam ler e compreender a língua portuguesa;
- Que sejam capazes de utilizar tecnologias.

4. EM QUE CONSISTE O ESTUDO?

O presente estudo assenta na realização de uma sessão de testes, na qual será solicitado ao seu educando que:

1) Realize um conjunto de tarefas solicitadas pela investigadora, na versão atual da aplicação EduCITY (https://educity.web.ua.pt/app.php) e no seu protótipo redesenhado pela investigadora no software de design de interfaces Figma (https://www.figma.com/);
2) Avalie, em termos de perceção de experiência de utilizador, a versão atual da aplicação EduCITY e o seu protótipo redesenhado;
3) Identifique falhas e melhorias na versão atual da aplicação EduCITY e no seu protótipo redesenhado;

O teste comparativo será realizado presencialmente, recorrendo a um **espaço exterior no recinto da escola,** depois de agilizado prévio agendamento, sendo expectável uma duração de **60 a 90 minutos**.

Nenhum participante usará o seu dispositivo móvel, uma vez que será a investigadora a facultar os aparelhos, com a app EduCITY já instalada. A app EduCITY não pede o nome do(s) utilizador(es) e não tem login/registo.

A informação será recolhida através de uma grelha de observação e questionário.

5. QUAIS AS CONDIÇÕES DE PARTICIPAÇÃO?

A participação do seu educando neste teste é totalmente **voluntária**, tendo direito a não querer participar. Se concordar em participar, poderá desistir em qualquer momento sem qualquer prejuízo para o seu educando. Caso queira desistir, a meio ou no final do teste, bastará dar indicação à entrevistadora dessa sua vontade, terminando esta toda a recolha de dados que esteja a realizar e apagando de imediato os conteúdos recolhidos até àquele momento.

6. QUAIS OS POTENCIAIS RISCOS E BENEFÍCIOS ASSOCIADOS À PARTICIPAÇÃO DO SEU EDUCANDO?

Não estão previstas quaisquer contrapartidas associadas à participação do seu educando. A investigadora recorda que o que está a ser testado são a aplicação e o protótipo, não a participação do seu educando, e que não há respostas certas nem erradas. Não estão previstas quaisquer contrapartidas associadas à participação do seu educando. Não se antecipam potenciais riscos ou benefícios diretamente associados à sua participação.

7. QUEM SÃO OS RESPONSÁVEIS PELO TRATAMENTO DA INFORMAÇÃO?

A responsável pelo tratamento dos dados é a Mestranda Carolina Baptista, contactável pelo email carolina.baptista@ua.pt.

8. COMO SERÃO TRATADOS OS DADOS DO SEU EDUCANDO?

Toda a informação recolhida ao longo deste estudo será tratada de forma confidencial e armazenada em local seguro, com acesso controlado e garantias de reposição em caso de falha.

Apenas a responsável acima identificada (ponto 7) terá acesso aos dados que podem identificar o seu educando. Todos os restantes elementos da equipa de investigação do projeto poderão ter acesso à informação depois de anonimizada.

Os dados pessoais não irão ser comunicados a nenhuma entidade externa nem há possibilidade de serem transferidos para países terceiros.
Não serão tornados públicos, de nenhuma forma, quaisquer dados/resultados que permitam a identificação do seu educando.

De forma a facilitar a análise da informação, a investigadora procederá ao registo de notas e gravação de áudio. Na análise da informação, o nome do seu educando será substituído por um código, de forma a que não seja possível a sua identificação.

A investigadora procederá à transcrição dos testes em formato anónimo no mais curto espaço de tempo possível, previsivelmente **2 a 4 semanas** após a sua realização, sendo, nesse momento, apagados os conteúdos previamente gravados que contenham informação pessoal relativa à pessoa do seu educando.

Os dados anonimizados e os resultados do estudo podem ser partilhados com revistas internacionais ao abrigo do movimento *opendata* e apresentados publicamente em congressos científicos e outras publicações.

Este estudo teve a aprovação do Encarregado de Proteção de Dados da Universidade de Aveiro, dando cumprimento ao Regulamento Geral de Proteção de Dados (RGPD), garantindo a segurança e confidencialidade de todos os dados facultados pelos participantes, em todas as fases do processo.

9. QUAIS OS SEUS DIREITOS E COMO PODE EXERCÊ-LOS?

Ao aceitar participar neste estudo e na qualidade de titular dos dados pessoais do seu educando, informa-se ainda que terá direito, enquanto aplicável (enquanto os dados pessoais do seu educando, incluindo gravações, não forem apagados), a:

a. Aceder aos seus dados e a receber informação sobre o processamento dos seus dados pessoais;
b. retificar quaisquer imprecisões sobre os seus dados pessoais durante o período de recolha ou de tratamento dos mesmos;
c. solicitar o apagamento dos seus dados pessoais;

Tal solicitação deve ser dirigida, por email, ao Responsável pelo tratamento de dados acima identificado (ponto 7), que deverá agir de acordo com as suas pretensões.

10. COMO SABER MAIS INFORMAÇÃO?

Caso deseje obter informações adicionais ou esclarecer qualquer dúvida sobre este estudo, poderá contactar a responsável pelo tratamento identificada no ponto 7.

Também, e se assim o entender, pode apresentar dúvidas ou colocar questões ao Encarregado de Proteção de Dados da Universidade de Aveiro, pelo email epd@ua.pt, ou através de carta dirigida ao Encarregado de Proteção de Dados, Universidade de Aveiro, Edifício da Antiga Reitoria, piso 4, Campus de Santiago, 3810-193, Aveiro.

Poderá ainda, e a qualquer momento, apresentar uma reclamação perante a autoridade responsável - Comissão Nacional de Proteção de Dados (CNPD), se entender que os seus direitos sobre os seus dados pessoais foram infringidos.

11. DECLARAÇÃO DE CONSENTIMENTO INFORMADO

Para que possa tratar os dados do seu educando, necessito do seu consentimento, que deve ser livre, explícito, inequívoco e informado. Nestes termos e presente toda a informação supra, muito agradeço que proceda à escolha da opção que melhor entenda:

☐ **Declaro, ao abrigo do RGPD e da LPDP, que dou o meu consentimento para a recolha e tratamento dos dados pessoais do meu educando, necessário à execução do projeto identificado.**

☐ **Declaro, ao abrigo do RGPD e da LPDP, que não dou o meu consentimento para a recolha e tratamento dos dados pessoais do meu educando.**

O presente formulário é assinado no dia: ____/_____/_____ em _____ (indicar o local em que assina o formulário)

_____

(Assinatura do Responsável pela Recolha dos dados, conforme documento de identificação)

_____

(Assinatura do Encarregado de Educação, conforme documento de identificação)

_____

(Assinatura do Participante, Titular dos dados, conforme documento de identificação)

Agradeço a sua atenção.

Appendix 8 - Post-Test Questionnaire about the EduCITY App

Questionário Pós Teste sobre a app EduCITY

APP EDUCITY

Código do Participante: _____

Este questionário tem como objetivo avaliar a tua experiência com a app EduCITY. O questionário é anónimo e os dados são tratados apenas para fins educativos e científicos. Não há respostas certas ou erradas. O que importa é a tua opinião!

Por favor, responde às perguntas seguintes, assinalando uma única resposta para cada questão. Muito obrigada!

Nota sobre a Escala AttrakDiff2:
Esta escala mede diferentes aspetos da experiência do utilizador, usando pares de palavras opostas. Assinala com um **X** o ponto da escala que melhor representa a tua opinião, onde **o número 3 da esquerda significa que concordas totalmente com a palavra da esquerda, e o número 3 da direita significa que concordas totalmente com a palavra da direita. O número 0 representa neutralidade ou um meio-termo entre as palavras.**

Exemplo:

(3)	(2)	(1)	(0)	(1)	(2)	(3)
○	○	○	○	○	○	○
Concordo totalmente com a palavra da esquerda	Concordo bastante com a palavra da esquerda	Concordo ligeiramente com a palavra da esquerda	Neutro ou meio-termo	Concordo ligeiramente com a palavra da direita	Concordo bastante com a palavra da direita	Concordo totalmente com a palavra da direita

Secção 1: Qualidade Pragmática (PQ)
Esta dimensão avalia o quão útil e funcional a app é para atingires os teus objetivos.

		(3)	(2)	(1)	(0)	(1)	(2)	(3)	
1	Próxima do homem	○	○	○	○	○	○	○	Próxima da tecnologia
2	Simples	○	○	○	○	○	○	○	Complicada
3	É possível usar	○	○	○	○	○	○	○	Não é possível usar
4	Compreensível	○	○	○	○	○	○	○	Não compreensível
5	Previsível	○	○	○	○	○	○	○	Imprevisível
6	Bem estruturada	○	○	○	○	○	○	○	Confusa
7	Fácil de controlar	○	○	○	○	○	○	○	Difícil de controlar

Secção 2: Qualidade Hedónica de Identificação (HQ-I)
Esta dimensão avalia a capacidade da app se alinhar com os valores ou a imagem do utilizador.

		← (3)	(2)	(1)	(0)	(1)	(2)	(3) →	
8	Que estabelece ligação com as pessoas	○	○	○	○	○	○	○	Que não estabelece ligação com as pessoas
9	Profissional	○	○	○	○	○	○	○	Não profissional
10	Elegante	○	○	○	○	○	○	○	Vulgar
11	De primeira qualidade	○	○	○	○	○	○	○	De baixa qualidade
12	Integradora	○	○	○	○	○	○	○	Alienante
13	Aproxima-me das pessoas	○	○	○	○	○	○	○	Afasta-me das pessoas
14	Apresentável	○	○	○	○	○	○	○	Não apresentável

Secção 3: Qualidade Hedónica de Estimulação (HQ-S)
Esta dimensão avalia o quão bem a app estimula a curiosidade, o desenvolvimento pessoal e a aquisição de novas competências, proporcionando uma experiência envolvente e cognitivamente estimulante.

		← (3)	(2)	(1)	(0)	(1)	(2)	(3) →	
15	Inventiva	○	○	○	○	○	○	○	Convencional
16	Criativa	○	○	○	○	○	○	○	Sem imaginação
17	Ousada	○	○	○	○	○	○	○	Cautelosa
18	Inovadora	○	○	○	○	○	○	○	Conservadora
19	Cativante	○	○	○	○	○	○	○	Aborrecida
20	Desafiadora	○	○	○	○	○	○	○	Pouco exigente
21	Novidade	○	○	○	○	○	○	○	Comum

Secção 4: Perguntas Adicionais

1. O que mais gostaste na app?

_____
_____
_____
_____

2. O que mudarias ou melhorarias na app?

_____
_____
_____
_____

3. Achas que esta app te ajudaria a aprender de forma divertida? Porquê?

_____
_____
_____
_____

Appendix 9 - Post-Test Questionnaire about the Prototype

Questionário Pós Teste sobre o protótipo

PROTÓTIPO

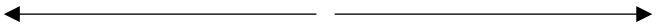
Código do Participante: _____

Este questionário tem como objetivo avaliar a tua experiência com o protótipo EduCITY. O questionário é anónimo e os dados são tratados apenas para fins educativos e científicos. Não há respostas certas ou erradas. O que importa é a tua opinião!

Por favor, responde às perguntas seguintes, assinalando uma única resposta para cada questão. Muito obrigada!

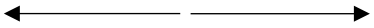
Nota sobre a Escala AttrakDiff2:
Esta escala mede diferentes aspetos da experiência do utilizador, usando pares de palavras opostas. Assinala com um **X** o ponto da escala que melhor representa a tua opinião, onde **o número 3 da esquerda significa que concordas totalmente com a palavra da esquerda, e o número 3 da direita significa que concordas totalmente com a palavra da direita. O número 0 representa neutralidade ou um meio-termo entre as palavras.**

Exemplo:



(3)	(2)	(1)	(0)	(1)	(2)	(3)
○	○	○	○	○	○	○
Concordo totalmente com a palavra da esquerda	Concordo bastante com a palavra da esquerda	Concordo ligeiramente com a palavra da esquerda	Neutro ou meio-termo	Concordo ligeiramente com a palavra da direita	Concordo bastante com a palavra da direita	Concordo totalmente com a palavra da direita

Secção 1: Qualidade Pragmática (PQ)
Esta dimensão avalia o quão útil e funcional o protótipo é para atingires os teus objetivos.



		(3)	(2)	(1)	(0)	(1)	(2)	(3)	
1	Próximo do homem	○	○	○	○	○	○	○	Próximo da tecnologia
2	Simples	○	○	○	○	○	○	○	Complicado
3	É possível usar	○	○	○	○	○	○	○	Não é possível usar
4	Compreensível	○	○	○	○	○	○	○	Não compreensível
5	Previsível	○	○	○	○	○	○	○	Imprevisível
6	Bem estruturado	○	○	○	○	○	○	○	Confuso
7	Fácil de controlar	○	○	○	○	○	○	○	Difícil de controlar

Secção 2: Qualidade Hedónica de Identificação (HQ-I)
Esta dimensão avalia a capacidade do protótipo se alinhar com os valores ou a imagem do utilizador.

		(3)	(2)	(1)	(0)	(1)	(2)	(3)	
8	Que estabelece ligação com as pessoas	○	○	○	○	○	○	○	Que não estabelece ligação com as pessoas
9	Profissional	○	○	○	○	○	○	○	Não profissional
10	Elegante	○	○	○	○	○	○	○	Vulgar
11	De primeira qualidade	○	○	○	○	○	○	○	De baixa qualidade
12	Integrador	○	○	○	○	○	○	○	Alienante
13	Aproxima-me das pessoas	○	○	○	○	○	○	○	Afasta-me das pessoas
14	Apresentável	○	○	○	○	○	○	○	Não apresentável

Secção 3: Qualidade Hedónica de Estimulação (HQ-S)
Esta dimensão avalia o quão bem o protótipo estimula a curiosidade, o desenvolvimento pessoal e a aquisição de novas competências, proporcionando uma experiência envolvente e cognitivamente estimulante.

		(3)	(2)	(1)	(0)	(1)	(2)	(3)	
15	Inventivo	○	○	○	○	○	○	○	Convencional
16	Criativo	○	○	○	○	○	○	○	Sem imaginação
17	Ousado	○	○	○	○	○	○	○	Cauteloso
18	Inovador	○	○	○	○	○	○	○	Conservador
19	Cativante	○	○	○	○	○	○	○	Aborrecido
20	Desafiador	○	○	○	○	○	○	○	Pouco exigente
21	Novidade	○	○	○	○	○	○	○	Comum

Secção 4: Perguntas Adicionais

1. O que mais gostaste no protótipo?

_____

_____

_____

_____

2. O que mudarias ou melhorarias no protótipo?

_____
_____
_____
_____

3. Achas que este protótipo te ajudaria a aprender de forma divertida? Porquê?

_____
_____
_____
_____

Appendix 10 - Table with the Main Insights of the Focus Group Participants' Feedback

Comentários dos Alunos		
Expectativas	**Comparação com expectativas**	**Discussão de melhorias**
alguns alunos disseram preferir uma app com pessoas e não bonecos (algo mais sério) + alunos gostaram mto da ideia de criar a sua própria personagem (um avatar); se for um boneco, não pode ser infantil (tipo personagens do fortnite ou freefire)	jogo tem mais texto do que estavam à espera	acrescentar níveis, moedas, leaderboards ... PBL + ter tempo limitado para responder (dificuldades - ex: nível 1 tinha mais tempo para responder e nível 2 ter menos) + ter um avatar (ex: flamingo) que pudessem personalizar: se houvesse leaderboard, era esse boneco que aparecia + pontos converterem-se em moedas que os deixavam comprar roupas/acessórios para personalizar o avatar + ganhar badges/conquistas (ex: acertou x perguntas)
a maior parte imagina-se a jogar sozinho ou com os amigos. Alguns participantes imaginam-se a jogar com os pais. **Quando estivessem a jogar com amigos, cada um estaria no seu telemóvel e não em grupo**	alguns alunos admitiram que app está mais desenvolvida do que eles achavam	ter algo que torne btn mais chamativo: cores/imagem e que torne mais óbvio que é um btn e não um símbolo
colaborativo (gostam da ideia de colaboração/competitividade): ter uma "sala" onde pudessem estar todos a jogar juntos, mas cada um no seu telemóvel - ex:brawlstars (com skins e modos de jogo + salas de amigos)		
"gostamos de juntar os amigos e jogar uns contra os outros"		
tabelas de rankings, "tipo kahoot" (top 3 com os pontos)	gostam do conceito, mas acham queo jogo pode tornar-se secante, "não dá aquela vontade de jogar novamente"	mudar localização do btn ou ARBook fixar sozinho (1 dos alunos achou que se ARBook fixasse sozinho, ele iria perder imersão)
imaginam-se a jogar a este tipo de apps em tempo de aula pq acaba por ser diferente e mais interessante de aprender do que estar sentada na mesa a ouvir o professor falar	gostaram do ecrã de resultados por fazer um resumo do que tinha sido o jogo de cada um e por estar bem organizado	acesso à localização para sugerir jogos que estejam próximos da área onde utilizador se encontra - secção "Recomendados/jogos perto de si"
poder escolher o nível de dificuldade com base no ano de escolaridade	btn RA: alguns alunos perceberam que era suposto clicarem e outros não perceberam, achavam que era um símbolo	todos concordaram que a app podia ter mais animação ao interagir com a mesma - ex: ao tocar nos botões
"no perfil, ter medalhas à medida que iamos ganhando pontos e jogando" - deu-se o exemplo das divisões no duolingo	btn fixar ARBook: 1 aluno percebeu que era um btn, outros não perceberam e houve alunos que nem viram o btn	ter uma música de fundo
inicialmente, estavam a pensar em jogos que dessem para alunos do 1º ao 12º anos, e só mudava o nível de dificuldade, consoante o ano de escolaridade	para todos os alunos, foi fácil entender onde deviam clicar para navegar na app	no leitor de vídeo, poder fechar vídeo para responder qnd já sabem a resposta OU vídeos mais curtos
tmb surgiu ideia de ao abrir app pela 1ª vez, escolher logo nível de escolaridade e adaptar conteúdo consoante o ano escolhido (apesar de quererem ver, de qql maneira, os jogos dos outros anos) + app mudar automaticamente ano de escolaridade qnd fosse um novo ano letivo	todos concordaram que era intuitivo distinguir perguntas com 1 opção de resposta das perguntas com várias	todos concordaram em ter feedback sonoro qnd se acerta ou erra resposta
no fim do jogo, ter acesso a um ecrã com classificações gerais (pontos, respostas certas, respostas erradas) + poderem ver correção das respostas à medida que forem respondendo	ser apenas quizz pode ser secante	aspeto da app: user poder escolher o tema (dark, light, glass, ...)
inicialmente, estava reticentes com uso de RA		entre vídeos, imgs e RA, preferem a RA , MAS tmb gostaram muito do áudio
"À medida que o utilizador responde corretamente, ganha moedas que dps pode usar para comprar um chapéu para o seu avatar"		ter uma modo extra para dar extra pontos, em que apareciam perguntas flash a que utilizador tem de responder o mais rápido possível (tipo ronda joker no jogo joker)
"tirar uma foto corpo inteiro e o jogo fazer o meu avatar"		
personalizar o meu avatar - ex: altura, cor, acessórios		
poder ver lista de jogos consoante a minha localização		
"gostava de poder escolher a matéria das perguntas" ou um "filtro, onde aparecem todas as matérias que há ou o nosso ano de escolaridade e nós selecionamos as que queremos"		
"e são só perguntas da matéria da escola ou pode ter perguntas da região? Seria bom" + "e perguntar sobre as árvores" + "acho mto importante aprender sobre coisas q não sejam da escola, como monumentos, a história, edifícios, regiões"		
"apps com jogos para jogar com os amigos são sempre fáceis de perceber, mas as apps para criar coisas para a escola tendem a ser muito mais difíceis de utilizar" + "às vezes as apps só estão em inglês e eu não sei mto de inglês" + "quando tenho de trabalhar em alguma coisa para a escola, por exemplo no canva, às vezes eu clico em botões a achar que vai acontecer uma coisa e acontece outra completamente diferente do que eu estava à espera" + "para mim, quanto mais texto tem, mais difícil é de perceber" + "**eu acho que uma ótima ideia seria ter um tutorial para a primeira vez que se usa a app**"		
"ter vidas em cada jogo e à medida que se errava, perdia vidas" - "na minha opinião, por um lado, qnd um jogo é fácil demais ou erramos e não acontece nada, o jogo fica aborrecido/cansativo e paramos de jogar; por outro lado, qnd o jogo é super difícil, as pessoas tmb se cansam de nnc conseguir fazer nada"		
se for para ser jogado na escola, os alunos preferiam abordar temas de matéria dada nas aulas; se for fora, aplicar a matéria da escola na zona que estão a visitar		
participantes acham que seria mais interessante usar a app do que estar na sala a estudar para aprender, pq seria divertido tmb (ou dar matéria na sala e aplicá-la na app, como se fossem exercícios) - disseram tmb que teriam mais vontade de aprender ao usar a app pq seria mais divertido --> **app como ferramenta para consolidar aprendizagens**: "podíamos usar a app em vez de fazer fichas de exercícios"		
"seria fixe um mesmo jogo ter diferentes níveis de dificuldade: fácil, médio e difícil; e cada utilizador escolhia o nível que queria"		
Estilos de UI: (falaram de usar cores mais vivas) 1- A (acharam B mto infantil, mas A talvez demasiado sério) 2- B (disseram que B era mais estilo duolingo e gostaram disso, acharam B mais organizada "dá para perceber melhor onde temos de ir buscar as coisas") 3 - ficaram divididos entre A e B (alguns disseram que B parecia demasiado app de casino online "parece que querem que eu aposte dinheiro e eu não vou receber nada" + gostaram de A parecer mais simples e ter aspeto de app educativa: "deixa-te num espaço de conforto, ao contrário da outra que tem muita coisa a acontecer") - 2 alunos disseram que têm tendência a usar o dark mode 4 - A, por parecer app educativa. B parece um jogo de armas 5 - A (acharam a A "**perfeita**" e a B mto infantil). Gostam dos avatars, das cores e do layout, em geral.		

Appendix 11 - Table with the Main Insights of the Teachers' Feedback

Análise Crítica		Discussão de Melhorias	
T1	**T2**	**T1**	**T2**
Contexto de uso ideal: visita de estudo a lugar combinado ou recreativamente com a família. Para a escola, ter um jogo educity envolve muito trabalho e preparação.	**Contexto de uso ideal:** "pensando na app para educação, autonomamente não; imagino a app numa **aula fora da sala de aula ou numa visita de estudo."** + "Podem jogar individualmente, mas sempre numa ótica educacional, aliado ao ensino e orientação do professor, que dps pode ter acesso às estatísticas do jogo" + "esta app fornece-nos algo mais estruturado: a app proporciona informação relevante e estruturada a qualquer pessoa, in loco" + "para mim, em contexto escolar, a app funciona como algo orientado em termos de visita de estudo: os alunos vão, visitam, recolhem informação, respondem às questões orientadas"	Grafismo das caixas de resposta: ter cores distintas, opções de formação do texto que permitam criar contrastes.	"seria interessante distinguir melhor a pergunta do resto do texto"
Idealmente, deve-se apostar em jogos que possam ser utilizados mais vezes e replicados - ex: locais com oferta pedagógica (museus, associações, instituições)	"para mim, esta app foi muito interessante porque me permitiu trabalhar a verticalidade do ensino: os meus alunos do **12º** estão a fazer jogos para os do 11º ano, ou seja, estão a proporcionar aprendizagens aos colegas mais novos e trabalham como se fossem colegas meus"	Destacar o texto de feedback "está certo/errado"; algo que o permita distinguir do texto de feedback complementar + alterar ordem destes textos (1º certo/errado e dps porquê)	"para mim, seria mto interessante haver um nickname (tendo atenção às questões do rgpd) associado a cada telemóvel para poder avaliar os resultados de cada um e identificar o grupo"
Para ser usada em contexto de aula, os jogos deveriam abordar matéria que seja segura que continuará a ser abordada no futuro, para que o jogo se mantenha atual e possa continuar a ser utilizado por alunos nos anos seguintes		dps de responder a pergunta com RA, voltar a deixar explorá-la na página de feedback. Alguns dos alunos queriam revê-la e não conseguiam pq ela já não estava disponível	"parece-me bem adicionar um btn de submissão de resposta pq depois não se consegue voltar atrás"
Desafios sentidos pelos alunos ao usar app: "os grandes constrangimentos estiveram relacionados com o facto de os alunos terem começado a responder sem estar no local, a ligação à internet." + "O que eles não perceberam sem explicação foram as RAs. O botão não lhes despertou curiosidade, tivemos de ser nós professores a alertá-los para o uso da RA. O mesmo aconteceu qnd estávamos na formação, em que não percebemos que era um botão" + Alunos têm tendência a ser precipitados, querem simplesmente carregar nos botões: têm tendência a não ler as perguntas	**Desafios sentidos pelos alunos ao usar app:** "o maior problema dos alunos foi a bateria" + "os alunos não lêem as informações" + "quando pergunta tem mais que 1 opção de resposta, não liam essa informação e só selecionavam 1" + apesar de estarem entusiasmados, alunos focavam-se no 1º lugar e acabavam por não prestar atenção à informação	Destacar o btn RA/torná-lo mais intuitivo para o utilizador, "mensagem a dizer 'clica aqui'" (ideia de **tutorial**) + jogo só deixar responder à pergunta se utilizador estiver no local devido (mas reconhece que não seria uma solução prática e que depende altamento do contexto educativo/recreativo em que jogo estiver a ser utilizado)	
"Ainda bem que a plataforma limita o texto que pode ser utilizado pq, se não, nós escrevíamos textos enormes"	"ao experimentar app, os alunos estavam animados e queriam acertar às perguntas " + "gostaram da forma como aparecem os conteúdos: ao realizar o jogo, já começaram a sentir o potencial da app"	qnd só tem 1 opção de resposta, ter btn de confirmar/submeter para validar opção	
"Acho que a app tem todo o potencial para evoluir e pensar no que é necessário para ela evoluir é uma mais-valia com esta experiência que nós vamos tendo"	acha que app tem potencial para potenciar aprendizagens no exterior: "os alunos dizem que ver as imagens num manual ou estar in loco a ver o ponto de interesse é totalmente diferente. Ao ter perguntas na app que perguntam sobre aquilo que estão a ver em concreto, ainda ajuda a que se torne mais interessante" (estar inseridos no contexto faz toda a diferença e isso nota-se no entusiasmo dos alunos) **--> isto tmb se torna um incentivo para os professores utilizarem a app educity**	"eu sinto que a aplicação é um bocadinho quadrada, tem muitas caixas: torná-la um pouco mais agradável, mais dinâmica" + "alterar as linhas quadradas e os ângulos retos" + "o cor-de-rosa é um pouquinho intenso no sentido em que é muito usado: uma palete mais variada seria mais interessante"	
"Foi uma experiência mto interessante pq nos obrigou a pensar e a ver mais longe do que se fosse um quizz qualquer"	"a app educity é uma mais-valia pq permite a qql pessoa jogar jogos, já feitos e validados por outros professores, e aplicá-los na sua turma" + "na minha escola, vamos tentar motivar os outros professores a usarem o jogo com as suas turmas. Se o jogo não estiver publicado, podemos sempre usar o código, que disponibiliza o jogo para quem o tiver"	"saber o circuito e duração/distância aproximadas a percorrer no jogo tmb poderia ser muito interessante" + "essa infromação pode influcenciar eu fazer o jogo ou não"	
"se fossem individualmente, mas estando próximos dos outros a jogar, penso que a colaboração iria surgir naturalmente" + "mas acho que faz mais sentido jogarem em grupos de 2 ou 3" + "penso que os pequenos grupos são os mais vantajosos para a aprendizagem"	"não tenho como identificar os alunos: vou ter de tirar uma foto ao grupo com o telemóvel para saber quem estava a utilizá-lo"	"dividir o texto em diferentes fases, permitindo ao utilizador voltar atrás para ver o que está escrito tmb seria mto bom" **(chunking)**	
alunos tiveram tendência a ver RA mto rápido, não levavam o seu tempo a explorá-la	"por vezes, o btn de RA fica escondido pq o texto é demasiado longo"		
alunos precipitados ou toque acidental nas opções de resposta leva a respostas erradas não intencionais	"é muito positivo poderem descarregar o jogo que querem previamente e não terem de usar a net enquanto jogam.		
alunos jogarem fora do contexto escola irá depender do tema do jogo (ex: desporto) e desse tema ser ou não do agrado dos alunos. **"acho que a app pode facilmente ir além daquilo que é a escola"** - ex: com câmaras municipais, juntas de freguesia, empresas			

Appendix 12 - Table with the Main Insights of UX/UI Experts' Feedback and Highlights of Focus Group Participants' Comments About Each App Screen

Ecrã/ Componente	Comentários dos Designers		Comentários dos Alunos	Observações Gerais (padrões comuns, problemas críticos)
	Designer 1 (D1)	Designer 2 (D2)		
1 (aviso aos utilizadores)	Não é apelativo: é só texto e um botão. **SUGESTÕES:** logotipo da app	"este ecrã é fácil de ler, contudo, tendo em conta o p. a., acho que poderia ser mais dinâmico e não ser só texto" SUGESTÕES: ter imagens, animações, ... ser um pop-up em vez de ser um ecrã todo preto	não gostaram do ecrã escuro só com letras	
2 (pop up com download de conteúdo RA)	pop up não tem margem suficiente: texto está demasiado apertado SUGESTÕES: largura do pop up ser igual à largura dos botões da home page			
3 (loader)	"este loader não está centrado" SUGESTÕES: centrar loader verticalmente + ter uma animação com o flamingo em vez do círculo	gosta do loader, acha-o "fofinho" SUGESTÕES: centrar loader verticalmente		
4 (home page)	"afinal acho melhor que estes botões fiquem da largura do pop-up, parecem muito esticados" "logotipo está grande e quase no limite do ecrã" "tem muito botão" "não sei o que é créditos" SUGESTÕES: ter mais espaço negativo em baixo e em cima por causa das diferentes dimensões dos telemóveis + tentar reduzir número de botões ao esconder alguns ou tentar organizar melhor a hierarquia (ex: novo jogo e modo livre num mesmo botão e só no ecrã seguinte é que user escolhe o que quer) + tutorial para 1ª vez que se entra na app e o btn "como jogar" ficar escondido + botões "pontuações, créditos, política de privacidade e sair" passarem para uma área de **perfil** e adicionar btn "apagar conta" +"política de privacidade tem de estar na app"	todos os botões têm a mesma hierarquia "e acho que não deve ter todos a mesma hierarquia" - "quero começar um novo jogo e sou obrigada a ler todos os botões em vez de ser óbvio como concretizar o meu objetivo". Btns "créditos" e "política de privacidade" não são assim tão interessantes para quem está a jogar nem é preciso tê-los tão evidentes. Btn "sair" está ao mesmo nível do btn "novo jogo", não acho que faça sentido. Acha que "novo jogo" não é intuitivo o suficiente para perceber para onde btn direciona jogador: "o que me dá a entender é que é um único jogo (...) nunca teria percebido/pensado que era uma lista de jogos" SUGESTÕES: "pontuações" e "como jogar" podiam ser ícones e não botões: como jogar + poderia ser um "?" ou "i" + para sair ter um ícone + mudança de linguagem em "settings" e não na home page +btns "novo jogo", "modo livre" e "pontuações" serem os mais evidenciados/com mais destaque + "créditos" e "política" serem os menos evidenciados + btn "sair" não estar sequer presente na página + flamingo pode ter o destaque que tem, mas logotipo EduCITY ficar mais pequeno + fundo sólido + sugestão para nome de btn "novo jogo": "avançar"/"iniciar"/"lista de jogos"	1 dos alunos afirmou gostar do background, por combinar com a mascote, os restantes não gostaram e dizem preferir tons pastel + alunos falaram da possibilidade de ter um avatar ou personalizar o flamingo (ex: com acessórios) + dps de algum tempo, todos perceberam que deviam clicar no btn "novo jogo", mas qnd leram pela 1ª vez, alguns acharam que era para serem eles a criar um jogo de raiz. Todos concordaram que seria mais intuitivo se btn tivesse nome "lista de jogos"	Clarity: Nem smp é claro o que o btn "Novo jogo" significa: D1: "parece que ou só há 1 jogo na app e vai-me mandar diretamente para esse jogo ou vai-me mandar para uma lista com os jogos todos" hierarquia: btns têm todos o mesmo peso e cor, sendo 7, são demasiados elementos com a mesma hierarquia, não fazendo distinção entre eles
5 (lista de jogos)	"não parece um ecrã de jogos, parece um ecrã com muito conteúdo, super mini" campo de inserir código: extremamente grande, comparado com a dimensão dos items da lista e demasiado em baixo, a border é mto pequena considera insuficiente a única info que vê do jogo ser o nome ao tentar apagar jogo da lista: "este apagar é mto esquisito" SUGESTÕES: passar botões do menu inicial para ícones e fazer uma nav bar ter imagens como capa cada jogo para perceber qual o tema "quadradinhos com imagens, típico de jogos"	percebeu bem a distinção entre "jogos para descarregar" e "pronto a jogar" + considera que a interface está demasiado carregada com conteúdo. Gosta das ondinhas. secção de "inserir código" - tipografia diferente da restante, input tem cantos retos qnd tudo o resto é redondo, não acha que faça sentido ser um overlay por cima dos jogos. Não percebeu o que é que o código privado era. Acha cada card de jogo tem a tipografia demasiado pequena, especialmente pensando que app é para ser utilizada no exterior. Não gostou do alinhamento e posição que cada btn dentro do card de jogo tem. Btns de cada card de jogo: "i" não tem a mesma linha estética/estilo de ícone que os restantes (lixo, play e descarregar) "este ecrã tem um background azul, não entendo pq é que tem uma caixa branca a tapá-lo" Percebeu facilmente o significado de cada btn Acha que linha estética de **apagar jogo** está desfasado do estilo da app: btn "sim" a vermelho e "não" a verde confunde. SUGESTÕES: inserir secção do código de forma a ficar incorporada, como se fosse uma 3ª categoria (na mesma hierarquia que "pronto a jogar" e "jogos para descarregar"), não em overlay + associar cores a áreas diferentes - ex: vermelho matemática, azul português + aumentar tipografia de cada card de jogo, para que btns e texto possam respirar e ter mais legibilidade + colocar "pronto a jogar", "jogos para descarregar" e "jogo privado" numa lista (tipo dropdown) e utilizador abre apenas aqueles que quer; dps de clicar no dropdown, ter jogos em mosaico e não lista (questionou como faria nesse caso para apagar jogos) + OU ter as 3 categorias com 1 ou 2 cards de cada jogo e btn "ver mais" que redireciona user para nova pág. com todos os jogos + escolher uma única forma para confirmar descarregar e apagar jogos: ou pop-up ou no próprio card de jogo - se jogos continuarem em lista, o apagar pode ser com drag, como se faz nas mensagens	"Este ecrã está bom, mas mudava as cores" Não colocariam imagens para associar a cada jogo (tipo thumbnail) Todos perceberam facilmente o que era o btn de descarregar jogo SUGESTÕES: temas distintos com esquemas de cores e estilos diferentes (dão exemplo do chess.com)	Consistência: ao descarregar jogo, surge um pop-up, mas ao apagar não, os btns SIM/NÃO aparecem no próprio card Convenções: btn "não" a verde e "sim" a vermelho confunde

Ecrã/ Componente	Comentários dos Designers		Comentários dos Alunos	Observações Gerais (padrões comuns, problemas críticos)
	Designer 1 (D1)	Designer 2 (D2)		
6 (ecrã de informação sobre jogo)	"estes ícones estão todos desalinhados, nada integrados" SUGESTÕES: alinhar altura dos ícones com altura do texto, espaçá-los igualmente	qnd clicou no btn "i", fez um som de surpresa: "estava à espera de uma descrição mais concreta do jogo, por exemplo, por onde é que eu vou andar, uma espécie de sinopse como os filmes têm" "acho a informação que conta sobre cada jogo bastante interessante. Os autores... depende... como jogador não me interessa tanto" ícones não estão alinhados: uns parecem maiores que outros, stroke diferente entre eles "não parecem ser da mesma biblioteca de ícones" acha que ícones e label ajudam a interpretar significado do ecrã, apesar de label estar pequena SUGESTÕES: prefere que tamanhos fiquem uniformes, mesmo que seja necessário fazer scroll aumentar tamanho da label do ícone para ficarem do mesmo tamanho + acrescentar uma sinopse e os pontos de interesse (sugeriu ver como sites de *escape rooms* fazem) + colocar o mesmo espaçamento entre títulos/secções + remover campo de "código privado", nesta página não faz sentido, só ocupa espaço que pode ser útil para inserir nova informação	"Muitas coisas das que nós dissemos já estão aqui: disciplinas, RA, nº de pontos de interesse, autores". Disseram que não colocariam mais informação	consistência: botões com espaçamentos e linha visual diferentes; tipografia adota diferentes formas e tamanhos: apenas maiúsculas, minúsculas, mistura; espaçamentos entre secções estão diferentes
7 (pop-up de descarregar jogo)		Parece demasiado flat SUGESTÕES: ver como Apple ou Airbnb fazem Texto sobre tamanho do jogo devia estar mais pequeno que a pergunta ter um título para o pop up, texto e distinção entre botões		evitar erros: não há distinção entre o botão de Sim e Não, são iguais: cor/tamanho (não têm de ser verde/vemelho, mas devem ser distintos pq levam a caminhos diferentes) hierarquia: texto sobre tamanho do ficheiro deveria ser mais pequeno que pergunta
8 (página de introdução com flamingo)	texto demasiado longo "não adoro a barra de baixo" SUGESTÕES: chunking: "seria mais interessante o texto aparecer aos bocadinhos", ou ir aparecendo aos poucos (animado) ou aparecer/sair (com som de teclas a escrever)	"continuo a achar q podia estar mais dinâmico" texto demasiado longo e corrido: "miúdos de hj em dia vão passar à frente, sem ler", "é muita informação ao mesmo tempo" SUGESTÕES: Repartir texto em diferentes passos (chunking), como se fosse um onboarding com ícones e/ou animações, um story/tiktok pq "já estão habituados a ter essa interação" neste ecrã não ter a barra inferior		consistência: botões com espaçamentos diferentes
9 (intro ponto de interesse)	não entendeu o que era o ponto de interesse, disse que precisava de mais contexto não entendeu hierarquia entre ponto de interesse e instruções da introdução SUGESTÕES: ter smp img do ponto de interesse para contextualizar o utilizador; e/ou mapa com direções	demorou mto tempo a ver a parte a azul (nome do pto de interesse) "para mim, o ponto que tem mais destaque neste ecrã é o flamingo. Tudo o que está acima é como se não importasse e o que está abaixo já é importante" SUGESTÕES: colocar imagem do local + passar img do flamingo para cima e deixar mais central info sobre local ter uma espécie de checklist/animação com os locais por onde vai passar, qnd terminasse todas as perguntas, dava check		
10 (pergunta com 1 opção de resposta certa)	não gosta do scroll e não percebeu que o podia fazer desde o início acha que em determinados ecrãs, há demasiado texto, algumas opções de resposta ficam escondidas. Acha que o espaço superior do ecrã está mal utilizado e a ocupar demasiado espaço questiona se ver o nome do jogo enquanto joga é necessário qnd ecrã tem uma imagem, não percebeu que a podia abrir e ampliá-la: "não tem btns de aumentar nem nada". "Quando opções de resposta têm mto texto, ficam estranhas, os botões parecem esmagados" SUGESTÕES: pergunta estar inserida num chat, como se fosse o flamingo a enviar a pergunta via mensagem, com a pergunta num balão de fala num chat: aparecer 1ª msg com intro, dps conteúdo multimédia noutra msg, dps pergunta e opções + ecrã parecer um chat/uma conversa - ou apenas a fala do flamingo e pergunta em chat (como no duolingo) + todas as opções devem estar visíveis na posição inicial do ecrã: em último caso, colocar transparência na barra de baixo para se ver que há algo por trás + icones ou parte deles que estão na barra de baixo passarem para cima + limitar caracteres das opções de resposta	ponto de interesse acaba por ter mais destaque que a pergunta Não percebeu o que era RA achou texto demasiado corrido, o que dificulta a leitura (direções e introdução devem estar distintos) "falta o submeter" qnd opções de resposta têm mto texto: não há espaçamento entre linhas, btns parece, todos iguais "tenho de me esforçar imenso para perceber qual é a diferença entre eles" intro da pergunta: "muito texto, muito junto, demasiada informação ao mesmo tempo, não consigo reter a informação" SUGESTÕES: evidenciaria mais a pergunta, dar contraste entre pergunta e introdução perguntas só com 1 opção de respostas tem de funcionar da mesma forma que perguntas com várias opções texto dos btns não estar centrado organizar texto de outras formas: destacar a bold, usar tópicos	"estão um bcd longos estes textos"	intuitivo: scroll não está intuitivo visibilidade: qnd o texto é longo, algumas opções de resposta ficam escondidas mancha de conteúdo demasiado grande em baixo e espaço superior mal utilizado consistência: a submissão das perguntas com 1 opção de resposta certa e as que têm mais que 1 comportam-se de forma diferente legibilidade: texto demasiado corrido e por vezes demasiado longo, o que dificulta leitura

Ecrã/ Componente	Comentários dos Designers		Comentários dos Alunos	Observações Gerais (padrões comuns, problemas críticos)
	Designer 1 (D1)	Designer 2 (D2)		
11 (feedback resposta correta)	SUGESTÕES: não usava btn para ver vídeo, colovaca vídeo a passar automaticamente	acha que barra de baixo ocupa demasiado espaço texto justificado torna-se mais difícil de ler SUGESTÃO: colocar um balão de fala do flamingo para dizer "certo/errado" texto alinhado à esquerda	gostaram de poder perceber pq é que resposta estava certa ou errada	
12 (feedback resposta errada)	"jogo diz **resposta errada** duas vezes, o que é super frustrante para o utilizador" "não me lembro no que acabei de clicar" SUGESTÕES: dps de escolher opção de resposta, permanecer no ecrã com as opções e mostrar opção que escolheu a vermelho ou verde (resposta certa ou errada) e feedback nesse mesmo ecrã --> ex: duolingo	acha que ordem por que feedback surge (1° explicação, dps certo/errado) está mal questiona pq é que o feddback certo/errado e o explicativo se apresentam de maneiras diferentes (um está num card e o outro não tem background) SUGESTÕES: qnd escolhe resposta, ter feedback direto (ficar vermelho/som) no ecrã em que assinalou resposta e feedback no ecrã seguinte OU overlay no mesmo ecrã com certo/errado + feedback +feedback certo/errado estar a negrito e aparecer antes do feedback explicativo + remover caixa azul com o ponto de interesse por completo, aparecer no local do nome do jogo, ou ter outra representação mais clara ter animação a pedir para girar o telemóvel para ver o vídeo	gostaram de poder perceber pq é que resposta estava certa ou errada	estado do sistema: utilizador não consegue ver opção que escolheu dps de confirmar a sua resposta + ter animação a pedir para girar o telemóvel para ver o vídeo hierarquia: feedback explicativo vem antes do "certo/errado" legibilidade: texto justificado é mais difícil de ler
barra inferior	não conseguiu entender o ícone dos pontos de interesse não gostou do facto do ícone das perguntas lhe dizer a quantas já respondeu, mas não a quantas acertou/errou	"o que é que é isto? Posso clicar?" - em relação ao btn da RA na barra SUGESTÕES: ícone do mapa estar num círculo e todos deviam ter o mesmo tamanho reduzir dimensão da barra e ponderar ícones (ex: btn RA faz sentido? O que está a fazer lá se qnd há AR, aparece btn na página)		
13 (pergunta com várias opções de resposta certas)	critica a existência de muitas formas distintas (cantos) há demasiadas bordas e caixas: caixa da pergunta, caixa da opção e caixa para selecionar SUGESTÕES:	SUGESTÕES: ver app calm		consistência: nas perguntas com várias opções de resposta, os componentes têm formas diferentes: cantos + ou - arredondados a submissão das perguntas com 1 opção de resposta certa e as que têm mais que 1 comportam-se de forma diferente
14 (pergunta com RA)	não percebeu que havia um botão para despoletar RA - "não percebi pq este botão está com a mesma forma e tamanho do flamingo, que não é clicável"	demorou mto tempo a perceber que o btn no centro do ecrã era para despoletar RA, foi várias vezes à barra de baixo "não parece um btn, parece uma img"	alguns não perceberam que RA era um btn	intuitivo: não percebeu btn de AR
15 (câmara RA)	" é muito chato isto virar de lado, tenho de virar o telemóvel"	btn de fixar não segue linha visual dos restantes (btn reto qnd os outros são redondos) SUGESTÕES: alterar posição do btn de ir para trás e o de fixar - visto que se ecrã está na horizontal, tudo tem de seguir essa orientação	não perceberam btn de fixar	consistência: btn de fixar não segue linha visual dos restantes

Ecrã/ Componente	Comentários dos Designers		Comentários dos Alunos	Observações Gerais (padrões comuns, problemas críticos)
	Designer 1 (D1)	Designer 2 (D2)		
16 (AR Book)	"é suposto clicar?". Não percebeu que podia fixar o AR Book pq não viu o botão. "Que chato, tenho de fazer un-pin para voltar para trás e ir para a pergunta". "isto parece uma tabela, mas tem os botões todos desalinhados". "Isto está 0 enquadrado com o que tu tens atrás". acha que às vezes as imagens são demasiado parecidas entre si "sou uma utilizadora q odeia ler". "Tenho de estar smp a andar para trás e para a frente, é mto esquisito" Teve de voltar para trás pq já não se lembrava da pergunta: "é uma seca perder o contexto da pergunta pq 1º preciso de perceber como funciona a RA, dps há uma carrada de btns para andar para trás e para a frente e entretanto já me esqueci da pergunta" SUGESTÕES: AR com folha interativa: " é fixe, mas já devia começar maior e centrada pq isto é péssimo". + Em vez de estilo tabela, AR Book podia ter uma interação mais semelhante aos livros + Exploração do ARBook ser incluído no tutorial do início.	ficou confusa com btn de alterar linguagem percebeu que ícones eram meramente decorativos e não clicáveis "a interface parece antiga, está flat" SUGESTÕES: alterar funcionamento dos btns de língua - qnd está em EN, bandeira UK e qnd está em PT, bandeira PT alterar nº de ícones no ARBook, não ter 3 de um lado e 2 de outro, ter apenas 1 de cada lado nas páginas de conteúdo, tirar btn de linguagem interface mais arredondada, para estar de acordo com linha visual do educity ter uma apresentação mais moderna (mais redonda, usar sombras) poder alterar orientação do ARBook Não colocar links nas imagens AR com folha interativa: indicações deviam estar mais dinâmicas, pq não parece estar intuitivo	"isto está bué interessante", "está fixe" alguns preferiam que a câmara no background fosse desativada enquanto têm ARBook aberto Gostaram das cores "não percebi nada, isto é para selecionar mais q 1 ou só 1?" (não perceberam funcionamento) "como é que se sai daqui agr?"	visibilidade: não viu btn de fixar ARBook enfadonho, ações excessivas cognitive load: teve de ver ARBook 2x pq se esqueceu da pergunta qnd explorou o ARBook a 1ª vez ter cuidado com dimensão das imagens no ARBook pq não dá para aumentar consistência: interface de ARBook mto quadrada e com cantos afiados, totalmente diferente do resto da app
17 botão/área de vídeo	conseguiu perceber que é uma área clicável por causa da familiaridade que o btn de play tem para si: "se me mostrasses só a imagem de cima, eu não percebia que era clicável" não se importa que vídeo seja na horizontal, mas acha imperativo dar para o ver na vertical SUGESTÕES: "preferia ver a thumbnail do vídeo e clicar logo lá para ver" ver vídeo na horizontal e na vertical	SUGESTÕES: seria melhor ter a thumbail do vídeo e o ícone do play no centro	estavam à procura do btn para fechar/sair do vídeo	btn de play (vídeo) é consistente com o resto do mercado
18 (ecrã fim de jogo)	(da página anterior para a do fim de jogo) "isto agr fez uma transição diferente que nnc tinha feito"	"acho este logo desnecessário"		
19 (loader fim do jogo)	" pq é que isto tem o loader se eu consigo ver os resultados que estão atrás? A menos não tinha transparência" SUGESTÕES: não ter transparência no loader	"porque é que ele está a carregar se eu já consigo ver o que está atrás?" "o loader demora sempre muito tempo nesta app, não é rápido" SUGESTÕES: não concorda que loader seja transparente trocar loader por barra de progresso (com %) para user saber		eficiência e system status: loading demora sempre muito tempo. User não sabe qual é a % do progresso

Ecrã/ Componente	Comentários dos Designers		Comentários dos Alunos	Observações Gerais (padrões comuns, problemas críticos)
	Designer 1 (D1)	Designer 2 (D2)		
20 (ecrã resultados)	não percebeu a representação do rácio perguntas corretas/incorretas, achou que o nº de incorretas era o nº total de perguntas SUGESTÕES: ter 2 campos distintos com nº de perguntas corretas e nº de incorretas	"questões corretas e incorretas está errado. Isto não pode estar assim, isto parece uma fração" pontuação: não houve nada no início que me tenha indicado como é que era feita a pontuação. **Como é que eu tenho 19 pontos? Também não sabia que havia pontuação para a RA**": **"estive a jogar o tempo inteiro sem saber que havia pontos"** - "sistema de pontuações é muito estranho" valorizou o registo da duração do jogo acha que este ecrã devia ter uma linha visual diferente da dos outros: fundo está amarelo, título está na zona do ponto de interesse resolução está baixa: "pq é que às vezes usam imgs e outras usam ícones?" "só usei aquela barra gigante 1x para ver o AR e podia ter usado o btn na interface": "perde-se espaço desnecessário com a barra gigante" SUGESTÕES: separar campo de questões corretas e de questões incorretas + ter indicação de quantos pontos vale cada pergunta alterar interface deste ecrã para ficar diferente dos do jogo - ter uma apresentação diferente para ser claro para o jogador que jogo terminou ter um btn que permitisse ver perguntas e respostasdo jogo neste ecrã esconder ícone dos sensores para iphones ou jogos que não recorrem a sensores "não acho q o btn AR deva estar ali numa situação em que não é suposto usá-lo"	"está bonito", "está fixe", "está organizado"	system status: interface deste ecrã é demasiado semelhante à dos ecrãs de jogo, pode ser pouco percetível que jogo já terminou
21 Modo livre	não percebeu o funcionamento do modo livre, a investigadora teve de explicar "não faz sentido aparecerem os pins apenas dos jogos que eu tenho instalados" SUGESTÕES: "ter pins de localização dos pontos de interesse sempre"	"estes btns não parecem btns" "resolução dos ícones do mapa é horrível" SUGESTÕES:		
22 (overlay aviso RA)		SUGESTÕES: overlay tornar-se num pop-up ou não ter transparência ou, tendo, background desfocar para não prejudicar legibilidade		
23 (autores do jogo)		achou desnecessário ter nome dos autores		
24 (pontuações gerais)		"isto é a minha pontuação geral? Quantos jogos é que eu já fiz?"		
25 (como jogar)		SUGESTÕES: hierarquia dos textos não estar justificado não tem de ter um card, pode ser só um fundo ter uma intordução, ter regras, explicar sistema de pontuações, ... Onboarding na 1ª vez q user entra		

Appendix 13 - Comparative Open-ended Questions to Apply on the Last Questionnaire

Código do Participante: _____

Perguntas de comparação direta (a inserir no último questionário pós teste para garantir que utilizador já testou tanto app como protótipo).

1. Comparando com a app atual, o que gostaste mais no protótipo?

_____
_____
_____
_____

2. O que achaste que estava melhor na app atual do que no protótipo?

_____
_____
_____
_____

3. De forma geral, qual das duas versões achas que seria melhor para ajudar na aprendizagem de forma divertida? Porquê?

_____
_____
_____
_____

Appendix 14 - Table with Participants' Scores on each AttrakDiff2 Item, for the App and Prototype

Participant_ID	Group	Order	Version	PQ1	PQ2	PQ3	PQ4	PQ5	PQ6	PQ7	HQ-I1	HQ-I2	HQ-I3	HQ-I4	HQ-I5	HQ-I6	HQ-I7	HQ-S1	HQ-S2	HQ-S3	HQ-S4	HQ-S5	HQ-S6	HQ-S7
P1	A	First	Prototype	0	2	3	3	0	2	3	-1	0	2	3	1	0	3	1	2	0	1	2	-1	2
P1	A	Second	App	-1	0	3	3	2	2	2	0	1	2	1	2	0	3	2	2	1	2	3	0	2
P2	A	First	Prototype	0	2	3	3	2	2	2	3	2	3	3	3	3	3	3	2	1	3	2	1	1
P2	A	Second	App	-3	3	3	2	3	3	3	3	3	3	3	2	3	3	3	3	2	2	3	3	3
P3	A	First	Prototype	0	2	2	3	0	0	-2	2	1	0	2	1	0	3	2	3	0	2	3	2	0
P3	A	Second	App	0	2	3	2	0	3	3	3	3	2	2	3	2	3	3	3	3	3	3	2	2
P4	A	First	Prototype	3	3	3	3	-2	3	3	3	2	2	2	2	2	3	1	2	2	2	2	1	1
P4	A	Second	App	3	3	3	3	2	3	3	1	2	2	3	2	2	3	2	3	2	2	2	2	2
P5	B	First	App	2	2	2	0	1	1	2	1	-1	-2	-2	1	-1	1	-1	0	-1	-2	-1	-2	0
P5	B	Second	Prototype	0	-1	2	2	1	2	1	1	3	2	1	2	-1	3	2	2	-1	1	0	-1	0
P6	B	First	App	0	-3	2	0	0	2	3	0	0	-1	-1	-1	-1	1	-2	-1	0	-1	-3	3	-2
P6	B	Second	Prototype	0	2	2	1	0	2	2	1	2	2	1	0	-2	1	0	1	-1	0	-1	0	-1
P7	B	First	App	3	3	2	3	0	1	2	3	1	1	2	2	0	3	2	1	0	2	1	3	-1
P7	B	Second	Prototype	2	2	2	3	1	2	0	3	0	1	1	1	2	2	2	2	0	1	0	1	0
P8	B	First	App	1	1	2	2	-1	2	1	1	1	0	1	0	0	1	-1	2	0	0	1	-1	-1
P8	B	Second	Prototype	2	2	2	2	0	3	2	0	2	3	2	0	0	2	0	3	0	1	1	1	1

Appendix 15 - Table with Each Participant's Overall Mean on the AttrakDiff2 Scale, per Test Order

Participant_ID	Group	Order	Version	Test Mean	
				First	Second
P1	A	First	Prototype	1,38	1,52
P2	A	First	Prototype	2,33	2,52
P3	A	First	Prototype	1,33	2,38
P4	A	First	Prototype	2,05	2,38
P5	B	First	App	0,00	1,14
P6	B	First	App	-0,24	0,71
P7	B	First	App	1,62	1,48
P8	B	First	App	0,57	1,38

Appendix 16 - Table with Participants' Responses to the Open-ended Questions

Participant_ID	Group	Order	Version	Phase	Questão 1	Resposta 1	Questão 2	Resposta 2	Questão 3	Resposta 3
P1	A	First	Prototype	After using prototype	O que mais gostaste no protótipo?	A facilidade de manuseio que ajuda as pessoas com mais dificuldade.	O que mudarias ou melhorarias no protótipo?	Talvez colocasse cores mais vibrantes.	Achas que este protótipo ajuda a aprender de forma divertida? Porquê?	Sim, porque as tecnologias são divertidas e toda a gente gosta.
P2	A	First	Prototype	After using prototype	O que mais gostaste no protótipo?	Cores e onde clicava	O que mudarias ou melhorarias no protótipo?	Nada	Achas que este protótipo ajuda a aprender de forma divertida? Porquê?	Sim. Mesemos nos telemóveis e jogamos com os colegas
P3	A	First	Prototype	After using prototype	O que mais gostaste no protótipo?	As cores	O que mudarias ou melhorarias no protótipo?	Em si, nada	Achas que este protótipo ajuda a aprender de forma divertida? Porquê?	Sim, eu aprenderia imenso e ao mesmo tempo divertir-me-ia
P4	A	First	Prototype	After using prototype	O que mais gostaste no protótipo?	A estrutura dos elementos	O que mudarias ou melhorarias no protótipo?	Nada	Achas que este protótipo ajuda a aprender de forma divertida? Porquê?	Sim, porque havia coisas que eu não sabia e fiquei a saber.
P5	B	First	App	After using app	O que mais gostaste na app?	O flamingo que ficava a comentar sobre as respostas.	O que mudarias ou melhorarias na app?	Colocava os botões um bocado mais vibrantes e adicionaria uma espécie de sistema de pontos.	Achas que esta app ajuda a aprender de forma divertida? Porquê?	Não, na minha opinião a app não é cativante nem chamativa.
P6	B	First	App	After using app	O que mais gostaste na app?	Nada.	O que mudarias ou melhorarias na app?	Aspeto e perguntas mais fixes.	Achas que esta app ajuda a aprender de forma divertida? Porquê?	Não.
P7	B	First	App	After using app	O que mais gostaste na app?	O facto de que fiquei a conhecer mais e tem um bonito aspecto.	O que mudarias ou melhorarias na app?	Deixá-la-ia mais atrativa.	Achas que esta app ajuda a aprender de forma divertida? Porquê?	Sim, porque é um jogo que não cansa.
P8	B	First	App	After using app	O que mais gostaste na app?	A apresentação, é bonita.	O que mudarias ou melhorarias na app?	Nos vídeos, eu colocaria um "X" para sair mais facilmente do vídeo.	Achas que esta app ajuda a aprender de forma divertida? Porquê?	Sim, pois foi divertido.

Participant_ID	Group	Order	Version	Phase	Questão 1	Resposta 1	Questão 2	Resposta 2	Questão 3	Resposta 3
P1	A	Second	App	After using app	O que mais gostaste na app?	As cores eram vibrantes e chamativas.	O que mudarias ou melhorarias na app?	Colocaria mais sons e talvez algumas animações.	Achas que esta app ajuda a aprender de forma divertida? Porquê?	Sim, porque toda a gente gosta de tecnologias.
P2	A	Second	App	After using app	O que mais gostaste na app?	É diferente. Nunca tinha feito isto.	O que mudarias ou melhorarias na app?	Mais animações. É muito estática.	Achas que esta app ajuda a aprender de forma divertida? Porquê?	Sim. Não sei explicar porquê, mas é divertida.
P3	A	Second	App	After using app	O que mais gostaste na app?	Dacor e da qualidade	O que mudarias ou melhorarias na app?	Nada	Achas que esta app ajuda a aprender de forma divertida? Porquê?	Sim, pois as perguntas estão com uma boa estrutura
P4	A	Second	App	After using app	O que mais gostaste na app?	Está bem estruturada	O que mudarias ou melhorarias na app?	Nada	Achas que esta app ajuda a aprender de forma divertida? Porquê?	Sim, seria mto divertido aprender com esta app numa aula diferente.
P5	B	Second	Prototype	After using prototype	O que mais gostaste no protótipo?	A organização e facilidade de uso	O que mudarias ou melhorarias no protótipo?	Nada	Achas que este protótipo ajuda a aprender de forma divertida? Porquê?	Sim, é interativo e dá vontade de jogar mais
P6	B	Second	Prototype	After using prototype	O que mais gostaste no protótipo?	Gostei muito de usar os avatares e poder escolher outros	O que mudarias ou melhorarias no protótipo?	Tornava-o mais interativo	Achas que este protótipo ajuda a aprender de forma divertida? Porquê?	Sim, porque gosto de jogos.
P7	B	Second	Prototype	After using prototype	O que mais gostaste no protótipo?	Gostei mais das perguntas e dos avatares.	O que mudarias ou melhorarias no protótipo?	Tornava-o mais rápido.	Achas que este protótipo ajuda a aprender de forma divertida? Porquê?	Sim, porque é um jogo engraçado
P8	B	Second	Prototype	After using prototype	O que mais gostaste no protótipo?	É bonito e organizado.	O que mudarias ou melhorarias no protótipo?	Nada, mas podia ser mais rápido.	Achas que este protótipo ajuda a aprender de forma divertida? Porquê?	Sim, pois é mais divertido e mais relaxante.

Participant_ID	Group	Order	Version	Phase	Questão 1	Resposta 1	Questão 2	Resposta 2	Questão 3	Resposta 3
P1	A	First	Prototype	After using both	Comparando com a app atual, o que gostaste mais no protótipo?	A facilidade de uso. É muito intuitivo. Gosteidos sons e das animações.	O que achaste que estava melhor na app atual do que no protótipo?	É menos lenta.	De forma geral, qual das duas versões achas que seria melhor para ajudar na aprendizagem de forma divertida? Porquê?	O protótipo, porque é mais organizado e intuitivo.
P2	A	First	Prototype	After using both	Comparando com a app atual, o que gostaste mais no protótipo?	As cores e os desenhos.	O que achaste que estava melhor na app atual do que no protótipo?	Não sei.	De forma geral, qual das duas versões achas que seria melhor para ajudar na aprendizagem de forma divertida? Porquê?	Ambos são bonitos.
P3	A	First	Prototype	After using both	Comparando com a app atual, o que gostaste mais no protótipo?	Tudo	O que achaste que estava melhor na app atual do que no protótipo?	Tinhas mais mistura de cores.	De forma geral, qual das duas versões achas que seria melhor para ajudar na aprendizagem de forma divertida? Porquê?	A app, é menos lenta.
P4	A	First	Prototype	After using both	Comparando com a app atual, o que gostaste mais no protótipo?	Dava para mudar a imagem de perfil no protótipo	O que achaste que estava melhor na app atual do que no protótipo?	Nada.	De forma geral, qual das duas versões achas que seria melhor para ajudar na aprendizagem de forma divertida? Porquê?	O protótipo, é mais interativo
P5	B	First	App	After using both	Comparando com a app atual, o que gostaste mais no protótipo?	A beleza da RA. É mais chamativa que a app.	O que achaste que estava melhor na app atual do que no protótipo?	É mais rápida.	De forma geral, qual das duas versões achas que seria melhor para ajudar na aprendizagem de forma divertida? Porquê?	O protótipo. É mais fácil de usar e dá mais vontade de jogar
P6	B	First	App	After using both	Comparando com a app atual, o que gostaste mais no protótipo?	É mais bonito.	O que achaste que estava melhor na app atual do que no protótipo?	Nada.	De forma geral, qual das duas versões achas que seria melhor para ajudar na aprendizagem de forma divertida? Porquê?	O protótipo, porque é mais divertido.
P7	B	First	App	After using both	Comparando com a app atual, o que gostaste mais no protótipo?	Dos avatares e da RA	O que achaste que estava melhor na app atual do que no protótipo?	É mais rápida	De forma geral, qual das duas versões achas que seria melhor para ajudar na aprendizagem de forma divertida? Porquê?	As duas tiveram as mesmas perguntas, mas o protótipo era mais chamativo.
P8	B	First	App	After using both	Comparando com a app atual, o que gostaste mais no protótipo?	Os sons e a forma como está organizado.	O que achaste que estava melhor na app atual do que no protótipo?	Respondia melhor e não parava de funcionar.	De forma geral, qual das duas versões achas que seria melhor para ajudar na aprendizagem de forma divertida? Porquê?	O protótipo, é muito mais bonito e estava mais organizado.