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SCRIPTING ARGUMENTATION IN TECHNOLOGY- ENHANCED LEARNING: A PROPOSED SYSTEM ARCHITECTURE

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Argumentative knowledge construction is an important component of critical thinking. Learners who collaboratively argue about a subject can potentially develop domain knowledge and have the opportunity to use evidence critically in order to make sense of the subject under consideration. Moreover learners have to take into account claims and evidence of each other during argumentation and in this way they develop mental models for argument construction and sequence. However, research indicates that learners tend to be inconsistent in distinguishing claims and theories from evidence that support them. Furthermore they rarely know how to efficiently construct knowledge through argumentation. In this regard, the use of collaboration scripts can assist learners to understand and participate in argumentative discourse while facilitating the process of argumentative knowledge construction. Unfortunately, this need for scripting argumentation is poorly reflected in the design of computer-based environments which mostly do not incorporate scripts. This paper provides a unifying view of the functional characteristics of existing argumentation tools and also analyzes the major features of collaboration scripts. Furthermore the paper presents a proposed system architecture for a computer-based tool that supports argumentative knowledge construction integrating also collaboration scripts for guiding students' individual and group work. The architecture provides a coarse-grained description of the system components and describes user facilities that need to be considered in a script-based system.

Keywords: technology-enhanced learning; argumentation; collaborative scripts; argument visualization

1 INTRODUCTION

In many domains of everyday life the knowledge on argumentation is a constitutive element as people come across ill-structured problems and it is necessary for them to have appropriate skills to argue successfully. Even though knowledge on argumentation starts to develop early in life (Stein & Albro, 2001; Stein & Bernas, 1999), recent research suggests that adults do not have satisfactory knowledge on argumentation (Kuhn, 1991). There is a necessity across Europe (Litosseliti et al, 2005; Andriessen, 2006) of acquiring argumentation skills in all stages of education, ranging from secondary school to university education to scientific development. In this way learners will be able to manage the expansion of information and communication technology and the social changes that emerge. Students who argue about a subject can develop knowledge for the subject and mental models for argument sequence. Argumentative knowledge development leads learners to inference generation, problem solving and finally deeper learning. Argumentation can take place either in face to face scheme or in computer mediated one (Weinberger et al, 2005). The computer mediated scheme argumentation has many advantages over face to face. It can foster collaboration and participation and provide scaffolds for the learners to develop skills for argument construction as well as for argument sequencing. Such scaffolds can be visualization tools or collaborative scripts.

Although argumentative knowledge construction seems to be a required skill, current research indicates that learners rarely know how to argue effectively, as they have difficulties constructing arguments and evaluating the arguments of others (Kuhn, 1991). This is due to their tendency not to collaborate if they are left alone (Kollar et al, 2006) without appropriate support. Collaboration scripts aim to scaffold learners by structuring inefficient interactions and guide the process for successful argument construction and argument sequence. We have research results showing evidence that scripts can guide argumentative knowledge construction and are beneficial for learners in some cases (Dillenbourg, 2002; Weinberger et al, 2005b). This leads us to try to incorporate collaboration scripts in educational environments (Weinberger et al, 2005). Although there are many computer-based environments that support argumentation, few of them support script integration.

In this paper we take a review of the literature about argumentative knowledge construction, analyze argumentation in technology-enhanced learning environments (TELEs), examine the characteristics of argumentation tools, investigate the potential of scaffolding argumentation with visualization tools and collaborative scripts, and propose a script-based system architecture for a technology-enhanced environment to support argumentation process with collaboration scripts. Finally we explain the modules that our system will incorporate and set future work to be done.

2 ARGUMENTATIVE KNOWLEDGE CONSTRUCTION

By the term argumentative knowledge construction is meant that students engage in discourse activities with such a frequency that will lead to knowledge acquisition (Weinberger & Fischer, 2006). Learners and their partners collaborate to construct arguments about a

specific content and through this argument construction they acquire knowledge about argumentation and the content under consideration (Andriessen et al, 2003).

Acquiring knowledge about argumentation means that learners understand how to construct a single argument and how to sequence arguments correctly. Construction of a single argument meets the Toulmin's model (Toulmin, 1958) characteristics which include three fundamental concepts: claim, data and warrant. Claim is a position that we stand for, which we support by providing data and evidence, and finally give a reason/warrant why these data support the claim. Supporting our position we can refer to rebuttals that demonstrate how our argument can be strengthened via limitations. Argumentation sequence involves construction of arguments, counterarguments and integrative arguments and according to Leitão this sequence represents a knowledge building circle (Leitão, 2000).

Knowledge about domain content comes through argumentation sequence, which can be used as an indicator about knowledge construction (Leitão, 2000). At first, learners construct arguments following Toulmin's model to support their positions. By constructing arguments learners self-explain the learning material, and integrate new knowledge into existing cognitive structures. Following argument construction, learning partners construct counterarguments in order to challenge the initial positions. Construction of counterarguments facilitates meta-cognitive activities and engages learners in rethinking of their primary positions. Finally learners construct integrative arguments and consequently refine their initial positions. By sequencing arguments and counterarguments in order to solve problems learners acquire domain specific knowledge as well as knowledge on argumentation.

This is consistent with the Baker's learning mechanisms (Andriessen, 2006) which briefly can be summarized as follows. Making knowledge explicit during the first phase of argument construction, learners provide explanations for their claim and profit from the procedure of preparing a justification or an argumentative defense which often leads to deeper learning. During the phase of counterarguments' construction, learners may undergo conceptual change debating a question from their learning partners and may transform their initial position. During the phase of constructing integrative arguments learners work together to produce new knowledge scaffolding individual learning, so they participate in co-elaboration of new knowledge. Eventually learners familiarize with the question and argument formulation, as well as the articulation transformation and deeper learning so they are in the increasing articulation phase.

The argumentative knowledge construction can take place in face to face as well as in electronic environments (synchronous or asynchronous) (Litosseliti et al, 2005). Different environments have differences with regard to the teaching of argumentation skills. Face to face communication improves learners' ability to rapidly construct counterarguments and generally to "think on their feet". Current research suggests that arguing in an electronic environment has a number of advantages over face to face (Andriessen et al, 2003; Marttunen & Laurinen, 2001; Weinberger et al, 2005). Argumentation is a collaborative task and consequently should be intergraded in a Computer-Supported Collaborative Learning (CSCL) environment. A CSCL electronic environment encourages peer interaction which is a prerequisite for argumentative knowledge construction. An asynchronous CSCL environment encourages learners to construct new arguments, evaluate their positions or rethink arguments by providing sufficient time to deliberate over them. A synchronous CSCL environment can

combine elements from face to face and asynchronous communication, as it can support learning when a number of topics need to be discussed simultaneously or when some topics need clarification or when less confident learners, who are not so active participants in face to face collaboration, are involved (Litosseliti et al, 2005). Finally a CSCL environment can implement special tools and scaffolds that guide learners in effective argumentative knowledge construction which can lead to deeper understanding.

3 TECHNOLOGY-ENHANCED ARGUMENTATION

Obviously, technology has the potential to support argumentation. In review of the literature, we can find software systems which have been developed to assist learners to construct their arguments on the computer screen and to scaffold argumentation (Kirschner et al, 2003). We can distinguish systems in two categories, some focusing on the content of single argument and the others focusing on the process of argumentation. Technology systems of the first category scaffold argumentation by offering new and multiple ways of representation (argument maps) while systems belonging to the second category scaffold argumentation by providing roles for each learner. Both groups aim to raise awareness of argumentation and somehow guide and structure the way students argue. Tools that these systems use are totally new and sometimes their usage may require considerable experience from learners to appropriate them to their advantage (Andriessen, 2006).

Systems that fall into the first group scaffold argumentation using tools that visualize single arguments to facilitate argumentative knowledge construction (Kirschner et al, 2003). In order to implement visualization, tools realize different representations that have different effects. Such representations are text, matrices or graph, (Suthers & Hundhausen, 2001). Other tools may visualize how arguments are related to each other through diagrammatic representations (Kirschner et al, 2003) and develop awareness of argumentative discourse.

Belvedere is a software tool for constructing and reflecting on diagrams of one's ideas, such as evidence maps and concept maps. The tool was designed by Daniel Suthers and aims to support problem-based collaborative learning scenarios in which secondary school students work collaboratively on a computer and learn critical inquiry skills in the context of science (Suthers, 2003).

DUNES (Dialogic Argumentative and Negotiation Educational Software) project (<http://www.dunes.gr>), which ended in January 2004, aimed at the development of a "discussion space", featuring dynamic "argumentative maps". This "discussion space" supports the elaboration of several scenarios for collaborative learning, including decision making, constructive argumentative discussion etc. DUNES is divided in three components, the OASIS web portal and Learning Management System, the PASEO desktop which offers synchronous communication tools for collaborative sessions and finally the DIGALO session for graphical representation of argumentation and discussions.

Another tool that helps learners understand and use the diverse range of information found on the Web is SenseMaker. The tool was developed as a part of the KIE project that helps students figure out the relationships that exist between different Web resources. As learners investigate pieces of Internet evidence, they organize the items into different

categories or frames in SenseMaker (Bell, 1997). In this way, they can construct an argument or they can organize different resources during a project.

These software tools share some common structural features. Firstly, there are some types of nodes with different geometric shapes like polygons, rectangles, ovals or circles, which are used for symbolizing different semantic aspects of argument construction like claim, information, question, comment, explanation etc. Besides there are different spatial characteristics like lines, icons, colors, and sizes that may be used for symbolizing other semantic aspects of argument elements like links, support or opposition (Tergan & Keller, 2005).

Systems that fall into the second group may scaffold argument sequence by using tools that assign learners certain roles (Andriessen, 2006; Pilkington & Walker, 2003). Students must be aware of the argumentation roles, as the adoption of such roles can improve argumentative reasoning (Pilkington & Walker, 2003). Pilkington & Walker classify the roles assigned to learners in three groups. One role is to challenge (positive/negative feedback) other learners' arguments in order to provide evidence. Another assignment is to ask for explanations and clarifications (exploratory inquiry), and other one is to provide information (content building) either spontaneously or when they are asked to. As an example learners can be asked by their learning partners to explain the contents of a text in an argument or to criticize their learning partners' contributions at specific points in the learning process. To investigate role-playing Suthers et al, 2003 designed activities with Belvedere, while Andriessen, 2006 refers to NetMeeting as the environment used.

4 SCRIPTING ARGUMENTATION

Another technique to scaffold argumentation to be successful is by using collaboration scripts (Dillenbourg, 2002; Jeong & Joung, 2007; Jermann & Dillenbourg, 2003; Weinberger et al, 2005; Weinberger et al, 2005b). Since argumentation is a collaborative activity, the successful argumentation relies on successful collaboration which in turn relies on effective interaction of learners. However, when learners are left without scaffolds they tend not to engage in argumentation properly. This can be attributed to the asymmetrical nature of argumentative knowledge (Stein & Bernas, 1999). One is more informed about his own positives and the weaknesses of the opponent than vice versa. People who argue usually do not ask each other questions, do not explain and clarify their opinions, do not articulate their reasoning, do not elaborate and reflect upon their knowledge (Kollar et al, 2006) and seldom if ever, take into account counterarguments (Stein & Bernas, 1999). This is generally true irrespectively of the knowledge someone has acquired on a specific domain. A collaboration script aims to support these learning activities by structuring and scaffolding inadequate collaborative learners' interaction. Collaboration scripts can guide learners what to do in a learning task, can assign individual roles, can structure the sequence of cognitive activities someone engages in. Actions which otherwise spontaneously occur (Kollar et al, 2006).

The form of a collaboration script is described by Kollar, Fischer and Hesse, in their conceptual analysis for cooperation scripts (Kollar et al, 2006). Scripts are described by using

five components: the participants that a script requires, the activities that they engage in, the roles they assume, the resources that they make use of and the groups they form. Every script has mechanisms to describe the group formation, the distribution of the components to participants and the sequencing of the previous two mechanisms. Regarding the granularity, the scripts under consideration can be classified in the fine-grain, as they are supposed to scaffold specific skills like argument construction.

We can have scripts that scaffold the content building or clarification and scripts that guide the process of argumentation. Scaffolds that provide learners with content building or clarification may include questions, prompts or messages that guide them to discuss synchronously or asynchronously specific aspects of a problem (Jeong & Joung, 2007). Scaffolds that guide learners' interactions may include role assignments or role prompts and activities that are associated to them (Jermann & Dillenbourg, 2003). In this way scripts facilitate the construction of a single argument according to Toulmin's model (Toulmin, 1958) and the construction of argumentation sequences according to Leitão (Leitão, 2000). Both script categories should support learners to apply concepts from prior knowledge to problems as well as the new theoretical concepts they are supposed to learn.

Facilitating argumentative knowledge building with scripts is based on Angela O'Donnell's scripted cooperation approach (O'Donnell, 1999) and can be implemented either in face to face or in computer mediated argumentation. Therefore, a script can be integrated in a software environment and guide the formation of specific arguments or the process the learners should follow by specifying different learning activities, without external intervention.

The research results show evidence that learners who used special argumentative scaffolding tools engaged more directly with each others' positions and produced more extended argumentation as well as improved argumentative reasoning (Andriessen, 2006; Jermann & Dillenbourg, 2003; Weinberger et al, 2005; Weinberger et al, 2005b). On the other hand, research suggests that the use of scripts may have side-effects in some processes of argumentative knowledge construction, while in other processes do not (Dillenbourg, 2002; Weinberger et al, 2005; Andriessen, 2006). Learners often engage only in low-level argumentation (Bell, 1997), and rarely converge on a comparable level of knowledge acquisition. They usually take the proposed arguments for granted (Andriessen, 2006) and when someone started argumentation soon ended in reconciliation.

5 A SCRIPT-BASED SYSTEM ARCHITECTURE

Using scripts in the argumentation process seems to be a promising scaffolding technique for students and instructors. Scripts can scaffold the procedure that a group should follow while striving for new knowledge through argumentation.

However, even though the value of scripts is documented by scientific research (Dillenbourg & Jermann, 2007; Jeong & Joung, 2007; Jermann & Dillenbourg, 2003; Weinberger et al, 2005; Weinberger et al, 2005b), learning design has not systematically integrated scripts into technology-enhanced learning environments (TELEs) until now. The

existing TELEs for argumentation adopt a type of visualization that resembles to concept mapping (Kirschner et al, 2003), but with no scripts that can scaffold students' attempts. The only support these environments offer to students is a help file, which is located either on the local machine or online. The help appears in the form of a coach that gives ideas or suggestions or in the form of a help screen that explains the use of the various tools. Afterwards the students are left to their own devices.

In order to address the lack of appropriate software tools we propose the development of script-based environments that support learners in argumentative knowledge construction. Such systems should enable the instructor to create an argumentation script and guide a group of students through a path to complete an argumentative activity. The system-architecture for that kind of environment is depicted in Figure 1. The core elements of this script-based system are: a communication transactions database, a script database, a communication module, a script module and a visualization module.

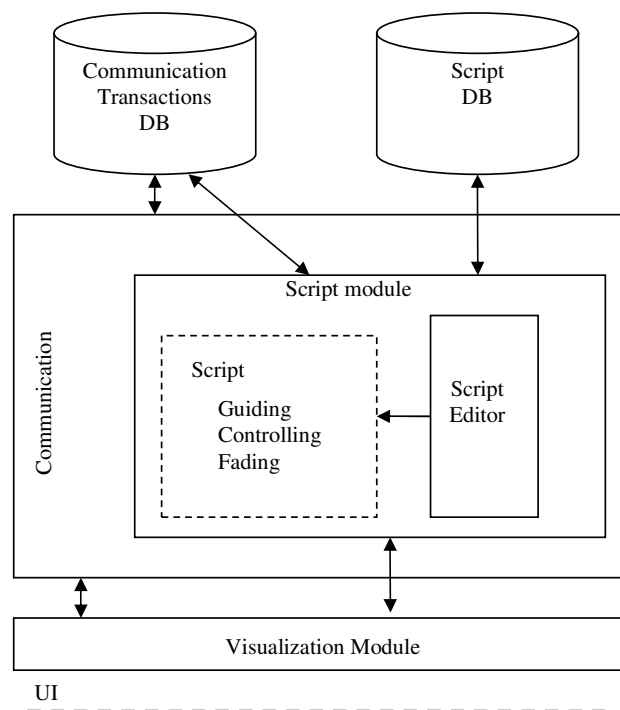


FIGURE 1. Script-based system architecture for argumentation

Data of the group argumentation activity are stored in the communication transactions database. These data will be accessible from authorized users at any time for analysis or for review of a session. Scripts that instructors create are stored in the script database and are used by the script module.

We consider the script module to be the basis of our system. The script module provides guidelines and support for a group of students in order to complete an argumentation activity designed by the instructor. Each student is assigned a role to act (for example finding rebuttal for the claim) and a task to complete (Kollar et al, 2006). The script also defines individually or group developed deliverables during or after the activity. Scaffolding students' activities using scripts may gradually fade as the students become more experienced in the argumentation process. So we regard a threefold functioning mechanism for the script module which includes script creation capabilities for the instructor, guiding capabilities for the students and monitoring capabilities for analyzing the results.

Consequently, a script module requires two components: an argumentation script editor and the actual script. The argumentation script editor allows the instructor to develop the collaborative argumentation scenarios and to facilitate group formation, the role assignment for the students, the task definition (Kollar et al, 2006) and the script specifications designation. The actual script can operate in different modes: an "off mode" where the students have no support from the environment, a "guiding mode" where the script guides the students through the appropriate path of activities, a "controlling mode" where the script not only guides but also monitors the activities that take place in the argumentation and intervenes in the process, a "fading mode" where besides the monitoring of the activities the script can decide to withdraw partially or completely according to the learners' experience.

The communication module offers the tools for the communication among the collaborating students (for example a forum) and is also responsible for recording communication data in the communication transactions database.

Finally the visualization module is responsible for the visual representation of communication transactions in the system user interface (UI). It is also responsible for the visual representation of single scripts (according to the Toulmin's model) as well as argument sequences (according to Leitão's model). Moreover this module provides visualizations of the participation of each student, of the group as a whole and of the activity process.

6 USE CASE

To provide a better understanding of the way that our system can support collaborative learning let us consider the following scenario. Suppose an instructor wants his students to argue on a complex and debating issue included in the curriculum. For this reason, the instructor forms groups of three students and assigns each student to read a number of articles that present two different views of the subject under consideration. All three students read the same articles but the role of each student is different. Each one of the first two students is responsible of presenting and supporting one of the two views mentioned before, while the third student is responsible for challenging/rebutting the arguments of the other two students.

In this way conflicts are created among the students and they have to discuss their ideas, arguing over a period of time in order to resolve them. When consensus is reached, a debriefing session follows where the instructor presents to the whole class the results of the argumentation. After the debriefing session, each group has to write an article presenting their shared understanding.

The above scenario supports argumentative knowledge construction as students develop knowledge about argument construction and argument sequence, as well as domain knowledge. The instructor can implement the scenario on the Web using our suggested system with the script editor and a set of available tools (e.g. the forum tool or the chat tool etc). Students can login into the environment and read the assigned tasks. Each student or group can use only the set of tools the instructor made available in order to collaborate and complete their scheduled tasks. While the scenario is under deployment the script guides students in every step of the procedure.

For the description of the scenario the instructor using the script editor defines the groups that will participate in the activity, the roles for the actors/students, the phases of the procedure and the assignment of roles to groups or students. For each role or phase the instructor may provide instructions for the students, guiding them or he may declare the communication tools that the students can use in order to complete their tasks. When he finishes the script is stored in the script database.

When a student logs into the environment an instance/copy of the script is played. Each student interacts with the user interface and the system presents the contents of the script, the available communication tools and any guiding instructions. The system records in the communication transactions database the interactions of the students and the contributions each student makes. The recorded data can be displayed to the students in a suitable format or can be analyzed by the instructor.

7 CONCLUDING REMARKS

In this paper we argue that knowledge on argumentation is important for lifelong learning and learners should develop argumentative knowledge construction skills. Towards this objective we suggest that TELEs for argumentation should facilitate the learning process by integrating script modules that scaffold the process of argumentation activities. To advance the integration of scripts in TELEs, we have presented a system architecture that enables instructors to design argumentation activities using an argumentation script editor and guide a group of students to complete a series of tasks. The system provides all the modules needed to design argumentation activities, to support student's communication and to monitor elements needed for analysis. Future work includes the creation of a system prototype, development of modules discussed and an analysis of the data collected operating the environment.

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