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CONSTRUCTIVIST LANGUAGE LEARNING TOOL

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Abstract. *The topic of this paper is a constructivism-oriented foreign language learning tool currently in the development at the CIITLAB laboratory of the University of Niš, Faculty of Electronic Engineering. This tool is a follow-up to the existing DSi e-learning framework, developed at the same laboratory which expands its feature set in the direction of constructivism. One of its primary aims is foreign language learning, and it is expected to be positioned as a component in larger e-learning environments, though it is able to operate in a stand-alone fashion. The tool is in the prototype phase and it is being tested against several use cases. The core concept of the tool is coupling the ubiquitous drag and drop user interface with the semantic structure of the textual instructional documents. By dragging and dropping, the learner interacts with the tool and affects the document semantics. The approach is learner-centered and enables the learner to take the active role in learning.*

Key words*: e-learning, language learning, constructivism, semantic, rdf, drag and drop*

1. INTRODUCTION

It has been nearly a century since technology has first found its way into the realm of teaching. Though the exact moment remains vague, it is widely accepted that its first occurrence took place in 1920s, with the 'learning machine' by Sydney Pressy (Pressy, 1926). This is not to be confused with distance education, though the two terms semantically overlap and are frequently confused. The first known distance education dates back to 1728, when the Boston Gazette newspaper published a first correspondence course ad ever; however, this approach applied no true learning technology. In 1960, the first serious computer-based education attempt was made with the PLATO system (Smith, 1976), able to serve 1000 students simultaneously. In 1970 the first PhD on this topic was written (Bernard Luskin) and six years later the first online college[1] was founded. The computer-based education as we know it today was not possible until the invention of the World Wide Web in 1989 (Berners-Lee, 1989). The things sped up at accelerated rate until the e-learning 'hype cycle' peaked in 2000,[2] which was followed by a sobering and more realistic stage, stretching up to today. To date, the entire development of the field has been more chaotic than structured (Holmes, 2006) while the precise definition of e-learning remains elusive (Nicholson, 2007). The swift growth of number of tools suitable for teaching, especially from Web onwards, provided plethora of

[1] https://en.wikipedia.org/wiki/Coastline_Community_College, retrieved on September 30th, 2015.
[2] https://www.gartner.com/doc/493556/hype-cycle-elearning-

options ready to be tested out; however, many can not be considered e-learning (Horton, 2001) but rather media of connection and storage of classical education – which can be achieved even with pre-computer technology. E-learning is frequently defined as the delivery of personalized, dynamic learning material in real-time (Drucker, 2000) or just-in-time education with fast value chains (Stojanović, 2001), denoting that it is about technology-enabled approach, rather than technology itself. Use of some type of technology is always implied, as well as interaction with peers, while physical distance from the teacher is a frequent feature (Ally, 2008). The information and communication technology (ICT) is viewed as primary means for improvement of teaching (Martinez-Torres, 2011), but also as democracy in learning (Khan 2015). Within this paradigm two major directions emerged: learning (content) management systems (LMS/LCMS) on one side and intelligent tutoring systems (ITS) on the other; first two focused on content and activity management, and the third one oriented towards ‘teaching by a machine’, through application of artificial intelligence (Samuelis, 2007). As the field developed, its branching deepened into more dimensions, including pedagogical and technological aspects, interface design, evaluation, management, institutional issues, resource support and ethical aspects (Aguti, 2014), or scales, as system magnitude or learning timeframe. (Phillips, 2012). Though tendencies in the development of learning technologies are visible, the overall development of the field lacks clear structure, just as its key notions still lack precise and standardized definitions (Moore, 2010).

1.1. Theoretical Foundations of E-Learning

The research activities in the field show similar lack of structure, with majority of publications in the form of specific technology usage description and results evaluation (Nichols, 2003), most of which more descriptive than quantitative in nature and with the emphasis on technology, neglecting or omitting theoretical foundation (Ravencroft, 2001). The absence of a unified theoretical model to lead the way (including, for example, a standardized vocabulary of new terms), the development in this area is obstructed and multi-directional. As a response, control and advisory bodies began to emerge, offering surveillance, metrics, best practices and guidelines. The IEEE Learning Technology Task Force offered one of the first sets of fundamental e-learning development principles (Nichols, 2003). It contains ten items, third of which states that the choice of e-learning tools must reflect, rather than dictate, the pedagogy of the course - reflecting the importance (and current neglecting) of theory.

Though technology has led the development in e-learning, it is interesting how it reflected the major learning theories in a spontaneous way, probably due to its gradual sophistication. Early on, before computers, machines were mechanical and raw. There was no space for personalization or any type of ‘human touch’, only a basic stimulus-response mechanism. This technology reflected the *behavioral* type of learning, as a function of change in visible behavior, while the mind was not observed (but instead treated like a *black box*). With modern computer systems, particularly with the introduction of graphical user environments (GUI) and the Web, the teaching process could be subtler and more complex, reflecting the *cognitivist* learning theory, shedding more light onto the immeasurable processes in the human mind: retention, reasoning, reflection, abstraction, motivation, metacognition, etc. This theory implies that the learner be presented with information with multiple presentations (textual, graphical, audiovisual); the long-term memory should be applied to the learning process in order to integrate (or link) the new material from the short-term memory, information should be presented in chunks (Miller, 1956), individual learning styles must be taken into consideration, etc. These requirements could not be met with simple, mechanical tools. However, modern computer is a natural environment for them. Starting from the outside behavior and moving towards the inside mental processes, the next thing to consider is the role of the student in the learning process. This is where the *constructivist* learning theory takes place.

The major shift provided by the constructivist learning theory is advancing the student from the passive role of the receiver of information/knowledge, as presented and paced by the teacher, to the active role of constructing the knowledge through the interaction with their environment (Keene, 2014). This shifts the learning paradigm from teacher-centered to student-centered, enabling the student to *construct* the knowledge by actively researching, experimenting, collaborating and using their existing knowledge to build upon it in a 'spiral' fashion. In order to achieve this, the student must be presented with the sources of knowledge, as well as the appropriate challenges and means of collaboration with peers, while the teacher takes the role of the facilitator. Other constructivist learning elements include the testing of gained knowledge in practical situation and learning in the contextual manner. Though this set of requirements might seem elaborate, it is achievable even with generic learning solutions such as Moodle[3] (Moreno, 2007) or Blackboard[4] (Liaw, 2008). The latter study showed that the primary concern of students, prior to the quality of the multimedia learning material, is the *interactivity* of the system, which speaks in favor of constructivist approach. Similar to the general field of e-learning, the research in constructivist learning technology usually yields descriptive results and sets of guidelines (Koohang, 2009). However, precise, quantitative measurements do exist. In a study of adult introductory Java programming course (Alonso, 2009) the results showed that classical e-learning came out worse in overall learning outcome than the classical, face-to-face learning. However, when altered to apply constructivist principles to learning, the outcome was better than in traditional setting; still, the average effort (invested time) was significantly smaller in traditional setting, but at the price of higher cost for participants. Despite the shortage in quantitative research, constructivist approach to e-learning appears promising. The central topic of this paper is an e-learning tool developed to facilitate the constructivist learning behavior elements in students.

1.2. Technology in Language Learning

The review of literature in the field of technology-aided language learning from 1990 to 2000 shows similar trends as in general e-learning domain (Liu, 2002). The primary concern has shifted from the acceptance of computers in language teaching in 1990s, to the issue of effective integration of technology into the teaching workflow, while the research was firstly focused on discussing technologies and later on the technology effectiveness in learning. The majority of studies are descriptive in nature, predominantly founded on student self-evaluation (Stepp-Greany, 2002), or their perception of the

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[3] https://moodle.org/

[4] http://www.blackboard.com

learning technology used. Often, even in the students' evaluation the accent on technology is noticeable (Yang, 2007). Probably the most important issue in technology-aided language learning are various aspects of language. Studies show that e-learning brings different levels of benefit in various aspects (Hui, 2008). One of the conclusions is: with all the issues mentioned so far, it is up to technology to provide information, not to integrate it (Blake, 2009). However, in this domain, providing is much more than displaying.

In the following chapter an overview of the proposed language-oriented e-learning tool is given. The user experience is discussed in more detail, while the technical underpinning is explained briefly. The last section gives several learning scenarios specific to language learning, such as learning and exercising homonyms, synonyms and similar word groups, brainstorming for creating essay paragraphs and text comprehension exercising.

2. THE LANGUAGE-ORIENTED E-LEARNING TOOL

In order to present the principle behind the proposed language-oriented e-learning tool (LOET), a brief overview of its origins must be given. The fundamental concept behind it is the intersection of simple human-computer interaction (drag-and-drop) and the layering of the textual learning material into two: the text itself and the underlying semantic structure of it, which defines relations between key notions from the text (Jovanović, 2007). The importance of these relationships came from the definition of learning. If we assume that learning is the act of acquiring new, or modifying/reinforcing existing knowledge, behaviors, skills, etc.,[5] and understanding is a relation between the knower and an object of understanding, and the one who understands is able to think about it and uses concepts to deal adequately with that object[6], it can be concluded that learning implies acquisition of a new concept about an abstract or a real entity (object, principle etc.). Furthermore, if we assume that a concept is an abstraction or generalization from experience, or the result of a transformation of the existing ideas[7], the act of learning implies forming mental connections between the known and new ideas (forming new concepts). In this respect, relations between notions are fundamental to knowledge, therefore to learning. In visual terms, knowledge may be presented in a form of a well-connected graph, with notions in nodes and relations in edges. Acquisition of knowledge about a new notion (node) implies forming meaningful relationships (new edges) from the known (existing graph) to the unknown (new notion). Approaches like this exist (Sowa, 1984), (Sowa, 1992). The approach proposed (Jovanović, 2007) builds upon these ideas in the direction of readily available e-learning accelerating feature and is closer examined in Jovanović (2015). The knowledge transfer in this approach is uni-directional: the learner can only obtain information from the system. This is aimed at linearizing the path through the course (lowering the number of returns for reviewing definitions, thus lowering the time needed to complete the course). Bearing in mind the benefits of constructivist approach to e-learning, the LOET described in this paper has

[5] https://en.wikipedia.org/wiki/Learning
[6] https://en.wikipedia.org/wiki/Understanding
[7] https://en.wikipedia.org/wiki/Concept

been altered to put the learner in a more active position by adding the assessment dimension and through allowing the user to add their own relations. This not only puts the learner in charge of learning, but also opens up a vast array of new application modes in language learning. Also, it is not a holistic learning environment. Instead, it is a singular tool that can be used as a component in larger e-learning systems, as well as operate as a stand-alone Web application. Strictly speaking, LOAT can be labeled a framework, as it represents a set of functionalities rather than a specific solution implemented in a specific technology, as programming languages, development frameworks, and supporting data structure can vary with no bearings on user experience. In the current state of development, LOAT is implemented as a stand-alone compact Web application.

The current version of the tool is aimed strictly at textual learning materials. Upon logging onto the system, the student is presented with the lesson (it can contain various types of material, however only textual part is of interest), as presented in Figure 1.

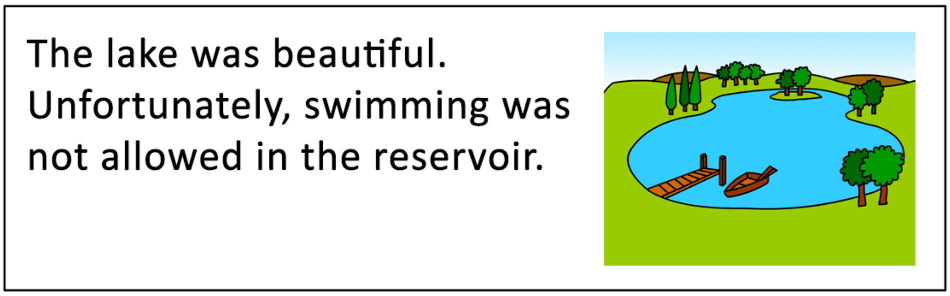

Fig. 1 Initial learning situation

All words in the text are drag-enabled. This means that the learner can drag all the words in the text in the same fashion that they drag icons on their desktop, only the area of dragging is limited to the main area of the browser window. This is shown in Figure 2, where the word 'reservoir' is dragged away from its original position.

Fig. 2 Text draggability, word-wise

When the learner drags one word and drops it onto another, for example the word 'lake', a text field opens up, offering them to enter a relation between notions denoted by the two chosen terms in the context of current learning domain, as shown in Figure 3.

Another way this interaction can be implemented is through predefining multiple options for the learner to choose from; this way learner's input is not freeform, but rather structured in a predefined way (as shown in Figure 4.)

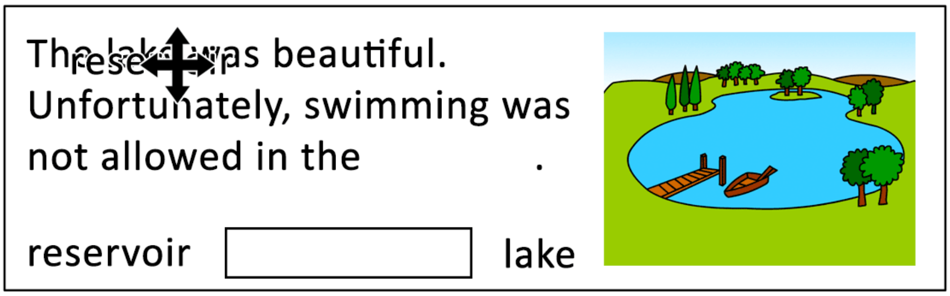

Fig. 3 New relation prompt on word drop action

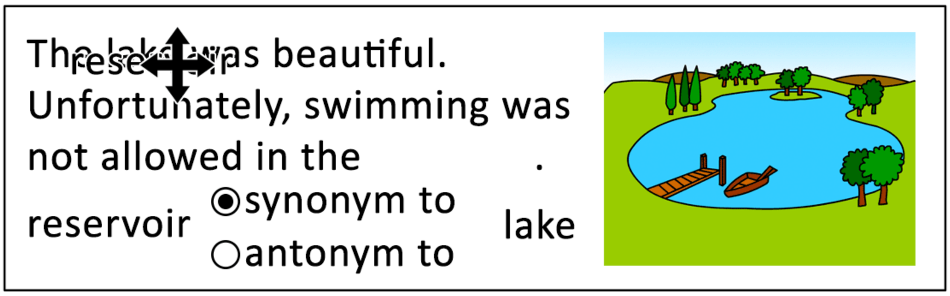

Fig. 4 Several offered options on word drop action

The learner may enter more than one relation. In case any relations between the two terms are already entered, the tool will display them along with the text field ready for a new relation. The entered relations are stored in a separate document which is created by the system at the session start.

The format of the document may vary. In the current version, the Resource Description Framework (RDF)[8] document type, defined by the W3C[9] within the Semantic Web[10] initiative, was chosen for several reasons. First of all, RDF is a W3C standard and one of the fundamental Semantic Web technologies. Semantic Web is a new version of the World Wide Web and its development is carefully monitored and directed by the W3 Consortium, founded and led by the World Wide Web author (Berners-Lee, 2006). Semantic Web upgrade will enable automated computer reasoning and data integration, unleashing the power of today's computers that stand helpless before unstructured, human-understandable but machine-unusable data. As it slowly emerges as the new Internet paradigm, Semantic Web brings about numerous standards and interoperability options, one of which is the RDF. Thus, storing data in this format will

[8] https://www.w3.org/RDF/
[9] http://www.w3.org
[10] http://www.w3.org/standards/semanticweb/

make it easily accessible for processing in the new Web environment, integration of multiple separate data collections will be straightforward, as well as integrating data into more complex and sophisticated structures.

The RDF approach is fairly simple. An RDF document is a collection of triples – statements in the subject-predicate-object form. RDF is a specification of a data structure, not a specific language to express data. Most frequently used language for formal RDF expression is XML[11] (Figure 5 shows a statement ‘John Smith owns Tesla X’ where ‘John Smith’ is a subject, ‘owns’ a predicate and ‘Tesla X’ an object).

```
<rdf:Description rdf:about="John Smith">
       <owns>Tesla X</owns>
</rdf:Description>
```

Fig. 5 The RDF/XML expression of an RDF statement

The structure this simple has relatively low expressive power, and is lacking formal semantics that would enable automated reasoners to reason upon RDF documents, as they can in case of more structured representations, such as the OWL.[12] As the tradeoff, RDF is missing limitations and firm structure, thus being able to address wider scope of data scenarios. Moreover, a plethora of tools for manipulating the RDF documents (such as RAP[13]) already exists, which does not hold for more complex data structures. In the proof-of-concept phase, RDF appears to be the most reasonable solution, placed in the sweet spot between simplicity, usability and standards.

3. English Language Learning Example Scenarios

In this section, several example tool usage scenarios are given. The tool presented is not limited to these and its set of functionalities can be expanded to cover more activities, such as assessment. Directions of further development are given in the last section.

3.1. Synonyms, Homonyms and the Like

Each binary relation between words is perfectly suitable for this tool. Examples include synonyms, homonyms, homophones, homographs, hyponyms, meronyms, etc. In the basic mode, the learning tool would display a paragraph, and on each word drag a text-field would appear for the learner to enter a specific relation between the chosen words, be it a synonym, homonym or any other (Figure 6). Different relations within a single text may exist. In the second proposed mode of use, instead of allowing the learner to freely type, and perhaps mistype like in Figure 6, the tool would offer a list of possible relations for the learner to choose from (the case of words ‘immature’ and ‘juvenile’ is shown in Figure 7). This is a more structured approach, with less freedom on the learner side but also less prone to typing errors. It is worth mentioning that this scenario, as well as any other, may be performed in a collaborative manner, as the semantic document,

[11] http://www.w3.org/XML/
[12] http://www.w3.org/TR/owl2-primer/
[13] http://wifo5-03.informatik.uni-mannheim.de/bizer/rdfapi/

which contains relations, and can this way be built by a group of learners. Moreover, this approach can be generalized to any type of assessment. Another possible mode of operation is a form of a self-questionnaire: the learner can compose their own text, the one that gives the context for the words to be learned in which they are best remembered, and the underlying semantic layer can be applied to it, bringing these words into relations and enabling questions as described.

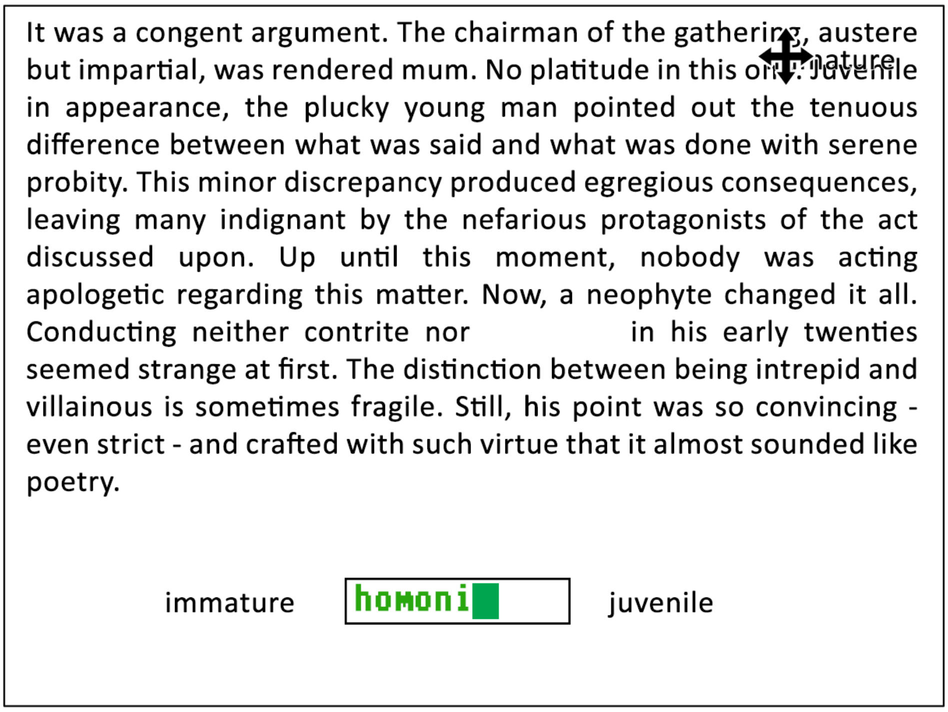

Fig 6. Freeform learner’s input

3.2. Essay Composition Brainstorms

Though the initial tool has been envisioned with simple binary relations in mind, there are no limitations as to the length of the relation. This can be applied in early stages of courses on essay composition. It is a common practice that any course on essays begins with the composition of paragraphs, starting with brainstorm sessions. Supporting this phase, the tool can present the learner with a paragraph of text to choose keywords from and contrast them at will – entering the content of a possible essay paragraph (Figure 8).

3.3. Collocations and Similar Problems

Collocations are frequent and important in English language. They are spatial in nature, positioned closely within a context. The spatial nature of collocations can be emphasized in the visual sense, by pulling collocated words close together using the proposed language learning tool. This use case fits in the second mode of the tool – the learner is not required to type any relation. The relation 'is to be collocated with' is, in this case, predefined within the lesson. It is up to the learner only to provide all instances of this relation. The student can freely drag any words, but only a subset of words will form collocations. The system may provide instant or delayed feedback, depending on the chosen pedagogy.

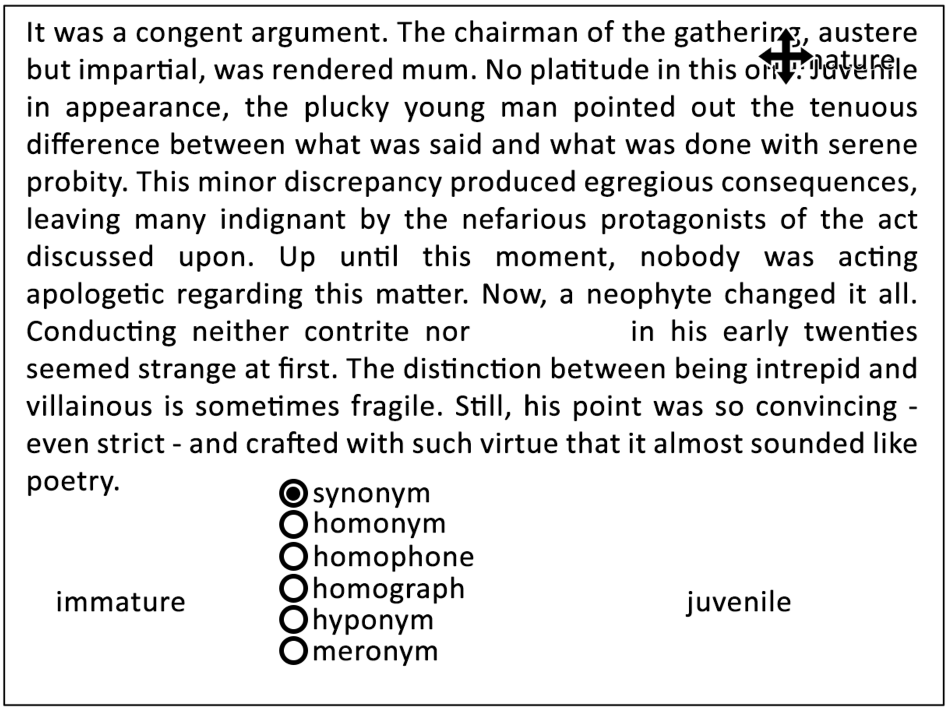

Fig 7. Structured and more restrictive interaction

The paragraph presented to the learner can have several definite and/or indefinite articles omitted. The learner is expected to drag the present articles onto the words they find appropriate. In case of indefinite article, instead of typing, the tool can offer two options to the student: *a* and *an*. This exercise can help the learner to both differentiate definite from indefinite article positioning, as well as practice indefinite article *a*/*an* situations.

In another scenario, the *I was/I were* type of difference can be practiced. Both *was* and *were* words can be present within the paragraph, in an example sentence. In all other sentences, both *was* and *were* are omitted. Student is expected to drag appropriate form onto appropriate words. In this scenario the relation ('belongs here') itself is also 'hardcoded' into the lesson.

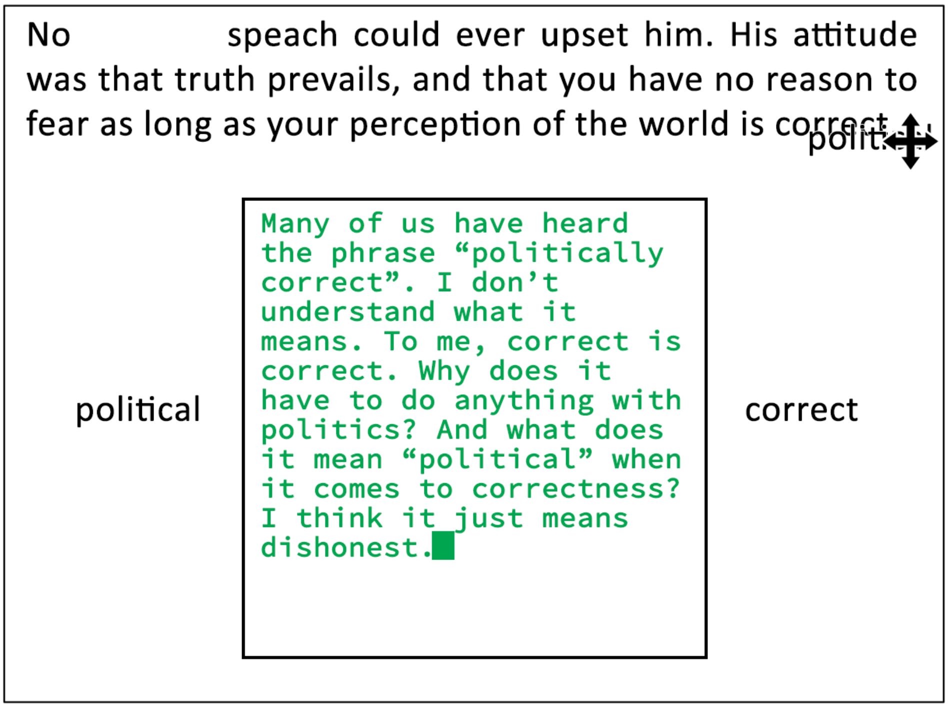

Fig 8. Contrasting notions to inspire paragraphs

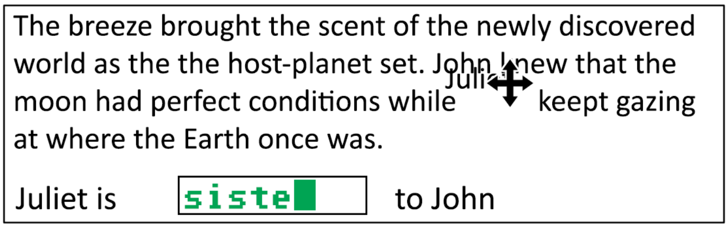

Fig 9. An example of a newly entered relation

```
<rdf:Description rdf:about="Juliet">
       <sister>john</sister>
</rdf:Description>
```

Fig 10. The newly formed RDF triple

3.4. Text Comprehension and Other Student Input

The system can be altered to allow free input of any relations, as depicted in Figure 9. One possible scenario is the assessment of a text comprehension in which the learner would be required to enter all possible relations that exist in the text. In general, this approach allows not only open type questions, but also collaborative work and peer assessment, as the students grading their peers' input feature is easy to implement. If relations can be entered freely, with the large number of learners, their input is likely to show a normal distribution of values, the most accurate being the most probable. This way a knowledge base of relations can be formed in a Web 2.0 fashion, adding to both learning and future testing. Moreover, relations that learners enter can be marked by their peers, introducing peer-assessment scenario into the learning process. The consequence of each entered relation is a new RDF triple, as shown in Figure 10.

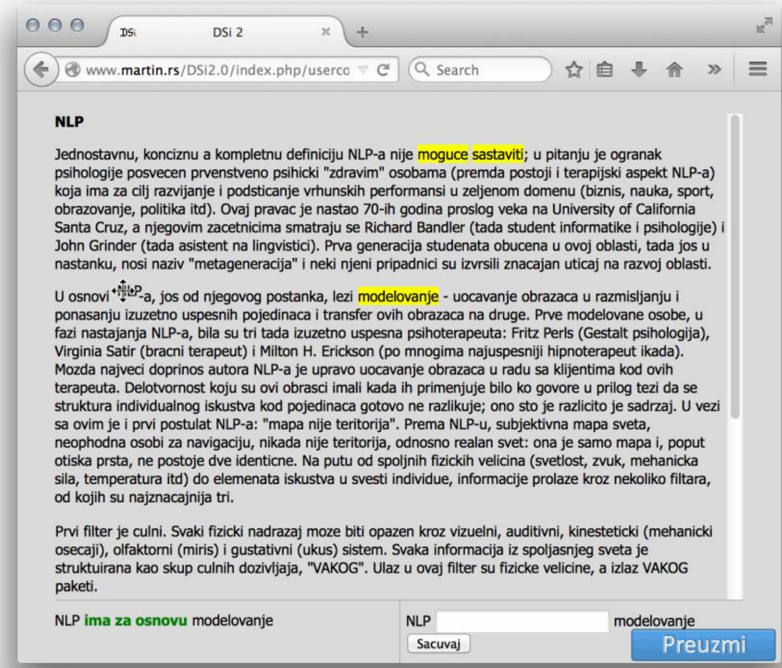

Fig 12. The screenshot of the current prototype

4. CONCLUSION

The constructivism-oriented e-learning tool discussed in this paper, currently in the prototype testing phase (one testing/debugging situation, with a random text in Serbian, is shown in Figure 12), promises numerous ways of application in the domain of language learning. The simplicity of its core principles and versatility of its modes of operation may cover a wide array of language learning situations. Nevertheless, it bears a number of limitations and has wide space for improvement. The first noticed issue, during informal pilot-testing, is the learners' confusion about its usage. This comes as no surprise, as such approach is completely new. There has been a small number of cases when learners considered dragging and dropping of words a sort of a cheat. Emphasis must be put on short but effective training prior to using the tool. Another limitation lies in the free form of relations. At the current phase of the tool development, relations are given as plain strings of characters, formulated in human form, with no formal semantics at hand. Though this approach is simple to develop and use, it is limited in terms of any future automated reasoning, as well as vulnerable to simple typing errors. Finally, the optimization of the technical side needs to be performed, as the tool puts significant load on the Web server for it needs to respond to learner's interactions in real time. Further development of the tool will go in the direction of assessment and collaboration, with the peer-review approach in mind. Further on, the development will assume the direction of automated quiz question generation, based on learners' interactions with the learning material.

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