VITHEA Kids 2.0

Cláudia Patrícia Balixa Filipe
claudia.patricia@tecnico.ulisboa.pt

Instituto Superior Técnico, Porto Salvo, Portugal

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Abstract

Communication disorders include deficits in language, speech and communication, which can also be caused by other related disorders such as Autism Spectrum Disorder (ASD). Individuals with communication disorders face numerous adversities in their daily life, which can be minimized through solving exercises. Some efforts have been made to develop applications that can provide these exercises and also be suitable for its users, in particular for children with ASD. Virtual Therapist for Autism Treatment on Children (VITHEA Kids) is an application that provides the possibility of creating exercises and customizing various aspects of interaction with the platform, as well as a talking animated character.

As technological tool, it has to provide the best user's and developer's experience. So, our main contributions to VITHEA Kids are: 1) a software reengineering, which supported 2) making improvements to existent functionalities and 3) adding new functionalities, related with: prompting, since children will need some support on learning new skills; reinforcement, motivating children to practice the targeted behavior; and emotions, due to the impact of emotions on learning. Also, a set of exercises, with functional thematics was included in the application.

Keywords: Communication disorders; Autism Spectrum Disorder; Communication skills; Software reengineering; Computer-assisted learning.

1. Introduction

Communication allows human beings to express their feelings and needs, likes and dislikes, to interact and build relationships, thus being an extremely important part of a human development. Individuals with communication disorders face numerous adversities in their daily lives. According to the Diagnostic and Statistical Manual of Mental Disorders (DSM) [2], "Disorders of communication include deficits in language, speech, and communication". The data compiled by National Institute on Deafness and Other Communication Disorders (NIDCD) shows that 7.5 million people in the US have some trouble using their voices, and 8 to 9% of young children have some speech sound disorder, like stuttering. Also, between 6 and 8 million people in the US have some form of language impairment.

In Portugal, according with an epidemiological study [20] (with 748 children between five and eleven years old), 48,2% of the children presented some speech or language alteration, of which:

- 34,1% are articulation alterations;
- 12,2% are language alterations;
- 1,1% is voice alterations;
- 0,8% is resonance, breathing and stuttering alterations, and not conclusive assessment.

In its fifth edition, DSM differentiates communication disorders from other disorders that also induce difficulties to communication, like ASD, which, due to its particular characteristics, will be the main disorder addressed in this project.

Some of the existent difficulties can be minimized through solving exercises that help to develop some skills (e.g., word naming, generalization skills). Therefore, several therapy exercises have been developed, intending to minimize the inherent difficulties of communication. Most of these therapies are based on a psychology approach called Applied Behaviour Analysis (ABA), which uses interventions based on concepts like prompting and reinforcement, combined with others.

Also, given the particular interest of children with ASD on computers and software [10, 19], several Computer-aided learning (CAL) applications have been developed, first for computers, then for tablets and smartphones. The developers' goal is to promote the interventions' practice, with reduced monetary costs, and make the applications easy to use and carry.

Despite the growing popularity of CAL applications, there are still gaps that can be filled, as it has been mentioned by Mendonça [13], namely:

- Most applications are paid or include paid features;
- Few applications offer these contents in European Portuguese;
- User's progress is not commonly taken into account;
- There are few customization options.

To fulfill these gaps, Mendonça developed VITHEA Kids [13, 14], which is an application for helping children with ASD to improve their language and communication skills. In order to continue that effort, we used VITHEA Kids as the base of our work, since our main goal is to provide an application that comprises enough exercises and custom options to make it suitable for its users (children with ASD) and caregivers, such as professionals and therapists or even parents or familiars that will value a helpful tool. Our contributions for VITHEA Kids are:

- Reengineering VITHEA Kids' software since, as a technological tool, it should keep providing the best user's and developer's experience;
- Improving VITHEA Kids usability and functionality through the fulfillment of several gaps that the system presented, regarding both the system's architecture and the user interface design;
- Adding a new prompting module: prompting is a technique used in the traditional exercises (i.e., exercises that do not resort to software applications), that consists of helping the child (e.g., providing cues). The prompting module is aimed at customizing the prompts that will be used in the exercises of VITHEA Kids;
- Adding a new reinforcement module: reinforcement is also used in traditional exercises, typically by rewarding the child. This module will provide options about the rewards and the rewarding strategies;
- Adding a new emotions' module: children with ASD face emotions' related difficulties, and emotions can also be useful in learning. This module will include emotions in VITHEA Kids, through an existing animated character and by providing new exercises about emotions;
- Creating a set of exercises, with different thematics related with functionality;
- Evaluating the reengineering process regarding the developer's experience, by describing what changed in the new application's version, and prepare a user testing session to assess the acceptance of the new modules, the impact of the changes and the users' satisfaction when interacting with VITHEA Kids.

2. Background

To fully understand the context around our work, we will provide background concepts, like communication disorders and ASD, and describe VITHEA Kids as it will be the baseline of our work.

2.1. Communication Disorders

A communication disorder is an impairment in the ability to receive, send, process, and comprehend concepts or verbal, nonverbal and graphic symbol systems [3] and it can be manifested as a deficit in speech, language and/or hearing.
Speech is the expressive production of sounds, including the articulation, fluency, voice and resonance quality [2]. Some speech related disorders characteristics are: difficulties in coordinating movements of the articulators (jaw, tongue and lips) with breathing and voice; phonological difficulties; frequent disturbances in the normal fluency and time patterning of speech, like sound and syllable repetitions, sound prolongations and broken words (e.g., "I-I-I-I see him") [1].

Language is the way an individual communicates in terms of form, function and symbols (like spoken/written words, signs for sign language, pictures) [2]. A language disorder is about the production and comprehension of the symbols. According to DSM [2], the impairment may be related with: the form, i.e., the rules that govern sound combinations and/or words' structure and construction (phonology and morphology), and the syntax, which is the order, combination and relation of words in a sentence; the content, meanings of words and sentences, i.e., semantics; and the function, using language to functional and/or social purposes. A disorder related to impairments in language's function is the Social (Pragmatic) Communication Disorder, which consists in persistent difficulties in the social use of communication [2] (e.g., greeting, sharing information, having a conversation).

Hearing is a physiological capability to perceive sound. Impairments at the auditory system level may limit the development, comprehension, production and/or maintenance of speech and/or language. Hearing disorders can be related to detection, recognition, comprehension and perception of the sound at different levels.

2.2. ASD - Autism Spectrum Disorder

Besides Communication Disorders, there are other disorders associated with communication difficulties, such as ASD, which is a spectrum for a set of developmental disabilities that can cause

significant social, communication, and behavioral challenges. So, children diagnosed with it may have difficulties developing language skills and understanding what is said to them [15].

Eugen Bleuler was the first person to use the "autism" term, around 1911, to refer to one group of symptoms of schizophrenia. Leo Kanner described Autism in 1943 [9], exemplifying the case of eleven children who had common behaviors among them, but not common with children of their age. Autism was then described as the "inability to relate themselves in the ordinary way to people and situations from the beginning of life" considering that those children were in an "autistic aloneness", ignoring the external stimulus or reacting as if they cause them pain. Likewise, there is a need for being left undisturbed and everything that is brought from the outside, or changes the environment, represents a dreaded intrusion.

Regarding communication, eight of the eleven children started to speak, either at the normal age or after some delay. The other three did not learn to speak at all. However, none of the talking children used it to communicate with others. Also, learning concepts took many years, since these children associate a concept to a particular and literal situation (e.g., one of the children learned that his father would put him in the shoulders if he said "yes", after father asked if he want to, so for him "yes" only has this meaning). Likewise, personal pronouns are repeated just as heard (e.g., when a child wants some milk or dessert, he utters "Now I will give you your milk" and "Are you ready for dessert?", because once his parents uttered that way). This phenomenon happened with all the eight speaking children. Despite the fact that these children could echo things they had heard before, they do not easily attend to what is said to them. It requires numerous reiterations of the question or command before there is even so much as an echoed response.

In 1944, Hans Asperger also described a group of children with the same behaviors as Kanner. However, he also mentioned those children had an exceptionally good development in what concerns to cognitive and language skills [4, 21].

Nowadays, ASD is described in DSM as having having persistent deficits in social communication and interaction, namely, deficits in social-emotional, in nonverbal communication (e.g., facial expressions), and the absence of interest in peers, and restricted, repetitive patterns of behavior, interests, or activities (e.g., repetitive motor movements, lining toys or objects, repeating words; keeping the same routines, eat the same food, take some route; high focus capability and interest in details).

This definition covers all the previous ones, e.g., Kanner's autism and Asperger's disorder, into the autistic *spectrum*.

2.3. VITHEA Kids - Virtual Therapist for Autism Treatment on Children

VITHEA Kids is an application for helping children with ASD to improve their language and communication skills, and their caregivers to assist them with it, providing a tool that allows creating a set of exercises, which are created by the caregiver on the Caregiver's module and can be solved by the child on the Child's module.

The Caregiver's module allows managing exercises, images, children's and caregivers' information. There are also options to customize the interaction between the caregiver and the child. The exercises have a topic (e.g., *"Animals"*), a difficulty level (e.g., *Introductory*), the question/instruction, the stimulus, the correct answer and a set of possible answers (distractors).

VITHEA Kids has also an animated character, Catarina, and her utterances (e.g., greeting or congratulating) can be set by the caregiver for each child. Another customizable option is the set of reinforcement images to be used when the child answers correctly to a question.

On the Child's module, the child can select the type of exercise he wants to "play", and the first exercise will be presented by Catarina, which utters the question, and shows an optional complementary image (stimulus), and a set of possible answers (text), where one of them is correct and the others are distractors. If the child selects the correct answer on the first try, the reinforcement image will show up else the distractor disappears to help the child to select the correct answer and the correct answer is highlighted, along with Catarina uttering the remaining options.

Regarding the application's architecture, it is worth mentioning that VITHEA Kids' architecture was based on another system, Virtual Therapist for Aphasia Treatment (VITHEA) [17, 18].

The caregiver's module is a Web application, deployed with Apache Tomcat (a Java Web Server), which persists data in a MySQL database. The Tomcat's web container handles the requests from servlets, in this case, the Java Server Pages (JSP files which embed Java code in Hypertext Markup Language (HTML) files). The system's architecture is arranged in layers: the model (data layer), view (presentation layer) and controller ("business logic" layer) using Apache Struts 2. Using Struts, requests are sent to a controller, which calls the re-

spective action class that interacts with the model. The model returns an action forward for the controller to know which tile it should send to the client. A tile is a part of the web page (presentation layer) that is loaded without having to refresh the whole page. The caregiver's module also uses Spring, a framework that uses several design patterns, and Hibernate, another framework that helps to map the database schema with the Model classes.

The child's module is an Android application, which makes Hypertext Transfer Protocol (HTTP) requests to an Application Programming Interface (API), composed by two Android projects (Catarina's Unity project and the exercises' project). The requests are done in AsyncTasks, while a loading dialog is presented to the user.

Although the system's architecture seems very robust and promising, the development was compromising by the usage of many frameworks. Some difficulties were early identified:

- Errors were not easy to understand: when there is some error the application stops loading and, to find out the error, it is necessary to search on a great dimension log file from Tomcat (catalina.out);
- Solutions were not easy to find: to find the solution for an error, or even the code where something was wrong or missing, was not trivial since there are many files and XML configuration files where the error could be and it is not possible to debug;
- Performance was not the best: after some page requests, the system turns very slow until it crashes and the page is not retrieved anymore. This also happens out of development environment, e.g. in tests environment causing a bad user experience;
- Low developer's productivity: during the development, every change in the code requires a redeploy of the project so the changes take effect on the application. Also, Hibernate annotations were very hard to map with database schema, causing many bugs and consuming much development time, and as an attempting to correct some of these bugs, it was necessary to adapt the database schema to map with the models and with the annotations, deviating from what a good database design should be;
- Steep learning curve: learn how all the frameworks work and co-work was hard, which may (or may not) contribute to the previous points, but it still is a valid point since VITHEA Kids is a project with a great potential that should be easy to add new modules and functionalities without much of an effort.

In this context, with the continuous application improvement and growing goals in mind, and considering some new technologies and frameworks, we consider that a software reengineering is required for VITHEA Kids.

Regarding user experience, VITHEA Kids has some limitations in both caregiver's and child's modules namely: the need of a caregiver's personal area; the missing implementation of some Create, Read, Update and Delete (CRUD) operations; the lack of preferences options; image exercises are not integrated with the child's application; the creation/edition forms lack of visual and help hints in case of error; it is not possible to preview exercises; the child's application is not supported for 5.x Android versions, and the child as to always login once the session is not kept.

Also, there are functionalities requested by the caregivers who try VITHEA Kids like organizing exercises into sequences and being able to navigate through exercises in the child's application; video and audio support to diversify exercises; the possibility to select the preferred animated character (between Catarina, Filipe or Edgar (from ChatWoz [8]) and its background image, according to the child's preferences.

3. Related work

The present section will address the most relevant subjects which based the software reengineering, improvements and new functionalities proposed to VITHEA Kids.

3.1. Software reengineering

During a software reengineering process, LinkedIn changed its platform from Spring to Play Framework, a web framework based on a lightweight, stateless, web-friendly architecture, that intends to make it easier to build web applications in Java and Scala. Some reasons for this decision were pointed by comparing Spring and Play Framework (Table 1), where the problems identified in Spring and solved by Play Framework are the same difficulties identified and described in Section 2.3.

Play Framework was also compared with another frameworks like Spring, Ruby on Rails and Node.js, in terms of performance, concurrency, learning curve and maintainability, where it was possible to conclude that Play represented a good option. In terms of architecture, Play Framework is RESTful and follows Model View Controller (MVC) pattern. It allows to easily expose a Representational State Transfer (REST) API, i.e., a set

	Spring vs. Play Framework	
Developer productivity	Long time to start and to see a change (minutes)	Hot-reload changes (seconds)
	Poor APIs	Powerful and composable APIs
	Few built-in functions for building a modern application	Modern framework (built-in support for JSON, web sockets, DB access, web service calls, etc.)
I/O	Blocking (every request holds a thread)	Fully non-blocking
Functional programming	Many mutable objects, annotations, XML configuration files, etc., which makes it harder to identify errors or to custom settings	Everything is a function and returns a value: classes, routes, templates, build system, etc., which makes it easier to think, develop, reuse, debug and custom code
Error reporting	Big log file	Clear error message and information about where the error is

Table 1: Spring vs. Play Framework

of endpoints that map with the controller methods. The access to these endpoints is done using HTTP, which means that any layer that can make an HTTP call (and deal with the results, e.g. JavaScript Object Notation (JSON) could use this API.

Regarding persistence, Play comes with Ebean ORM (an Object-relational mapping (ORM) tool), which allows generating the database schema based on model classes using Java Persistence API (JPA) annotations, just like Hibernate did in the previous architecture. Since Ebean is sessionless (i.e., does not require a persistence context to persist the data units, called entity beans) and it only uses a subset of JPA, it may be easier to use. Play also comes with Evolutions, which is a tool for tracking database changes and generate change scripts.

For LinkedIn, Play was a good choice to balance performance, reliability and developer productivity.

3.2. Applied Behaviour Analysis

ABA is a psychology approach that evaluates human behavior changes, regarding environmental stimuli (i.e., something that incites or quickens action, feeling, or thought). This evaluation is done through interventions, which are based on operant conditioning principles [12], like prompting and reinforcement (which will change the behavior). Prompting is an antecedent intervention's stimulus (precedes the behavior) that intends to help in order to improve the behavior. Prompting is important since it supports the child while developing the new behavior. A prompt can be an instruction, gesture, demonstration, touch or another stimulus. In a general way, prompts can be classified into [11] verbal prompts (e.g., words, instructions or questions); modeling, i.e., demonstrations of the behavior; manual prompts, which consist of physical guidance; gestural prompts (e.g., pointing to the correct answer); photographs and line drawings; textual prompts (e.g., checklists or scripts); or other types of prompt (e.g., tactile prompts, tones, alarms, and color cues).

The prompting principle should be adapted to the circumstances, since it is desirable that the child after some iterations does not need help anymore. The caregiver can start by always helping the child, and, after some iterations, only helping if the child does not give the correct answer after a while, until it is not necessary to help (Most-to-Least strategy). There are other strategies like Least-to-Most, where the assistance is increased only if the child does not perform the desired behavior within a specific amount of time, Delayed Prompts, where the time interval between the stimulus and the prompt is increased until the child answers correctly before the prompt, Graduate Guidance, which uses manual prompts that are reduced by changing their intensity or location, Stimulus Fading, which uses exaggerated physical dimensions like color, size and intensity and fade them until they are no longer needed, and finally Stimulus Shaping, where the physical characteristics of the stimulus are changed (e.g., for decimal numbers, first the representation may be "2 and 25", and gradually the "and" is becoming smaller until it can be represented as "2,25"[11]). Some companies already developed applications to help children, based on the prompting principle, which use different types of prompts.

Contrary to prompting, Reinforcement is a consequent intervention's stimulus (succeeds the behavior) that intends to strength a behavior (make it occur more frequently) providing a pleasant

reinforcer (positive reinforcement) or removing an unpleasant one (negative reinforcement). A reinforced behavior tends to be repeated (i.e., strengthened), but a behavior which is not reinforced tends to occur fewer times (i.e., weakened). The reinforcement can be delivery following different strategies[7]: continuous reinforcement (always); Fixed Ratio Reinforcement (after the target behavior occurs a specified number of times); Variable Ratio Reinforcement (given after the target behavior occurs an unpredictable number of times); Fixed Interval Reinforcement (given after a fixed time interval, during which the target behavior occurred); Variable Interval Reinforcement (given after an unpredictable amount of time, during which the target behavior occurred).

Reinforcement is very common in most application types, specially in games and gamification, and it allowed to create computer models to investigate certain matters, for example, the role of emotion in learning [6]. Since the first diagnostics of Autism, emotions were always a concern. Some children were labeled as emotionally disturbed. Even according to DSM [1], emotional impairments are part of the diagnosis as "marked impairments in the use of multiple nonverbal behaviors such as eye-to-eye gaze, facial expression, body postures, and gestures to regulate social interaction", "a lack of spontaneous seeking to share enjoyment, interests, or achievements with other people (e.g., by a lack of showing, bringing or pointing out objects of interest)" and "a lack of social or emotional reciprocity". The emotional impairments of children with ASD can be translated into different domains [5], like difficulty to express emotions, perceiving and understand emotions and facial expressions, or responding to emotions. Emotions can be classified as positive or negative, if they are pleasant or unpleasant, and as activating or deactivating, if they are beneficial or devastating. Positive emotions like enjoyment, excitement, hope and pride have an impact on learning, since they affect children's attention and motivation, and encourages the use of learning strategies and self-regulation of learning [16]. For example, the pride of a good grade will turn the child's attention to that goal, i.e., if the emotion is task-related, like enjoyment or excitement of learning, the child will be focused on that task. Again, emotions are complex since a positive emotion can help focus on the task or drive the child's attention away. For motivation and interest, activating positive emotions, like enjoyment, is very helpful in recollecting positive memories that help to remember the positive value of the task and the child's competence to solve it, in contrast with relaxation and relief, which are deactivating positive emotions that can reduce motivation. This is also true for the use of learning strategies and self-regulation of learning, since activating positive emotions helps to employ flexible, creative and deep learning strategies (e.g., elaboration of learning material) and enhance flexible thought and action, like planning and monitoring learning activities, promoting self-regulation, in contrast to deactivating positive emotions which can reduce any systematic use of learning strategies and inhibit self-regulation behaviors.

On the other hand, both activating negative emotions, like anxiety, anger and shame, and deactivating negative emotions, like hopelessness and boredom, contributes to decrease children's attention. However, activating negative emotions can sometimes help to increase motivation, as long as the child is expecting to succeed, to facilitate the use of rigid learning strategies (like rehearsal and rote memorization) and to look for external regulation of learning, since negative emotions reduce child's flexible thought and action. Deactivating negative emotions reduces motivation and any use of strategies or self-regulation. There are many applications for learning emotions.

4. VITHEA Kids 2.0

VITHEA Kids was created for helping children with ASD to develop communication skills, however there is a need for a software reengineering, and there are some improvements that can be done and some functionalities that can be added to the application. Regarding this, the present section describes this project intentions to contribute to VITHEA Kids.

4.1. Reengineering VITHEA Kids

Section 3.1 described how Play Framework solved LinkedIn identified problems regarding development. Expecting that Play Framework could solve VITHEA Kids' development problems too, an analysis using the same points from Section 3.1 was made, regarding VITHEA Kids:

- Developer's productivity: In VITHEA Kids using Spring, every change requires a redeploy to reproduce the changes on the platform. Using Play, the changes can be seen in seconds through the hot-reload system (when the code is changed, the code is compiled and the web page refreshes automatically).

- I/O: Spring is blocking, which means that, any time there is a request, it holds up a thread blocking the I/O, making the system crash after some requests. So changing for Play will improve the performance since it is a non-blocking framework making calls to remote services.

- Functional programming: Another mentioned difficulty was related to all the files and configuration files that needed attention when adding a new functionality. With Play, everything is a function that returns a value which makes it easier to develop and find problems in the code.
- Error reporting: Another pointed difficulty was identifying errors. With Play, errors are presented in browser and also in Command-line Interface (CLI) for more details, instead of the great dimension log file.

Play seems a promising framework for VITHEA Kids, but regarding the application's front-end, and despite Play having an HTML engine, it can fall short as the user interface is enriched and consequently more complex. There are many frameworks that could help building a fast web application that ensures a positive user experience (not crashing, being slow or showing inconsistent data). Angular is a JavaScript framework maintained by Google and a vast community. In terms of development, Angular makes it easier for programmers helping to create appealing interfaces with few code lines, also passing some of the back-end's burden to the front-end, since there is no need for the server side to generate the HTML, also improving the user experience.

In conclusion, using Play as back-end framework will allow re-using some of the existing Java code (for back-end), putting it inside of a "black box" with much fewer configuration files, becoming easier to develop. On the other hand, using Angular2 as front-end framework will enrich the front-end side and improve the user experience.

This modular architecture is also useful for the child module, since the current presentation layer can be replaced by a mobile application that makes the same HTTP requests and know how to parse the JSON answers. Thus, the biggest change comparing to the previous architecture, regarding the child's application is to share the base code with the caregiver's application, since both applications consume the API (rather than have two different applications, which meant two different projects with the same logic to maintain).

4.2. Improvements

Given the points identified in Section 2.3, the proposed improvements are:

- Caregiver's personal area: It is necessary to implement a login system which will allow the caregiver to have a personal area, where he can have his exercises, children records and multimedia resources.
- CRUD operations: These operations, for exercises, children and multimedia resources records, will be reviewed and implemented when missing.
- Preferences: As fitting the application for each child is important, a menu with preferences will be available with options related with the animated character and the new modules.
- Image exercises: Multiple-choice exercises with image answers will be fully integrated with the child's application.
- Pagination: The children, exercises and multimedia resources lists will have pagination (instead of showing too many on the same page).
- Forms: There will be visual hints for mandatory fields and help indications in case of error in the forms' fields.
- Preview exercises: The caregiver will be able to preview the created exercises.
- Android version: Since the application is not able to run in more than 50% of Android users, it was necessary to address this issue. The crash is related to Catarina's scene and the Unity's project needs to be rebuilt, with a different target version. After that, it will be possible to run the child's application in the most recent Android versions.
- Child's application session: This issue is causing a poor user experience, since the session is not kept between the application usages, meaning that the user had to log in every time he wanted to use the application. After implement the new authentication, it will be possible to store the token in shared preferences and the session will be kept between usages. The logout method will clean the token from the shared preferences.
- Sequences: It will be possible for the caregiver to create sequences of exercises and sort the exercises inside the sequence.
- Navigate through exercises: It will be possible for the child to skip the current exercise and return to the previous exercise, for every exercise inside the current sequence.
- Multimedia resources: The caregiver's application will support uploading audio and video resources and it will be possible to reproduce them in children's application.
- Animated character: The caregiver will be able to choose which animated character will be

present in the child's application: Catarina, Edgar and Filipe.

These changes will require deep changes in both caregiver's and child's application, from the data storage (database schema) to the back-end and front-end sides.

4.3. New functionalities

Regarding the new prompting module, the following types of prompting will be available:

- Change the visual look of the possible answers, either in size or color;
- Mark with a cross the wrong answers;
- The distractors disappear;
- Catarina reads the remaining possible answers;

Also, the caregiver will be able to choose the prompting strategy he wants to use, adapted from the known prompting strategies:

- Most-to-Least: the prompting is always given;
- Least-to-Most: the prompting is given when the child selects a wrong answer;
- Delayed: the prompting is always given after a number of seconds (unless the child selects the right answer before);
- No prompting.

The types of prompting can be combined (e.g., the right answer is the image in colors and with biggest size). The strategies are mutually exclusive except the Stimulus Fading, which can be combined with one of the others.

Regarding the reinforcement module, some caregivers have shown the desire of a greater variety of reinforcers, like animations and audio. It is intended to support these types of resource and also to be able to reproduce these animations in full screen if defined by the caregiver, so Catarina does not represent a distractive element. Catarina will also contribute to the reinforcement, as already does, but with emotions, through facial expressions and an utterance defined by the caregiver. The caregiver should also have the option to choose the strategy for applying the reinforcers for each child. The available strategies, adapted from the existing ones will be:

- Continuous reinforcement (or always): the reinforcer is always given, even if the child does not choose the right answer at the first attempt;
- Differential reinforcement: there is a reinforcer for the times the child chooses the right answer at the first attempt, and a different one for the remaining situations;
- First attempt reinforcement: the reinforcer is given only when the child chooses the right answer at first attempt;
- No reinforcement.

Regarding the emotions' module, as emotions are helpful for learning and given the difficulties that children with ASD face regarding them, it is part of this proposal to address this topic in VITHEA Kids. Catarina already supports some facial expressions characteristic of the following emotions: neutral, joy, sadness and surprise, which can be helpful to provide feedback to the child as reinforcement after an exercise.

Besides that, a set of exercises about emotions will be added to help children identifying emotions and facial expressions. These exercises follow the currently supported structure of exercises, i.e., an image representing an emotion for the child to select the right caption, or many images and a question to select what image answers to that question. We have collected images with facial expressions to be used in the set of exercises.

5. Evaluation

This section goal is to present the results of the changes proposed in Section 4.

In order to compare the development in the old and new architecture, an exercise of developing the same functionality in both architectures was done, allowing to compare the developer's experience. This exercises allowed to conclude that the developer's experience improved since:

- Play Framework and Angular2 have a modern development environment where errors are easier to understand;
- Since Play and Angular2 are more recent frameworks, it is easier to find on-line documentation, forum questions and community articles.
- The previous architecture had too many configuration files, that had been replaced by only one configuration file for Play and another for Angular2;
- Regarding performance, with the previous architecture, after a while using the caregiver's application (about one hour) we had to restart Tomcat's server. It has never happened with the Play's server;

- The abstraction level is higher in the new architecture, which allows the developer to focus on development and forget about the underneath details.
- Both Play and Angular2 have a gentle learning curve.

The suggested improvements were implemented, and therefore the user experience has improved, as well as the general VITHEA Kids' look (Figure 1).

Figure 1: VITHEA Kids 2.0

Also, there is now more functionality with the inclusion of the new prompting, reinforcement and emotions' modules, and VITHEA Kids is now more suitable for its users.

The next steps for the application are to perform user testing sessions, in order to get as much feedback from the users as possible, and so continue to improve the application.

6. Conclusions and Future Work

Communication is an extremely important part of a human development. There are several disorders that affect communication directly or indirectly, namely, ASD, which is a spectrum with numerous specificities. VITHEA Kids is an application that intends to help children with ASD and caregivers to fight these impairments, providing exercises that fulfill many needs. This application is free, easy to use and it is in European Portuguese, which was the main goal of its designers and developers, given the users' needs.

However, there was space for improvement, regarding software engineering, application improvements, and new functionalities adding.

For software reengineering process, we have implemented a RESTful API, using Play Framework for the back-end, in order to serve both caregiver and child's applications and for the front-end, we used Angular2.

This process improved the developer's experience and supported the required improvements to the applications, also improving the user experience. VITHEA Kids was also enhanced with new modules regarding prompting, reinforcement and emotions, aiming to improve the learning process of new target behaviors.

VITHEA Kids and its modules can be improved and enhanced even after this master thesis project. Some of the described improvements were not fully integrated and implemented, as we intended to, so first of all, they should be finished, tested and stabilized.

Another tasks left as future work are:

- Integration of voice exercises from VITHEA;
- Integration of the existing exercise generation module;
- During this master thesis project the logs of the child's application were disabled, being necessary to restore that functionality;
- Once the data is gathered it is important to show it, so a statistics module should be created;
- Creation of a dictations module, to provide dictations exercises;
- Creation of a mimic module, where the user can ask to the animated character to express an emotion' facial expression.

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