Development of an English Vocabulary Trainer for German Speaking Pupils and other Beginners of English with Focus on Learning Analytics

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Abstract—**Neuhold [1] developed a software for children to practice additions and subtractions, including tools to analyze the learner produced data to better understand this learning process and help teachers in finding appropriate measures to eliminate mistakes. Following this example we investigated in second language vocabulary acquisition (cf. [2, 3, 4]) and developed a functional prototype of an English vocabulary trainer in the field of learning analytics (LA), which aims at assessing learners' vocabulary competence to support teachers in decisions on appropriate interventions. The software prototype is mainly based on the lexical approach to language teaching (cf. [2, 5, 3]), our own teaching experiences and especially theories on the mental lexicon (cf. [2, 6]) were used for the realization of various analysis tools. Our working prototype points out how learning analytics can help to improve language learning in future classrooms.**

Keywords- learning analytics; vocabulary learning; L2 language acquisition; lexical approach; mental lexicon

I. INTRODUCTION

Vocabulary learning is an integral component in the acquisition of foreign languages and is considered especially important at the beginning of the learning process. In the context of Austrian schools students usually start learning English as a second language in first grade at the age of about ten years. At this age many students face issues with time management or simply lack interest in learning the language, which often results in very irregular and infrequent vocabulary learning. We observed during our daily work that vocabulary is learned only shortly before exams when it is absolutely necessary, and forgotten immediately after the exam. This may lead to serious communication issues when students face more difficult tasks, but completely lack basic vocabulary.

Vocabulary learning is not only a very demanding task for students, but also for teachers as it is their duty to keep track of their students' vocabulary development. This demands teachers to take notes of all of their students' contributions regarding vocabulary learning to keep track of individual issues and to detect general issues concerning many students of a class, which is utterly time consuming inside and outside of the classroom.

The research area learning analytics focuses on the computer based gathering and analysis of great amounts of data produced by students and provides features for teachers and learners which allow meaningful interpretations. Literature on the research area learning analytics points out that a crucial aspect of learning analytics is the easy readability of gained data, which allows teachers, students and other stakeholders to draw immediate conclusions [7, 8, 9, 10, 11, 12]. Active scientists in this field of research already developed a number of tools, which try to provide a useful overview of students' performances regarding various school subjects. In recent years a number of programs, which aim at assessing students performances in mathematics (cf. [13, 14]) history and other subjects appeared on the internet. Learning analytics as it is defined is a teacher centered approach and mainly aims at informing teachers about strengths and weaknesses of their students [15]. Thus, it is important to highlight that learning analytics is not meant only to actively support students in the actual learning process, but rather tries to inform teachers (as well as students) about the learners' current state of knowledge, and therefore, allows early intervention [16].

The aim of this paper is to describe the development of a functional prototype of a vocabulary trainer for beginners of English with focus on learning analytics. Vocabulary learning is a highly complex process. Literature on vocabulary learning provides various different theories on how human brains store vocabulary in the so called mental lexicon, but none of these theories seems to provide neurological evidence [2, 6]. However, studies which followed the lexical approach to language teaching tend to describe the mental lexicon as an interconnected net or web of semantics and word syntax or form and provide empirical data to underpin these theories. Although, these studies also lack neurological evidence they seem very plausible and are most likely to be true [2, 6]. For this reason, the lexical approach to language teaching is taken as a basis for the conception and implementation of the software. As the focus of the software is on learning analytics a main aspect of the trainer is the reasonable processing and

representation of collected data, to point out possible problem areas of learners

A. Method

We developed a prototype [17] of a vocabulary trainer for beginners of English. According to Alavi [18] as well as Larson [19] prototyping is based on four steps: identifying basic requirements, development of a working prototype, implementation and usage (field study), and revision. We first carried out a research on second language acquisition with special attention to vocabulary learning. We collected requirements and implemented a prototype with focus on learning analytics. The evaluation was conducted with a second grade in secondary school.

B. Outline

In section 2 of this paper we describe related work. Section 3 is concerned with the development of the prototype. Thus, we point out the requirements and assumptions, describe the functionality of the software, and describe details regarding the implementation. In section 4 we discuss the results of an evaluation (field study) of the software which was conducted with a school class. This paper concludes with a summary of the main findings and provides a brief outlook.

II. RELEATED WORK

We started with research on learning analytics to define the focus of the project. Then we carried out an extensive investigation on second language acquisition and paid special attention to vocabulary learning. Moreover, we did research on English core vocabulary for the creation of a vocabulary database.

A. Learning analytic

Internet usage is rising daily and so is the amount of data produced by individual users. Data is shared between institutions of various branches and places all around the globe and educational institutions are no exception [20]. A result of the heavy use of the internet for learning is an enormous growth of data about learners' behavior. In contrast to traditional forms of learning, as reading a book, or listening to a teacher, learning on the internet leaves traces of every interaction. Thus, every click and all other interactions between students and their computers can be captured while they are learning and retraced for later analysis. The learners' produced data can be merged and analyzed to gain insights into the learners' learning process [21]. These insights can lead to an early detection of problems in students' learning processes and enable teachers to actively intervene in their learning processes to solve these problems effectively [12].

Learning analytics seeks to analyze and understand the learning process as a whole in its full complexity. The complexity of most learning processes induces to the creation of similarly complex representations of analyzed data. According to Baker et al. [7] and Neuhold [1], it is significantly important to keep visual representations and feedback simple as too much insignificant information might rather result in confusion on the side of the stakeholders and does not allow reasonable interpretation [1].

Learning analytics is a teacher centered approach and seeks to support teachers in their decision making processes and provide an overview of possible interventions [22]. In order to reach this goal analysis and interpretation of student data is necessary. Campell and Oblinger [8] provide a model to logically describe the analysis process in five steps: capture, report, predict, act and refine. Clow [9] takes these five steps as a basis to define the learning analytics cycle, which is described as a closed and iterative process consisting of four main components: learners, data, metrics/analytics and intervention. Khalil and Ebner [21] added stakeholders to the cycle to get an overview about the whole process.

B. Vocabulary acquisition

The term lexical approach was coined and defined by Michael Lewis in 1993. The basic idea behind this approach to language acquisition is that the most important aspect of language learning is the learners' development of the skill to acquire and apply words and longer lexical units.

Supporters of the lexical approach also argue that through their approach learners' also develop the skill to recognize, understand and apply grammatical patterns and structures [5, 3]. Coady and Huckin [2] argue that the learning and acquisition of idiomatic lexical units is a highly important aspect of learning vocabulary in a foreign language, as the language use of native speakers to great parts also consists of idiomatic phrases and sentences.

Lewis [23] suggests the following four aspects as the basis of the lexical approach:

- "Lexis (the vocabulary of a language, as distinct from its grammar)[1] is the basis of language.
- Lexis is misunderstood in language teaching because of the assumption that grammar is the basis of language and that mastery of the grammatical system is a prerequisite for effective communication.
- The key principle of a lexical approach is that 'language consists of grammaticalized lexis, not lexicalized grammar.'
- One of the central organizing principles of any meaning centered syllabus should be lexis."

Coady and Huckin [2] explain the significance of theoretical findings on the lexical approach for teaching methods and point out the following aspects:

- "Early emphasis on receptive skills.
- De-contextualized vocabulary learning is a fully legitimate strategy."

However, the majority of well-known linguists consider the learning of words, phrases and lexical units, similar to the

[1] http://dictionary.reference.com/browse/lexis last visited on 2015, July 05

learning of grammar rules, as too artificial activities for the classroom which do not lead to the expected outcome [4]. This, however, is irrelevant for the development of a vocabulary trainer which aims at learning analytics, as the intended aim of the software is not to replace teaching, but to strongly support teaching.

Aitchison [6] states "[...] the human word-web – the way in which humans link words together in their minds. We noted that words seem to be organized in semantic fields, and that, within these fields, various types of relations exist." Empirical surveys on the mental lexicon revealed that orthographically similar lexical units with very different semantics seem to be a lot harder to acquire for most learners, than semantically similar words. Thornbury [3] suggest learning words not in alphabetical order, but according to their belonging to a specific semantic field. He also compares semantic fields to topics and states that both are basically inseparable as topics mostly consist of several semantic fields, which are assumed to be closely related in the mental lexicon.

Thornbury [3] points out that testing vocabulary is vitally important in the process of learning a language. He argues that testing vocabulary is not a simple one dimensional task, as there are many aspects to consider. He provides a list of important aspects to consider when testing vocabulary and suggest testing the following [3]:

- "the word's form - both spoken and written
- the word's meaning (or meanings)
- any connotations the word might have
- whether the word is specific to a certain register or style
- the word's grammatical characteristics - e.g. part of speech
- the word's common collocations
- the word's derivations
- the word's relative frequency"

A closer look at these aspects reveals that it is impossible to cover all of them in a single exercise, and Thornbury [3] suggest to pick one, two or at a maximum three of these aspects to create meaningful exercises and tests. Multiple choice matching tasks for instance usually aim at testing the recognition of word form and meaning, but not at grammatical characteristics. Another crucial aspect regarding vocabulary testing and the above mentioned criteria is the language level of students. Not all of these eight aspects are meaningful for beginners of a language. Thus, vocabulary testing with beginners of a language should from our point of view focus on word forms (syntax), word meanings (semantics) and partly on word derivations.

C. *Core vocabulary*

The term core vocabulary is often used to refer to a list or corpus of vocabulary containing the most important words, phrases or lexical units of a language. Research on core vocabulary reveals that linguists and other scientists who are concerned with defining a corpus of core or basic vocabulary in English, do not entirely agree on which lexical items should be included in such a corpus. The reason for a debate about which lexical items to define as core vocabulary is not only because of different perspectives on language, but mainly because language is not static, but constantly changing. Thus, new words are invented or adopted from other languages constantly and enter the corpus of commonly used words, while older words become out of fashion and disappear from the corpus [4, 3].

A majority of researchers refers to the Oxford English Corpus (OEC)[2] which is considered as one of the largest available corpora of English. Their constant long-term research on language and collection of language in use reveals interesting facts about existing language in general and more specific language use. By analyzing real language in use the OEC is able to provide lists which rank words according to their frequency of appearance, which indicates the importance of a word.

Thornbury [3] in his book explores vocabulary lists, coursebooks, vocabulary books, dictionaries and corpus data. Regarding coursebooks he states that they "select vocabulary on the grounds of: usefulness, frequency, learnability and teachability" [3]. A quick manual comparison of vocabulary from three different first grade coursebooks used in Austrian schools showed that all three books contain about a thousand to a thousand five hundred words. A further comparison of the vocabulary from the books to the Oxford 3000™[3], which is a vocabulary list based on the OEC containing the three thousand most important English words, revealed that all words used in the coursebooks also appear in the Oxford 3000™.

Thus, the vocabulary database for the software is a compilation of words from [24, 25, 26, 27] and contains about a thousand one hundred words.

III. PROTOTYPE

This section describes the functionality of the software by listing the requirements and assumptions, and provides a textual description of the single components of the software. Furthermore, it provides information about the technical implementation of the software.

A. *Requirements and assumptions*

This section provides a list of requirements and assumptions, which derive from the requirements. The list is divided into several sections starting with general requirements, over requirements regarding testing, analysis and the management of vocabulary.

General Requirements:

[2] http://www.oxforddictionaries.com/words/the-oxford-english-corpus last visited on 2015, July 05
[3] http://www.oxfordlearnersdictionaries.com/wordlist/english/oxford3000/ last visited on 2015, July 05

- The final software should be a functional and stable web application.
- The layout of the software should be kept simple and not too infantile.
- The target group of users are pupils of the first grade in secondary school and their teachers, or complete beginners of English.
- The software is used by three groups of users: students, teachers and administrators.
- The purpose of the software is not to provide a language course, but to assess students' vocabulary and provide analysis tools which allow meaningful conclusions about possible means of intervention.
- Students are not meant to learn new vocabulary when using the program. Thus, it can be assumed that students have already learned the tested vocabulary.

Testing Requirements:

- The first functional prototype only tests a student's knowledge regarding recognition of word forms and meanings.
- Students do not enter words or produce language, but only choose correct answers. Thus, the program does not assess performance but competence.
- Students should be able to run the test mode "endlessly", meaning that there is no fixed number of tested items, but students can stop whenever they want.

Analysis Requirements:

- Students can only access analysis of their own produced data for reasons of privacy.
- Teachers can only access analysis of data produced by their own students, but not of other teachers' students.
- Administrators can access analysis of all student produced data.
- Analysis tools must not include diagrams or other complex visual representations, but must be as simple as possible.

Management of vocabulary:

- Students have no other access to the vocabulary used for testing than in actual tests.
- Teachers can browse and search through the vocabulary database. They cannot add, delete or modify topics or word entries, but can enter suggestions for topics and words to be added to the database in a form which forwards their suggestions to administrators via e-mail.
- Administrators can add and delete topics, add and delete words, add and delete words to/from topics, edit word entries, and browse through the vocabulary database.

B. Functionality of the prototype

The basic concept for the vocabulary trainer prototype was mainly shaped by the requirements listed in the section above. Significant is the requirement that the software will be used by three different groups of users, which also shaped the other requirements. The more specific requirements basically suggest four different modes: a mode for administrators to manage the vocabulary database, a mode for teachers to browse the vocabulary database, a mode for students to test vocabulary and a mode to analyze learner produced data with different permissions according to a users' role. The first two modes are very similar, and therefore, were merged into one mode with different permissions for teachers and administrators. The final concept consists of three different modes: the manage/browse vocabulary mode, the test mode and the analyze mode. These three modes were implemented in the same order as stated before and will be explained in further detail in the following paragraphs.

Another aspect which heavily influenced the conception and implementation of the software was the theory on language acquisition mentioned in section 2. Especially, the theory on the lexical approach and the mental lexicon were used as a basis for the concept. Thus, the software aims at analyzing students' vocabulary in terms of the mental lexicon. Although, this theory lacks neurological evidence, empirical evidence in a way suggests that vocabulary is stored in the form of semantically linked and ordered word-webs with further connections according to word syntax. This leads to the assumptions that problems with vocabulary manifest within such semantic fields, and problem areas might be found among closely related semantic fields. For this reason, the vocabulary database was designed in terms of topics, which in its definitions can also be seen as semantic fields.

With regard to English words, phrases and other lexical units, such a design constitutes several problems. First, English words can be divided into two larger groups, namely content words and function words. Content words are unproblematic and can be assigned to semantic fields, function words, however, are of grammatical nature and do not convey meaning themselves but serve to shape the overall meaning of sentences [2]. Therefore, function words are not assigned to semantic fields, nor they are simply left out, but they constitute a separate category which is utterly important as among the top one hundred words in the Oxford 3000™ one mostly finds function words. Furthermore, phrases and longer lexical units must be treated differently than single words and were not included in this prototype.

1) Manage/Browse vocabulary mode:

This mode is used by teachers and administrators with respective permissions. Teachers can only browse through the vocabulary database and suggest new words and topics to add to the database. This is necessary as teachers often introduce vocabulary to their students which is not found in their coursebooks. However, they are not allowed to add, delete or

edit vocabulary and topics on their own, as this could lead to a very unstructured and useless collection of vocabulary. Another option for teachers, which was included in a former version of the concept, was that teachers should be able to create individual vocabulary pools from the existing vocabulary database. This function, however, was rejected for reasons of complexity and additional expenditure of time for teachers. As we see such functionality as necessary for the use of the software in a school context it should be included in future versions of the software.

Administrators have full access to the vocabulary database which allows them to: add or delete topics, add new words to the database or delete existing words from the database, add words to specific topics or delete words from topics, edit word entries or simply browse through the vocabulary database. In order to allow easy and fast management of the vocabulary database this mode must be intuitive and representations of the existing contents of the database must be simple and clear.

2) Test mode:

In a first concept of the test mode it was intended to incorporate the theory on language acquisition in the test mode to assess whether it is easier for students to learn vocabulary structured in semantic fields or otherwise (alphabetically ordered lists, etc.). However, with the introduction of the requirement that the program should not help students in their learning of new words, but only test words and implicitly help students through analysis, this approach shifted and the theory was used as a basis for the analysis, which also better corresponds to the theory underlying learning analytics.

Furthermore, the requirements regarding testing mentioned above, led to the conception of a very simple test mode. The testing of word recognition in terms of form and meaning can be easily achieved through simple multiple choice tests. For the prototype of the vocabulary trainer only one test format was implemented, which is a multiple choice (single choice) task. The application provides one word in either English or German and four words in the other language. Students are asked to click on the correct equivalent in the other language. Furthermore, students are asked to rate the question regarding difficulty on a six-level scale, when a word is tested for the first time. The ratings represent values between zero and one in steps of 0.2 where zero means very easy and one means very difficult. These ratings are stored in the database for single users in the form of tested word entries, and also influence the rating stored for single words, which is the average value of a base rating and all users' ratings of a specific word. The base rating is attached to topics and defined by administrators when they add new topics to the database. A word's base rating is the average value of base ratings of the topics it is assigned to. The ratings of words could reveal useful information about a learners' self-assessment and more generally about the difficulty of specific words for a majority of learners. Furthermore, the ratings attached to single words are used to compile homogenous tests in terms of difficulty.

3) Analyze mode:

The conception of the analyze mode and its means of analysis was the most difficult part, as theoretical findings on language acquisition provide no or only very little information about how to effectively assess students' vocabulary and come up with possible interventions for improvement. As mentioned above the theory on the mental lexicon was used as a basis for the design of the database and also serves as basis for the development of the analyze mode. Thus, one tool for analysis highlights students' possible problems with specific semantic fields. As the representation of analysis must not contain diagrams or other complex visual representations, this was realized in the form of a table using colors to highlight problems. Another feature is a self-assessment scale which should on the one hand inform teachers about their students' self-assessment, but also encourage students to honest ratings of words. Other features which were implemented in this mode were: general statistics regarding errors, progress and overall performance, a list of all errors, and information about past test results. In the current version the software does not provide suggestions for intervention, but leaves it to teachers to interpret the data and draw conclusions.

C. Implementation

The prototype was developed as web application under the name VOCABTrainer and runs in all well-established web browsers. This ensures easy access to the program as students can even use the software on their mobile devices. The software is hosted by a server of Graz University of Technology, which also hosts all other learning apps, and can be accessed at the Uniform Resource Locator (URL) http://schule.learninglab.tugraz.at/vocabtr/. Similar to all other learning apps provided by the Graz University of Technology, the VOCABTrainer uses the central usermanagement system, which demands new users to sign up before accessing the software. This is a necessary step to ensure an exact allocation of students, teachers, classes and schools. Furthermore, the software was developed under the Apache License, Version 2.0[4] which allows other developers to use and adapt the source code as they wish and paves the way for an unproblematic continuation of the project by other developers.

To ensure easy accessibility and platform independence the software was developed by technologies holding an open source license[5]. All used web technologies are free to access and can be easily obtained. The prototype was mainly implemented in PHP: Hypertext Preprocessor (PHP) 5.4[6] and we did not use a PHP framework for the implementation, but adapted a basic system following the example of Reimers and Thies [28], which was extended using a model-view-controller (MVC) [29] software architectural pattern. Furthermore, we used MySQL[7] for the database, jQuery 1.11.2[8], Cascading Style Sheets (CSS) and HyperText Markup Language (HTML)[9].

[4] http://opensource.org/licenses/Apache-2.0 last visited on 2015, July 05
[5] http://opensource.org/licenses last visited on 2015, July 05
[6] http://php.net/ last visited on 2015, July 05
[7] https://www.mysql.com last visited on 2015, July 05
[8] http://jquery.com/ last visited on 2015, July 05
[9] http://www.w3.org/standards/webdesign/htmlcss last visited on 2015, July 05

IV. EVALUATION

The evaluation (field study) of the VOCABTrainer was conducted with a second grade in secondary school. Although, the software is actually intended for first graders we decided to ask a second grade for their help as with learners of their language level we could be sure that they already learned the tested words. The class consists of seventeen students, which we considered enough for a first evaluation of the program.

We visited the class and introduced the software and ask them to use the program on a daily basis for one week at home. In order to make the whole procedure as comfortable as possible for the learners we prepared user accounts for them, and handed out sheets, which included the URL to access the VOCABTrainer, their user data and brief instructions for the use of the program. Furthermore, we kindly asked the teacher to inform us about possible problems the students had with accessing or using the program. In addition, we provided a simple feedback sheet for the students, and asked them to take notes of possible errors they encountered.

The evaluation revealed that the software runs stable and the students encountered no error messages or other unexpected behavior of the software. The gathered feedback was insofar useful as it enabled us to revise the vocabulary database and it also showed that the students had no problems in using the software, which showed that we met our goals in terms of usability. Furthermore, the implemented analysis tools for teachers showed that an easy and fast identification of strong and weak classes as well as students is possible through the overall performance indicator (rank). The productivity of the single students also revealed that students which were considered strong by their teacher were the most productive ones and weaker students rarely used the software. These tools, which provide an overview of the classes and students of a teacher, are considered helpful for teachers as they allow them to quickly track their students' efforts for improvement, which is a rather time consuming task if done manually in written form.

Another interesting tool is the self-assessment scale, which either indicated very good or very poor self-assessment, but rarely indicated a medium self-assessment value. The self-assessment of the students is closely connected to their teacher's impression of them, indicating that students who are considered strong learners show a better awareness about their own vocabulary competence than weaker students. Thus, the self-assessment indicator of weaker students on the whole showed rather poor self-assessment, which indicates a distorted self-awareness about their vocabulary competence. We consider the self-assessment scale especially helpful for teachers, but also for learners and parents, as this tool allows them to take measures to actively raise the learners' awareness about difficult words and check on the vocabulary competence development of students with poor self-assessment more frequently.

However, the results were not sufficient enough to draw meaningful conclusions about students' learning processes or to identify students' problem areas as the amount of collected learner produced data was not enough. In order to make clear statements about the usefulness of the implemented analysis tools of the current version of the software a longer evaluation will be necessary in future. Furthermore, this will allow us to refine or replace some of the analysis tools. Figure 1 illustrates the student analyze mode of the most productive student of the evaluation.

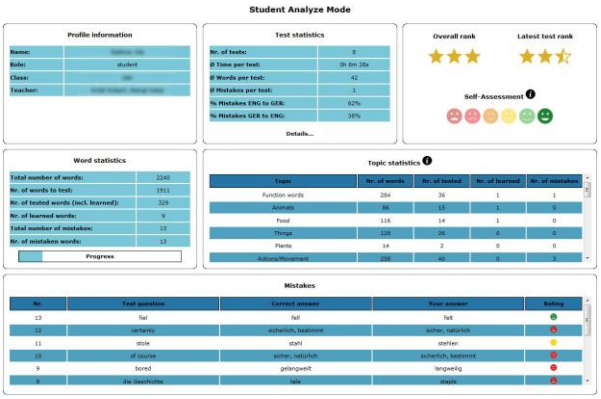

Figure 1. Student analyze mode of the most productive student after the evaluation period.

V. CONCLUSION AND OUTLOOK

To conclude, the aim of this paper was to describe the development of a prototype of a vocabulary trainer for beginners of English with focus on learning analytics. We explained the theoretical background used for the development of the software, described the functionality of the prototype, and presented the evaluation and its results.

The project was carried out in the field of learning analytics, and therefore, the main goal of the implemented software is to inform teachers about their students' English vocabulary competence. The information presented to teachers should allow them to better understand problems in their students' learning processes and consequently they should be able to actively intervene in these processes. In order to ensure easy and fast understandability of the analyzed data only symbols and tables were used for the representation of data.

For the implementation of the prototype we developed a simple basic system using a MVC software architectural pattern to ensure modularity and easy extensibility. The lexical approach to language teaching and especially theories on the mental lexicon were used as a basis for the software concept. The current version of the software basically consists of three different components to manage/browse the vocabulary database, test vocabulary and provide analysis models of learner produced data. The core part of the software is the component which provides various analysis tools for teachers to quickly identify weak classes and students. A detailed analysis of single student's vocabulary competence should help teachers to come up with appropriate interventions, and also foster students' self-improvement.

Unfortunately, the amount of learner produced data was less than expected in our first field study. However, the evaluation allowed us to revise the vocabulary database, and assess the stability and usability of the software. In order to

come up with clear statements about the usefulness of the developed analysis tools a long-term evaluation of the software is necessary. Furthermore, this will allow us to revise and improve certain analysis tools. Moreover, the existing source code should be embedded into a PHP framework in future versions of the software to increase modularity, extensibility and performance.

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