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Research Article

Participant Observation to Apply an Empirical Method of Codesign with Children

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Dental anxiety in children is a well-documented problem in the scientific literature. Tools mediated by Information Technology have been shown to positively influence children's mood based on distraction as well as relaxing activities. We propose an empirical method of codesign with children to generate app content for reducing dental anxiety. The results are embedded in text through a thick description as an ethnographic technique. The method was applied to 163 children (6–8 years old) from a summer school and a primary school, obtaining multimedia products that were integrated into an app prototype. Finally, although this use case of the presented method is applied to the health field, it can be transferred to any other field of application of codesign to children by using material that is specific to new scenarios.

1. Introduction

Anxiety related to dental interventions is a common problem in children [1]. There is evidence to describe the dentist's role as a scary person [2]. Colares et al. [1] found a prevalence of dental anxiety of 14.4% in a study involving 970 children aged 5–12 years. Nicolas et al. [3] evaluated 1,033 children aged 5–12 years and observed a slightly lower prevalence of 7.6%. Raja et al. [4] conducted a study in Islamabad aimed at estimating the prevalence of dental anxiety in children aged 5–10 years. Their results showed that 38% of the 252 participants had moderate or severe anxiety. Bezabih et al. [5] reported a prevalence of 74.1% of dental anxiety between moderate and severe in a study involving 240 children.

Children and adolescents' anxiety and fear have a significant impact on their dental health, as well as on their cooperative attitude when visiting the dentist [6, 7]. These problems may even be the reason to avoid or reject some dental treatments, especially in the case of children. Therefore, they mean a great challenge in children's treatments, becoming a barrier for dental health professionals [8]. Managing those patients is stressful for those professionals, demanding longer treatments and more resources. The resulting experience is also less pleasant for both the patient and the dentist [9, 10].

Anxiety and fear produce emotional, physical, cognitive, and behavioral interferences in individuals [8]. Evidence in the scientific literature suggests that children who suffer from anxiety and fear are likely to avoid dental health. This results in a higher incidence of untreated deteriorations and cavities compared to children with less anxiety and a more cooperative attitude [3, 11–14]. Dental health and quality of life are connected, and therefore, dental anxiety may have a negative impact on the mood and social relationships of children and adolescents. Furthermore, it can cause sleep disorders, low self-esteem, and psychological problems [15, 16]. On the other hand, the existence of a narrow

correlation between anxiety, pain stimuli, and pain perception has been proved. In this sense, anxious patients feel more and longer pain, increasing pain memory [17, 18].

Dentistry interventions cause common anxiety and fear problems in some children, resulting in a decrease in their quality of life. Therefore, it is crucial to develop evidence-based therapies to reduce or avoid these problems. Some therapies have been currently suggested that can be classified into three main different categories: psychotherapeutic, pharmacological, or a combination of both. Pharmacological therapies have shown lower patient acceptance, being only effective in short-term treatments [19, 20]. Appukuttan [21] conducted a review of the literature on management strategies for patients with dental anxiety and phobia. He identified psychological strategies such as the iatrosedative technique, behavior management techniques, relaxation techniques, guided imagery, biofeedback, hypnotherapy, acupuncture, distraction, increased control, systematic desensitization or exposure therapy, positive reinforcement, cognitive therapy, and cognitive behavioral therapy.

The ARCADE project (Figure 1) aims to study the feasibility of participatory design and development of a technological solution to reduce dental anxiety problems among children aged 6–12 years. Some of the aforementioned techniques will be further implemented.

This research project has a total of five phases. The first phase was described in [22], and as Figure 2 shows, this study deals with phase 2, where the app is not yet developed. The work presented in this study focused on participant observation [23, 24] to apply the codesign methodology to children to help the ARCADE project's research team develop an application to reduce pediatric dental anxiety (6–12 years old). We propose a heuristic methodology [25] based on human-centered design philosophy and translate the experience, satisfaction, and creation of children into an ethnographic text [26] or a detailed description [27] in the process of codesigning activities.

We focus on the idea that going to the dentist can be a distressing experience for children and that they may feel some level of apprehension about future visits. In the discussion, we can reflect on how the future management of this problem can interfere in different scenarios of reality or daily life: school, technology, health services, and cross-cutting to the family and especially children.

2. ARCADE Project: Objective Phase 2

Our goal in phase 2 is to obtain customized and engaging content for a Pediatric Dental Anxiety Management App. This process involves children in the design of this content and the experience of applying codesign with them. The aim of this investigation also implies an approach to the challenges from sociocultural to technological environment and vice versa, so in this way, IT understands how to make new tools and developments in order to respond to those challenges. We are beyond getting the app.

Figure 1: ARCADE project logo.

3. Theoretical Approach to Dental Anxiety and Related Works

Dental fear, dental anxiety, and dental phobia are three possible forms of this fear. Fear felt during real, immediately present, specific stimuli related to the dentist or the dentistry procedure is considered dental [28]. Dental anxiety is defined as a heightened fear in which the threat is unclear, ambiguous, or not immediately present [29, 30]. Finally, dental phobia is a persistent and excessive fear of dental stimuli and procedures that results in avoidance or significant distress [31].

The prevalence of dental anxiety is estimated to occur between 6 and 20% of children and young people aged 4–18 years, according to published studies [1, 3, 6]. Some studies, such as Rantavuori et al. [12] and Bezabih et al. [5], have reported even higher rates, finding that 38% and 74.1% of children have moderate or severe dental anxiety, respectively.

Dental anxiety has a significantly negative impact on the quality of life related to oral health of children [32, 33]. Children with dental anxiety are likely to avoid dental health, resulting in an increase in untreated deteriorations and cavities [3, 11–14, 34]. Not only physical problems but also emotional, cognitive, and behavioral disorders may be caused by childhood dental anxiety [8]. These include increased perception of pain, changes in mood, barriers to social relationships, sleep disorders, and low self-esteem [15, 16]. This impact could be extended throughout life because childhood dental anxiety is likely to continue into adolescence and adulthood.

Dental anxiety also impacts healthcare professionals who treat children with dental anxiety, as these children often have a less cooperative attitude when visiting the dentist [6], demanding longer treatments and more resources, increasing the stress of professionals, and resulting in an unpleasant experience for both the patient and the dentist [9, 10].

Numerous approaches have been proposed to manage pediatric dental anxiety, including pharmacological and nonpharmacological strategies. Among nonpharmacological strategies, behavioral techniques are commonly used because they are safe, inexpensive, and effective [34, 35]. Distraction methods have been widely used due to their effectiveness [36]. Pretreatment education, including tell-show techniques, is also commonly used to

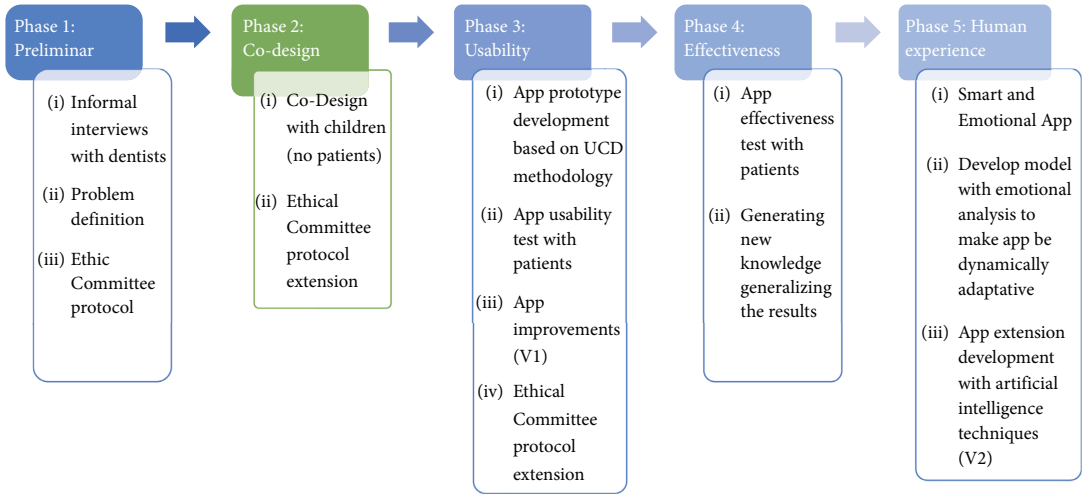


Figure 2: ARCADE project phases (scheme). This work deals with phase 2: codesign (green).

reduce child anxiety [35, 37]. Some of these techniques have been implemented using technology-based solutions, making them more attractive to children. Although these technology-based interventions are promising, there is still a lack of scientific evidence regarding their effectiveness [38]; therefore, further clinical trials must be conducted.

As an example of technology-based solutions, virtual reality distraction systems have been shown to be a successful behavior modification method in children undergoing dental treatments [39–43]. Among the diversity of information and communication technologies, mobile technology, especially smartphones and tablets, is shown to be a promising alternative to the treatment of childhood dental anxiety. Mobile devices have been used to treat children's conditions in various health domains, proving to be a viable and effective alternative [44]. Currently, children interact with mobile devices mainly for fun, associating a positive feeling/experience with their use.

The characteristics and features of mobile devices, such as ubiquity, reduced size and weight, ease of use, reduced cost, touchscreens, integrated speakers, and input for headphones, allow the implementation of behavioral techniques for dental anxiety, enabling interventions in different contexts: during dental visits, in the waiting room, during the pretreatment stage, and so on. Some studies published in the scientific literature have focused on mobile oral health in children, for example, Campos et al. [45], who designed and evaluated an educational oral health mobile application (app) for preschoolers. However, few studies have focused on managing childhood dental anxiety through mobile technology. Myers and Venable [46] conducted a study to assess the effect of playing a dental simulation game before operation on pain and anxiety in children during their first dental treatment session. The authors used a commercially available Android simulation game, called Crazy Dentist–Fun Games 1.0, twice a day for two weeks prior to the scheduled visit, and found a significant reduction in the heart rate of children, which could result in a decrease in anxiety felt during anesthetic injections and drilling. The dental team must also provide information to children explaining what is going to happen during the visit in an age-appropriate way [41]. This information is considered an important part of pretreatment education and thus may be included as content in the mobile solution. Therefore, all materials designed to be used to support the management of children with dental anxiety must be adapted to their needs, skills, and preferences.

Content design is a relevant stage in the development process of mobile solutions for children, especially those focused on the management of dental anxiety. Attractive and appropriate content increases user adoption and engagement rates in an anxiety management strategy that combines a user-centered design approach with age-appropriate participatory techniques to increase levels of acceptance and satisfaction among target users [47–50]. Therefore, involving children in the design of technological solutions to support the management of dental anxiety in children is a crucial factor, especially in the content design stage. Despite the previously mentioned benefits of including content specifically designed for children with dental anxiety, technology-based strategies for the management of childhood dental anxiety found in the scientific literature often used age-adapted content but were not designed specifically for children with dental anxiety.

4. Human-Centered Design Philosophy

Software engineering is a process-oriented field [51]. This fact organizes both the necessary steps and the calendar and cost limitations. In the design phase, software processes involve a broad set of activities and tasks that bridge the gap between requirements and construction while adhering to a set of project-specific (or company-specific) constraints.

The software process requires domain knowledge plus an understanding of what a software product can do [52]. The result is a description of a software solution to the domain-specific problem. From the perspective of the implementation domain, it is a descriptive model that must then be formalized as a prescriptive model that establishes how the software product must behave. The objective of this first

model is to explain how the software product will respond to the need. Figure 3 shows one cycle in the essential software process.

In this case, our phase 2 deals with the part "conceptual models" and is focused on software requirements and HCI design (blue elements in Figure 4). The design process is challenging because essential design process activities are often overlooked, done ad hoc, or simply not done at all. In many cases, a well-established and well-conducted design process serves as an indication of the success of the future project [51].

Managing the influences of stakeholders is challenging because it requires designers to exercise a high level of communication, negotiation, and technical skills to ensure that design decisions are made to accommodate all concerns without negatively affecting the project [53, 54].

In this behavioral context, we adapt terms such as "human-centered" or "experience-centered" design. This direction promotes the understanding of human-computer interaction as embodied in the meanings, experiences, and values relevant to personal or cultural contexts [55].

This movement has led researchers to explore the nature of human experience that emerges in interactions with technologies [56]. This research direction has opened up deeper investigations of the meaning of affect, emotion, and experience. We cannot truly design something human-centered without a deep understanding of the emotional experiences prevalent in our own human nature. However, it is also clear that focusing on such human aspects alone does not necessarily lead to successful design outcomes [57].

Although to some extent these claims are true, Lim et al. [58] state that emotions are significantly influenced by the design of interactive products. This view is demonstrated and validated by various researchers, such as Isbister et al. [59] and Desmet and Hekkert [60]. Norman and Ortony [61] also clearly mentioned that emotion can be designed in their explanation of "emotion by design," contrasting with the notion of "emotion by accident," which obviously also exists.

Lim [58] claimed that a given emotional response to an interactive design feature is not entirely predictable, but at the same time they showed that the various emotional responses to a given product quality are not completely random. Going further, they identified which emotions are prevalent for a given product quality, and it is possible to characterize the true source and nature of these emotions, looking for commonalities among the representative population.

As part of the human creative process, emotions play a fundamental role, and effect and emotion play an important role in HCI [62]. Lim et al. work out that emotions can indeed be designed and examine product quality based on Norman's three levels of emotional response (visceral, behavioral, and reflective). They found that the interaction-related features of a product can significantly influence the emotional experience. They also found that functional as well as interaction qualities of a product are directly linked to emotional experiences, leading to the conclusion that

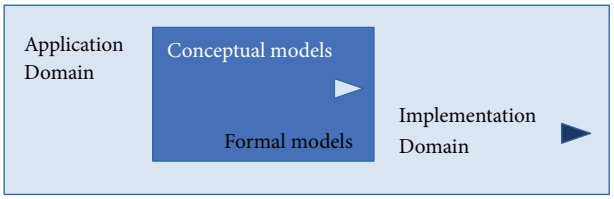


Figure 3: The essential software process [52].

emotion cannot be considered independent from functionality and interaction but result from these. Emotions need to be consciously designed into products and systems since people seem to perceive emotions and their effects even if they are not explicitly present.

On the other hand, Walker and Prytherch [63] motivate us to make use of psychologist's insights in behavior theory and consider users' responses to our designs as a result of the mental processes of perception, cognition, and emotion. They even suggest that design, by shaping users' experiences, can influence user behavior, which can be exploited to motivate the user. Highly motivated users will respond more interactively to a system, which in turn will result in better user involvement and understanding of the product. Since motivated users might be more prepared and willing to cope with usability problems, Walker and Prytherch argue for extending our perception of usability to include user motivation.

Although these emotional responses were not always tied directly to the device itself and influenced by contextual factors, Lim et al. discovered that certain controllable aspects of interactive products showed clear patterns of emotion in the responses of our participants.

As we describe in detail in the following sections, we propose an empirical codesign method, and we describe it using a heuristic methodology based on participant observation, think-aloud technique, codesign customized activities, and, finally, participant satisfaction questionnaires.

5. Hypothesis and Justification

In this work, we hypothesize that empathy can lead children to create multimedia resources that can increase the user experience and could be effective in reducing dental anxiety. At this point, it is important to draw attention to the creative process [64–67], in this case, of the children who participate in the codesign process, and how important the user experience (UX) (satisfaction, fun, entertainment, motivation, aesthetics, creativity, or emotions) is for the ARCADE project objectives.

Our hypothesis is based on highlighting the behavior of a group of 163 children, putting oneself in the other's place, developing empathy, speaking the same language, and transferring problems and situations from one to another, given the problem of childish dental anxiety. Thus, the following is proposed.

H1: A codesign methodology with children based on empathy can be stated to generate appropriate content for a

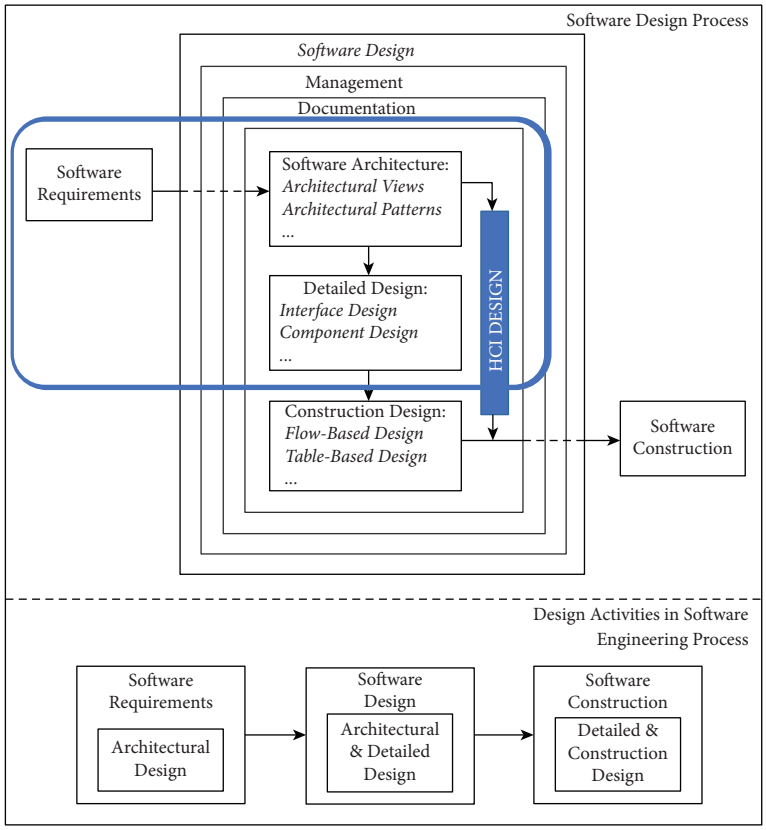


Figure 4: The software design process and design activities during the SWE process [51].

future app to get relaxation, entertainment, enjoyment, and distraction functionalities.

As we pointed out above, our hypothesis is within the process of creation in which Information Technologies (IT) tries to contribute both the scientific praxis and the observation of reality creating early content within a context that invites children (6–12 years old) to help other children, who hypothetically suffer dental anxiety. Consequently, we conducted the following research questions to contextualize our study:

RQ1: Is the proposed methodology able to obtain the appropriate functionalities for an application whose use is to reduce dental anxiety in children?

RQ2: What is the role of children in the proposed methodology?

RQ3: Regarding the functionalities of relaxation, entertainment, enjoyment, and distraction, how are they rated by other children in the context of codesign?

RQ4: Is the proposed methodology able to flourish emotions during the codesign process helping to get a better human experience?

RQ5: Is the proposed methodology able to increase empathy during the codesign process helping to get a better creative process?

RQ6: Are the results obtained through the proposed empirical method of codesign the expected ones?

RQ7: Is the proposed empirical codesign methodology generalizable to other contexts?

This study contributes to the literature on children's dental health from a codesign and human-centered design perspective by investigating the generation of content by observing the real behavior of children based on their interactions with the creation of games and the game itself. We also believe that it is very important to design systems that use interactive systems or that use gamification or video games, which allow user adherence; that is, users become more familiar with these systems, and, therefore, the efficiency of the final technology is much higher helping user-centered design and design methodology.

Likewise, a review of developments in mobile devices, mobile apps, and health apps around dental anxiety has been conducted to raise awareness of an app's potential to reduce dental anxiety and the innovative role it plays within this context [22, 68].

6. Methods

6.1. Resources. The technological and human resources required and involved in this study were as follows:

(i) Researchers and children

(ii) Laboratory classrooms and technological summer school

(iii) Technological tools: PCs, Scratch, Canvas, Power Point, Adobe Photoshop, and Android Studio
(iv) Material like templates and data collection from narrative creation, minigames, and audiovisual multimedia oriented to children
(v) Activities based on products developed by educators or reviewed by experts in education
(vi) Questionnaire (i.e., Likert scale)

6.2. Ethnographic Technique. Participant observation with an anthropological approach is proposed to obtain customized and engaging content for a future Pediatric Dental Anxiety Management App (relaxing multimedia, linear, and nonlinear stories). This methodology involves the categories of analysis mentioned in Section 3 and is divided into five levels:

(i) Triangulation, different scenarios, frequency, and duration between investigators and sessions
(ii) Data that must be socially located and cannot be treated as isolated data and out of context
(iii) Results depending on the circumstances, from who tells us what, at what time we are told, and how it is said, that is, we receive negotiated and mediated information in permanent construction
(iv) Multireferential data through literature review and other sources
(v) Identification of our context and the sense of the plot of reality that we investigate

7. Participant Observation to Apply Codesign to Children

As explained above, this document attempts to provide preliminaries to the main skills required for the application, the main issues raised, with a way to understand dental anxiety in children, and embedded results in text by a thick description. We present data that we collect in the study sessions and analyse them using known qualitative data analysis procedures that are being described in our methods. Therefore, the categories of analysis that guide the research fieldwork are as follows.

7.1. Categories of Analysis. On proposed production on the analytical categories of Díaz de Rada [26] in the ethnographic text, we have worked on the following sets in separate sections:

(i) The participants
(ii) The playful reality: environment and social behavior under codesign methods
(iii) Empathy-based design activities
(iv) The investigators lenses: the empirical method of codesign
(v) Frequency and duration of the interventions

7.2. Selection and Participation

7.2.1. Children. Participants in this study were children aged 6–12 years. The age was chosen according to Piaget's concrete operational stage [69]. According to this stage, children can think logically with concrete information but have more difficulties with abstract concepts, which is why many techniques need concrete objects to help bridge their thinking [66]. Also, during this stage, children are better able to cooperate with others, thus supporting a collaborative work approach [40]. All the children lived within the bounds of Seville City, Spain. This research was designed with two differentiated interventions.

(1) First Intervention. The first intervention was carried out with 24 children in total from the technological summer school at the University of Seville, Seville, Spain. Two groups of primary school children were studied. Ages range between 6–8 years and 9–11 years, respectively. The children who participated in this research were participants in the MindTech Program, a summer technology school at the University of Seville. The children participated in design sessions held in an IT lab at the Escuela Técnica Superior de Ingeniería Informática.

(2) Second Intervention. The second intervention included 139 children from three different levels of a primary school in Seville, Spain. Children in 2nd, 4th, and 6th grade are studied. Ages range from 7-8 years, 9-10 years, and 11-12 years; we held design sessions in the school classrooms.

7.2.2. The Research Team. We are all partners of the Escuela Técnica Superior de Ingeniería Informática at University of Seville. In most cases, we have no previous relationship with the participating children. However, it should be noted that children from the family environment of some of the team members participated. In addition, the school was selected because it is the school to which the children of a classmate go. In the process of analysis of the material generated during the project, a researcher from the area of social and cultural anthropology joins as a collaborator.

7.2.3. Illustrator. A professional illustrator made the backgrounds for the comic strips that the participating children created.

7.2.4. Developer. An Android programmer developed the mobile app prototype using material from the children and the illustrator.

7.3. Ethical Considerations. We also justify our work behind this question: What is ethics for? We agree with Hansen et al. [49] that ethics in codesign with children is very important. Thus, the children were again informed about the goals of the ARCADE project just before starting the workshops. As part of the consent forms during recruitment, parents were also informed through a website and brochures. For all

interventions, written informed consent was collected from children's parents or legal guardians with explicit signed consent. Activities, signed consent forms, and satisfaction questionnaires were approved by the Andalusian Ethics Committee. Additionally, we agree with Myers and Venable [46] that a set of ethical principles for design science research in information systems must be increasingly present.

7.4. The Playful Reality: Environment and Social Behavior under Codesign Methods. Codesign is a collaborative research method that aims to develop new knowledge as people develop and experiment with ideas. The term cocreation includes codesign, which can be considered a special case. However, the codesign objective is to design an artifact (technological solution). Codesign can be used during generative, pre/posttest, and evaluative research and during the complete development of an intervention [70].

A codesign process that involves children and young people includes additional challenges. Workshops must be productive but also engaging, and eHealth-related interventions can add complexity [71]. Several codesign frameworks to involve children in the design process have been developed. Mazzone et al. [72] described a framework of the elements of codesign sessions with children. Alvarado and Díaz [73] described a codesign framework that uses a technological platform to empower children to partner with adults. In addition to these frameworks, many participatory design or codesign methods and techniques have been used involving children in the development process of technology. Fails et al. [74] reported a synthesis of these methods and techniques. Focusing on the codesign of mobile device content involving children, Piaget [69] described the design activities conducted to create content [12]. Codesign with children was successfully used to design parental control app by [32].

All of these codesign methods and frameworks related to children have some common points to consider: researchers played the role of coordinators and/or observers during interventions, time-constrained workshop sessions were proposed, all tasks involved were usually designed by experts (e.g., pedagogues), engagement with children was key to obtain a successful result, and the final stage was data analysis or postprocessing.

7.4.1. First Intervention: Cocreation Processing Technological Summer School. On the one hand, at the technological summer school, the children had not met each other before the study. The following impressions belong to the ARCADE research team as participants and give weight to the idea that it was a nonfamily environment: "They are "strange" classrooms for boys and girls, so I understand that they would be somewhat self-conscious.... It is a computer room with several PCs. Children sit in groups of 2 or 3 children and must work as a team. "Researchers" are given directions first and then allowed to work as a team. In the case of creating digital comics/stories, the researchers try to liven up the activities by asking the children, giving them work guidelines, advice, and answering their questions. It is to some extent more active than the one followed in primary school (second intervention)."

On the other hand, the children were predisposed to use technology because one of the main objectives of the technological summer school was learning video game programming. Indeed, the research team also feeds the thought that: "It is a technological summer workshop, with a playful and relaxed environment in which the children were in. For them it is a new place and going to university draws their attention." This circumstance made the environment favorable for building a good behavior under codesign methods to allow good results in the questionnaires. In this sense, the satisfaction questionnaire (Figure 5) asked children how much they liked to create characters on paper, how much they liked to create the comic using the computer, how much they liked to play the minigames, how much they liked to develop their dental video game, and, in general, how much they liked the whole experience, whether they would repeat the experience, and whether they would change something.

Overall, the children were very satisfied with this experience (Figures 6 and 7). As the results showed, creating the storyboard before designing the characters in detail and finally drawing them was the easiest procedure for the children and was highly motivating. The creation of comics using digital tools was the most challenging activity for the children. However, the objective of achieving end products that could be directly used in the application was not completely successful.

Several reasons made the playful reality of this activity difficult. First, the defined codesign plan underestimated the time needed by the children to complete the task. Second, the children reported that the selected digital tool was too difficult to use. Also, the support of the tutor and the previous experience of the children were insufficient. Therefore, almost all digital comics were unfinished. Therefore, it was concluded that a second intervention was necessary with changes in some aspects of the cocreation in the participatory design method.

Children tended not to consider the characters created in the previous sessions, narrative creation (linear stories), or create a dental-related story.

7.4.2. Second Intervention: Cocreation Process in Primary School. The focus on the environment and social behavior under design methods is not only necessary but also effective because we could make some improvements and add them to this second cocreation process for children of 2nd and 4th grades (around 7 and 9 years old, resp.) due to the previous experience with the technological summer school intervention.

The first difference was that the children were used to working together in groups because they had met previously and because they were used to collaborating. This fact represents two consequences. This means that some processes, like narrative creation, were accelerated and children could write their own narratives instead of having an adult take notes (which in fact added more engagement to the

Acabas de participar en el proyecto de investigación ARCADE, te has convertido en una auténtica investigadora o un auténtico investigador. Hemos hecho muchas cosas en este proyecto y ahora nos gustaría que nos dijeses si te ha gustado participar. Para esto, elije las respuestas a las siguientes preguntas que reflejen tu valoración:

Preguntas	Respuestas				
	Muchísimo	Mucho	Regular	Poco	Nada
¿Cuánto te ha gustado crear los personajes en papel?					
¿Cuánto te ha gustado crear tu comic usando el ordenador?					
¿Cuánto te ha gustado probar diversos juegos?					
¿Cuánto te ha gustado desarrollar tu videojuego dental?					
En general, ¿Cuánto te ha gustado la experiencia?					

¿Repetirías la experiencia de ser una investigadora o un investigador? ☐ Sí ☐ No ☐ No lo sé

¿Cambiarías algo?

Figure 5: Satisfaction questionnaire for children in the first intervention (summer school).

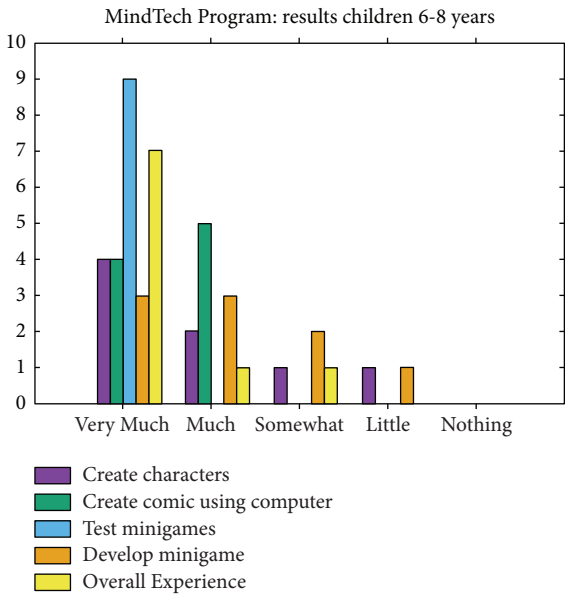


Figure 6: Results of the satisfaction survey for the first intervention with children 6–8 years of age (summer school).

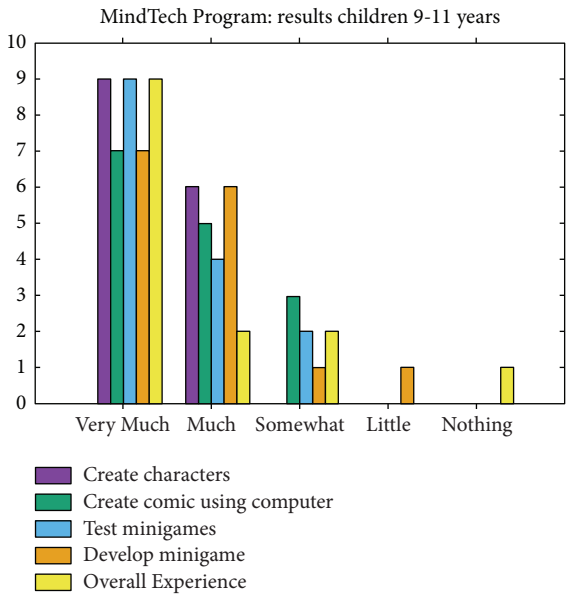


Figure 7: Results of the satisfaction survey for the first intervention with children aged 9–11 years of age (summer school).

activities). The other one can be read in the following text from a team participant: "In the class itself. Totally used to it, and hence the chaotic behavior of many of the boys and girls. It was much more complex to deal with this situation. Children, especially, although some girls did not stand still; they screamed, messed with the next person, argued, and lost concentration due to jokes from the rest of the team. There were even problems because some boys or girls did not want to form teams with others." However, the satisfaction levels were higher and even better than the previous experience with the technological summer school. Therefore, it can be concluded that the engagement of children in cocreation

processes (the main objective of most cocreation methods) was elevated with the proposed method.

The second change was to extend cocreation sessions for about one more hour for children in the second and fourth grades. No technological tools were necessary to use/learn to complete tasks that had previously proven to be time-consuming. These two facts allowed the children to complete almost all the tasks. In the case of the children in 6th grade (around 11 years old), the remaining time after video and audio selection allowed them to create better relaxing audio stories.

The last major improvement was to restrict some of the tasks performed by the children. For example, the comic or story backgrounds of the narratives were done by experts. This allowed children to focus on character creation and narrative. Furthermore, most of the participating children produced more material than needed. Thus, the best-quality narratives could be chosen for a better final product.

The satisfaction questionnaire for the second intervention in the 2nd and 4th grades is shown in Figure 8. In this case, the children were asked two questions: how much they liked to create the story and how much they liked to draw the characters and objects for the comic.

The satisfaction questionnaire for the sixth grade is shown in Figure 9. In this case, the children were asked two questions: how much they liked to select audio and video and how much they liked to create the story.

The results of the surveys that were passed on to the children after the participatory design sessions are shown in Figures 10–12.

7.5. Design Activities Empathy-Based. This section becomes essential as it shows that this method is flexible and allows for adaptability to different scenarios within two different environments (familiar and unfamiliar). For example, the goal of end products that could be directly used in the app was not successful. Accordingly, it was concluded that a second intervention was necessary with changes in some aspects of the cocreation in the participatory design method, as we stated before. Likewise, one of the participating researchers in this study explains the following in the interview with the collaborating anthropologist: "In general, the boys and girls understood the objective of the project, as well as the specific one of each task. After presenting the tasks to them, they had some initial doubts, but they all developed them without much inconvenience. They were delighted to participate. In my opinion, and just as a personal appreciation, I think the MindTech group was more motivated by doing a piece of work assigned to the group, while many of the boys and girls of the school were more motivated by the breakdown of the routine in class."

To carry out our process, the ARCADE project creates the following planning and codesign methodology and develops features such as narratives (linear/nonlinear), minigames, and 360 videos (+ music/sounds).

7.5.1. First Intervention: Technological Summer School. This intervention was split into two specific workshops during the technological summer school at the University of Seville. Each workshop took one week, so in total this first intervention took two weeks with 60-minute sessions each day (from Monday to Friday). The first week's sessions included a workshop named "Video Game Programming with SCRATCH," which involved children aged 9–11 years (14 boys and 1 girl), and the second week included a workshop named "Video Game Programming with KUDO" with children aged 6–8 years (6 boys and 3 girls). The objective of this intervention was to create characters and narratives (comics) to be included in a future app and identify types of minigames to be included in the app. The codesign intervention consisted of two parts: narrative creation (linear stories) and minigame selection.

(1) Narrative Creation (Linear Stories). During this first part, researchers guided children through these steps and collected information about the process and content (transcribing, observing children's reactions, helping children follow the session, and solving conflicts). The role of the researchers during the sessions was passive except when conflict resolution was necessary. Each group was assigned an experienced researcher in charge (Figure 13).

The cocreation of stories/tales followed these steps:

(1) Drawing characters on paper (Figure 14)

(2) Making a storyboard on paper (Figure 15)

(3) Making a digital comic with the characters and storyboard (Figure 16)

  (3.1) Using a digital design application (http://www.canva.com) for children aged 9–11 years.

  (3.2) Using a visual programming language (https://scratch.mit.edu/) for children aged 6–8 years.

To handle the groups, to transcribe their story, and to make decisions during the creation process, the children were placed into groups of three. The children used creative techniques, including a "Comic Making Fun" activity, extracted from Martin [75] (Figure 17), examples of comic topics proposed to the children to inspire them (Figure 18), and a game activity with customized cards and cut characters (Figure 19).

(2) Selection of Minigames. In the second part of this intervention, children were put in pairs (in some cases, groups of three) to select five types of minigames. Participants played these minigames for a while and then responded to a questionnaire that included open questions. Its translation into English is shown in Figure 20.

Researchers previously selected the minigames to ensure that they were appropriate for children. The minigames checked by the 9–11-year-old children included Sudoku, Puzzle, Jelly Slice, Cookie Crash, Bubble, Bugs, Swarm, and Doctor. Children aged 6–8 years checked minigames on the Pocoyo site that included eight categories of minigames.

During the second part, the researchers guided the children through the list of minigames and used the questionnaire to select the minigames, as shown in Figure 20. Furthermore, they collected information about the selection process (observing children's reactions, helping

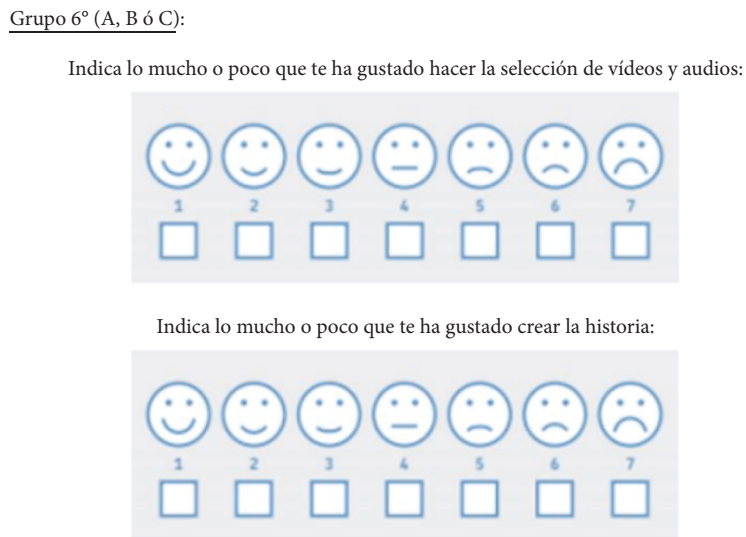


Figure 8: Satisfaction questionnaires in the second intervention for children in the 2nd and 4th grades (primary school).

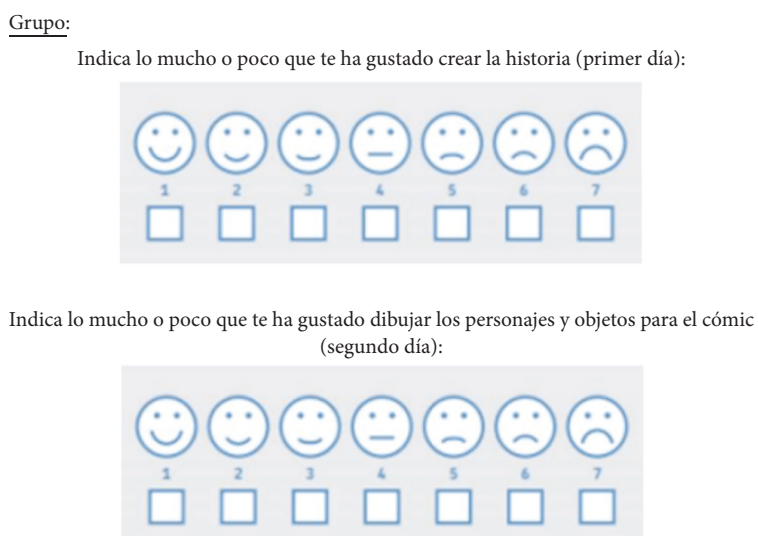


Figure 9: Satisfaction questionnaires in the second intervention for children in sixth grade (primary school).

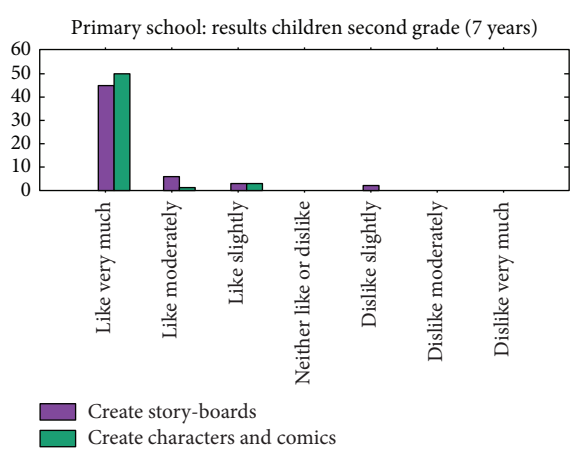


Figure 10: Results of the satisfaction survey for the second intervention in the second grade for children aged 7 years (primary school).

children follow the session, and solving conflicts). Each group was assigned a researcher in charge.

Relating to mediation in communication, whether oral or in a register or nonverbal, during the observation, the technique of thinking aloud was used in all sessions in order to obtain empirical data and collect information for the user-centered design. During this first part of narrative creation, experienced researchers guided the children through these steps and collected information about the process and the content (transcribing, observing children's reactions, and helping children follow the session).

Multimedia was a novelty introduced in this second intervention. According to Navit et al. [76], audio-story distraction is very effective in reducing dental anxiety in children. They also argued that instrumental music is not effective. Navit et al. established this hypothesis: audio or

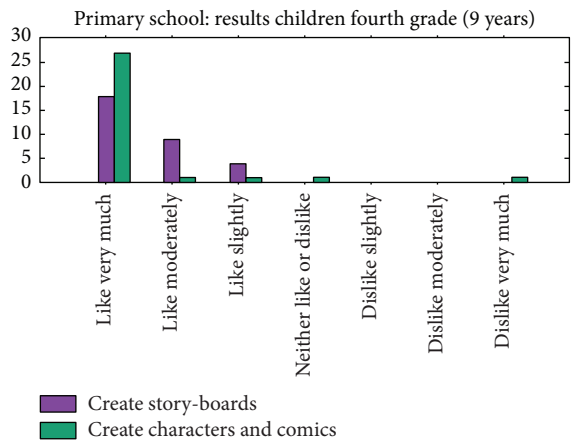


Figure 11: Results of the satisfaction survey for the second intervention in the fourth grade for children aged 9 years (primary school).

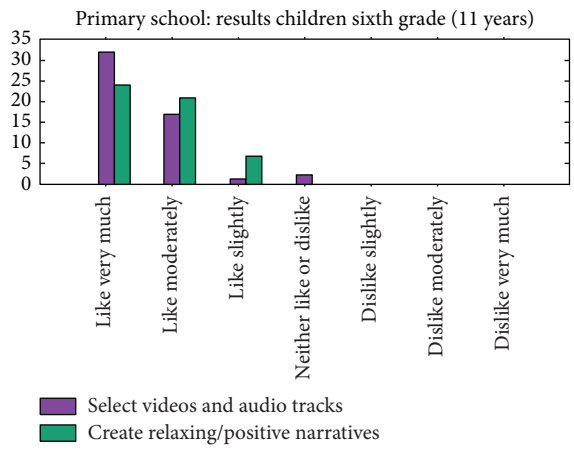


Figure 12: Results of the satisfaction survey for the second intervention in 6th grade for children aged 11 years (primary school).

Figure 13: First intervention in a technological summer school (youngest session).

music is still effective in relaxing and distracting children, but it must be different from instrumental music. Therefore, sounds of nature were used instead. In addition, the relaxing effect of audio was reinforced with video (also from natural environments).

7.5.2. Second Intervention: Primary School. The objective of this intervention was codesigning characters and narratives and selecting video and audio to create relaxing multimedia scenarios to be included in a future app; thus, the intervention had two differentiated parts of content creation:

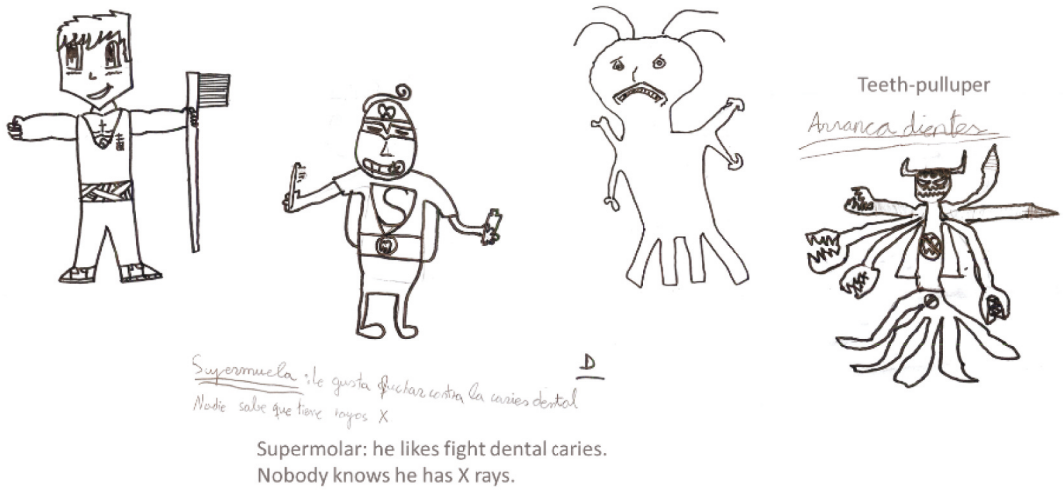
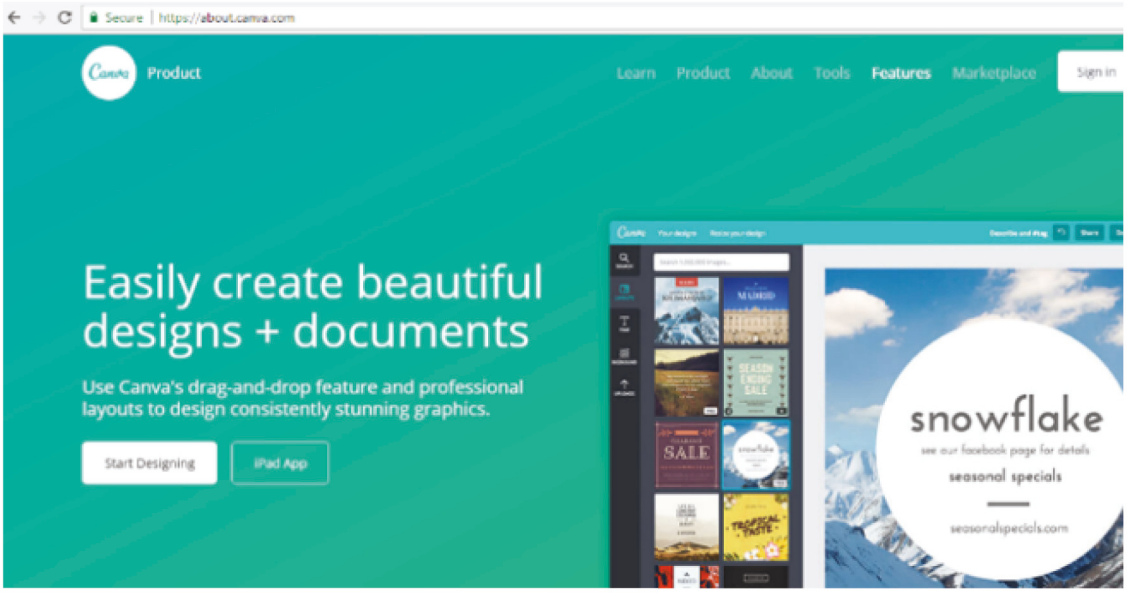
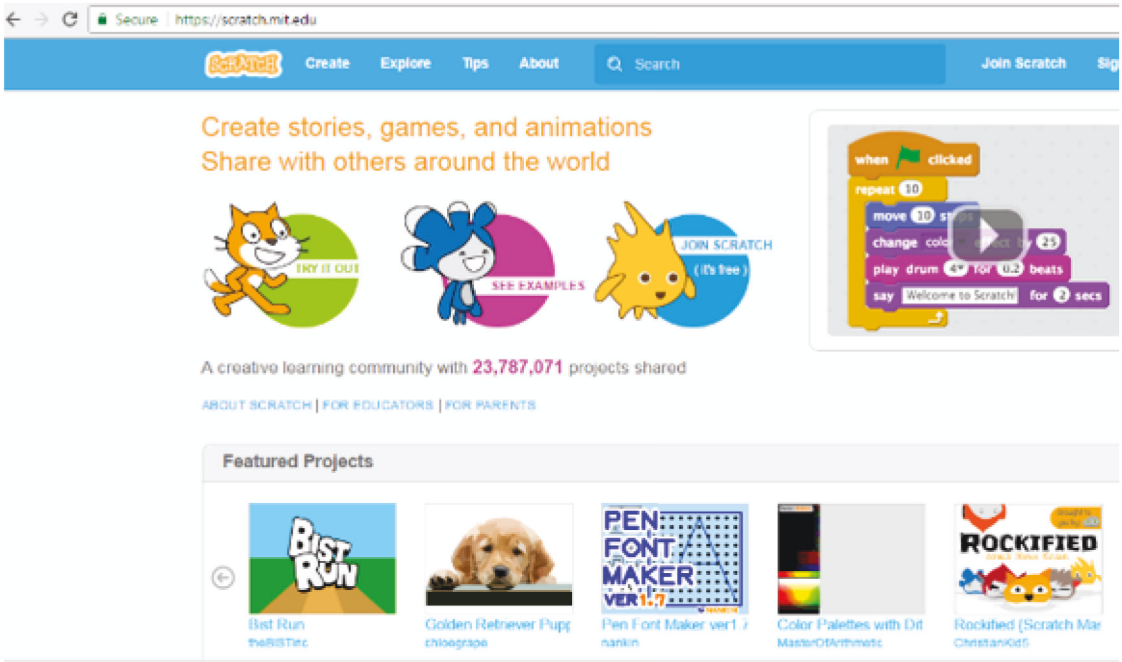


Figure 14: Characters drawn on paper created by the designer children.

Figure 15: Characters and dialogs (sticky notes) created for the children's storyboards in the first intervention (summer school).



(a)



(b)

Figure 16: Tools used for digital design: Canva (a) and Scratch (b).

(1) Narrative creation: first part (Figures 21 and 22)

  (i) Building linear stories (7-year-old children)

  (ii) Building nonlinear stories, with several endings (9-year-old children)

(2) Multimedia creation/selection (11-year-old children)-second part (Figure 23)

  (i) Selecting relaxing video and audio

  (ii) Creating audio stories to relax and encourage children

This intervention was carried out with three different grades (2nd, 4th, and 6th) of a primary school in a primary school in Seville, Spain. The participants were around 7, 9, and 11 years old, respectively. This second intervention consisted of two 60-minute sessions in each group for two weeks. In total, 139 children (68 boys and 71 girls) participated, with the following distribution by age:

  (i) 56 (27 boys and 29 girls) children aged 7 years.

  (ii) 31 (16 boys and 15 girls) children aged 9 years.

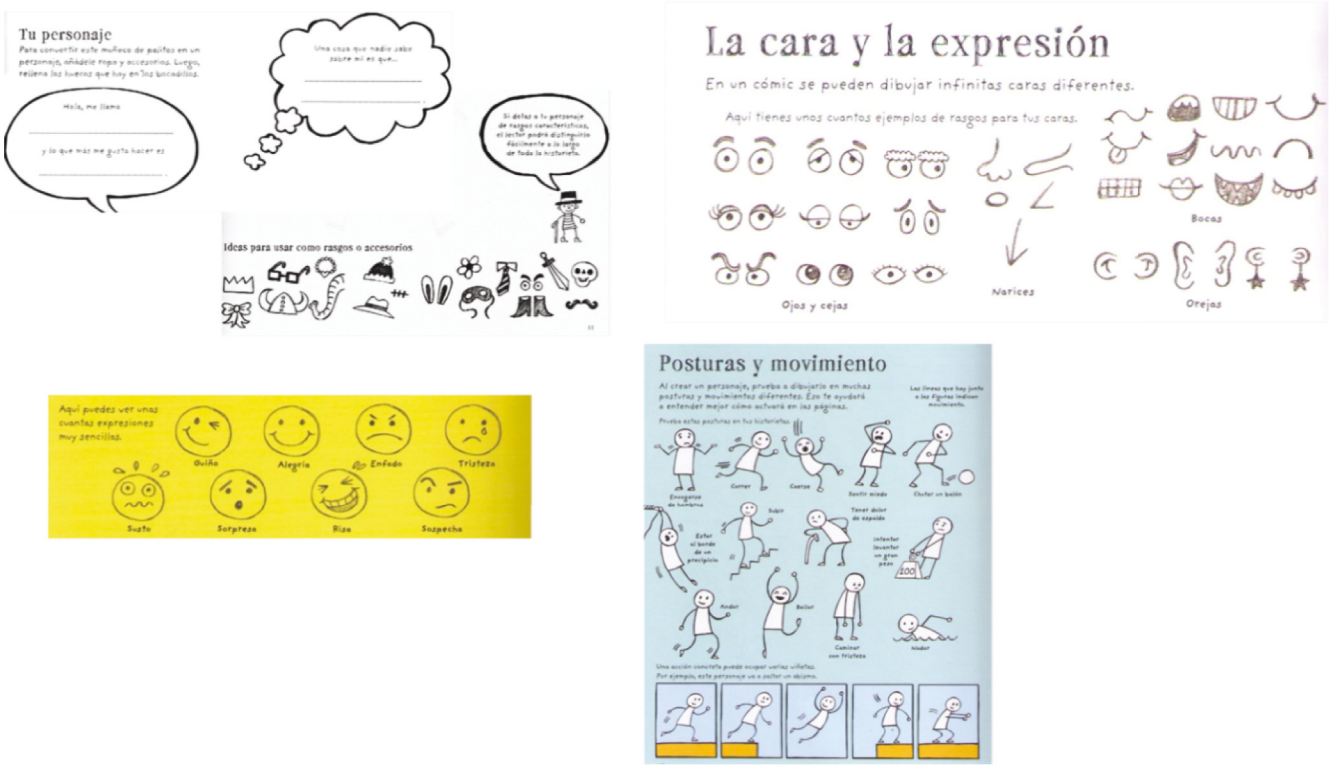


Figure 17: Material given to children to help them create comics (extracted from [48]).

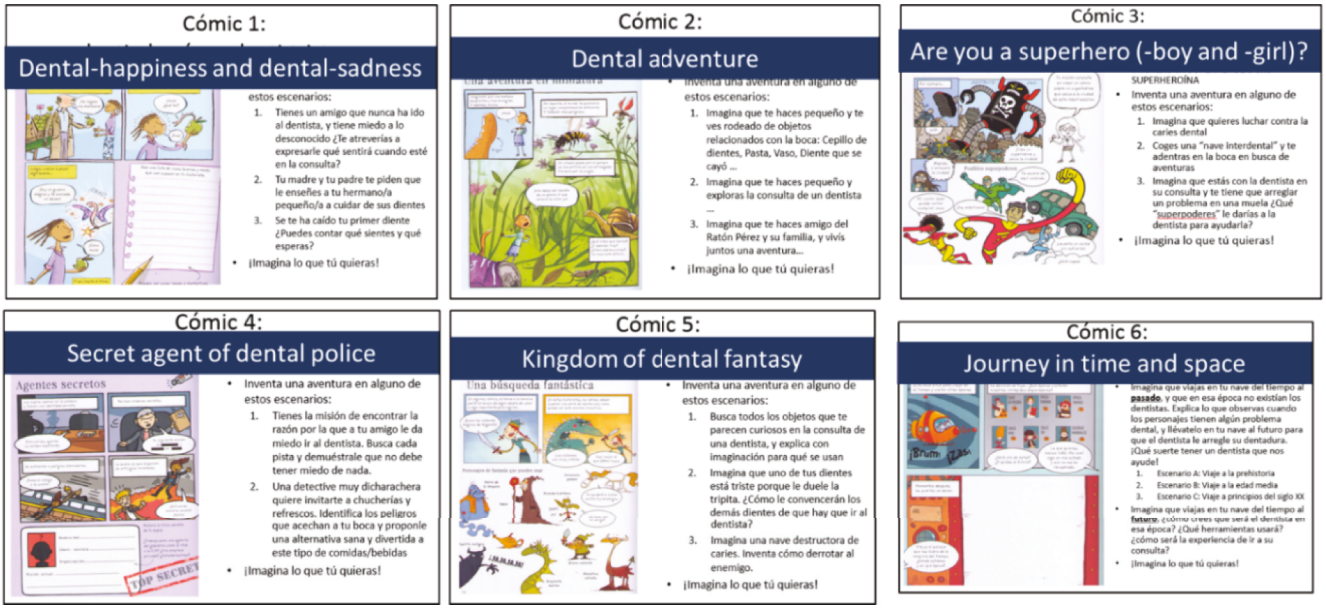


Figure 18: Examples of comic topics proposed to children to inspire them (extracted from [48]).

(iii) 52 (25 boys and 27 girls) children aged 11 years.

In this case, in order to build the narratives, the children were placed in groups of at least three members, a maximum of five, and exceptionally six to create collaboratively. Group sizes were larger than in previous experiences because the number of participants was higher, and this made it easier to manage fewer groups simultaneously. The children used creative techniques, including an activity "Enjoying Making

Figure 19: Examples of customized cards used by children to build stories focused on dental issues.

Game	Question	Answer	Notes
Game Name	Do you like?		
	What do you like more?		
	What do you like less?		
	What would you change?		

Figure 20: Questionnaire to select minigames in the first intervention (summer school).

Figure 21: Scenes created by children in the second intervention (primary school).

a Comic" (linear and nonlinear stories), extracted from Geertz [27] (Figure 18), and a play activity with customized cards and story cubes (Figure 22).

In the second part of the multimedia creation/selection, children in the sixth grade (11-12 years old) were put in pairs to select relaxing multimedia resources and create short positive stories to attach to the multimedia selection (Figure 23). Each pair of participants selected video and audio by answering the online user questionnaire shown in Figure 24. A 1–5 Likert scale was used to assess children's preferences for each resource. Finally, the children selected the best one.

During this second part, the researchers guided the children through the list of video and audio. In this case, the researchers elaborated on an online questionnaire previously mentioned (Figure 24), and the questionnaire was completed directly by the children during the session in the laboratory classrooms. Furthermore, researchers collected information on the multimedia selection process (observing children's reactions and helping them follow the session).

At this point, the objective of designing activities guides us on the senses and the playful identity that children and adolescents project to the game; approaching that definition

Figure 22: Story cubes used by children to build stories in the second intervention (primary school).

Figure 23: Children aged 11-12 years select relaxing video and audio in the second intervention (primary school).

that we were initially looking for, one of the heads of the research team established it as follows:

"It is about children creating content and trying out minigames based on small tasks that the researchers propose to them. We start from the hypothesis that if the contents are created (or, in the case of the minigames, selected) by children of the same age group as the children who will eventually use the app (children with dental anxiety), we can achieve that said contents are more attractive and the app is more effective as a distraction element."

8. The Investigators Lenses: The Empirical Method of Codesign with Children

As Bratteteig and Wagner [77] stated, there are several reasons to use participatory design: "improving knowledge upon the system built," "enabling people to develop realistic expectations," and "reducing resistance to change." This point is a paramount concern for our project to check if a collaborative method involving children in the content creation allows us to get the expected to be included in the app.

This method is based on Druin's [78–81] and Fails's [74, 82, 83] works, but it is focused more on creating the content than the technological interface where two different environments (familiar and unfamiliar) were tested. The steps in the codesign framework described by these authors were also considered. Therefore, the tasks for the workshops of the interventions were extracted from kits, books, and multimedia content designed for these activities and age ranges ("The Playful Reality" subsection). We distinguish eight steps along the empirical method of codesign in our observation:

(1) Resource preparation: before the first session, researchers prepared all the resources required for the sessions. Customized cards were made focusing on dental issues, templates were sought and printed, and so on. The resources were based on products developed by educators or reviewed by experts in education.

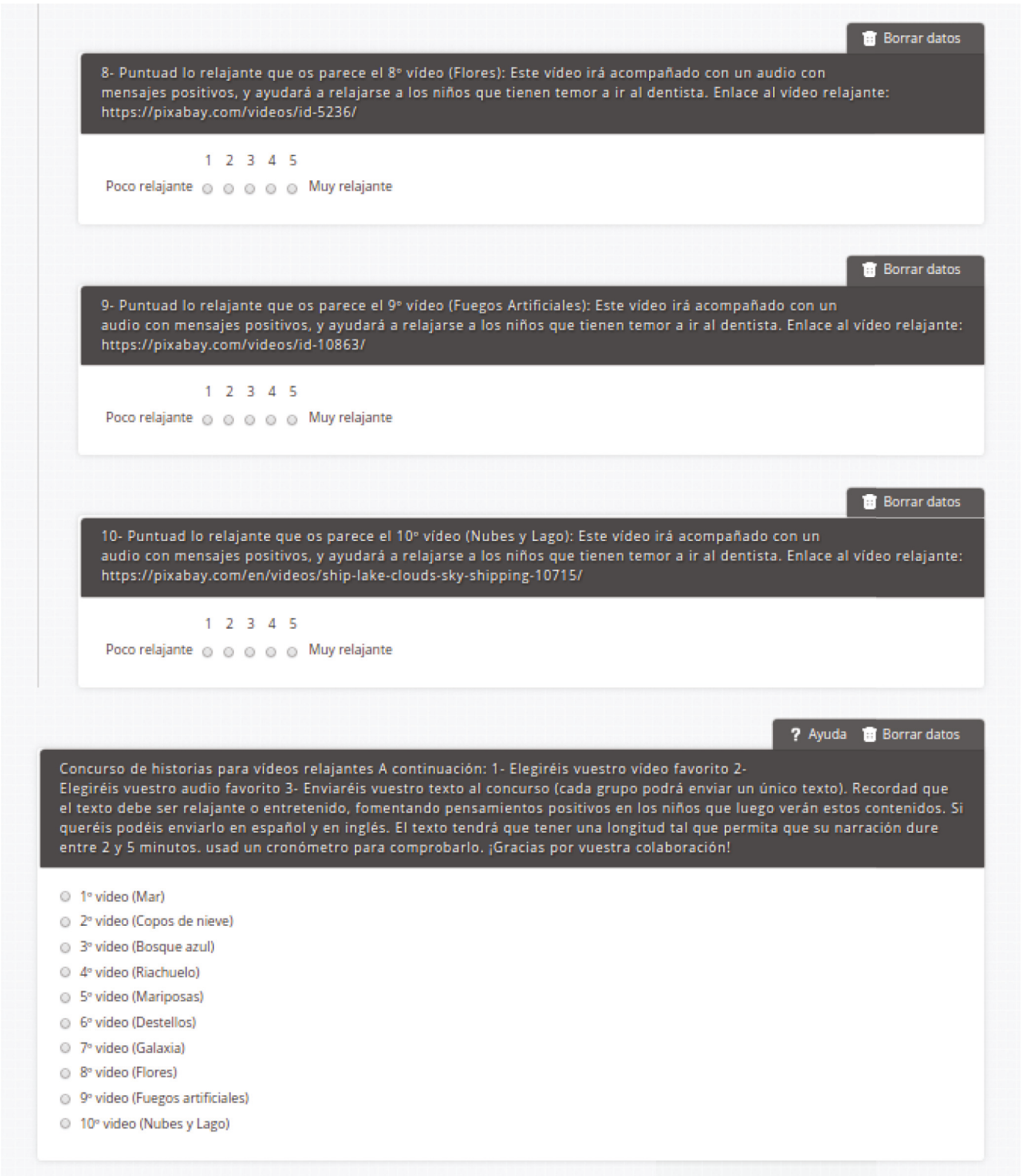


Figure 24: Online survey manager questionnaire to select multimedia resources in the second intervention (primary school).

(2) Contextualization of the project: at the beginning of the first session in each group, the researchers explained the project, providing children with the following context: helping to design an application for children with dental anxiety. The explanations were adapted to age.

(3) Participant grouping: to create the narrative, most of the groups had three members, in some cases four members, and five as a maximum

(4) Scenario distribution: six different scenarios were proposed to children as examples, extracted from Geertz [27] with mild modifications. The researchers customized these scenarios to focus on dental problems. The scenarios were randomly distributed to the groups.

(5) Narrative creation: depending on age, different creative techniques were used. Younger participants were asked to create comics while older ones wrote short tales. In all cases, the children used the example scenarios as a starting point. First, the children created the characters of their own story, then they made a storyboard using stickers and sticky notes, and finally, they created a comic or story collaboratively. More details are described in the Design Activities (Section 2C).

(6) Children's preferences/likes collection: in this step, the researchers collected information about the minigames and multimedia resources that the children liked. Here, the children were put in pairs and, in some cases, groups of three to perform two different actions in two different interventions.

(7) Selecting minigames: all the children played different minigames and selected which ones they preferred.

(8) Relaxing content selection and creation: the oldest participating children helped the researchers select relaxing video and audio to be included in the app. The children then created short positive stories to accompany the multimedia selection.

(9) Result postprocessing: once the sessions were completed, the resulting products (characters, comics, and tales) were digitized and processed to be included in the final version of the app.

(10) Integration of processed content products into an app: finally, a mobile app prototype was designed and implemented using the results of the previous steps.

To determine the role of children, we keep in mind the three dimensions of Druin [79]. We selected the following value for each dimension by consensus: elaboration level, for a prototype, and for getting a better result (engagement of the app for children aged 6–12 years). As a result, the "design partner" [83] was selected as the role of the participating children in the narrative design and the "informer" in the selection of the taste.

But how have we measured children's satisfaction with games? During the selection of games, ARCADE investigators conducted questions and considered asking questions to the child participants during the process of participant observation as follows:

(i) For each game: do you like it? What do you like more? What do you like less? What would you change?

(ii) After seeing all the games: What games do you like the most? What do you like most about those games?

We also made a rubric to fill in during the session. The researcher assumes the role of interviewer/entertainer to identify the playful identity of the children. Here is an example of the transcription of a recording Arcade_A_-session4_probe_minigames_ (child + child):

"I'm going to ask you a few questions now about everything we've done in the course, throughout the week, to see if you liked it or not, and you have to answer me ... look... [researcher / entertainer]... How many did you like to create the characters on paper?.. a lot, a lot! [Child]. . . and when did we create the computer? and try the games? [researcher / entertainer] I loved it [child]...and in general? [researcher / entertainer] Everything [Child]. . .and would you change anything? [researcher / entertainer] No [child].... Good. Well, thank you very much, and let us play. [researcher / entertainer]."

Likewise, our contribution starts out by studying children's emotional involvement in the problem of dental anxiety with our observation and obtaining first-hand information about the activities carried out by children through codesign. We understand that creation is born from empathy, and we also observe how in this practice different scenarios of reality are interwoven. Within the development of software focused on the person, we understand that it is necessary to know the different scenarios through which children possibly move to establish and carry out an optimal process since they will be indicators of the future success of our project. As we stated in this study, designs are shaped by many different influences from stakeholders, the development organization, and other factors. In this sense, the product, that is to say, the app, implies four possible settings: education/school, Information Technology, public health services, and in a transversal way the family. Therefore, we seek to carry out a consistent process for software development. But why do children respond with high participation? We illustrate with the following reasons why the number of groups of children under observation ($n = 163$) is motivated and how they are related to the different scenarios or areas involved.

First, for instance, we focus on the area of school, education, and the family as the sociocultural attribution of children where the professionalism of the game prevails, the influence of the children's collective imagination (Pocoyo, minigames), the mind's eye and the naturalization towards innovation, and the creation of an object (material or immaterial); therefore, these areas are in a certain way at the core of the influence to generate content in our workshops.

Also, in their growth, they are at the age in which they produce natural actions towards the game, and, as a result, the own analytical category "games" is included in these spheres of their lifetime.

Second, by focusing on Information Technology as mediation in the essential software process with children, in a broader holistic context of human behavior, we promote that understanding of human-computer interaction embodied in relevant meanings, experiences, and values given by them in the role of researchers where expectations of help and solidarity with other children who are going to suffer dental anxiety at a given time are created. Above all, we observe that they are comfortable with technology and open to relieve other children.

In a third stage of the analysis, we observed that our design would be shaped and influenced by another of the possible stakeholders, public health services, which can affect the development of our system and vice versa. In this way, we realize the theoretical fact in our empirical approach to manage these influences because they are critical to maximize quality. We face communication and technical skill challenges to ensure that design decisions are effective. From the point of view of this area, we take advantage of the valuable knowledge and ideas to contribute to the application design process with the help of children and adolescents. This sociocultural area brings us closer to seeking well-being in the care of child patients through the roles of children, human factors, in the design of new technologies.

Finally, in a transversal way, the digital culture that attracts children and adolescents appears, and, being aware of this, we use it to bring them closer in this way so that they contribute to dental health in general.

9. The Mobile Application

The resulting mobile app prototype integrates the codesigned content. After the interventions, the research team selected the resources the children created. Minigames and videos that had obtained the highest score were included in the app. Regarding narratives and illustrations, those that were more creative, original, and complete were selected and processed by the illustrator to be included in the app. It is an Android application written in Java via Android Studio. The app opens with a start screen in which the user is presented with three different tasks (Figure 25). It implements three parts: narratives (Figure 26), minigames (Figure 27), and relaxing multimedia stories (Figure 28). Once the user has selected the category of choice by tapping the panel, the list of all available items within the category is displayed. Navigating through all items is achieved by scrolling, and a resource can be selected by tapping on its panel. Each view has a return button in the upper left corner.

Navigation through the narratives was achieved by swiping left (go to the next page) and right (return to the previous page). Relaxing videos with storytelling started automatically when selected from the list. A progress bar was placed at the bottom of the videos.

The examples of ARCADE app screens shown in Figures 25–28 are captured by running on a tablet (10 inches).

10. Discussion

Having seen the results through our thick description, we can point out that we have worked with functionalities such as relaxation, entertainment, enjoyment, and distraction. Besides this, we can affirm how our results help to move the design space of applications for children forward with an emphasis on dental anxiety. That is to say, our first conclusion is that this empirical codesign method allows the codesign process with children to create content for a technological tool (app) that addresses the problem of pediatric dental anxiety. This fact moves the design space of applications for children forward to a greater and mutual approach between technology and the user. This helps us to answer the research question of whether the proposed methodology can obtain the appropriate functionalities for an application whose use is to reduce dental anxiety in children (RQ1).

This method achieved considerable material (narratives, multimedia resources) to develop the content for the app. In addition, this method allowed participants to participate in the interventions. We can affirm that the role of children is crucial. We have also observed how emotion in children depends on the functionality of products and their interaction with them. Children who participated in the process showed high satisfaction during the activities and were involved and concerned about how their work could help other children with dental anxiety [84–86]. The learning service with children is useful in codesign [87]. This helps us answer the research question on what the role of children in the proposed methodology is (RQ2).

Children show their preferences. Minigame test sessions were by far the favorite activity for both groups of children. They all completed their tasks, and all the children tested every game. The selected minigames were the main result achieved. In the case of children aged 6 to 8 years, the two favorite games were related to shooting balls and driving bumper cars. In the case of children aged 9–11 years, a game like the popular Candy Crush game called Cookie Crash was the favorite. The children's comments about why they liked or did not like the minigames (minigames questionnaire) were not conclusive. For example, some children liked certain games because they were difficult, but other children argued the opposite. Although we well know that the functionalities of the games are the generation of content for the development of the app, in the same way, we shape the experiences of children/adolescents to influence their behavior and motivate them. Therefore, these functionalities are positive for our objective. It helps us to answer the research question regarding the functionalities of relaxation, entertainment, enjoyment, and distraction and how they are rated by other children in the context of codesign (RQ3).

Figure 25: Main menu.

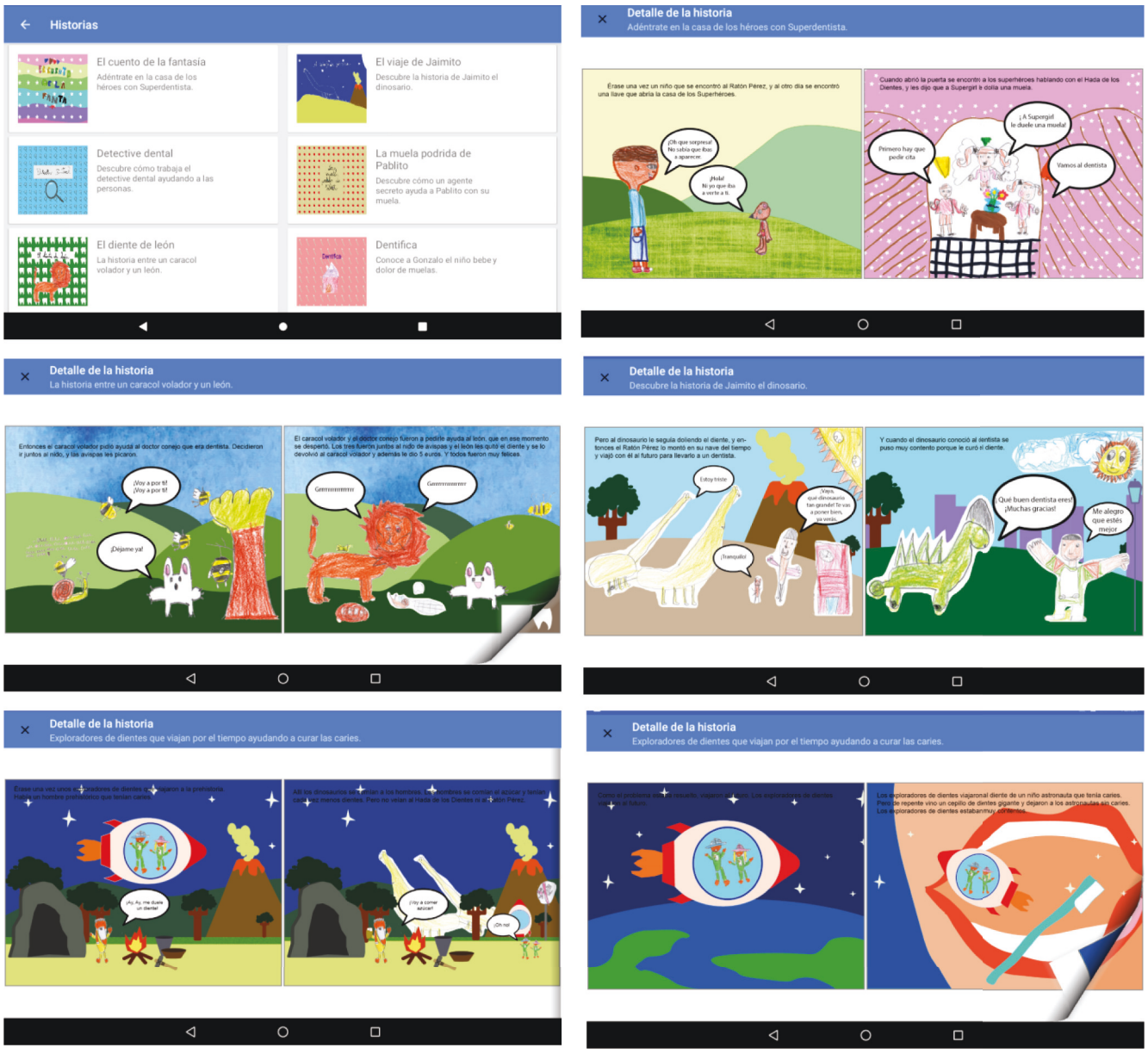


Figure 26: Narrative menu and examples.

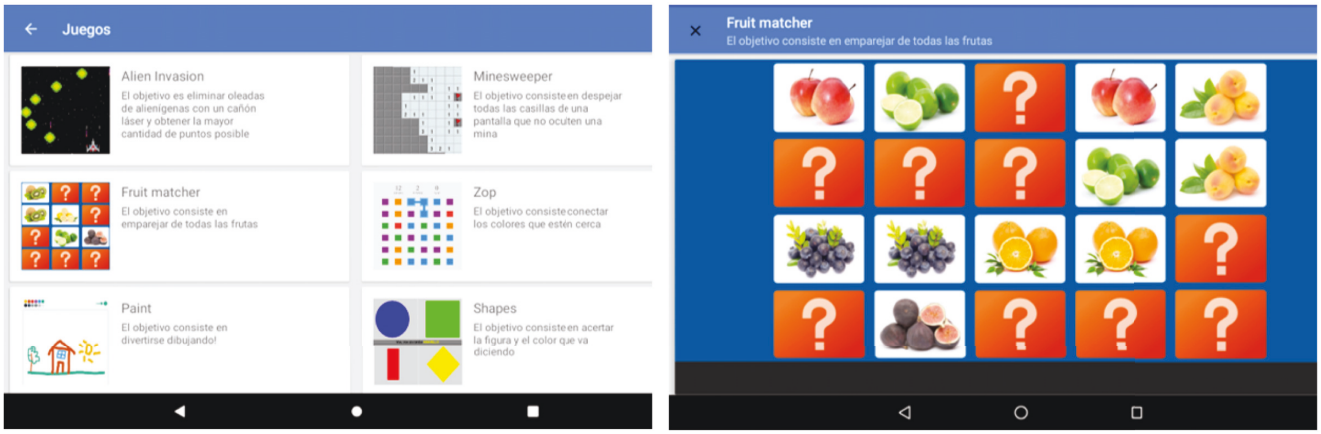


Figure 27: Minigame menu and example.

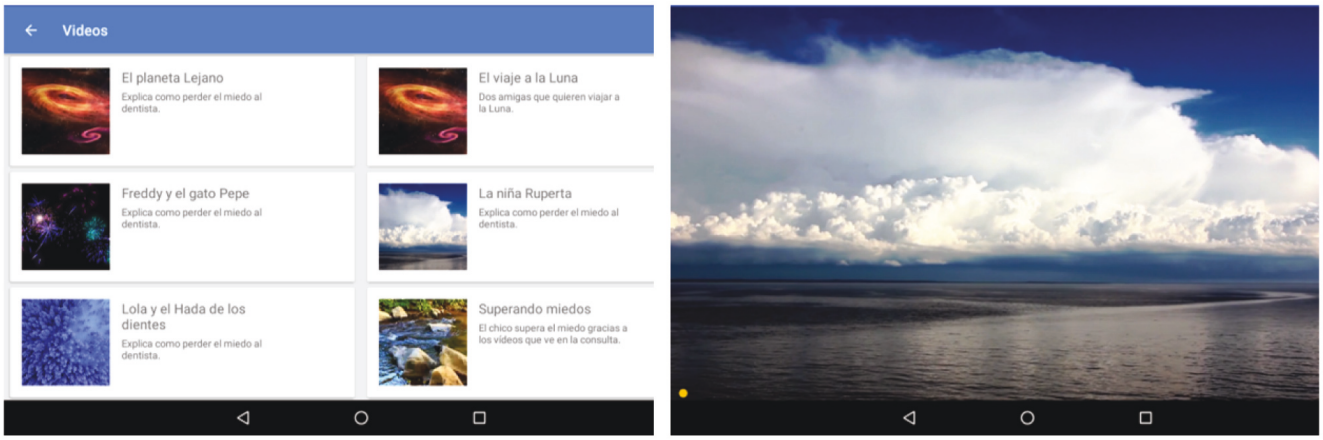


Figure 28: Video menu and example.

The interventions show how the participant children worry about other children suffering dental anxiety, feel empathy, and put their emotions into play. Encourage them and help them to contribute more and better during this codesign process. We think that the experience was very positive, and it allows us to answer research questions about if emotions (based on empathy) can help to get a better human experience and a better creative process during the codesign process (RQ4 and RQ5).

Regarding the research question on how useful the content generated by children is with the sole objective of helping other children with dental anxiety (RQ6), the results of the interventions show that the products can be used, combined, and integrated in the app. Despite the intervention methods depending on intermediate products and context [88], this method is flexible and allows adaptability to different scenarios, contexts, and ages. And we see that its usefulness is given by human nature itself when it is on the side of mutual attention between equals.

Finally, after implementing the empirical codesign method, we highlight that most of the methodology steps can be easily customized for other scenarios by changing the content of the task. For example, in Step 1 (resource preparation), custom cards would be made focusing on issues from other domains of the problem (instead of dental issues). In Step 2 (contextualization of the project), provide the children with the appropriate context: helping design an application for children with <some problem>. In Step5 (narrative creation), the example scenarios would be related to the new problem domain (instead of dental issues). In conclusion, it is generalizable to other contexts by using material that is specific to the new scenario (RQ7).

Future extended work on this topic will include validating the usability of the app; measuring the user experience; assessing the effectiveness of this kind of technological solution to reduce anxiety, including the effectiveness of the relaxing nature-based video and audio; evaluating the children's usage patterns, engagement, and satisfaction with the created stories and comparing their effectiveness with those created by adults; introducing other sources of data and elements in the app (wearable sensing, 360° video, affective computing); working in aesthetic aspects to get high adherence; and working in transferring or social entrepreneurship.

After this experience, the first consideration is that the context of the intervention significantly affects the products

that the children create. A familiar context provides a better environment to create in a collaborative way and makes it easier to guide the sessions. Also, in a formal learning environment such as a school, children are well prepared for a creation process because it is the natural context for doing new things. This fact was also noted by Moore and Brødsgaard [10] in which codesign sessions with children were conducted at the school. By utilizing their everyday environment, users (children) can be experts in the situation, thus creating a more relaxed atmosphere. The second consideration is that this experience reveals that even though the children were familiar with digital skills, the actual digital skills were not enough to create end products for the app. Prior training would be needed to obtain useful results. Better final products were reached without IT activities in the second intervention. Due to time restrictions during sessions and the high number of participants, a preprocessing stage was necessary. This is especially true if attractive and high-quality products are needed.

The third consideration is that this experience with children is evidence that codesign is an effective activity to empower children politically and intellectually [26] and to educate children about their own personal hygiene habits and food safety in a formal educational environment, getting "improved school meals and greater awareness of healthy eating and healthy lifestyles" [52]. By allowing children to have a voice in the design of the app content, we continue to support this empowerment. Empowerment as an experience of codesign has been supported in the literature [81]. It was also an opportunity for children to train other skills in the curricula related to emotional intelligence: developing good character and caring for and acting on core ethical values such as fairness, honesty, compassion, responsibility, and respect for yourself and others [23].

The fourth consideration is that, in this study, researchers had to prepare intense and dynamic material oriented to children. As a result, the children were excited about creating their characters in digital format (on the computer). They became more aware of their digital creation capabilities. Involving children in the codesign process poses some challenges, such as concentration problems and boredom. Codesign activities must be carefully designed to engage participants to avoid these issues. We combined the use of children-oriented teaching methodologies with gamification to create a fun atmosphere in which participants feel comfortable and entertained. Each session was moderated by at least three researchers who were sensitive to working with children. As a result, the participants had an overall very good experience. The last consideration is that, despite the effort of this process, the mobile app design and implementation turn into shorter processes. Moreover, the content of the app is guaranteed to be customized according to the preferences of the user (children). Based on this experience, this methodology can help improve the usability of the app and the efficiency of dental anxiety in future phases of the ARCADE project.

Regarding the satisfaction questionnaires, different designs were used. In the first intervention, the population was low, so to avoid dispersion in the responses, a 1–5 scale was used. In the second intervention, the population was significantly higher, so the scale used was wider (1–7). As the results show, this was not necessary because the children did not use the middle values on the scale of 1–7.

11. Conclusions

We have worked with functionalities such as relaxation, entertainment, enjoyment, and distraction. Our results help to move the design space of mobile applications for children forward with an emphasis on dental anxiety.

We summarize the discussion in the following conclusions. The proposed codesign methodology can obtain the adequate functionalities for an application whose use is to reduce dental anxiety in children. The role of children in the proposed methodology is participative and engaging. The functionalities of relaxation, entertainment, enjoyment, and distraction were rated by the children participants in the context of codesign with a Likert scale. The proposed methodology can flourish emotions during the codesign process, helping to get a better human experience. The proposed methodology can raise emotions based on empathy during the codesign process, helping to get a better creative process. The results obtained through the proposed empirical method of codesign are the expected ones. The proposed empirical codesign methodology is generalizable to other contexts. This methodology allows rapid and personalized prototyping when the mobile app design is driven by the content.

This work is the first to describe how to involve children in codesigning content for a healthcare app to reduce dental anxiety in an engaging and well-founded way. It is a deep study where detailed process and results are presented, and the final product of the proposed methodology is the first mobile app prototype that targets dental anxiety in children.

Data Availability

The data used to support this study are included within the article and are available from the corresponding author upon request. The app is currently available in Spanish at http://grupos.us.es/pigmalion/proyectoARCADE and will soon be available in the Google Play Store. The multimedia resources checked by the participants and described in the section "Design Activities Empathy-Based" are available at http://grupos.us.es/pigmalion/irlandesas.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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