

Orthographic Educational Game for Portuguese Language Countries

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Abstract: The new orthographic agreement introduces some changes in the vocabulary of the Portuguese language. Although these changes have modified a small percentage of the vocabulary words, people are struggling to adapt to some of the new orthographic rules. Aiming to mitigate this problem using a ludic approach, we developed Orthographic Educational Game (JOE). JOE focuses predominantly on the rules of accents and hyphens. The game is divided into two modes: training and playing. In the playing mode, the current level of knowledge of the player in orthography is checked and measured. In the training mode, each word comes with a hint related to the rule that is being practiced at the moment. The game was evaluated through an experiment with both undergraduates and high school students. The results indicated that more than 80% of students enjoyed learning orthography through the game-based approach of JOE.

1 INTRODUCTION

The new Orthographic Agreement has the objective of aid the cultural and political exchange among all countries that are part of the Community of the Portuguese Language Countries (CPLP). The mandatory adoption of new orthographic rules in Brazil was scheduled to start in December of 2012, but it was postponed until January of 2016 to align with the schedule of other countries. The Ministry of Education has encouraged the adoption of new orthographic rules since the beginning through earlier adjustments of school books. Although the estimated changes in the vocabulary of the Portuguese language do not go beyond 2% (Garcez, 1993), students still experience difficulties in adapting to some of the new orthographic rules.

Primarily this occurs due to two main reasons. The first one is a large number of words that are exceptions to the orthographic rules. The second is the complexity of some orthographic rules. In some cases, these reasons may be combined, such as the case of the hyphen. The general concept is that hyphen serves to connect elements forming words composed by juxtaposition and connect prefixes and suffixes to radicals. However, this concept is detailed in a set of rules that are hard to follow and with many exceptions (Ganho and McGovern, 2004).

In many cases, students try to memorize the rules and exceptions. However, the traditional approach of

memorizing subjects is no longer attracting students. Thus, new ways of teaching and practicing are increasingly needed (Domínguez et al., 2013). Educational games are becoming a complementary option to address this type of problem. It is a motivating tool for learning in today's society. The use of educational games has shown effectiveness in many studying situations. It is a way of exercising the activities in a ludic way. Thus, enhancing creativity and attention of students (Papastergiou, 2009).

In this paper, we present an Educational Game (JOE). The primary purpose of JOE is to aid people to adopt the new orthographic rules, by focusing on the accents and hyphen rules through a game-based approach. We intend to answer two research questions: (i) Is JOE able to support teaching accents and hyphen rules? (ii) Is JOE able to make students motivated and to enable them to learn the new orthographic rules? JOE was designed for Android platform and is available for free at Google Play Store. We have conducted an experimental evaluation with two sets of students (high-school and undergraduate students). Students filled a questionnaire both before and after the training. It was possible to measure the number of hits and errors both before and after using JOE. The experiments also evaluated the user interaction with the game, which enables to measure both learning and motivation of the student to play again.

The remainder of the paper is organized as fol-

laws. Specifications and agreements of Portuguese usage are reviewed in Section 2. Section 3 contains related work, whereas Section 4 explains JOE. Computational experiments are reported and discussed in Section 5. Concluding remarks are drawn in Section 6.

2 NEW ORTHOGRAPHIC AGREEMENT

The discussion of this New Portuguese Orthographic Agreement seems recent, but it refers to the early twentieth century. The first Orthographic Agreement was approved in 1931 when, at the initiative of the Brazilian Academy of Letters, in consonance with the Lisbon Academy of Sciences, decided to create a reference model for the official publications and teaching (Garcez, 1993). At that time, however, Brazilian government did not join the initiative.

After several failed negotiations among all the countries of Lusophone (Garcez, 1993), nearly six decades later (in 1990), the new Orthographic Agreement was created in Lisbon (Portugal). It was approved five years later but only came into force in 2009.

This change in the orthographic rules arose from the attempt to unify the orthography between the countries of the CPLP, formed by Brazil, Portugal, Angola, Mozambique, Guinea Bissau, Cape Verde, East Timor, Sao Tome, and Principe (Ackerlind and Jones-Kellogg, 2011).

To assist in the transition of orthographic reform, the Educational Complex of the United Metropolitan Colleges, in partnership with the Museum of the Portuguese Language, launched the Orthographic Reform Guide (Ganho and McGovern, 2004). The period of transition for adopting the new orthographic rules would be up to 2013 for most countries of the agreement. However, in Brazil, the mandatory adoption was extended to 2016. It should be emphasized that although the orthographic reform pass to be unified, the pronunciation and vocabulary of each country does not change (Almeida et al., 2010).

3 RELATED WORK

The game-based approach use features and game principles to ease learning and problem-solving. The game motivates players to continue to meet the challenges of the next phase. In an educational game, the content of the studied subject need to be related to

the theme of the game, showing examples from everyday life. The game should allow for students to gain the necessary skills for each new lesson (phase). The presence of phases is one of the characteristics that define a game. They usually start easier and the complexity increases according to the skills and experience gained. In the process of rewards, for example, it is interesting, when players fail, show them where they went wrong and to encourage them in the search for recovery (De Sousa Borges et al., 2014).

Some classic games that involve orthography include *Hangman* (Madeo, 2011), *Word Search* (Diah et al., 2010), *Crosswords Puzzle* (Leow, 2001), and *Spell Up*. These games have a ludic aspect and of the reward, which encourages students to study more, but, in its essence, is not intended to teach, nor to explain the grammatical rules involved. In computer games, there is a broad range of projects. In the context of JOE, it is worth mentioning seven: *Alfagame*, *Duolingo*, *Babbel*, *Busuu*, *O que vem a seguir*, *SoletrandoMob*, *OrtograFixe*, *Amargana*, *Grapphia*, *Na Ponta da Língua*, and *Novel*.

Alfagame (Netto and Santos, 2012) is an educational game designed for children in the literacy process. The objective of the game is to allow students to reinforce the contents previously learned in the Mathematics and Portuguese language through play. The contents are addressed through challenges, exploiting the fixing of students in recognition of consonants, vowels, and word association, as well as resolutions of math addition and subtraction. The game can be downloaded from authors website and is designed for Windows.

Duolingo (Munday, 2017), *Babbel* (Parejalora et al., 2016), and *Busuu* (Álvarez Valencia, 2016) are similar applications. They have as primary objective to enable users to learn a foreign language interactively and apply game-play trend that has been gaining strength in recent years. Just as today's games, there is an interaction with social networks to encourage players to compete with each other and continue playing. In addition to social networking, there is also an internal system in which players can post on a friend's wall, discuss a lesson that was not understood, reporting an error in translation, among other things.

O que vem a seguir is a software designed for Windows. The game aims to show the use of digital educational games as a way of promoting the assimilation of content and sharing student's interest in educational tasks. It requires a responsive attitude, which only occurs when individuals seek to understand the facts actively by their knowledge of the learning object (Araújo et al., 2012). *Soletrandomob* is an ap-

plication designed for Android. The game shows the sound of a word and the player must spell it correctly and may ask for tips, like the use of the word in a sentence. Such tip is an attempt to help the player by entering the word in the context of interpretation. In the end, it shows the number of correct answers during the execution of the game. Also, in case of errors, it shows messages with the right word (Santos and others, 2010). *OrthograFixe* (Marques and Silva, 2012) is a game where features words move up and down at different speeds. The user must press the word that is spelled correctly. The game treats hyphen rules based on prefixing and recomposition. Whenever the user makes a mistake, pops up an error message indicating the wrong orthographic rule.

AmarginA (Yamato et al., 2017) is a game designed for mobile phones and tablets that aim to practice orthography. Letters are shuffled, and the player should change their position until the desired word is correctly written. *Grapphia* (Assis et al., 2017) was designed to aid students in spelling words that have digraphs that correspond to the same sound. Similarly, *Na Ponta da Língua* (Gaspar et al., 2016) is an open source tool that aims to help students address this same problem in a ludic way letting students play with the origin of words. *Novel* (Novais et al., 2017) is an educational game to aid in the autonomous learning of orthographic rules by improving the performance of students in social writing practices. Elements such as badges (medals or achievements), points, progress, and narrative are used to make users feel motivated to perform tasks.

From related work, it is possible to observe that JOE is a single initiative that focuses on accents and hyphens. JOE differs as it incorporates a broader range of hyphen rules and separates the training stage from the game itself. Moreover, in JOE, the user hears the word and should write it the right way, which makes a different perspective for the game-play.

4 JOE: THE ORTHOGRAPHIC GAME

JOE game was focused on supporting the changes in rules of accentuation and hyphen introduced by the new orthographic agreement. Such decision is reasonable since these rules are considered the ones that arise main doubts for general people. JOE supports general rules of accentuation, such as open diphthongs “éi” and “ói” and paroxytone homographs (Ganho and McGovern, 2004). The accent and hyphen rules addressed by JOE are described in Table 1.

4.1 Architecture

The JOE architecture is based on MVC (Model, View, and Controller layers). Each of these layers follows some features and has distinct functions. The game control actions are modeled by use case diagram of Figure 1, which shows an overview of main features that are present in JOE (training and playing).

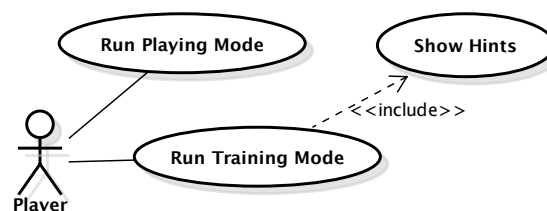


Figure 1: Use case diagram defining the actions of the user through controller layer, simplifying the features that exist in JOE.

The conceptual model, represented by the class diagram was described in the Unified Modeling Language (UML) (Fowler, 2003). The model was developed incrementally and consolidated mode after the fixation of the scope, of the rules and the completion of the experimental evaluation form, to ensure that the implementation of the game follows what was planned. Figure 2 shows the class diagram. The yellow classes match the Model layer. The blue ones correspond to View layer, and the grays classes refer to Controller layer.

The Model layer is composed of six classes highlighted in yellow. The Norm class models the general types of rules (accent and hyphen). The Rule class models a single orthographic rule. It has a keyword to identify the rule, a description and its difficulty (for player’s score). A Rule is composed of a set of hints that are modeled by class HintRule. The HintRule class contains a text that is displayed in Training mode for each advanced word to help in learning the related rules. The Word class models all the words of the game, their audios, and their usage (common or uncommon). It has a rule identifier and related game mode. The GameMode class presents two possible ways to use the game: Play and Training. The History class stores the score and total hits to play and the time spent by the user during the training mode.

The View layer has the game screens and is described by the six classes in blue. They are designed from XML files and loaded into classes that extend the Activity class. They receive or send interactions in components, changing values in their properties, such as the sounds of words, messages, and effects.

The Controller class represents the Controller

Table 1: Accent and hyphen support for the new orthographic rules used in the game.

Keyword	Rule
Juxtaposed	The hyphen is used on words composed per juxtaposition whose elements (nouns, adjectives, verbs or numerals) constituting a syntagmatic or semantic unit and with own accent, even if the first element is reduced.
Toponyms	The hyphen is used with compounds toponyms started by the adjective <i>grão/grã</i> , or by a verb, or when exists an article between its constituent elements.
Botanical and zoological	The hyphen is used with compound words that designate species botanical and zoological.
<i>Bem, mal</i> , and vowel	The hyphen is employed in compounds formed by adverbs <i>bem</i> or <i>mal</i> (first element) and any word beginning with a vowel.
<i>Além, aquém, recém</i> , and <i>sem</i>	The hyphen is used in compounds with the elements <i>além</i> , <i>aquém</i> , <i>recém</i> , and <i>sem</i> .
Locutions	The hyphen is not used with locutions of any kind.
Occasional and Historicals	The hyphen is used in occasional vocabulary dazzle or the historical combinations.
<i>éi</i> and <i>ói</i>	Open diphthongs <i>éi</i> and <i>ói</i> followed by vowel paroxytones lose the accent. Note: When oxytone, these, along with <i>éi</i> , remain with the accent, followed or not by 's'. The acute accent is used on the 'i' and 'u' tonics of oxytones or paroxytones if they are hiatuses and are alone in the syllable or accompanied by 's'. Note: When before 'nh' or after diphthong decreasing, they are not accented.
'i' and 'u' on hiatus	The acute accent is used to differentiate a few pairs of paroxytones homographs.
Paroxytones homographs	The hyphen is used in prefixed or recomposed words whose second element is started by 'h'.
Second element 'h'	The hyphen is used if the first element ends with the same vowel that begins the second element.
The shock of vowels	The hyphen is used if the prefix is <i>circum</i> or <i>pan</i> and the second element starting with a vowel, 'h', 'm', and 'n'.
<i>circum</i> and <i>pan</i>	The hyphen is used when the prefix is <i>hyper</i> , <i>inter</i> or <i>super</i> and the second element begins with 'r'.
<i>hiper</i> , <i>inter</i> and <i>super</i>	The hyphen is used when the prefix is <i>ex</i> , <i>sota</i> , <i>soto</i> , <i>vice</i> , or <i>vizo</i> .
<i>ex</i> , <i>sota</i> , <i>soto</i> , <i>vice</i> , or <i>vizo</i>	The hyphen is used when the prefixes <i>pós</i> , <i>pré</i> , and <i>pró</i> are tonics and graphically accented.
<i>pós</i> , <i>pré</i> , and <i>pró</i>	The hyphen is not used when the prefix (or false prefix) ends in a vowel and the second element begins with 'r' or 's' and should be duplicated.
vowel + 'r' or 's'	The hyphen is not used when the prefix (or false prefix) ends with a vowel and the second element begins with a different vowel.
Elements with different vowels	The hyphen is used in pronominal forms linked to the verb by enclisis or mesoclisiss.
Enclisis and mesoclisiss	The hyphen is not used in 'co' + word beginning with "o".
'co'	

layer. It is responsible for mediating the data requests to interact with the View providing the correct data from the Model layer. It also has specialized methods that perform the opening and sequencing of screens. It is also responsible for controlling the storage of all result data (either from training and playing) to be shown at the end of each match.

4.2 Graphical Interface Design

Since the game was intended to be easy to use, attractive, and ludic for students, the interface was designed before any View implementation in Android. The interface was modeled using Mockups (Nguyen et al., 2016) as shown in Figure 3. The game has three main screens that interact with the player. The first contains the game mode options with a summary of all matches performed (number of hits, score, and time played).

During mode selection, the main play screen is in-

voiced with a set of words. Each word should be listened by the user, who has to spell it correctly. In training mode, the user has a button, named *verificar palavra*, which provides a hint message related to the spelling rule for the listened word.

During playing mode, the screen has a countdown. When the counter reaches zero or set of words is fully explored, a result screen is displayed, showing the elapsed time for the game, the number of correct answers, and the number of errors of hyphen and accentuation. This summary is important for players to identify their performance. The game features three screens that interact with the player. The initial one contains the mode game options, plus a Historical set of hits, the score and the time devoted to all matches performed.

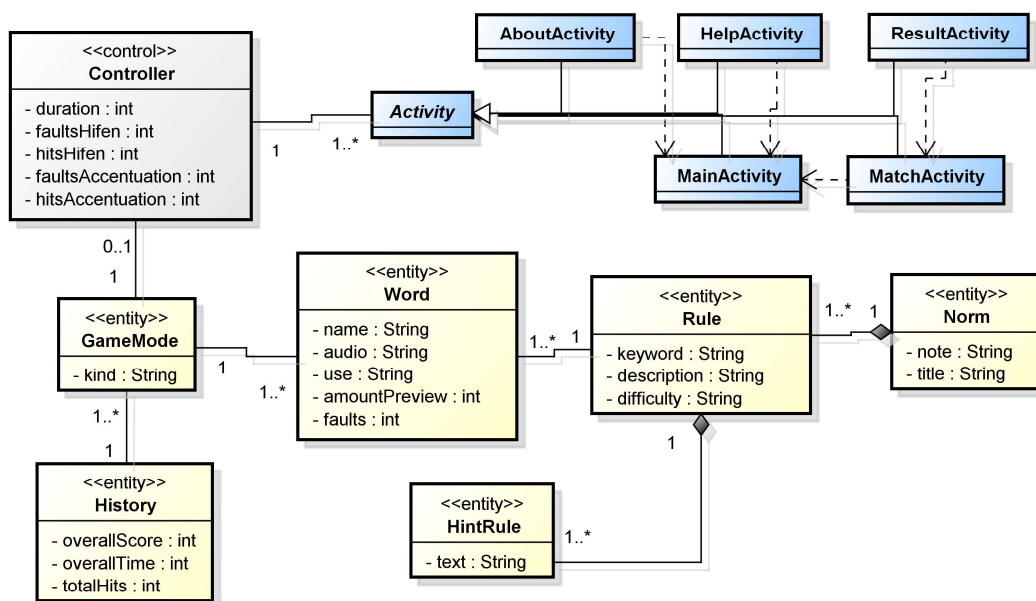


Figure 2: Class diagram of JOE. Classes in yellow, blue, and gray respectively corresponding to the Model, View, and Controller layers.

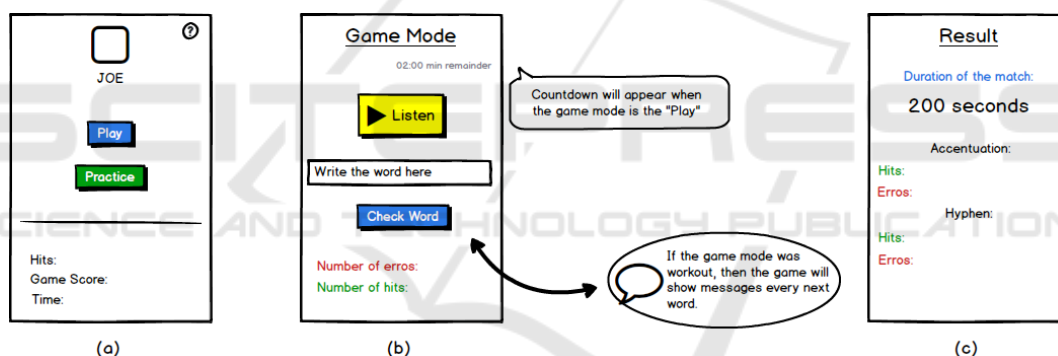


Figure 3: JOE's Interface design modeled using Balsamiq Mockups: (a) Home screen with choices for game mode. It also contains hits, score, and time played in previous matches; (b) Play mode screen where questions need to be answered by user during a fixed time. During training mode, the word check button displays a hint; (c) The result screen shows the number of hits and misses in both hyphen and accentuation rules.

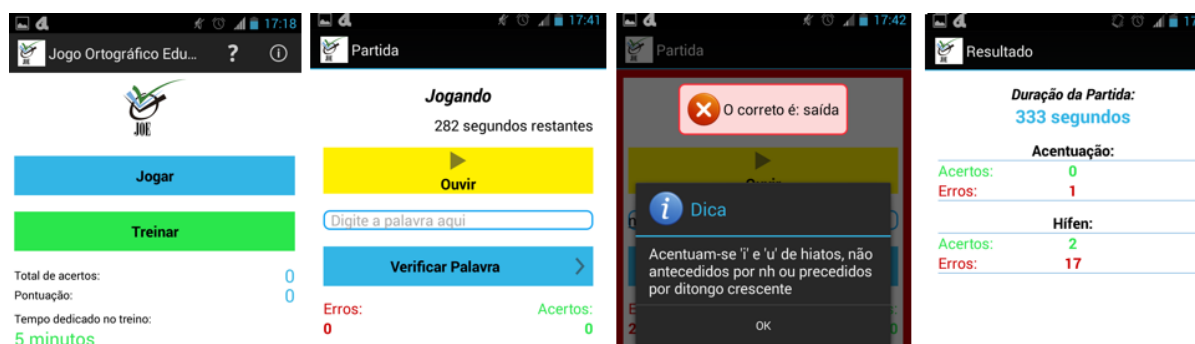


Figure 4: Game Screen: (a) Home; (b) Play Mode; (c) Help; (d) Results.

4.3 Implementation Discussions

The game was built using Android Studio tool, and the main features are depicted in Figure 4. The game was developed using the API 8 (Android 2.2 Froyo) to support a large number of devices. JOE is available for free on Google Play Store. All the screens correspond to classes derived from the Activity class. It invokes the Controller to carry out interactions with the database and to exchange parameters between screens. Also, the screen orientation was set to portrait to avoid the problem of displaying items (misfits, cut or outside problems). JOE requires portrait display, even if the user changes the device orientation.

The game information such as words and messages have been stored in the device via the SQLite library. This library allows for the creation of multiple tables in a single file. Its memory consumption and CPU requirements are adequate for mobile devices that are not as powerful as conventional computers. When JOE is opened, the vocabulary is loaded into an SQLite database for faster queries. To populate the tables for the game, we applied the `xmlResourceParser` interface of the Android library. An XML file was created with the filled attributes and accomplished a structure that while reading the file, the data was properly loaded into database tables.

During the recording of audio for the quiz, we found some difficulties on Google speech module as it did not pronounce the new orthographic rules correctly. Due to that, some words were sent to Google module in a phonetically written style. Table 2 presents some examples of the recorded audio: their correct writing (first recording), the resulting sound from the first recording and it was written for the audio corresponds the correct word.

5 EXPERIMENTAL EVALUATION

The experimental evaluation was designed using software engineering experimentation approaches (Juristo and Moreno, 2001). The experiment addresses two central research questions: didactics and learning (Q1) and students' impressions (Q2). It was composed of experimental procedure and evaluation form. The evaluation form contained 41 questions. It collects the experience of users interactions with the game, and their impressions related to usability, ease of learning, and motivation to play again. The last ten questions were for usability evaluation (SUS (Albert and Tullis, 2013)). The evaluation form was created using Google Forms. Some questions were designed for quantitative analysis, whereas other

questions were designed to support the main results through qualitative analysis.

The experiment was conducted in two days, with 62 volunteers (29 of high-school and 33 undergraduate students). All volunteers were invited via the Facebook social network. We measured students' performance prior and after using JOE. On Day 1, the experiment was conducted with the students of the first and second year of high-school and on the second day with students from different periods of graduation in Computer Science. JOE was assessed by running it on an Android emulator, or by students in their own Android devices (either by downloading the application by PlayStore or by Bluetooth). Statistical analysis using all collected data was performed and implemented in R (Lander, 2017).

The first question (Q1) is related to the didactics of JOE and student learning after training. Figure 5.a presents the overall performance (percentage of errors) of both high-school and undergraduate students in spelling word with correct accent or hyphen. The overall error is high (more than 50%) prior training. This level of mistakes is an expected result since both accentuation and hyphen rules presented in JOE are considered difficult in Portuguese. In both cases, the number of errors decreased after training. Relatively, we observed a better improvement with high-school students (from approximately 65% to 50%). This decrease can be explained by the time they spend during training (Figure 5.b). They trained approximately five minutes more than undergraduate students.

Figure 6 details the analysis presenting the distribution of errors using box-plot separated by both accent and hyphen rules. It can be observed that the number of errors using hyphen was much higher than with accentuation. Also, considering the median errors, the number of accentuation errors improved after training. Such behavior is not apparent with hyphens. Thus, we applied Wilcoxon rank sum test for both hyphen and accentuation errors for all students comparing students' performance prior and after training. For accentuations, we observed a p-value of approximately 0.01, which refuted the null hypothesis of no performance difference prior and after training. It was possible to evidence an improvement of students in the subject. However, for the hyphen, we got a p-value of approximately 0.15, which did not refute the null hypothesis (no significant difference) in hyphen scenario.

To better clarify this result, we have deepened our analysis by observing if students' previous knowledge on these subjected interfered with their performance. Figure 7 depicts the relative number of errors prior, during, and after training according to students' pre-

Table 2: Recording of Audio.

Correct Writing	Incorrect sound	Phonetic correction
Coreia	Corêia	Coréia
A fim de	Afindi	A fim dê
Abaixo de	Abaixo di	Abaixo dê
Acerca de	Acerca di	Acerca dê
Ao passo que	Ao passo qui	Ao passo quê
Baiuca	Baaiucá	Baiúca
Boiuno	Booiunô	Boiúno
Circum-escolar	Circúm-escolar	Círcum-escolar
Circum-hospitalar	Circúm-hospitalar	Círcum-hospitalar
Circum-murado	Circúm-murado	Círcum-murado
Cobra-capelo	Cobra-capélo	Cobra-capelo
Eletrossiderúrgica	Elêtrossiderurgica	Eletrossiderúrgica
Geo-história	Gêo-historia	Geo-história
Micro-onda	Mícro-onda	Mícroonda
Para	Parâ	Pára
Sota-piloto	Sota-pilôto	Sota-pilôto
Turma-piloto	Turma-pilôto	Turma-pilôto

vious knowledge: none, hyphen only, accentuation only, and both hyphen and accentuation. Students who indicated an earlier knowledge only on hyphen rules had worse performance. The students who reported knowing both hyphen and accentuation had the best performance before training, but they did not improve after training. Finally, students who indicated that they did not have previous knowledge of both hyphen and accentuation rules did not improve significantly after training. The result suggests that JOE does not necessarily replace traditional teaching, but it can be a great ally, especially for students who practice it more often, so that hints could be better explored.

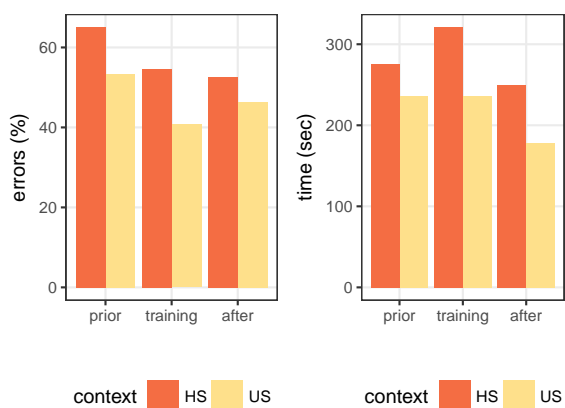


Figure 5: Relative errors (a) and time spent (b) for high-school (HS) and undergraduate (US) students reported by rule knowledge on accentuation and hyphen prior, during, and after training.

The second question (Q2) is related to students' impression with JOE. The evaluation form contained

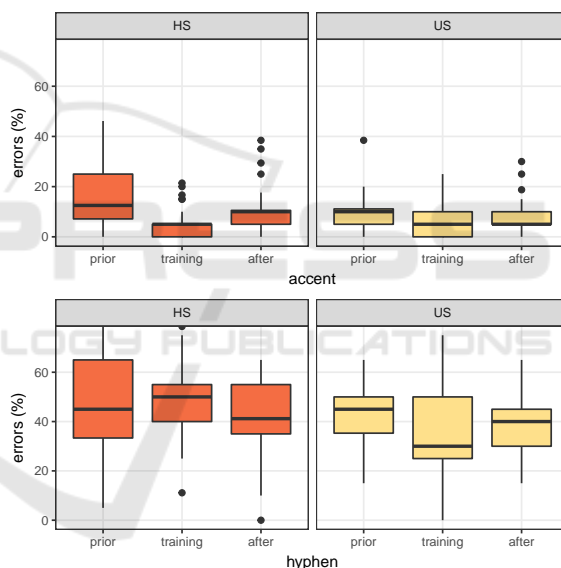


Figure 6: Box-plot of relative errors of both accentuation and hyphen rules for high-school (HS) and undergraduate (US) students reported prior, during, and after training.

two questions about the hints presented during training. The first one asked if the student found hints useful and the second asked if hints were easy to comprehend: 82% and 77% of students, respectively, agreed with these questions. Also, we asked if students were motivated to use and if they learned using JOE. Again, 82% and 84% of students agreed with these questions. Figure 8 confirms such affirmations, as students that indicated that playing JOE motivates to learn orthographic rules improved their number of errors after training. Also, students who registered that they learned with JOE, apparently reduced their number of

errors after training.

We also applied a usability analysis using SUS (Albert and Tullis, 2013). The SUS index obtained by JOE was 79. Taking into account that it is a scale of 0 to 100, where the closer to 100 better, this result corresponds to good interface design (Bangor et al., 2009).

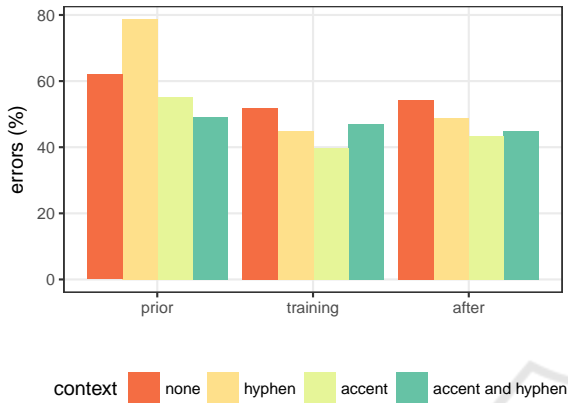


Figure 7: Relative error performance according to the previous knowledge in either hyphen and accentuation rules. Students who indicated that knew both hyphen and accentuation rules presented the best performance before training. Students who just meant to know accentuation showed the best performance after training.

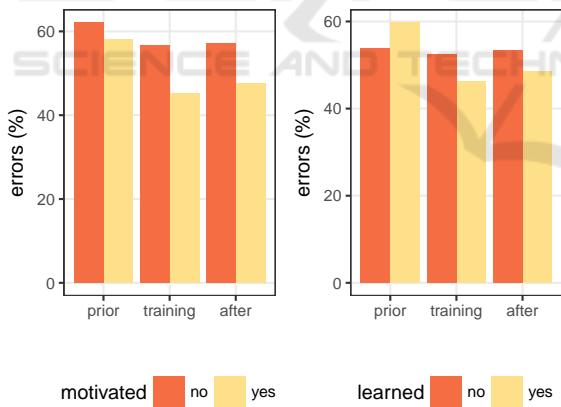


Figure 8: Relative error performance of students prior, during, and after training according to motivation and to learning benefits.

6 CONCLUSION

JOE is an educational game that focuses on learning/teaching accents and hyphen rules of the new Portuguese orthographic agreement. The tool is available for free on Google Play Store. An experiment with both high-school and undergraduate stu-

dents was conducted. From the experiments, we observed that practicing Portuguese using a game-based methodology is beneficial for students no matter their grade level. We achieve more than 80% of students' engagement to learn Portuguese with JOE. However, further investigation is needed to attract the other 20% of the student, who did not feel motivated to use JOE.

The game, although interesting, was considered difficult by most students. Some difficulties found by students were related to understanding the pronunciation of words made by the game. The experience of recording the audio for words showed this difficulty. It was also observed that the students, after training, had a higher hits rate on accentuation. We will study the reasons for not achieving better performance on hyphens. Particularly, if there is the need for the game to tell students that they need to train more hyphen rules.

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