Alma: An adaptive learning models environment from texts and activities that improves students’ science comprehension

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Abstract

This paper presents the Adaptive Learning Models from texts and Activities (ALMA) environment and the interaction of undergraduate students in Computer Science with it, while studying the learning goal “Computer Networks’ Principles”. The learning design of ALMA is based on Kintsch’s Construction-Integration model for text comprehension and takes into account the learner’s background knowledge in order to propose a text of appropriate cohesion from four versions of a text, orthogonally varying local and global cohesion. Learners’ comprehension is also supported and assessed through a series of activities such as a free text recall measure, case studies, activities of active experimentation, text-based, bridging-inference, elaborative-inference and problem-solving questions and a sorting task. Moreover, ALMA proposes a learning sequence according to students’ learning style; however students can set their own. Students interacted with the system and expressed their opinion about the course designed via ALMA which was very satisfactory.

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1. Introduction

In the field of text comprehension, many researchers have been examining issues focusing on assisting comprehension through personalized learning environments. There is a growing literature of studies supporting learner models, which are related to text comprehension. SimStudents, an integrated learner model for history and equation problem solving, uses an ACT-R based cognitive model (MacLaren & Koedinger, 2002). Other systems include the Empirical Assessment of Comprehension (Mathan & Koedinger, 2002) and the model of comprehension and recall which is based upon Trabasso & Van den Broek’s model (Fletcher, van den Broek & Arthur, 1996). The latter considers text understanding as a process of finding, by the reader, the causal path linking text from the beginning to end. Recently, various approaches have been proposed (Zapata-Riviera & Greer, 2002) which involve learners in negotiating dialogues, as well as learner models that encourage inspection and modification of the model. ReTuDiS is a tutorial dialogue system for learner modeling text comprehension through personalized reflective dialogue (Grigoriadou, Tsaganou, & Cavoura, 2005). Interactive Strategy Training for Active Reading and Thinking (i START) is a web-based application that provides young adolescent to college students with high-level reading training to improve comprehension of science texts. i START is modeled after an effective, human-delivered
intervention called self-explanation reading training (SERT), which trains readers to use active reading strategies to self-explain difficult texts more effectively (McNamara & Levinstein & Boonthum, 2004).

Adaptive Learning Models from texts and Activities (ALMA) environment is based on Kintsch’s Construction-Integration model for text comprehension (Kintsch, 1998). It proposes that reading primarily involves the surface, text base and situation model levels of comprehension. Most relevant here are the text base and situation model levels. A good text-base understanding relies on a coherent and well-structured representation of the text, whereas a good situation model relies on different processes, primarily on the active use of long term-memory or world knowledge during reading. Links between text-base and background knowledge must be activated in the reader’s mental representation of the text. Motivated readers encountering a gap in the text will attempt to fill it, and doing so requires accessing information from their background knowledge, which in turn results in the text information being integrated with long-term memory. This gap-filling process can only be successful if readers possess the necessary background knowledge. The degree to which the concepts, ideas and relations with a text are explicit has been referred to as text cohesion, whereas the effect of text cohesion on readers’ comprehension has been referred to as text coherence (Graesser, McNamara, & Lowerse, 2003; McNamara, E. Kintsch, Songer, & W. Kintsch, 1996). Text coherence refers to the extent to which a reader is able to understand the relations between ideas in a text and this is generally dependent on whether these relations are explicit in the text. Texts have local and global structure. Microstructure refers to local text properties and macro-structure to the global organization of text. Micro-structure is generally cued by the text via explicit indicators of relations between concepts and ideas (e.g. connectives, argument overlap, and pronominal reference). Micro-structure can also be constructed on the basis of the learner’s knowledge when there are details or relations left unstated in the text. A text’s macro-structure can be cued directly by the text via topic headers and sentences.

Consequently, for a good situational understanding, a single text cannot be optimal for every reader: low-knowledge readers should benefit more from an easier, cohesive text, whereas high-knowledge readers should be allowed to infer with harder, less cohesive texts. McNamara et al, (1996), examined students’ comprehension of four versions of a biology text, orthogonally varying local and global cohesion. They found that readers with low- and high-background knowledge benefit from a cohesive and a minimally cohesive text respectively. Gasparinatou & Grigoriadou (2010, 2011) investigated the role of text cohesion and learners’ background knowledge in the comprehension of texts in the domain of computer science. The results showed that high-knowledge readers benefit from a minimally cohesive text, in contrast to low-knowledge readers who learn better from a maximally cohesive text. These empirical findings motivated the design and the development of ALMA. The remaining sections of this paper present: (2) An Outline of the ALMA environment, (3) an empirical study with ALMA, (4) The Data Analysis, (5) the results of the analysis and (6) the conclusion.

2. An Outline of the ALMA Environment

ALMA actively engages students in the learning process. It takes into account readers’ background knowledge in order to propose the appropriate text version from four versions of a text with the same content but different cohesion at the local and global level. To achieve this goal, it suggests that the student performs a background knowledge assessment test, with scores characterized as “high”, “median” and “low”. ALMA motivates high knowledge students to read the minimally cohesive text at both local and global levels (lg), median knowledge students to read the text with maximum local and minimum global cohesion (Lg) or with minimum local and maximum global cohesion (lg) and low knowledge students to read the maximally cohesive text (LG). ALMA also allows the student to choose the preferred version of text and records the time spent reading it. The following three types of rules were used to maximize local cohesion: (1) replacing pronouns with noun phrases when the referent was potentially ambiguous (e.g. In the phrase: “This has been very popular for exchanging music files via the internet”, we replace “This” by “The peer-to-peer model”. (2) Adding descriptive elaborations linking unfamiliar and familiar concepts (e.g., “In networks, computers users can exchange messages and share resources”,is elaborated to: “In networks, computers users can exchange messages and share resources-such as printing
capabilities, software packages, and data storage facilities that are scattered throughout the system"). (3) Adding sentence connectives (however, therefore, because, so that) to specify the relation between sentences or ideas. In the global macro cohesion versions of the texts (IG and LG), macro propositions were signaled explicitly by various linguistic means (i.e., macro signals): (1) adding topic headers (e.g., Network Classifications, Protocols) and (2) adding macro propositions serving to link each paragraph to the rest of the text and the overall topic (e.g., “Afterwards, the rules by which network activities are conducted, will be discussed”) (McNamara et al., 1996).

ALMA supports and assesses students’ comprehension through a series of activities such as: text recall, summaries, text-based, bridging inference, elaborative inference, problem solving, case studies, active experimentation and sorting tasks. Text recall helps students remember the basic ideas in the text by translating it into more familiar words. The students are also encouraged to go beyond the basic sentence-focused processing by linking the content of the sentences to other information, either from the text or from the students’ background knowledge. The empirical findings have shown that students who are able to recall the text and go beyond the basic sentence-focused processing are more successful at solving problems, more likely to generate inferences, construct more coherent mental models, and develop a deeper understanding of the concepts covered in the text (Chi, de Leeuw, Chiu, & LaVancher, 1994). Summaries also encourage students to go beyond the text and like text recall can be perfectly good indicators of well-developed situation models (Kintsch, 1998). Text-based questions, as they demand only a specific detail from the text, measure text memory. Bridging-inferences questions motivate students to make bridging inferences which improve comprehension by linking the current sentence to the material previously covered in the text (e.g., Oakhill, 1984). Such inferences allow the reader to form a more cohesive global representation of the text content (Kintsch, 1998). Elaborative-inference questions motivate students to associate the current sentence with their own related background knowledge. The most important is that students are encouraged to engage in logical or analogical reasoning process to relate the content of the sentence with domain-general knowledge or any experiences related to the subject matter, particularly when they do not have sufficient knowledge about the topic of the text. Research has established that both domain knowledge and elaborations based on more general knowledge are associated with improving learning and comprehension (Pressley, Wood, Woloshyn, Martin, King, & Menke, 1992). Elaborations essentially ensure that the information in the text is linked to information that the reader already knows. These connections to background knowledge result in a more coherent and stable representation of the text content (Kintsch, 1998; McNamara et al., 1996). Problem-solving questions motivate students to use the information acquired from the text productively in novel environments. This requires that the text information be integrated with the students’ background knowledge and become a part of it, so that it can support comprehension and problem solving in new situations (Kintsch, 1998). Sorting task has great potential as a simple task and can be used both as a method of assessment and as a mode of instruction. Students are asked to sort a set of key words contained and not contained in the text, in certain groups. They are encouraged to do this task twice, once before reading the text and once more after reading the text. The sorting data are used to determine how strongly reading the text affected students’ conceptual structure concerning the information in the text. We are interested in the degree to which the information presented in the text influences their sorting. Sorting task is an alternative method for assessing situation model understanding. Active experimentation activities motivate students to undertake an active role and through experimentation to construct their own internal representations for the concept they are studying. Case studies motivate students to engage in the solution of an authentic and thus interesting problem. They are asked to analyze it and propose solutions (Pyatt, 2006). The problem is described in detail and is followed by a series of questions aiming to guide the students in the problem solving procedure.

Moreover ALMA supports multiple Informative, Tutoring and Reflective Feedback Components, aiming to stimulate learners to reflect on their beliefs, to guide and tutor them towards the achievement of specific learning outcomes and to inform them about their performance (Gouli, Gogolou, Papanikolaou, and Grigoriadou, 2008). ALMA also actively engages students in the learning process by taking into account readers’ learning preferences in order to propose them to start from activities that match their learning preferences and continue with less “learning preferences matched” activities in order to develop new capabilities (Kolb, 1984). To achieve this goal, it suggests that the student performs the “Learning-Style Inventory (LSI ©1993 David A. Kolb, Experience-Based Learning Systems,Inc.)”. The Learning – Style Inventory describes the way a student learns and how he/she deals with ideas and day-to-day situations in his/her life. It includes 12 sentences with a choice of endings. Consequently, ALMA is adapted to students’ background knowledge and learning style resulting in personalized learning.
ALMA also includes the authoring tool (ALMA_auth) which provides the author with the option of developing and uploading the educational material. Finally, ALMA includes a forum where students have the possibility to collaborate with each other and also with the instructor. The learner model in ALMA keeps information about: (1) learners' background knowledge level and learning style, and (2) learners' behavior during interaction with the environment in terms of the learning sequence chosen, time spent on reading the text, time spent on an activity, etc.

Figure 1: ALMA environment

3. The empirical study

The aim of the empirical study was to investigate how the learning design of ALMA, can support the learning process of students, with a wide range of backgrounds and different learning preferences, in the context of introductory computer science courses. The study was conducted during the winter semester of the academic year 2009-2010 in the context of the undergraduate course “Introduction to Informatics and Telecommunications.” The course objective is to give students strong background knowledge in the computer science topics: data storage, data manipulation, operating systems, networking and Internet, algorithms and programming languages. Specifically, the main research questions were: (1) Do the students agree to study the proposed by ALMA text version according to their background knowledge? (2) Do the students agree to follow the learning sequence proposed by ALMA according to their learning style? (3) If students had the option to study the learning goal “Networking and Internet” with: (a) the traditional teaching method, (b) the learning environment ALMA, (c) a combination of the traditional teaching method and the learning environment ALMA, what would they prefer for: (1) their undergraduate studies?, (2) postgraduate studies?

3.1 Participants

The study sample consisted of 74 first-year students who were taking the course “Introduction to Informatics and Telecommunications” at the Department of Informatics and Telecommunications of the National and Kapodistrian University of Athens, Greece. Their participation was in the context of an activity having the following objectives: (1) to study the learning goal “Computer Networks’ Principles”, (2) to assess the course designed via ALMA.

3.2 Procedure

The empirical study took place for three weeks and consisted of the following phases: (1) presenting the ALMA environment in the classroom, (2) interacting with ALMA and working out activities, which took place for 2 weeks, and (3) completing a questionnaire on the effectiveness of ALMA in supporting the learning process in such a course. This phase lasted one week. During these three weeks, students cooperated with each other and the instructor via the ALMA forum.
3.3 Materials and Tasks
In order to investigate how to support the learning and teaching process in the context of the course “Introduction to Informatics and Telecommunications”, educational material in the form of text and activities described in unit 2, was developed. Students studied the learning goal “Computer Networks’ Principles”. All tasks were completed remotely.

3.4 Data Collection
In order to answer the research questions, we analyzed: (1) ALMA log files created automatically by the environment. In particular, students’ sequence during interaction with the environment and performance in the activities was identified. This way, we obtained an indication of how ALMA supports students to deepen their knowledge and develop an adequate situational model, (2) the assessment questionnaire completed by the students.

4. Data Analysis
4.1 Achievement measures
Having an objective to investigate students’ exploitation of ALMA facilities and particularly to identify the sequences of actions that students performed in order to study the aforementioned topic, we analyzed ALMA log files.

4.2 Questionnaire
The evaluation questionnaire, filled by the students, consisted of Likert-scale type and other types of questions asking students to express their opinion on the effectiveness of ALMA in supporting the learning process (indicative question is: “Do you agree to study the proposed by ALMA text version according to your background knowledge?”). Students’ answers, in Likert-scale type questions, varied from 1 to 5 (1 indicates “I strongly disagree”, 5 indicates “I strongly agree”). Additionally the students were given the option to express their opinion about each one of the questions, as well as to make comments.

5. Results
The results for the 1st and the 2nd research questions are shown in Table 1.

<table>
<thead>
<tr>
<th>Research question</th>
<th>Description</th>
<th>Mean (SD)</th>
<th>Median</th>
<th>Response distribution (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Agreement with the proposed by ALMA text version according to their background knowledge</td>
<td>4.2 (0.9)</td>
<td>4.0</td>
<td>1.4 2.7 16.2 31.1 48.6</td>
</tr>
<tr>
<td>2</td>
<td>Agreement with the proposed by ALMA learning sequence according to their learning style</td>
<td>4.2 (1.0)</td>
<td>4.3</td>
<td>2.7 2.7 17.6 27.0 50.0</td>
</tr>
</tbody>
</table>

For the 1st research question: “Do you agree to study the proposed by ALMA text version according to your background knowledge?”, both mean and median were high on the 1-5 high scale (4.2 and 4.0 respectively), indicating a high overall agreement of the sample with the suggested text by the environment. More specifically, 79.7% of the students stated that they agreed to study the text version proposed by ALMA. In the case of the 2nd research question: “Do the students agree to follow the learning sequence proposed by ALMA according to their learning style?” results were similar (4.2 and 4.3) with 77% of the students reporting agreement with the learning sequence proposed by ALMA.

Regarding the 3rd research question “If you had the option to study the learning goal “Networking and Internet”
with: (a) the traditional teaching method, (b) the learning environment ALMA, (c) a combination of the traditional teaching method and the learning environment ALMA, what would you prefer for: (1) your undergraduate studies?, (2) postgraduate studies?”. 83.8% and 81.1% of students would prefer a combination of the traditional teaching method and the learning environment ALMA for under and postgraduate studies respectively. 14.9% and 12.2% of students would prefer ALMA for under and postgraduate studies respectively and finally 1.4% and 6.8% would prefer the traditional teaching method for under and postgraduate studies respectively.

6. Conclusion

In conclusion, ALMA could be a valuable tool for supporting the learning process in introductory computer science courses and helping students to deepen their understanding in the undergraduate curricula of computer science. Students had a positive opinion about ALMA environment because they were activated to use their background knowledge while reading and they believe that ALMA gives the opportunity to achieve better results in learning from texts in computer science than reading a single text target at an average reader. Moreover, students had a positive opinion about the learning sequence proposed by ALMA and they believe that a combination of the traditional teaching method and ALMA environment would be the best for their under and postgraduate studies.

Our future plans include the summative evaluation of ALMA environment with under and postgraduate students and also with specialists in the assessment of web based learning environments. We further intend to design and develop educational material for other undergraduate computer science courses and also for courses in secondary education.

References


