Opportunities and Challenges for Adaptive Collaborative Support in Distributed Learning Environments: Evaluating the GLUE! Suite of Tools

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Abstract— **Adaptive Collaborative Scripting systems provide learning benefits by adapting leaner scaffolding to the students and their current context. However, their development is still in its infancy and they are not widespread in the Technology Enhanced Learning TEL practice, which often uses VLEs like Moodle and other Web 2.0 tools. In order to assess the feasibility of applying the ACS approach on a larger scale, this paper presents the initial results of a short-term evaluation of the GLUE! suite of tools. The main goal of this specific evaluation process was to identify possible opportunities and ideas on how to design and deploy adaptive Computer-Supported Collaborative Learning (CSCL) activities using widespread VLEs and Web 2.0 tools in order to maximise community acceptance and lower development efforts. The main findings of the evaluation provide incentive to further explore both the impact and the complexity of the design and the deployment of adaptive collaboration scripts.**

Keywords-Computer-supported collaborative learning; adaptive collaboration scripts; CLUE!; flow patterns;

I. INTRODUCTION

In technology-enhanced education there exist currently two trends that are shaping the way educational institutions (especially higher education) use technology to support learning, most often when they follow blended learning approaches. On the one hand, Virtual Learning Environments (VLEs [1]), such as Moodle, or Personal Learning Environments (PLEs [2]) are employed in order to centralize the access to the learning activities. On the other hand, so-called "Web 2.0" tools (such as wikis, blogs, online collaborative tools such as GoogleDocs) are also becoming widespread in technology-enhanced education [3]. The clash of these two trends has recently prompted an interest in research and development regarding the integration of VLEs/PLEs and external Web 2.0 tools [4]. This heterogeneous technological landscape with central learning environments plus external tools has been labeled by some authors "distributed learning environments" (DLEs [5]). This study evaluates one of such DLEs, from the point of view of adaptive collaboration support, to exemplify main challenges and opportunities of that approach in this kind of technological background, which is becoming increasingly common.

Adaptive collaboration support (ACS) has become the focus of intense research efforts in the CSCL domain [6]. Various researchers have experimented using dynamic supportive mechanisms, in order to provide more flexible and efficient forms of group support. One important form of collaboration support is the collaboration script [7]. Collaboration scripts are didactic scenarios that specify the way in which learners interact with one another [8]. Conventionally, CSCL scripts correspond to fixed ways of didactic and computational support to collaborative learning. In other words, they provide the same level of support for all students. This kind of support may be unnecessary for students who have good internal collaboration scripts or who are already experienced collaborators, and thus may lead to "overscripting" drawbacks [9]. Moreover, scripting has been criticized for its loss of flexibility (difficulty of modifying a script in run time according to the needs of the instructional situation) [10]. Using adaptive techniques into the fixed collaboration scripts may be an improvement over fixed techniques. Adaptive interventions tailor the collaborative learning process to the needs of the individual students or groups. Moreover, these techniques provide the opportunity for flexible reactions to expected and/or unexpected events that occur during the script enactment [11]. However, systems that adaptively support collaboration (1) are strongly related to a specific domain of instruction and cannot in general be used in another domain; (2) use advanced Artificial Intelligence methods for making inferences on the collaborative situation and providing support [6].

Then, how could we apply and evaluate the benefits of ACS to the increasingly common context of DLE systems? One significant example of DLE systems that reflect the fusion of the VLEs/PLEs and the external Web 2.0 tools, corresponds to the Sofocles or GLUE! [12] (after the project or the architecture names of this initiative) suite of tools which focuses on collaborative learning. We believe that it is rather important for the CSCL community to evaluate these type of tools under the perspective of adaptive and flexible interventions as another research direction towards the design and development of ACS systems. Through the evaluation of the GLUE! suite of tools, we explore in what degree it is feasible to integrate adaptive collaboration support to distributed learning environments. In the following sections, we present briefly: (a) the main tools that conform the Sofocles suite, (b) the characteristics of the evaluation, and (c) the main findings of the evaluation.

II. Technological Context: the Sofocles Suite

A. *The Sofocles suite*

Given its technological diversity, teaching and learning using DLEs provides many advantages over using a traditional VLE (the possibility of choosing the tool that is most adequate for a learning activity being the most often cited one). However, this same technological heterogeneity makes it difficult for teachers and students to navigate through the whole learning activity lifecycle (activity design, instantiation, enactment, evaluation [13]). Sofocles[1] (*Service-based architecture for the support of design, enactment and evaluation of flexible scripted CSCL situations)* is a research project funded by the Spanish Ministry of Science and Innovation, which aims to provide tools (not only technological, but also conceptual) for teachers and students to help them in managing learning activities in DLEs throughout the learning activity lifecycle, with an emphasis on community acceptance (i.e. minimizing the barrier of entry for institutions and practitioners, allowing them to use their current available technologies) and collaborative learning. Given this focus on collaboration, the Sofocles technologies were a good candidate for our case study trying to delve into the opportunities and challenges of DLEs for Adaptive Collaborative Scripting. Below we briefly describe the main tools that compose the Sofocles suite, as embedded in the CSCL script lifecycle (see Figure 1), although we do not put emphasis on Ontoolsearch (for semantic search of appropriate tools to be used in the learning situations) and CSCL-EREM (for design of the evaluation mechanisms).

1) *GLUE!*

One of the main problems of *enacting* learning activities in DLEs is that, by definition, these environments are de-centralized. What this means in practice is that teachers have to manage the lifecycle of each tool used in the DLE separately (for example, going to the external Web 2.0 services and creating the resources that are needed by students, and then providing links to each of them, by email or from the central access point, e.g. the Moodle VLE). For students, it often means that the continuity of the learning activities is broken as they go through the different services and tools involved. The Group Learning Unified Environment (GLUE![2]) [12] is an architecture and reference implementation that enables teachers to manage external tools and integrates them visually for the students within the central learning environment, in the same way as an internal tool of the VLE would be. Due to its architecture based on adaptors, this integration is supported simultaneously for multiple VLEs (currently Moodle, LAMS and MediaWiki) and for a wide variety of external tools (currently Google office suite, MediaWiki, Wookie widgets and up to 17

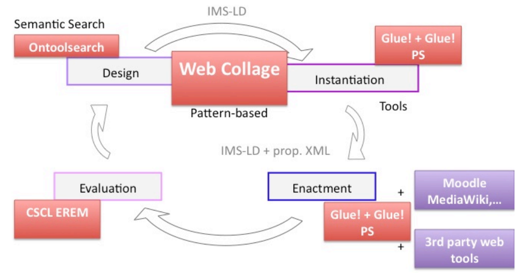

Figure 1. The Sofocles suite in the CSCL script lifecycle

external tools). This extensible support for learning environments and tools that are already in use in institutions allows for easy adoption and acceptance.

2) *WebCollage*

Another common problem teachers face in their practice with DLEs is the design of collaborative learning activities. This design is done differently for each VLE/PLE, and those designs are hardly reusable from one environment to another. Educational Modeling Languages (EMLs), such as IMS-LD [14] provide a way of expressing the learning activity design in an environment-agnostic way, favoring reusability and sharing of learning designs. However, EMLs are complex for non-technical people, and it is very difficult for non-expert teachers to design pedagogically sound collaborative learning activities. WebCollage[3] is the latest version of the Collage learning design tool [15], which enables teachers to design collaborative learning activities by reusing and combining well-known best practices in collaborative learning (called collaborative learning flow patterns, or CLFPs [16]) and assessment, and particularizing them to the teacher's situation (defining the concrete activities, groups, participants and resources to be used). The learning designs (units of learning) done with WebCollage can be exported to IMS-LD, to be enacted automatically in any compliant learning environment.

3) *GLUE!-PS*

Even if WebCollage allows teachers to define collaborative learning activities fit for DLEs, and GLUE! allows them to enact activities in such DLEs, currently there is a gap between the design and enactment of learning activities, due to the fact that most widespread learning environments do not support EMLs or other learning design tools. Thus, deploying the learning design with the teacher's ideas and plans, to the DLE where they are to be enacted is currently done manually in most cases, which is error-prone and time consuming, especially in the case of collaborative learning where students often work in small groups using different resources [17]. The GLUE! Pedagogical Scripting [17] is an architecture for the deployment and real-time management of learning designs in DLEs. Due to its adaptor architecture it supports learning designs expressed in a variety of formats (not all learning design tools support the IMS-LD standard), as well as the deployment across different kinds of VLEs and external tools (as many as

[1] http://www.gsic.uva.es/projects/sofocles

[2] http://www.gsic.uva.es/glue/

[3] http://pandora.tel.uva.es/wic/

GLUE! does, since it uses GLUE!'s support for external tool integration).

III. EVALUATION OBJECTIVES

The main goal of the evaluation was to examine the GLUE! suite of tools as a whole in order to provide a sufficient and useful base towards the direction of adaptive collaboration support. The evaluation aimed to identify whether it is feasible and easy for a teacher/designer to a) design, b) instantiate and c) deploy a specific collaboration script (which includes adaptive supportive mechanisms). Moreover, the evaluation had as an objective to propose new directions in order to modify the tools to support more flexible and adaptive collaboration scripts. The evaluation process included a teacher/designer and a student phase. The main steps of the teacher phase were: (a) design the collaboration script with the WebCollage, (b) instantiate the collaboration script with the WebInstanceCollage, (c) deploy the collaboration script with GLUE!-PS, and (e) use Moodle to integrate third party tools into the script deployment through the GLUE!. On the other hand, the student evaluation phase included only the assessment of the final implemented script in the VLE environment. The VLE that was selected for the evaluation was Moodle.

Throughout the evaluation process, a detailed inventory of the emerging problems-issues-ideas was created. Along with this recording, a series of focused interviews with the key designers and researchers of the GSIC group, who are mostly connected with the GLUE! tools, were conducted.

IV. THE PROPOSED ADAPTIVE COLLABORATION SCRIPT

The proposed script for the evaluation was a prototype adaptive script based on the main form of a typical reciprocal script. This script has already been evaluated in experimental conditions with rather positive results concerning students acceptance and engagement [18]. This script was selected for this specific evaluation because it combines the typical script characteristics (e.g. roles and tasks) and an adaptive scaffolding mechanism. The script included three phases. During the fist phase the students individually study the learning material and provide a deliverable to the teacher answering a series of domain questions. Based on these deliverables, the teacher forms mildly heterogeneous dyads stratified by their domain knowledge. The assigned task for the second and the third phase (the collaborative activity of the script) is to provide answers to open-ended domain questions (using a chat tool). These are essentially "learning questions" that provide the opportunity for structured peer interaction. However *before* answering each learning question, dyads are asked to discuss and agree on theory keywords that are relevant to the subject under investigation. Overall, each one of the two phases comprises one keyword question (KQ) and one learning question (LQ). The adaptive support of the script is an adaptive prompting mechanism. Dyads are prompted after each keyword question (KQ). The system (chat tool) is monitoring the keywords that the students provided and compared to seven keywords that the teacher had pre-declared as the most important for the subject under discussion.

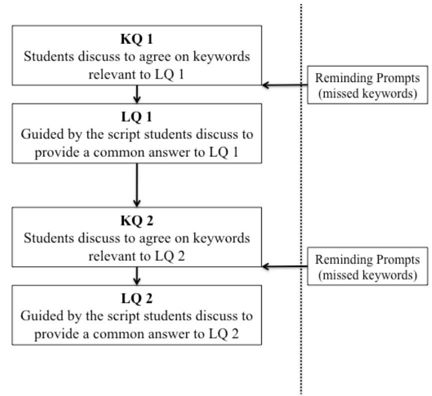

Figure 2. The collaborative activity (second and third phase of the proposed script)

In case some keywords are missing from the students' dialogue, the system/teacher responds with a relevant prompt that included information about the missing keywords (see Figure 2). Finally, the script also provides guidance on the roles (author and reviewer) that the students have to follow during the two LQs. One of the students is assigned the author role (responsible for introducing an initial answer) and the other one the role of reviewer (to review and propose improvements for the suggested answer). Afterwards, the dyad works in a similar manner on the third phase of the script. In the second phase, LQ peers exchange their roles.

The integration of the flexible collaboration script, the problem-issues inventory and the face-to-face interviews with the researchers revealed new aspects especially on how we can design, instantiate and deploy adaptive collaboration scripts. In the following, the main findings about each tool are presented towards the above direction.

V. THE MAIN FINDINGS

The main findings of the evaluation concern: a) the design and the instantiation phase (WebCollage tool), b) the deployment phase (GLUE!-PS tool) and c) using the GLUE! directly through the Moodle.

A. The Design and Instantiation Phase

From the Pattern-based to the not-only Pattern-based mode: WebCollage is a tool that helps a teacher to design and instantiate a collaboration activity. According to the tool specifications, the teacher should choose one CLFP (collaborative learning flow pattern) in order to design his activity. However, most of the times in everyday educational practice, a teacher would try to alter and change a specific CLFP in order to achieve the ideal (for him) script. For example, the script that was selected for the evaluation is not a typical script and it cannot be directly related to one of the CLFPs proposed by WebCollage. During the evaluation phase, the teacher 'adapted' a CLFP (the 'Think Pair Share' pattern) in order to fit the proposed script (skip the third and final phase of the CLFP). Although the CLFPs have their own pedagogical value, sometimes it is difficult for a teacher to include all phases or rules not only for pedagogical but also for simple practical reasons. This loss of flexibility or, in other words, the difficulty of modifying a script according to the needs of the instructional situation has already been mentioned in the literature [10]. For this reason, it would be appropriate a more general, new 'not-only patterned' version of the WebCollage. This could be happen in two ways: a) by adapting the predefined CLFP (e.g. the teacher is able to remove a CLFP phase from the design and/or replace it by another phase from a different CLFP) and b) by creating a custom script (the teacher is able to create a script from scratch and define the number of phases or tasks). This 'not-only pattern-based' version is a step forward to provide more flexible scripts. The teacher, based on his/her experience, can modify a predefined script according to the special needs of a specific educational activity.

A third member to the 'teacher and student' design: the System: The design of the collaborative activity of the script was implemented in WebCollage as the second phase of the Think Pair Share CLFP (Figure 3). In this phase each dyad answers to the first Keyword question. Then, the system evaluates the answers and provides an adaptive feedback. In WebCollage the design can only include the pairs (students) and the teacher. In other words, it is not clear who or what actually assesses the task and adaptively supports the student groups. In most adaptive CSCL systems, an 'engine' (e.g. conversational agent) assesses the interactions, or the deliverables by the students and then provides the relevant feedback to groups or to individual students. In order to have flexible support, the adaptive CSCL systems increasingly introduce AI and Web 2.0 techniques to support pre-task interventions, in-task peer interactions, and learning domain-specific activities. Under this perspective a design tool for collaborative activities should describe adaptive mechanisms, which are performed by specific software, more clearly.

The patterns into the design: how we can support the teacher: Both the atomic patterns [19] and the adaptation patterns [20] could be the base to provide flexible adaptive support to a teacher or a designer during the design phase of a CSCL activity. In order to develop adaptive collaborative learning systems, one first important step is to closely observe, analyse and formalize successful pedagogically interventions that teachers may activate in their effort to effectively support teammates.

The list of the atomic patterns gives us the opportunity that by modelling just a few aspects (such as student domain knowledge, group synthesis, group size and learning resources) one can already implement certain adaptive system interventions in order to help the teacher to design enriched CSCL activities. The most usual problem/issue is that a teacher/designer may not be aware of good practices that he could integrate into his design. If the design system is able to identify specific design schemes, a flexible supportive/recommended feedback based on the patterns idea could provide the proper and most relevant support.

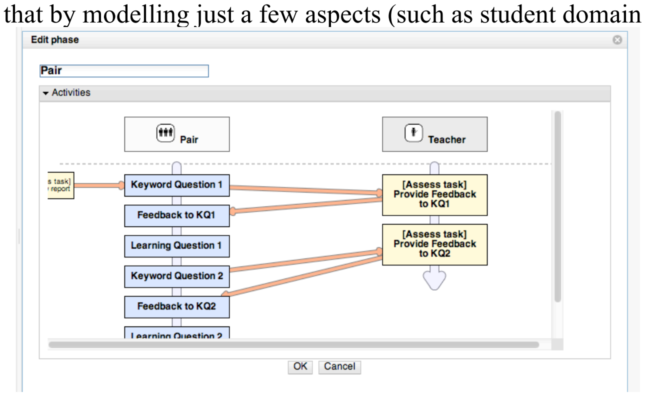

Figure 3. The collaboration activity of the proposed script, as shown in WebCollage

B. Deployment phase

Notes about the student and the teacher: Adaptive system behaviour was initially introduced in systems for individual learning (''adaptive educational systems'', or AESs), in order to adapt their operation to learner needs during learner-system interaction. The adaptation procedures that an AES is able to perform vary: from curriculum sequencing (providing to students the most suitable sequence of knowledge units to follow or learning tasks to accomplish) to intelligent analysis of student problem solution activity. In the CSCL literature, the adaptive collaboration support techniques aim to model the major aspects of the collaborative activity (such as domain, collaborative activity, problem–solution, student/group profile, peer interactions) and activate learner/group assistance interventions when needed and in the form needed. In other words, different student groups with different characteristics (models) should or could be treated differently. Moreover, the teacher should be aware of this special treatment or of the needed interventions that should be done by him. During the deployment phase with GLUE!-PS, the teacher should be able to define the different kind of support (e.g. new guidelines or new material) that each group could have according to each model as long as with the specific advices about this phase (e.g. is it a collaborative activity or not). Moreover, the system should describe the assessment phase (either performed by him or a system) and provide the relevant information to the teacher that is going to enact the activity through the LMS. The teacher should be aware about the assessments that he had already designed.

C. The GLUE! and the VLE

A pattern as a GLUE!let: By using the GLUE! through the VLE authoring environment, a teacher is able to use easily and effectively third party tools (these third party tools, in GLUE! terminology, are called GLUE!lets). However, these tools are not connecting directly to the previous and next phases of the described activity. Thus it is almost impossible to provide adaptive support to students or groups of students. The question here is: what if we can use an atomic pattern or an adaptation pattern as another "external tool", as we do with e.g. GoogleDocs? As said before, the list of the atomic and adaptation patterns provides the proper field for modelling. By modelling just a few aspects one can already implement certain adaptive system interventions and describe them as tools external to the VLE. These modules based on the pattern-based approach, when integrated in the design of the CSCL activity, can enrich the system operation with adaptive features. This perspective will allow the user (teacher) to focus on the pedagogical aspects of the adaptation, hiding the more technical details. In other words, we describe a situation where the CSCL tools (for example the LAMS VLE with GLUE!) will offer to instructors the possibility of implementing a pattern as a whole, instead of letting them struggle with a number of relevant arrangements necessary for reifying the pattern.

VI. CONCLUSIONS

The main findings of this paper highlight some first issues concerning the integration of adaptive supportive techniques into distributed learning environments. More specifically, design tools should have a specific "role" for the "engine", the software that is responsible to model the characteristics and provide the relevant adaptations. Furthermore, the design tools should integrate guidelines that would appear to the teacher/designer. These guidelines should be based on the patterns that emerged from the everyday educational practice and the recorded problems or issues. Moreover, this evaluation revealed some interesting and positive points: (a) distributed learning environments provide the base to explore the adaptive collaboration support, following a different way than developing from scratch ad-hoc systems, (b) it is more clear for the developers and designers to define the target of the adaptation (e.g. adaptation to help the teacher during the design of the activity or adaptation to support a group of students during a phase of a script). However, the teacher/designer should be aware of the different models that the adaptations would be based on. For example, if the adaptation would allow teacher to adapt the learning flow of a script during runtime, then the model that would allow this adaptation should take into account both the structure of the script and the possible problems that would trigger the adaptation.

Overall, this paper shows that adaptive collaboration support is an open and challenging research area. The evaluation of the GLUE! (or Sofocles) suite of tools provides incentive to further exploring the impact of more complex and thoughtful adaptive support mechanisms in the context of collaborative learning through distributed learning environments.

VII. ACKNOWLEDGEMENT

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