Learning Evolution: A Proposal of serious Game that automatically corrects dictation

completed research

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Abstract

The remarkable use of serious games has gradually pushed them to be present in every single domain, notably in language learning, as new generations are no longer motivated to use traditional learning tools. The development of language learning beckons for more attractive educational tools such as educational games. This paper proposes an interactive 3D game that automatically customizes corrections provided to a multitude of various types of dictational errors and consequently assesses the learner. Such a game requires high graphical level and natural language processing. It is based on the connection between Unity3D platform and NooJ (Natural language processing) platform. The learning process of the game is based on Kolb's experiential learning theory.

Keywords

Serious games, learning development, dictation, automatic correction, NooJ, Unity3D.

Introduction

Since serious games invaded both social and economic fields, they have become a progressive part of our daily culture (Koster 2012). The gaming industry is earning a considerable place, in terms of market segment, and economic value. This industry has been expanding over the last decade and has invaded several fields (Alvarez and Rostaing 2014). The growing use of these games has gradually put them in an important area of research, the aim being to understand their acceptance among a large audience and their success keys. These games propose educational content and switch gradually from being an entertaining tool to a more valuable learning experience. This oxymoron, by mixing two antagonistic terms "game" and "serious", presents a powerful way to playfully broadcast educational content. Their use is not restricted to training or advertisement; they are invading sensitive domains such as the army, medicine and education (Alvarez and Rostaing 2014; Ersöz 2000; Wright et al 1984). For instance, new generations are highly technophile; they need educational material in coherence with the set of technologies they are used to. Serious games are developing educational support and have their own added value with a more engaging learning experience (Alvarez and Rostaing 2014; Alyaz et al 2017). Indeed, they constitute a new phenomenon in education regarding "softness" of learning introduced into the game (Alyaz et al 2017). Even traditional learning games, such as hangman, domino and dice-anagram, have already taken an important place in Foreign Language Learning (FLL) and teaching processes (Ersöz 2000; Wright et al 1984).

For example, in (Alyaz et al 2017) researchers deduced that serious games improve student performance. Statistics show that vocabulary acquisition in German language learning increases from 72.78% before the game activities to 81.11% after the gaming experience. This is due to the exciting adventure enveloping the learning process. In addition, in language learning, dictation is considered amongst the most reliable exercises and positive method for training linguistic skills (Alyaz et al 2017).

Dictation, transcription, and reproductive writing such as learning, training, and examination activities are not new; what is new to the considerations in this implementation, is the combination of the mentioned with a serious game (Alyaz et al 2017). There are numerous studies, which report that during dictation, almost all aspects of linguistic communication are considered from phonological, grammatical to lexical knowledge, thus concluding that dictation is a positive method for training linguistic skill (Gary 2017; Coniam 1995; Oller 1979). However, existing games (Alyaz et al 2017; Trooster et al 2016; Simao et
al 2016) do not deal with automatic and customized correction of dictation. Learners need to compare their own responses with the correct ones provided by the game. Consequently, learning processes are not based on theoretical background (simple types of exercises). In this paper, we propose a new serious game that tries to fulfill this research gap.

Our proposed game requires Natural Language Processing (NLP) platform in order to provide interactive responses dealing with an immense number of eventual mistakes. The connection between the linguistic platform and the game allows a customized and automatic correction so that the learner understands types of committed faults and the eventual correct answer. We have chosen French for the provided prototype although the NLP platform allows the expansion of the game to other languages. Our game is based on the Experiential Learning Theory (Kolb 1984) as the objective is to guarantee an effective learning experience.

**Background**

**Serious games**

Alvarez et Rostaing (2014) define serious games (SG) as "computer applications with the original intention of combining both serious (serious) contents, with amusing aspects of video games (games)." Such an association is obtained by providing a scenario learning from the programming point of view, to implement a set (sounds and graphics), history and appropriate rules, so it deviates from restricting the game to entertainment. Indeed, SG is a fun game for serious purposes. The main objective is to exploit the entertaining aspect of video games to facilitate much more formal learning concepts, traditionally taught by traditional methods of teaching or training.

**Serious games for revolutionizing learning**

Game-based learning has been part of education for decades. However, with new technological advances, digital games have recently emerged as a new educational tool. According to several experts (Ebner and Holzinger 2007) in the research field, the use of serious games in education help students improve their learning performance, which demonstrates that these types of games are a very important part of the process of children's knowledge and social development. In the same context, the studies of (Ebner and Holzinger 2007) have shown that educational computer games can improve students' academic interest and thus increase their motivation and desire to complete such a learning process without feeling bored. This type of study shows that serious games are seeking to merge in and out of class learning while playing, repeating the learning process thanks to the entertaining part of the game that develop the student's capacity, combining classroom activities with play activities, which ensure following a teacher's instructions outside class, in a fun way that increases the rate of memorization.

The use of serious games within the field of education often has a positive impact on students. The above-mentioned studies allow us to see that the potential of learning through educational games has the ability to affect the psychological aspects of students in a positive way, so that they become more responsive and motivated. In Hamzul and Nik (2014), the study is related to online games integrated into the educational system in the context of Malaysia. It shows the positive impact of online games on the learning process of students, in terms of interest, competitiveness, motivation and success. According to these studies, Game-based Learning has been used in education during the learning and teaching process for certain subjects such as mathematics, science, history and language.

In Lameras et al (2017), the study argues that serious games are used to acquire knowledge and skills applied to a particular discipline, module or educational topic. This would lead to the assumption that games could be used for enhancing learning and teaching across different academic territories thanks to the games features engagement (Giannakos 2013). According to Gunet et al (2006) and Hainey et al (2011), two conceptual dimensions have been suggested to link the entertainment aspect with the learning features of the game. The first is motivation and the second is attention. Which urges the learner to repeatedly consume content (playing the same level more than one time to achieve learning outcomes or improve performance). These dimensions have the power to introduce new rich mediated content along with exploratory in-game learning activities that allow students to retain their attention and expand their knowledge beyond the intended learning outcome set out by the teacher (Lameras et al 2017).
In Berta et al (2015), researchers assert that technology is one of the toughest subjects that are difficult to learn in a traditional and an abstract way. They believe that practical activities are needed not only to apply concepts but also to help learning itself. To do so, they propose an approach based on a smart gaming experience (serious game) as a promising approach to allow children to have an experience of concepts and facts that are difficult to learn with standard learning tools (books, lessons, multimedia contents, etc.). Thanks to the game environment and elements of enjoyment, learners are integrated in an educational runway merged with guided exploration, competition, and collaboration Berta et al 2015, that would potentially motivate the child to continue and advance in his learning.

Another field that serious games has swept over and proved itself in training this field’s new competencies, is manufacturing, which has been a challenge for high value companies in overcoming obstacles such as dangerous environment. To highlight serious games’ power in the learning process (Training), Li et al 2017 came up with the idea of transforming a traditional process; a paper manual task, that train employees, within a serious game. The results show that the Training Game was more effective for learning procedural knowledge than the Paper Manual and it can be seen that participants were more confident and engaged. Landers and colleagues indicate in their work Landers et al 2017 that game elements, drawn from serious games literature are used to gamify existing instructional processes in order to improve learning. They believe that game elements must be integrated in a motivational, attractive and interactive way in order to be effective in the learning process. In language learning, Sahrir et al 2011 reported a positive perception of university students in learning Arabic online. Rosman et al 2013, used a meta-analysis study to analyze several current articles published by selected journals that looked at studies related to the potential of using video games to learn vocabulary "Bahasa Melayu" by international students. The results show that video games have power as an effective teaching aid and are able to motivate students in language learning. Past and current studies have revealed a potential for the effectiveness of digital games-based learning in education; Language learning is crucial and requires practicing several skills; practicing, reading, writing, pronunciation, dictation. This requires concentration and endurance that is difficult to maintain for a long period of time. As a result, learners will quickly feel bored, lose concentration, and neglect a commitment to learn. Games overcome this dilemma by integrating heavy learning materials in a fun way and make the learning process entertaining and encouraging (Lepper and Cordova 1992).

Existing games do not provide automatic language processing for users and have not customized their responses. Therefore, they propose standard exercises without a theoretical background. Indeed, learners they must write their answers and compare them later with the correct ones provided by the game (Alyaz et al 2017). We must take advantage of the power of natural language processing tools, which will allow the automation of several language learning processes, mainly dictation and writing techniques. For this reason, we have used the NooJ linguistic platform to develop the resources designed to correct the language learners’ spelling and syntax errors.

The choice of the NooJ platform was not done randomly. Spelling and grammar correction is interesting many companies. Among the existing works, there is LangageTool, Grammalecte and Hunspell. Despite the system’s rapidity in giving the answer of these correctors, we did not use one of them, first of all, because of the impossibility of extending the work if we want to, due to the fact that they are black boxes and we have no idea how their system is working or which grammatical rules they are using. Second, they do not provide a clear interface to make it easy for any user to use them. Third, there is no explanation offered to the learner with the correction to help him/her to memorize the exercise. Both Grammalecte and LangageTool lack the possibility of connecting to the game editor Unity3D; Hunspell, on the other hand, makes it possible to connect but does not provide a grammatical correction. So, we progressed in implementing our own system, with the consideration and reflection for use of one or the other, NooJ platform and the NLTK library build in Python. To be absolutely certain of our decision, we tested them both; Both of them presented a clear interface, understandable to different types of users (teachers or students), making it possible to connect to Unity3D and give the chance to extend the work and add explanations.

We devoted a long period to the NLTK library; the results at the beginning were good because we had effective spelling correction; when we moved to the grammatical aspect, the results were not encouraging. The more we developed and extended the work, the more the system got heavier and took a lot of time to respond, which posed a major problem. Therefore, we moved on to test the NooJ platform by building our
linguistic resources. The more we delved into them, the more the results becomes more coherent and encouraging. There was an ability to extend and develop new ideas, the response was given instantly, and of course, NooJ stood out with another strength by offering a command line program: noojapply. The noojapply command editor allowed us to apply our linguistic resources (dictionaries and grammars) to texts and corpora in an automatic way, and it can therefore be used in two ways; either in a direct way from a "SHELL" script, or more sophisticated programs written in Perl, C++, Java, etc. This editor can be used also in a professional environment such as the construction of a linguistic search engine. This is possible through a dynamic .NET library: nooengine.dll, consisting of a set of public object-oriented classes and methods. These classes and methods can be used by any application. NET and in any .NET programming language (Fehri 2012).

1. Legend:
   • + : Refers to a low mastery of the criterion.
   • ++ : Refers to a strong mastery of the criterion.
   • - : Refers to a non-mastery of the criterion.

2. Criteria:
   • A: Interface clarity: Adaptability with a variety of users.
   • B: Connectivity: The ability to connect the platform with the game editor.
   • C: Extensibility: The possibility of extending the work.
   • D: Response time: The rapidity of providing an answer.
   • E: Answer richness: The permission to provide explanations.

<table>
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<tr>
<th></th>
<th>Grammalecte</th>
<th>Langage Tool</th>
<th>Hunspell</th>
<th>NLTK</th>
<th>NooJ</th>
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Table 1 Comparison between different linguistic tools

On the other hand, Unity3D is a leader platform in game development. It provides a vast set of free 3D assets, animations, characters, plugins, tutorials and a highly connected community. The 3D games developed on Unity3D are immersive with high graphics that support many 3D formats with flexible interoperability with 3D design tools. The game must address the level of existing games in terms of sound, graphics, animations, colors, assets, etc., because the game environment is as important as the gameplay itself, in order to make the players comfortable and attracted to the game’s content. The connector aims to automate the dictation process without the need of a human being. To do this, we intend to use the linguistic resources as an information channel between the two domains, since language learning is a very crucial task that requires several skills such as word recognition, grammar, spelling, conjugation, etc. In the aim to deal with this multitude of tasks and guarantee an effective learning process, we mobilized the experiential learning language theory by Kolb (1984) with its four steps.

**Experiential Learning Theory (Kolb 1984)**

Kolb (1984) has proposed four main steps in this kind of learning:

- **Concrete experience:** This is the first step in Kolb’s cycle. It starts with doing something in which the individual, team or organization are assigned a task. According to authors, key to learning is active involvement in the experience. We cannot learn by the simple act of reading or watching.
- **Reflective observation:** In this second step, one takes time-out from the experience of doing something and steps back in the aim to reflect on what has been done.
- **Abstract conceptualization:** At this step, the learners capitalize what they have learnt by comparing their new state of knowledge with their start point.
- **Active experimentation:** Once the learners integrate the new knowledge and put it into practice within the appropriate context.
Method

Given an identified business need, design science research tries to meet it through the building and evaluation of artifacts (Hevner et al 2004). In this paper, we are addressing the development of a new educational game in language learning. This research will use a design science approach to meet this business need. According to Hevner and colleagues (2004), this problem-solving paradigm allows researchers to meet unsolved problems by designing and developing artifacts. Later, these new artifacts will be evaluated regarding the utility they provided in responding to the business need (Hevner et al 2004). This approach is very suitable for the design and evaluation of a serious game by demonstrating its practical feasibility and utility through lab and field studies according to Hevner et al.’s (2004 p. 86) Design Evaluation Framework. Design science proposes four kinds of artifacts that could be produced (March and Smith 1995).

System overview: NooJ/Uniy3D connector

Within recent decades, natural language processing has achieved a high level of success and has reached a peak of popularity with IBM Watson (Dras et al 2010). Its application in the field of serious games has already begun since recent years, given the high percentage of the communication aspect in serious games, especially since these communications pass through linguistic information. Our approach is summed up in the use of natural language processing tools to study while playing. The game is meant to prove that we have reached a level that the student can practice dictation without the presence of a human being to correct his mistakes. This shows that serious games can completely replace the traditional educational methods given (Vrettaros et al 2015) To do this, we intend to combine two major methods; Unity3d from gaming and NooJ, which is a development environment from natural language processing. This is where our contribution comes in; our system is focused on achieving a connection between the two platforms Unity3D and NooJ.

To ensure the connection between the two platforms, we used NooJ’s command-line program noojapply. This command editor has given us the possibility to connect Unity3D to NooJ and vice versa. All of this will be done according to a well-studied pedagogy to provide students with challenging game activities to be attractive and maintain their motivation but not so difficult that they are frustrating and discouraging. The connection between Unity3D and NooJ initially requires the linguistic resources to be ready for use of the dictation correction process. Therefore, the first step we made in implementing this connection was to create the necessary resources. Since dictation is dedicated to building skills; speaking and spelling words correctly from individual letters we initially focused on building NooJ resources (dictionaries and grammars) to recognize certain word forms of their components (prefixes, affixes and suffixes) (Silberstein 2013). This task allowed us to determine if each word entered by the player was correctly written or not. However, this was not enough to correct the dictation or detect misallocation between the subject and the verb or any wrong combination in the sentence. We have therefore resorted to constructing syntactic grammars that allow the description of complete sentences and decide whether the sentences formulated are consistent, in terms of agreement on gender, number and person or not.

Linguistic approach

Coherent correction requires linguistic processing according to the three morphological, syntactic and semantic levels. However, in this instance, we are interested in the two morphological levels, orthographic correction, and the syntactic one for grammatical correction. To be able to correct the mistakes committed by the player, it is crucial to detect them first. It is from this point that we begin this phase. Now we can classify the error according to three categories: a misspelling, syntactic and semantic. Depending on the type of mistakes, we will develop resources that allow recognizing them and proposing a corresponding correction. Logically, it is necessary to start by treating spelling mistakes; to check if the word entered by the player is correct or not (exists in the dictionary or not). Our approach consists primarily of creating the dictionary that will help us, at an advanced level, to detect the fault. After achieving this task, we are interested in recognizing the exact type of the fault to be able to give a corresponding correction; this will be achieved by the creation of morphological grammars, allowing the
recognition of the entries and the proposition of the corrections. If we are sure now that the entry of the player is orthographically correct, that is to say that all the words are correctly written and exist in the dictionary, we will check if the succession of these words form a correct sentence; this is ensured by the creation of syntactic grammars that check the sentences’ grammar. The mistakes that the syntactic treatment fail to find solutions for, will be treated in another phase, which is based on semantic processing.

One of the most common misspellings that we tried to treat is the consonant doubling. Our approach consists on constructing a grammar that recognizes isolated consonants and outputs the same form but with duplication of the consonant. Then, thanks to the lexical constraint «<$Pref#$V1#$C#$C#$V2#$Suf=:DIC>» (Figure 3), it is necessary to verify that the produced form exists in the dictionary. By providing an explanation, the learner is able to understand his mistake and memorize it in order to avoid future mishaps.

Connection approach

After building the linguistic resources, we proceed to compile them for use as parameters in the noojapply command-line program editor. When the player listens to the dictation provided by the game editor, he/she enters his answer into a text box inside the game. After saving his answer and sending it, Unity3D (within a C# code) will divide the entered sentence into separate words in an automatically generated text file. Each of these words will be an entry to be processed by the NooJ platform. Therefore, noojapply will be called from the C# code in the game. At this point, we are able to connect the input of the player that was automatically saved in a text file, to the compiled linguistic resources. So, these latter represent the parameters that noojapply needs to work properly. Thus, noojapply applies the linguistic resources to the player’s entry word-for-word in loopback to detect possibly misspelled words and send the result of each word to Unity3D to be saved in an index file. After applying resources designed for spell checking and correction, the resources designed for grammar correction will be applied to detect any incorrect agreements in the sentence.
Serious game automatically correcting dictation

Figure 3 Grammar of detection and correction of double-consonant words.

The coherent answer which is given, will be the one that corresponds to one of the grammar’s paths and will therefore be saved in an index file generated automatically by the command-line program noojapply. This index file is what we will rely on to display the correction to the player. The result is finally displayed to the player as a correction to his mistakes.

Figure 4 Connection approach overview

Implementation of Experiential learning theory

Dictation task helps to enhance a set of skills, namely: listening, writing, grammar rules, spelling. Dictation allows several learning goals: word recognition, plural and singular differentiation, developing listening skills, developing writing skills, discovering faults, understanding the type of faults and the corresponding customized corrections, reuse of the word (or its derivation) inside a sentence. Effective learning implementation in the game play is seen through the four stages proposed by Kolb’s cycle:

<table>
<thead>
<tr>
<th>Concrete experience</th>
<th>Implementation in the game</th>
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<tbody>
<tr>
<td>Listening to the dictation, writing an eventual wrong response and receive detailed correction to each fault in a customized way</td>
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<table>
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<tr>
<th>Reflective observation</th>
<th>Learner receives detailed correction with warnings and remarks that strengthen the new skills provided by the customized correction.</th>
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<tr>
<th>Abstract conceptualization</th>
<th>Learner capitalizes the new skills through regular questions and reaches evolution with score augmentation after every correct answer. Learner will have a list of his past faults with their correction.</th>
</tr>
</thead>
</table>

| Active experimentation | Learner will reuse correct form of words or their derivation in writing paragraph or sentences. |

Table 2 Implementation of Kolb learning steps
Experimentation

The game is mainly based on learning by exploring the terrain. The player firstly faces a main interface that allows him to choose a new game to play, continue the last session or leave the game. During the exploration, quiet relaxation music is played in the background to give the player the desire to continue playing. Once the player faces an object with a red light in the scene, he will get closer to it. If this object is closed, that is to say, it is only available with a definite unit of keys (points). In this case, a warning is displayed informing the player that he cannot access this object because of lack of keys. The candidate thus, in this case could not enter the school because of key insufficiency. Therefore, he must look for open objects to increase his keys score. While getting closer to an open object, the player is able to do the exercise in order to increase his luck in the keys collection. When the candidate enters the object environment (On Trigger enter) he will no longer be able to move, and will be asked to wait to listen to the entire dictation.

When he finishes listening, a panel appears containing the fields where the player will be supposed to write his sentence with an image of the object to give more clarification. The dictation in the next figure is the simple phrase "un arbre" (a tree in English), so two fields appear to the player. He will also find in the panel displayed in front of him two buttons; a "Re-écouter" (listen again) button that allows the player to listen to the dictation again in case he did not hear or get confused, and another button "Enregistrer" (save) that makes him able to save the data that he has written in an automatically generated text file.

A new "Terminer" (finish) button is now displayed instead of the "Enregistrer" button, which launch the noojapply call process and read the response sent from the NooJ platform to display it. This task is a background process that is based on coming and going between the two platforms NooJ and Unity3D in terms of data exchange. These are some examples of detected mistakes and their corrections (Figures 5, 6 and 7).

Evaluation of the game prototype

We plan assessing the game, at first hand, by using (Scapin and Bastien 1997) evaluation approach. This approach provides 8 criteria and a total number of 20 sub-criteria in order to evaluate ergonomics of the game, such as the compatibility between the user characteristics (memory, competences, age, requirements, etc.) and the tasks provided by the game, the immediacy of feedback, incitation, guidance, etc. According to (Pries-Haje and Baskerville 2008) the evaluation could be naturalistic (case studies) or artificial (lab experiment). In this research, we plan to conduct a lab experiment with students who are familiar with serious games.

100 Students will use the game for a period of 20 minutes through a specific scenario. Later, they will respond to a qualitative questionnaire about satisfaction with the game and learning outcomes. Students will be asked to mention any problems through the game use and can make recommendations (difficulties to understand a game level, bugs, fuzzy game rules or scoring issues).

Design validation and implications

According to Hevner and colleagues (2004, p 82), evaluation is crucial to an artifact design. To check the validity of our artifact, the seven guidelines of the Design Evaluation Framework of Hevner et al. (2004) should be respected. In order to produce new artifacts and add them as applicable knowledge to the knowledge base (see Framework for Information Systems Research by Hevner et al (2004, p. 80).
Table 2 Guidelines of the design evaluation framework

<table>
<thead>
<tr>
<th>Guideline</th>
<th>Implementation</th>
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<tbody>
<tr>
<td>1: Design as an artifact</td>
<td>We are developing a game and its application showing gradually how to solve a specific problem related to learning goals.</td>
</tr>
<tr>
<td>2: The relevance of the problem</td>
<td>This game fulfills a business need as expressed by professionals as a means to learn a new language (French)</td>
</tr>
<tr>
<td>3: Evaluation of design</td>
<td>The game is under development; it has not been evaluated yet. In the next sub-section, the evaluation game process that we will conduct in order to assess the game. An ex post evaluation should be done as well.</td>
</tr>
<tr>
<td>4: Research Contributions</td>
<td>Our literature review demonstrated that such serious games in language learning are needed.</td>
</tr>
<tr>
<td>5: Rigorous research</td>
<td>The development has been rigorously defined using a combination of research methods including a literature review, mobilizing learning theories and following design steps.</td>
</tr>
<tr>
<td>6: Design as a research process</td>
<td>We have respected a rigorous research process starting from literature review and learning theory.</td>
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<tr>
<td>7: Communication Research</td>
<td>Our results are and will be communicated in two steps: First, the method and initial experiments are presented through publications to other researchers; we want them to help us to consolidate and expand the game and its application. Moreover, students and teachers could use the game and provide us with feedback and recommendations for its future improvement.</td>
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Discussion and conclusion

Serious games are powerful pedagogical tools that ensure educational goals achievement and engage players in deep learning. However, they need strong support from natural language processing in order to be able to perform an automatic dictation task and correct the player’s mistakes in a personalized way. This study described the effort to design and develop a game for learning the French language. In addition, this work has identified the potential to connect two methods from two main branches, each one of them being no less important than the other. In this paper, we report on the design of a new educative serious game, aiming to improve language learning and provide automatic and customized corrections for learner mistakes. The game was developed following a design science approach to meet a business need expressed in dictation exercises. Our contribution is both theoretical and practical as we propose a connection approach, application scenarios and a supporting tool (under development). We are enhancing iteratively the current version by removing bugs until we have obtained a bug free version.

This game opens the doors to transform foreign language learning to a joyful exercise which could diminish stress and boredom in classrooms. It could be seen as an evolution in the educational system and fitting new generations’ requirements and needs (more ludic and less stress). Since serious games constitute a non-evitable change that researchers must study and evolve in order to take advantage of their assets on learning outcomes and levels. Regarding the heavy content of a foreign language learning, the use of serious game allows smoother way to pass new information and a real leaning vector to practice new language individually and in effective and joyful manner.

However, there are some limitations related to this work: evaluation of the game and evaluation of the design research process. In order to complete the Design Science Evaluation Framework, lab experiments and field studies have to be conducted in the aim, to evaluate the game artifacts and to further enhance them.
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