Promoting Healthy Development in Early Childhood: A Proposal of a Mobile Application

Joana Tavares[a], Rita Santos[b] and Oksana Tymoshchuk[c]
DigiMedia, Department of Communication and Art, University of Aveiro, Santiago University Campus, 3810-193 Aveiro, Portugal

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Abstract: Developing digital solutions to support parents of children in early childhood is crucial for enhancing parenting practices and promoting child development. In the context of an intervention project that advocates the child's emotional, social, cognitive and cultural development and stable growth from prenatal life until the first three years of life, a multidisciplinary team collaborated to propose a mobile application supporting parents in promoting their children's healthy development during this period. The study followed a development research methodology, including a literature review, comparative analysis of existing apps, prototype development, and evaluation. This approach, combined with user-centred design, helped to identify critical features and design principles for an effective parental support app. The resulting app proposal foresees personalized resources, from different categories, a digital diary, suggestions of activities to be carried out with the child and recommendations of events. Evaluation results showed that an app based on this proposal can be an important resource for parents and foster positive parenting behaviours, benefiting parents and children. This research contributes to the growing field of digital health solutions for early childhood development, presenting a promising tool to enhance parental support and child well-being.

1 INTRODUCTION

It is crucial to prioritize promoting healthy behaviors at all life stages, giving every child the best start in life, through, among other things, health literacy (Diário da República, 2021), and also to foster "better cooperation between or integration of services for families and children, particularly with health and social services, and schools, at national, regional and local level" (Council of the European Union, 2019, p.9). Recognizing this need for a new perspective on early childhood, the Águeda Health Centre conceived the Cres(SER) (Growing up) project in 2017. Supported by the Regional Health Administration of the Centre, this project promotes children's emotional, social, cognitive, and cultural development from prenatal to the first three years. It involves a multidisciplinary team of education, psychology, and primary health care professionals.

Aiming to improve the access to information and convenience for parents through digital health solutions, effectively overcoming barriers to healthcare access and use, the Cres(SER) project aims to widen its intervention by providing a mobile application to support parents in fostering healthy child development during the first years of life.

Historically, parents obtained health information from friends, family, and doctors. However, recent studies on health information-seeking behaviour suggest that this situation is changing (Benoit et al., 2021; DeWitt et al., 2022). With the expansion of mobile device usage, the information supply has become more widespread and accessible. Many healthcare apps are focused on pregnancy and early childhood, offering many features and goals. However, these apps face several problems. According to Virani et al. (2019), factors such as a lack of personalization, unattractive design, absence of interactive features, poor functioning, and

[a] https://orcid.org/0009-0008-6346-4642
[b] https://orcid.org/0000-0001-9741-6210
[c] https://orcid.org/0000-0001-8054-8014

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unreliable information reduce parents' involvement and lead to app abandonment. According to their research, apps that are aesthetically pleasing, user-friendly, functional, engage users and provide reliable information are considered high quality (Virani et al., 2019).

In this context, this research was developed to inform the characteristics, features, and services of an app that can support parents in creating a favourable environment for children's healthy and stimulating development and present a proposal for Cres(Ser) app to support early childhood development. A literature review was conducted to understand how digital solutions can help parents and identify aspects that should be considered in designing a mobile app for healthy development in early childhood. Then, a benchmarking of mobile apps in early childhood was also carried out. Finally, a proposal for an app capable of supporting parents in creating a favourable environment for children's healthy and stimulating development was developed using a user-centred design approach. Creating an empowering app requires understanding users' needs and collaborating with professionals and end-users. Thus, the development of the proposal was accompanied by several moments of discussion and evaluation from users and other stakeholders.

2 UNDERSTAND PARENTS' NEEDS

Parents are the first line of defence in recognizing and managing their children's behavioural health needs and promoting their well-being (Grodberg et al., 2022). According to research on Evaluations of Social Interventions (Terzian & Mbwana, 2009), greater parental involvement in a child's mental and behavioural health care can triple the chances of positive outcomes.

People increasingly use smartphones and the Internet to search for health information, such as to understand the cause of a particular illness, access ways to assess the severity of symptoms and get prepared before consulting a doctor (Benoit et al., 2021).

Maternal healthcare during pregnancy and parenting support are examples of areas in which there's a growing proliferation of apps, with considerable diversity in visual style, functionalities, and objectives (Bailey et al., 2022). Several researchers emphasize the need to harness digital technologies for early childhood development, ensuring all families can benefit from the same digital possibilities for their children's well-being (Hatzigianni et al., 2023). Mobile apps are generally offered free of charge and can circumvent the difficulties associated with conventional treatments, such as financial burdens, access restrictions, and social stigma. These digital tools emerge as viable and accessible alternatives, removing traditional barriers often preventing access to appropriate treatment and care (Neary & Schueller, 2018).

Parents appreciate the convenience of technological solutions, which provide round-the-clock assistance, when more traditional parental support services are unavailable. These solutions empower parents, offering scalability and possibility of community collaboration (Darling et al., 2020). These solutions help parents feel more confident in assessing their children's health, significantly changing health-seeking behaviour (Benoit et al., 2021).

3 CONSIDERATIONS WHEN DESIGNING AN APP TO SUPPORT PARENTS

In '5 Design principles for e-health', it's stated that e-health services and products often prioritize technology over user needs. This shows that designers must solve and understand problems, considering the user's needs, limitations, living context, and associated issues (Amaral, 2019). To meet this challenge, it is essential to adopt approaches such as User Centred Design (UCD), which focuses on creating solutions based on end users' needs and feedback, and Participatory Design (PD), which actively involves users in the design process. These approaches ensure the resulting system is user-friendly, engaging, adaptable, accessible, and valuable.

As mentioned in the Good Communication Practices Guide of the National Health Plan (2022), it is essential to consider communication as a strategic tool for the success of health strategies (Duarte Melo et al., 2022). This guide highlights, for example, the importance of the communication tone, which reflects the organization's identity and values. This tone should be consistent across all channels, providing a coherent attitude, while adapting to different circumstances - be it more informative, empathetic, emotive, or formal.

Other research also recommends that a solution presents a hierarchy that prioritizes information,

guaranteeing complete but gradual access, i.e., having access to everything but not having it all at once (Amaral, 2019). Even so, the system is intuitive enough to allow the user to perform basic operations, without introducing unnecessary or complex terminology.

Credibility and trust are also essential when developing health-related products and services. Based on numerous studies, Sousa (2017) defined five interface dimensions relevant to increasing those elements:

Visual Dimension. It is essential for communicating and understanding interfaces, going beyond aesthetics. It must fulfil functions that positively influence interaction and the credibility perceived by the user. The author discusses some basic elements of visual communication, such as point, line, shape, direction, tone, colour, texture, scale, dimension, movement and typography, as essential components of the visual dimension.

Information Architecture. Information architecture organizes, structures, and names content to make it easier for users to find, understand, and carry out tasks.

Interaction: Interaction design on digital platforms seeks to create functionalities that facilitate interaction between users and systems. Garrett (2011) defines three objectives for improving usability and effectiveness: creating meaningful paths, ensuring clear communication between navigation and interaction elements, and establishing a clear relationship between information and actions.

Social Presence. The social presence dimension represents presence, connection and communication between individuals and organizations mediated by the interface. Individual variables, such as willingness to suspend disbelief, familiarity, means of communication, gender and seeking sensations of humour, affect social presence.

User Experience. The user experience goes beyond utility, encompassing affection, sensation and meaning in the user's life. It is interesting to many professionals and relates to all the other dimensions of the Interface, assuming its most emotional component.

By considering these dimensions, holistic experiences that solve problems effectively can be created, engaging users, promoting trust, and establishing meaningful connections.

The scarcity of comprehensive design guidelines specific to the area of this study represents a significant challenge, affecting the quality and effectiveness of these solutions. This often results in products with usability problems, inadequate professional involvement, and a poor understanding of the healthcare context (Stevenson & Oscarsson, 2021). Also, most apps fail to provide personalized experiences for parents, including specific cultural considerations. Instead, they provide generic information that may only be relevant in certain contexts for parents (DeWitt et al., 2022).

4 BENCHMARKING

In a previous study, a first survey was carried out about apps related to early childhood to understand the current market landscape. Using keywords such as "baby development" and "parenting", we identified 278 apps from Google Play and 401 from the App Store. We applied the following inclusive criteria: 1) user rating of at least 4 (scale: 1-5), according to previous evaluations of the application; 2) rating ≥100; and 3) available free version. Apps dedicated to only one of the following needs were excluded: feeding/breastfeeding/sleep monitoring, parental control as well as apps focused only on pregnancy, apps showing growth metrics, photo albums, games, and apps unavailable in English or Portuguese. Ten apps were identified (Cunha et al., 2023). This was followed by an analysis of their features using subscales A to D of the Mobile App Rating Scale (MARS) (Stoyanov et al., 2015).

Based on this previous analysis, we further analysed the five apps that had the highest scores: Kinedu - Baby Development; Baby Daybook - Tracker, Schedule; Baby + | Your Baby Tracker; BabyCenter - My pregnancy and my baby today; and Prodigy baby - parenting app. This benchmarking aimed to analyse the functionalities and visual aspects of these apps identified from a previous focus group with parents of children developed by the team and from the literature review.

The comparative analysis of these apps considered the following aspects (see Figure 1 on Annex 1):

- Visual content (videos);
- Customized information;
- Tips on various stages of development;
- Page for the community;
- Page for entering milestones;
- Notifications/alerts;
- Sharing content to other sites/networks;
- Gamified approach;
- Free application plan;
- Fremium application plan.

The results show diversity in the criteria included by the apps. This creates a vast market that can meet some specific needs. However, no app combines all the relevant functionalities identified by the research team as promoting healthy early childhood development.

Overall, the app with the best result was Prodigy Baby, which lacked only two aspects analysed - tips on various stages of development and a free plan, and the app with the worst performance was Baby Daybook, which is just a tracker, so it lacks multiple features. The most recurrent aspects of this analysis were the possibility of entering milestones, entering notifications or alerts, and sharing content with other networks. These three aspects are related to memory and recollections, whether remembering an activity or some memorable moments. On the other hand, the least recurrent aspects were the screens dedicated to the community, the gamified approach, and the availability of free apps.

5 METHODS

The study followed a development research approach (De Villiers, 2005). This purpose-oriented approach seeks to address real-world problems, promoting innovative solutions and establishing fundamental principles to guide future actions and decisions. It was outlined in two distinct phases: **Phase 1** - study and analysis of the problem previously described and **Phase 2** - development and evaluation of the proposal. These phases were further subdivided into stages (see Figure 2 on Annex 1) that were identified considering the UCD methodology, thus, considered iterative development and evaluations. Health and education professionals provided important inputs while potential users participated in the final evaluation, checking that the proposal could suit their needs.

Phase 2. Proposal Development

The primary project target includes families with children up to 3 years old. Stakeholders such as health and education professionals were also considered, as their involvement is crucial for effective implementation of the Cres(SER) project.

The phase 2 began with developing a medium-fidelity prototype, guided by principles established from the study's first-phase conclusions.

The first validation moment was conducted in a focus group with health and education professionals with knowledge and experience in the field to assess how logical and efficient the information organisation was. In addition, the adequacy of the names of the information categories was discussed to ensure a more intuitive and effective user experience.

The transition from the mid-fi prototype to the hi-fi prototype marked a significant milestone. Throughout this process, once again, the principles from Phase 1 acted as essential pillars to guide the decisions to refine and improve the prototype and visual identity was also incorporated. An interview with professionals who have collaborated in the past with the Cres(SER) project validated the hi-fi prototype and confirmed the appropriateness of the changes.

In the final research stage, the prototype was subjected to usability tests to assess its effectiveness and identify areas for improvement with parents of children up to three years old (app users).

We used non-probabilistic convenience sampling to select participants who could make relevant contribution. Águeda Health Centre of Portugal helped recruit participants and provided venues. Participants were asked to read and sign the informed consent form and respond to characterization questions. They were also asked to think aloud during the tests, and notes were taken using an observation grid.

Based on the results of these tests, final adjustments were made to the prototype. This iterative process ensured the prototype met quality standards and satisfied user expectations.

6 RESULTS

6.1 Focus Group

Following developing a medium-fidelity prototype, we validated it with experts in a focus group (FG) context.

In February 2024, we conducted an FG comprising 12 participants - health professionals and education professionals - linked to parenting projects. Due to their frequent interactions with various parenting situations, these participants offered a comprehensive understanding of the needs, challenges, and dilemmas that parents often face at various stages of parenting. Thanks to their constant immersion in the field and the PD approach, professionals provided valuable information on the quality of communication between the app and users and the effectiveness of the strategies adopted for sharing information.

The FG's objectives were: 1) Understand how health and education professionals receive and perceive the app; 2) Assess whether the app's functionalities are the most relevant; 3) Explore ways to promote engagement with the app. This focus group allowed us to gather valuable insights and feedback from professionals in the field. Their expertise helped us validate our design choices, identify potential areas for improvement, and ensure that the app's functionalities aligned with the needs of both parents and professionals. The discussions during this session provided information that guided our subsequent design iterations and feature refinements.

The main changes have been the categories of interest, which have been moved from the Register to the Homepage. The idea is for all areas to be of equal interest to parents and are presented on the homepage. To make it easier to search for content, a search bar has also been added to filter content by text or video (Figure 1).

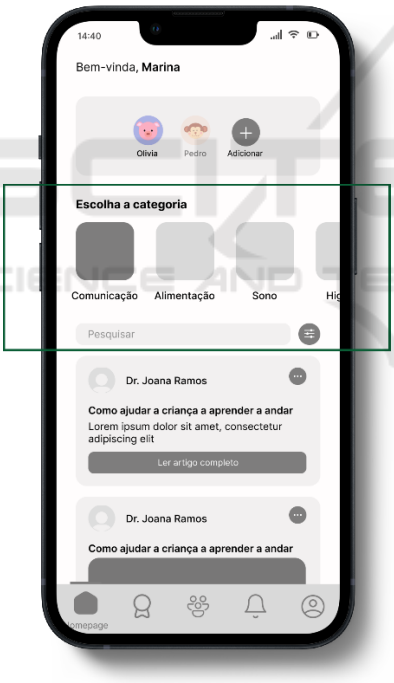

Figure 1: First change regarding the FG.

Next, the Milestones screen has been modified and renamed Activities, containing only recommended activities that encourage parents to get involved with their children. These activities are categorised by age group and type (physical, cognitive, linguistic, social, emotional, and cultural), offering a complete guide for parents looking to stimulate their children's development; the Community screen, that no longer exists, leaving only the Playdates section (now called Events). In the participants' opinion, the Forum section could cause confusion among parents expecting answers to their questions from professionals. Instead, it was decided to focus on creating Cres(SER) Project events for parents. To make it easier to find events, a search bar was added with the possibility of filtering events into two categories: closest to you and most recent; finally, given the unanimity over the replacement of the word baby, it was changed to child throughout the application (see Figure 3 on Annex 1).

6.2 Semi-Structured Group Interview

In April 2024, the research team conducted a semi-structured interview with two health professionals who had collaborated with the Cres(SER) project in the past. While we had an initial script, it was intended that there would be flexibility to introduce new topics if necessary. The contribution of these professionals was vital to understanding their expectations and needs about the app under study.

This session enabled us to validate the high-fidelity prototype of the Cres(SER) app. The health professionals provided valuable feedback on the user interface, functionality, and overall user experience. Their insights helped us identify areas for improvement and confirmed that the app aligned well with the goals of the Cres(SER) project. For example, we changed the names of some important categories and page titles and personalized the sign-up page to include more positive parenting.

Based on the feedback received, we refined the prototype. These included adjusting the layout of specific screens to improve information hierarchy, enhancing the navigation flow, and adding features that the health professionals deemed essential for adequate parental support. The iterative process of prototyping and validation proved crucial in ensuring that the final product would meet the needs of both parents and health professionals.

The main changes have been a variety of new avatar options have been introduced in user registration. These options were carefully chosen based on previous discussions, with the aim of promoting more positive parenting. To further personalise the user experience, the possibility of choosing a photo from the user's personal gallery has also been added (Figure 2).

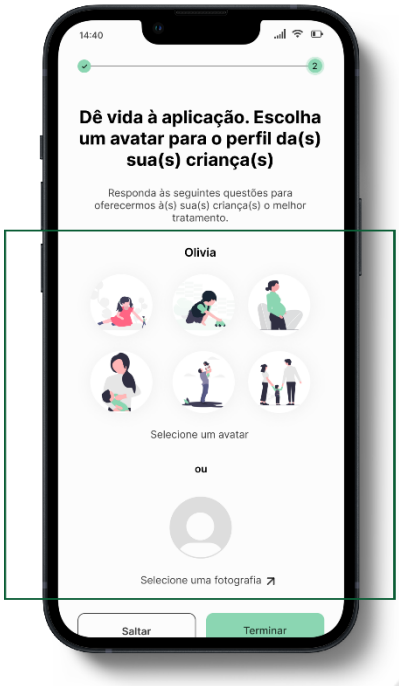

Figure 2: First change regarding the Interview.

Finally, the titles of the Progress and Your Progress pages have been changed to Evolution and Your Achievements, respectively (see Figure 4 on Annex 1).

6.3 Usability Tests and Final Proposal

In May 2024, the research team conducted usability tests with seven parents of children up to three. These tests provided crucial insights into the app's usability and user experience, allowing valuable feedback for future improvements. The objectives of the tests were to 1) Evaluate the effectiveness of the prototype in meeting the needs and expectations of the participants and 2) Identify specific areas of the prototype that require improvement or adjustment.

Seven participants took part in these tests, all of them female. One participant had a 3rd cycle degree (7th to 9th grade), two had a secondary degree (10th to 12th grade), one had a bachelor's degree, and the remaining three mentioned having completed a master's degree. Notably, only one participant had experience with similar apps, and that experience came from an app from a children's center also in Águeda.

Two participants had some difficulty carrying out the tasks, although the remaining five performed the tests easily. At the end of the tests, participants were asked to respond to the System Usability Scale (SUS) to calculate a score for the prototype app. Considering the method established for calculating the SUS scale score (Barros, 2022), the prototype obtained an average score of 82 (excellent). This result indicates that the prototype has high usability, allowing users to complete their tasks and reach their goals simply and clearly, bringing user satisfaction. This result indicates that the prototype is effective in its high usability, allowing users to complete their tasks and reach their goals simple and clearly, bringing user satisfaction.

The first change made after the usability tests was the bar with the categories of interest, both on the Homepage and on the 'Your achievements' screen. Here, we wanted to improve the sense of continuity, so that users know that there are more categories of interest than those that appear on the screen by default. To this end, the thickness and saturation of the line accompanying the categories have been increased, emphasising the lack of margin on the right-hand side of the screen. We also increased the font weight of selected categories from regular to medium, along with the thickness of their indicator lines. We increased the spacing between categories so that the last category appears partially cut off by default, indicating additional content without requiring scrolling (Figure 3).

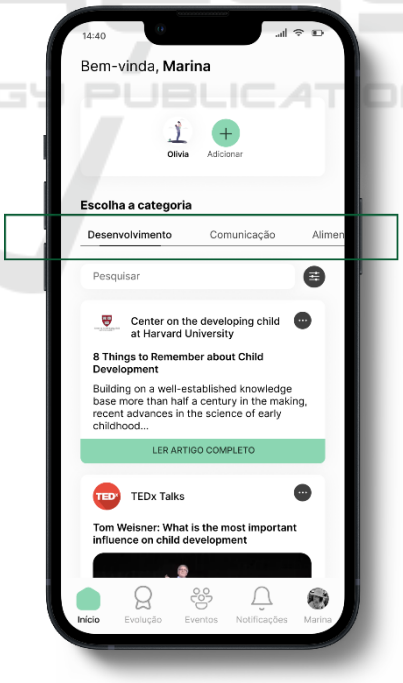

Figure 3: First change regarding the Tests.

Another key finding involved navigation to the 'Your events' screen. Since four out of seven

participants naturally navigated to the Events screen, we added a calendar icon in the top-right corner linking to personal events. We maintained the existing Profile link as well, since some participants logically looked there to access personal information (see Figure 5 on Annex 1).

After incorporating modifications based on the usability test results, we finalized the graphic proposal for the Cres(SER) app. This final version incorporates several features, including: the possibility of creating multiple profiles for different children; access to information on different categories of interest within healthy development; access to a personal digital diary, as well as activities that promote not only healthy development but also the connection between parents and children; access to a list of events that promote healthy development; notifications; and a profile, with access to features such as your achievements, saves, events, archive, and settings (see Figure 4 here and Figure 6 on Annex 1).

Figure 4: One of the main features of the final proposal (Milestones).

Finally, a design system was created for the Cres(SER) app (see Figure 7 on Annex 1), a set of components and guidelines that guarantee the visual consistency of apps, saving time in reproducing visual elements and patterns (Bergman, 2024).

This stage allowed us to create a comprehensive and user-friendly design for the Cres(SER) app. By establishing a cohesive design system, we ensured that all visual elements and interactions within the app would be consistent, intuitive, and aligned with the project's goals.

7 CONCLUSIONS

This study explored the importance that digital technologies can play, proposing a mobile app to support parents in promoting healthy development in early childhood.

By incorporating key features such as milestone tracking, timely notifications, and personalized content, alongside crucial design elements that enhance usability and engagement, the app stands poised to make a significant impact. Additionally, features and design elements such as alignment, scale and contrast, hierarchy, reliable content, ease of use, and personalization were considered as crucial to a solution's credibility, effectiveness, and usability.

Given that the proposal emerged directly from an initiative by the Águeda Health Centre, this not only validates the usefulness of the work carried out but also creates a significant opportunity for the efforts and insights to be applied practically and continuously. Also, the use of UCD and PD proved to be very relevant making it possible to understand the user's needs and involve them in the design process.

This research demonstrates an ongoing commitment to improving future generations' living conditions. The Cres(SER) app has the potential to make a difference in supporting families during the first years of children's lives.

Although the research was conducted in a specific geographical context, it could be applied to different regions and contexts, benefiting a wider population, with adjustments for diverse cultural and social needs. Expanding the test participants beyond the Águeda region would be valuable for future work.

In conclusion, this research underscores the critical importance of supporting healthy development in early childhood through digital technologies. The proposed Cres(SER) mobile app, developed through rigorous research and iterative design processes, offers a promising solution to empower parents in fostering their children's growth and well-being.

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