Learning Language Grammar with Interactive Exercises in the Classroom and Beyond

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Abstract: We describe how the principles of gamification, rich learning material, and personalized experience were used to design WordBricks, a software tool intended to assist learning natural language grammar, which is a challenging task for learners. We briefly discuss the distinctive features of successful educational software instruments with a large user base, and argue that the possibility of independent, personalized out-of-class interaction with an educational tool is nearly essential for success. In addition to these elements, our application implements a visual grammar formalism that turns solving grammar exercises into a puzzle game-like experience, attractive for the learners. The results of our ongoing classroom experiments show that the users of WordBricks score better on grammar tests thus proving the feasibility of our approach. Subsequent experiments with the Irish language also demonstrated that the students enjoyed playing with the application, which is important for learners with low levels of motivation and lack of modern multimedia teaching materials.

1 INTRODUCTION

The primary goal of this work is to report the intermediate results of our experiments with a mobile WordBricks application which is designed to assist natural language grammar acquisition. We are striving to gamify the process of learning language grammar, which is a challenging task due to both the complexity of human language and the difficulty of turning grammar exercises into fun game-like activities. Supported with user feedback and discussions with colleagues, we redesigned considerably our initial prototype (Mozgovoy & Efimov 2013), ported it to a mobile platform, and reworked the whole concepts of sentence visualization and the user interface.

WordBricks is designed with the following goals in mind: a) to develop a "visual grammar" formalism that expresses phenomena of natural grammar with simple graphical language of shapes and colors; b) to provide a "virtual lab-like" experience for independent experiments with language constructions; and c) to make grammar learning a more enjoyable and fun experience.

This work naturally enhanced our understanding of the principles of language learning application design, as we had to modify the system several times in response to user feedback. Our ongoing classroom experiments show that the students indeed improve their knowledge of grammar (as demonstrated with their test scores) and overall enjoy using the application. Representing grammar constructions in a simple and intuitive form is important for effective teaching, so we hope that our experience will be useful for the interested teachers and learners.

2 FUN AND EFFECTIVENESS OF EDUCATIONAL SOFTWARE

We believe that the most significant factors contributing to the success of an educational application are *fun (game-like) user experience*, *high coverage of a chosen topic*, *easy translation of game*

knowledge into real-world knowledge, and *the support of personalized, teacher-independent learning*. All these goals are very hard to formalize and achieve, and it is not a requirement to meet all of them to succeed.

2.1 Balancing Learning and Fun

Perhaps the most characteristic feature of a game is fun or ability to engage people, and this is the reason why *gamification* is a commonly mentioned goal of educational software. Unfortunately, it is difficult to extract the essence of "fun", and many edutainment developers tend to reuse individual salient elements of game mechanics to make educational software more attractive. This approach, dubbed "chocolate-covered broccoli" was widespread in 1980s and still found nowadays (Chen 2016). More resent research efforts aim to decompose games to find individual "fun factors", contributing to the overall enjoyability (Sweetser & Wyeth 2005). These works often emphasise relatively subtle factors such as *concentration*, *challenge* or *immersion* rather than colourful animation or fun characters. The difference is exemplified by well-known edutainment titles MathBlaster and DragonBox Algebra. With regard to pure game experience (let us ignore the educational value for now), MathBlaster is often criticized for simply being a bad game (Bruckman 1999), while DragonBox algebra is praised by the press for its high playability (Liu 2012).

"To engage and entertain the user" can be the only goal of a computer game, and designing a successful game still is not an easy task. Educational software also needs to meet pedagogical criteria in terms of coverage and deepness of the underlying materials. Many educational tools (and especially educational games) are devoted to a single narrow topic and therefore have strict limitations for practical use. For instance, DragonBox Algebra is designed for the sole purpose of practicing linear equations. Given that linear equations is only a small part of school algebra curriculum, it is difficult to expect that educational software can cover the whole range of topics in near future. Furthermore, game developers doubt that everything can be turned into a game. As Zach Barth puts, *"they want a game because games are fun, but they want it to teach all of their course curriculum which is never going to work"* (Cameron 2012).

In addition, acquired "game knowledge" should be easily expressible in common real-world terms and concepts. Recent experiments show that DragonBox Algebra fails to achieve this goal: while providing fun and engagement, it relies on a type of visual formalism that is hard to connect with the standard mathematical notation. The students who use far less appealing educational tools score significantly better on math tests (Long & Aleven 2014) (Dolonen & Kluge 2015).

2.2 Games for Conscious Learners

Another important factor is the support of personalized teacher-independent activities. An interesting report (Fincher et al. 2012) shows that cases of teachers actively searching for the ways to improve their teaching practices (whether it is a new teaching method or a certain technology) are rare. The most common source of change is direct interaction with students, a result of teacher-student dialogs, and observations of student attitudes and achievements. This may indicate that educational software can be targeted at potential learners without emphasising classroom use or teacher support.

Good examples of such systems, aimed at conscious learners, are flashcard software Anki and the Duolingo language learning service. Anki is a relatively simple flashcard organizer, and can hardly be qualified as "edutainment". However, learners widely recognize it as a significant improvement over paper-based flashcards; currently (January 2017) the Android version of Anki has millions of installations, and is rated by around 28 000 users. Duolingo (available as online service and as a mobile application) implements some game-like features, such as the system of ratings, achievements, and unlockable learning materials, but arguably is not "edutainment" either. However, with over 100 million active users, Duolingo is massively popular (Protalinski 2015), and characterized by some learners as "addictive" (Bogdan 2016).

Neither of these services pretends to be a game, instead trying to provide a relatively painless and flexible user-centred learning experience. One of the key features of such software is mobile platform availability that turns learning into a leisure-time activity: even several minutes of free time is enough to accomplish a simple assignment and achieve some progress. DragonBox Algebra also implements this idea of representing the learning process as a sequence of bite-sized activities; in general, this approach is a characteristic of modern mobile games, too. It is also interesting to note that both Anki and Duolingo rely on traditional models of language acquisition (flashcards, translation, reading and listening), so a successful educational system does not necessarily need to implement certain "innovative" approaches to learning.

3 GRAMMAR AS A GAME

Our WordBricks system is based on a traditional approach to learning natural language grammar as a system of explicit rules used to combine words into sentences. The principal problem we are trying to address is the non-interactivity of grammar books and exercises. A learner can see how to use certain words in certain combinations using the rules described in the given book section and test oneself with a set of predefined exercises, but has no chance to play with these words and rules. For instance, the learner might want to try to substitute one word with another, use a word in another context, or combine two rules to formulate a more complex sentence. Grammar books cannot provide a feedback loop, which is essential for language learning: we learn certain constructions, and then try to use them in different contexts and with different modifications, expecting others (the teachers) to correct us when needed. Furthermore, it is important both to correct grammatical errors, and to explain which rules are violated in student-supplied sentences.

Our work is heavily influenced by Scratch (Resnick et al. 2009), which is a system for learning the basics of programming. Programming languages have a grammar (albeit much simpler than human languages do), so it is essential to understand how individual instructions can be combined into complex structures. Scratch expresses grammar rules implicitly by representing instructions as blocks of different shapes, so that only matching blocks can be connected into a single structure. Such a "visual grammar" is an appealing concept, since it shows language rules in an explicit graphical form, immediately understandable by the learners. Our initial goal was to explore the possibility of implementing the same concept for natural languages. The idea to use shaped blocks to illustrate grammatical phenomena is known (Ebbels 2007), but this concept needs a strict description to be usable in a formal system, such as computer software.

Having a set of shaped blocks, a learner can combine them into sentences, and the systems of shapes and connectors ensures that the resulting constructions are grammatically correct (see Figure 1). Unfortunately, words in human languages may have numerous grammatical attributes (such as part of speech, gender, person and number), so not all of them can be encoded in shapes and colors while keeping the overall picture clean and free from graphical clutter. Therefore, we had to simplify our visual grammar, leaving brick shapes as the only visual clues (our first prototypes had additional icons), and resorting to textual hints when the users try to combine incompatible bricks of matching shapes. Note that the learners also need to understand sentence structure, since words are connected according to their roles in a sentence (e.g., a subject and an object are linked to a verb, while adjectives are linked to the corresponding nouns).

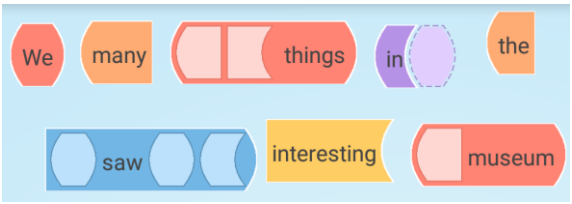

Figure 1: Example brickset of WordBricks

The resulting system has two primary flaws. First, it judges the compatibility of words on the basis of their grammatical attributes, while ignoring semantics. Grammar books, however, often rely on semantical categories, for example, to describe the choice of "a" vs. "the" or of present perfect tense vs. past tense. Second, the system of bricks and connectors is hard to adapt to *non-projective dependencies* that rarely appear in English, but may constitute up to 25-27% of constructions in some languages such as Czech and German (Havelka 2007).

Our current system does not emphasize game-like features. It allows the learners to load bricksets, which correspond to certain sections of a grammar book, and to freely experiment with them. There are plans to introduce scores and progress indicators and other explicit game-like elements in future versions of WordBricks.

4 CLASSROOM EXPERIMENTS

We consider the idea of "visual grammar" to be applicable to a variety of languages, so WordBricks is designed as a language-independent application with interchangeable sets of rules and exercises. Internally, they are stored in a human-editable XML format, which allows us to quickly add and modify exercises and grammar rules.

We conducted the first experimental study with a group of 21 Japanese-speaking computer science students enrolled in an elective English grammar course (Park et al. 2016). The students were divided into two groups, where the first group G1 (the control group) studied two grammar-related topics using a conventional textbox (Murphy 2012), while

the second group G2 relied exclusively on WordBricks, understanding the rules of English grammar by playing with shaped words and sentence elements. For both topics, the WordBricks group (G2) showed greater improvement, based on comparing results with a pre-test and a post-test. The average score of the WordBricks group (G2) increased from 15.90 to 24.20 points (out of 30 possible) for the first grammar topic, while the average score of the control (textbook) group (G1) increased from 15.18 to 21.00. Subsequently we conducted a similar experiment with a group of 16 students, where the average score improved from 17.13 to 20.69 for the control group, and from 17.94 to 20.31 for the WordBricks group (see Table 1).

Table 1: Results of the quantitative experiments

Exp. No.	Test type	Group	Group size	Mean score	Std. dev.
1	pre-test	G1	11	15.18	5.04
		G2	10	15.90	4.43
	post-test	G1	11	21.00	5.80
		G2	10	24.20	4.02
2	pre-test	G1	11	6.00	2.72
		G2	10	4.20	2.57
	post-test	G1	11	9.18	4.17
		G2	10	11.60	2.84
3	pre-test	G1	8	17.13	3.80
		G2	8	17.94	4.64
	post-test	G1	8	20.69	2.91
		G2	8	20.31	2.83

These results show that the application can be as efficient as a textbook, at least, in some environments. In addition, we collected student feedback relating to usability the application and enjoyment of their experiences. As one might expect, we had some sceptical comments from the students who were already sufficiently proficient in their understanding of the rules of grammar and needed to polish certain subtle points, rather than playing with the basic sentence elements. Some students also genuinely prefer books to any types of mobile applications. However, many remarks were enthusiastic, mostly from people who like computer games and technology in general (e.g., "I like fiddling with a tablet", "WordBricks is like puzzle games, and I enjoy to study and play games".)

5 THE CASE OF IRISH

As we already mentioned, one of the principal challenges of educational software is to have a balance between entertainment and sufficient educational value. We believe that WordBricks has the potential to become a balanced system that implements most basic grammar rules while attracting the users with puzzle-like interaction.

Game-like aspects are especially important for the learners with low motivation to study, and can help to keep learner interest at an acceptable level. Currently we are conducting experiments with integrating WordBricks into Irish language classes in the Republic of Ireland. In addition to the task of adapting WordBricks to a language with a very different grammar compared to English, we have to deal with limited learner interest in the subject itself. Irish is a compulsory subject in schools, but the attitude towards the language is a complex issue.

The vast majority of people in Ireland are first language (L1) English speakers, with only a very small minority (3%) using Irish as a community and household language (Government of Ireland 2006). These Irish speakers are bilingual (Irish/English) and there is no communicative need to learn Irish (Watson 2008). Most Irish school children attend English-medium schools, with only 6% attending Irish-medium schools (Gaelscoileanna 2016). While the overwhelming majority of population of Ireland (82%) believe that Irish should be taught in schools, only 43% think that Irish is more important than a foreign language. Many parents would like to see their children learning a 'useful' foreign language such as Chinese or Spanish. Furthermore, only 29% of population believe Irish language education should extend as far as to include some subjects taught in Irish (Darmody & Daly 2015).

Consequently, many learners tend to struggle both with the language and with lack of motivation; furthermore, parents often cannot help their children with Irish as they are not proficient themselves or have never learnt the language themselves (this especially concerns immigrant parents). The resources available to learners generally fall into two categories: high-quality language resources with limited interactivity or 'fun' resources that may have inaccuracies. For example, the government-supported organization Gaelscoileanna Teo provides a website, *irishforparents.ie*, intended to support parents whose children attend Irish-medium schools. Its resources are of high quality, but for the most part, static (although it has some interactive vocabulary activities). WordBricks aims to provide a high-quality, linguistically accurate resource that is also appealing to learners. The Irish WordBricks application is suitable for both traditional learners (i.e., school-going children) and parents/adults.

The initial version of the Irish WordBricks application deals with some of the basic constructs

of Irish that learners must master, yet find difficult due to the fact that they have a different structure than English. Most classroom-based teaching of Irish follows the traditional model of books, workbooks and teacher-led activities. These teaching methods can have an impact on the motivation to learn Irish (Hickey & Stenson 2011). In recent years, there has been greater emphasis placed on oral and aural aspects of the language, but for students, the lessons tend to be of limited interest and not particularly enjoyable.

The Irish WordBricks application enables learners to construct their own grammatically correct sentences in Irish. It helps to reinforce the different word order in Irish, as the learner cannot make incorrect sentences, as only correct blocks will fit into the required part-of-speech holder. For example, "I have a hat" is "*Tá hata agam*" in Irish (literally, "Is a hat with me"), and learners can find this structure difficult, especially as they may try to map the Irish words onto the English sentence structure (see Figure 2).

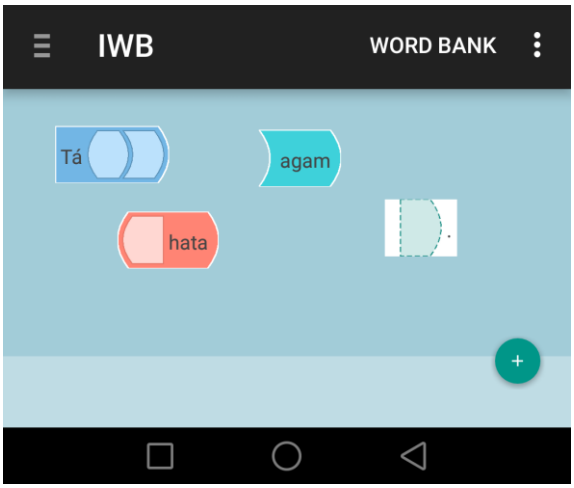

Figure 2: Irish 'have' construction in WordBricks

The initial version of Irish WordBricks has been trialled by both parents and young learners. The young learners reported that they enjoyed using the application and they found it easy to use. They thought it would be useful for learning Irish. Without prompting, one young learner suggested that there could be more vocabulary words so students could make more interesting and longer sentences (the initial version included a limited vocabulary so that learners could focus on structure). The young learners suggested that the application could be used for learning various types of sentences. When asked if they would use the application out of school, they said they might and that they would like a new topic each week.

Initial feedback from parents has also been positive. Parents whose children attend an English-medium participated in an Irish course for parents. Some parents had spent 13 years learning Irish (in both primary and secondary school), but had very limited mastery or recall of the language. There were also several immigrant parents who had never studied Irish before, but they were usually multi-lingual and were comfortable with other languages. The parents enjoyed using the application and thought it was a very good idea to have such an application for Irish. Several parents reported that they struggle to help their children with their Irish homework and have tried in vain to find something useful for them as parents to either revise their knowledge of Irish or learn it from scratch in the case of immigrant parents. They thought the application would be very useful for their children and would like their children to use it at home.

Several primary school teachers also reviewed Irish WordBricks. They have extensive experience of teaching Irish and are very aware of the need to use modern tools and techniques in (and outside) the classroom. They were positive about the application and thought that it would be a useful tool in their classroom. They liked the interactive element of the application and thought it would appeal to their students. Even though Irish WordBricks was initially designed for a single user in an independent learning situation, the teachers plan to use the application in the classroom with their students. They will ask students to form sentences using the classroom computer so that all students can see and become familiar with the grammatical structure being studied.

The next version of the Irish WordBricks application will incorporate new constructs requested by the primary school teachers. It will be deployed with students between 10-12 years of age, and the application will be used during their normal Irish language lessons. Our preliminary experiments showed that both parents and children enjoy playing WordBricks and think that such game-like approach is helpful for them to deal with beginner topics. In our turn, we are working to keep WordBrick exercises consistent with actual school curriculum and provide a practical instrument for the needs of teachers and learners alike.

6 CONCLUSION

Designing good educational software is a complex task that can be accomplished only if several goals are achieved. First, the educational system has to be attractive, which may require gamification in some cases, but at least it requires a pleasant and smooth user experience. Interacting with a good program should be a joy on its own. Second, it has to include learning materials of sufficient quantity and quality to justify the use of software rather than the traditional medium. Third, it should provide a personalized and teacher-independent experience. Observations show that the learners, not the teachers, often become the early adopters of new technologies and new ways of learning.

We are trying to design a software tool for practicing natural grammar rules based on these principles. We introduce subtle gamification with little visual effects but with a deeply integrated model of user interaction; we are working on the implementation of a sufficient number of grammatical rules for novice learners, and have put a heavy emphasis on independent, out-of-class activities for learners. The preliminary experiments conducted in Japan and Ireland are promising, making us believe in the potential of such an implicit game-like approach to the learning of natural language grammar.

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