TOWARDS NEW APPROACHES IN ADAPTIVE SUPPORT FOR COLLABORATIVE E-LEARNING

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ABSTRACT
Technological advances and evolving social circumstances have rendered e-learning an increasingly attractive and prosperous form of knowledge acquisition in recent years. However, the benefits of flexible, online, distance learning are in danger of being outweighed by the disadvantages resulting from reduced opportunities for group-oriented, collaborative learning. This paper reports on ongoing funded research work that aims to partially compensate for the lack of face-to-face contact between learners by employing adaptivity to actively support the collaborative learning process. The paper provides a general outline of the project's goals, ongoing work and foreseen outcomes, as well as on the planned case studies.

KEY WORDS
Adaptivity, Collaboration, E-learning

1. Introduction

The past decade has been marked by the popularisation and wide penetration of Internet technologies in general, and the Web in particular, in practically all facets of human activity. This trend has already had tremendous impact in the field of education. New teaching and learning paradigms have been established under the general "umbrella" of e-learning, such as blended learning [1], bringing a gamut of new opportunities to the open and distance learning front. The strides achieved in the respective fields, have been, however, accompanied by the lack (or limited amount) of face-to-face contact between instructors and learners, and especially between learners themselves, which has created new hurdles in the education process. The related problems can be coarsely classified into two categories: (a) lack of / limited "real-world" contact between instructors and learners makes it difficult for the former to provide individualised support and guidance; and, (b) lack of / limited "real-world" contact amongst learners has detrimental effects regarding social- and group learning- patterns.

This paper reports on ongoing research project work that is mainly concerned with the second dimension of the problem, namely the lack of face-to-face contact amongst learners.

It is widely acknowledged that a large part of success of the learning process lies with the opportunities of learners to interact with others: groupwork, exchanging ideas, and helping each other (thereby learning themselves) are standard "classroom" practices. With limited real-world contact, learners have limited means for formulating personal mental models of other learners' capacities, skills, interests, strong and weak points, disposition towards teamwork, willingness to help, learning progress etc. Without such models, learners cannot make informed decisions about everyday learning tasks like: whom to direct a question to; which person(s) have the complementary skills required to put together a group that can effectively work on a given task; when to contact them; etc.

In more concrete terms, it has been shown that fostering exchanges between online students can also lead to social cohesion, and, more specifically, to a psychological sense of community [2]. The later has been shown to be a major factor in attaining study-related satisfaction [3], achieving successful learning outcomes [4], preventing student burnout [5], and decreasing dropout rates [6]. Research about distance-learning has also revealed that interactions among students and instructors increase the effectiveness of learning [7] and is beneficial both to individuals and to institutions [8]. Despite these positive findings, open- and distance- learning (ODL) technologies available today do not yet suffice for enabling the types of interactions between learners afforded by traditional classrooms.

The need to support such interactions has given rise to computer supported collaborative learning (CSCL) systems, which provide tools that facilitate online interactions (chats, bulletin boards, discussion lists, …) Although CSCL systems have introduced vital mechanisms for these, they do not, as yet, provide sufficient guidance / direction for the learner before, during, or after the interaction sessions. They must rather

be seen as fundamental technology, upon which to implement didactic models. Furthermore, they fail to provide means by which learners can attain social awareness and coherence that would develop naturally in a classroom situation, like the general progress of the course or estimates about their own success as compared to others. The preceding shortcomings are magnified if one considers that modern pedagogical approaches (e.g., constructivism) bring the active participation of learners in the creation and assimilation of knowledge, and of creative group work, to the forefront.

Adaptivity has been proposed and employed as a plausible approach to achieving individualisation / personalisation in different forms of computer-supported or computer-mediated education. In this context, adaptivity entails the capacity, on the part of interactive systems, to dynamically modify their behaviour to accommodate the requirements and preferences of individual users, as these are explicitly provided or inferred by monitoring the users' actions at run-time. Currently, several systems exist which employ adaptive techniques to enable or facilitate different aspects of learning (e.g., Interbook [9], AHA! [10], TANGOW [10], MOT [11], to name but a few).

However, most of the aforementioned adaptive systems are targeted towards individualising the delivery of course materials to students, in lieu of an instructor. Little work has been devoted, to date, to the employment of adaptivity for supporting more social interactions, like informal communication in chat "rooms". In fact, it can be argued that current approaches reflect models that adopt a "teaching" perspective, where delivery of material is the primary goal. There are few efforts towards the "learning" perspective: modelling, anticipating, guiding or supporting activities in which the learners engage (especially in groups) before, during, and after the learning materials have been delivered, and which are vital to the creation, assimilation and internalisation of knowledge. Emerging work in the field seeks to combine adaptivity with advances in the domain of social software, but is limited to a narrow set of activities, like the case of adaptive social navigation support [12].

The ASCOLLA project described herein (please refer to the "Acknowledgements" section for more information) aims to employ adaptivity as the main vehicle towards new forms of collaborative learning. Specifically, the project aims to provide the technological means through which lack of (or limited amounts of) face-to-face contact between learners can be partially compensated for. To achieve this, the project is investigating the following topics: guiding adaptive collaboration support through (explicitly represented) group-oriented didactic approaches and group social contexts; fostering spontaneous, ad-hoc interactions between on-line learners, and providing in-course opportunities for short-lived, structured collaboration; and, facilitating the maintenance and exchange of personal learning histories within group settings.

2. Goals and objectives

The overall goal of the ongoing research work is to devise, facilitate and foster more collaborative and group-oriented learning approaches than are possible with today's technological means. In broad terms, the scientific objectives of the work are to: (a) widen the range of, as well as increase the amount of, guidance and support that ODL systems can provide to learners and instructors, and (b) provide novel means to support social cohesion in groups of learners, as well as the engagement of their members in collaborative / team tasks and processes.

According to [13], the potential roles of (intelligent) pedagogical agents within learning environments include: coordination management which involves the mediation of administrative aspects of the collaboration (e.g., scheduling, communication, access and control of shared resources, or notification, booking, monitoring, information mining, etc., for individual actors, groups and teams); and, coordination facilitation which involves supporting learners in their collaborative learning activities by mediating processes (e.g., development of shared goals, sharing of information, etc., as well as team building, group decision making, joint thinking, etc.)

The undertaken research work aims to adaptively support roles in both of the above categories, but has a clear bias towards the second one. It is, furthermore, important to note that we do not want to provide an embodiment of an intelligent "collaboration oracle" that unilaterally manages group-oriented learner activities. Rather we are working towards the technological embodiment of so called "adaptive learning spaces", wherein adaptive system support is intended to empower learners in achieving more efficient and effective collaboration within the e-learning environment, but without taking the initiative away from them. The rest of this section reports in more concrete terms on these objectives.

To start with, we are working towards explicitly representing group-oriented didactic approaches and introducing them into adaptive learning spaces as an additional way of encapsulating adaptation strategies and driving adaptive behaviour. Specifically, we intend to provide an easy way for instructors to define didactic approaches (e.g., in terms of pairing learners on the basis of their knowledge and skills) and associate these with a selection of appropriate adaptive behaviours on the part of the system.

Along similar lines, we are devising methods and techniques for identifying and representing the social-, learning-, and activity- oriented aspects of group contexts, and use them to support groups of learners. Such contexts will include "traditional" information about the learners and their (individual or collective) learning goals, but also information about the learner's current activities, availability for communication / collaboration, state of joint work (including produced artefacts and their state), etc.

Another objective is to achieve higher rates of spontaneous, ad-hoc interactions between on-line learners with little or no prior social contact. This will consist in providing opportunities for such interactions through the use of adaptive social awareness techniques, and in providing motivation for engaging in them.

Related to the above, we are also investigating new approaches to providing in-course opportunities for short-lived, structured collaboration between participants. Work in this direction will seek to attain an easy to employ framework for creating and organizing brief tasks that require the participation of multiple learners, and can easily be introduced in the course of computer-supported teaching.

Last but not least, we want to enable learners to manually and automatically populate their personal learning histories, as well as share them with their peers, investigate how this affects social cohesion, and whether and how this could be used for further improvements of collaborative learning activities.

To achieve these objectives, we are building upon the state of the art in the areas of: user-adaptive systems in general and adaptive e-learning systems in particular; community-based adaptation methods (such as collaborative filtering); computer-supported collaborative work, and, more specifically, computer-supported collaborative learning; social software; etc.

3. Developing new approaches

Basic technological infrastructure

To avoid investing time and effort for developing functionality already present in existing learning management systems (LMS), we are basing our developments on a widely used, open source LMS, namely, the Sakai e-learning platform[1]. This gives us the possibility to take advantage of the plethora of standards-compliant modules already available for the platform, and, more importantly, to focus our efforts only on those aspects of the technology that are important enablers for our objectives. Along these lines, the specific components being developed at the moment are as follows.

Semantic modelling components: We are using Semantic Web specifications, standards and technologies (such as RDF and OWL) for the modelling requirements of the project. Work is targeted at the combination of approaches and concepts typically encountered in the field of user modelling, for the modelling of context, activities, and knowledge, especially at the group level. Related software architectures (e.g. [14]) have been reviewed and built upon. We are looking specifically into modelling: learning- and collaboration- related characteristics of individuals and groups; individual- and group- knowledge in relation to specific topics and courses; individual- and group- interaction context; and, individual- and group- activities, at different levels of structuring (including unconstrained, free-form collaboration). Where possible we are trying to use, stay close to, or extend existing specifications both in terms of modeling learning content and learners themselves (e.g., SCORM, IMS CPS, IMS LIP), and in terms of modeling multi-learner activities (e.g., IMS Learning Design).

Decision-making and adaptation components: These are the components that monitor the evolution of the modeled aspects of the learners and groups (and their activities), and decide upon and actuate changes in the system's behaviour (both at the level of the interactive front end, and at the level of the system / service functionalities). Emphasis, here, is placed on the provision of *active* collaboration support, which is not constrained to the adaptive navigation of course materials, but seeks to adaptively enhance the collaboration processes themselves.

Collaboration facilities: The Sakai platform already includes several tools for asynchronous communication and collaboration (e.g., discussion forums, chat rooms, wikis, etc.) However, synchronous communication tools are not included as a standard part of the platform. As a result, and as is often the case with such environments, learners have to resort to external tools for such needs. This in turn has the downside that the learning history and experience is split over a multitude of systems, with coherence and cohesion left entirely up to the participants' individual efforts. One of the goals of the reported work is to bring together the required tools in a single environment, so that learning activities can take place uninterrupted, and in a manner that can be directly monitored and supported. To this end, we are working towards integrating and instrumenting the following tools into the platform: (a) a "whiteboard" for concurrent creation of structured graphics; (b) a group audio communication facility; and (c) a synchronous text chat facility. These can be thought of as "basic" platform elements, and will be expanded to maintain historical information about interactions carried out through them (such as, for example, in [13]), so as to facilitate the creation of personal and group learning histories (see next section for more details).

Higher-level services

The basic building blocks described in the previous section are put together to implement higher-level services that directly relate to the earlier stated objectives:

Individual and group learner modelling: Further to the "traditional" modeling activities already described, we are looking into the effective recognition of emerging patterns of behaviour by individuals and groups. Our goal here is to follow a two-step process: first identify such patterns in the first place; and, then, with the assistance of experts correlate the patterns with potential intervention

[1] For information about the Sakai platform please refer to: http://www.sakaiproject.org.

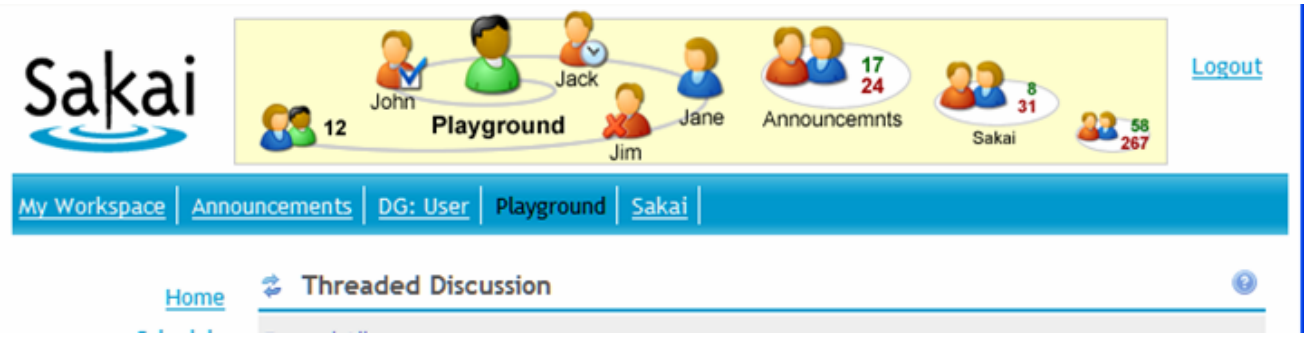

Figure 1: Interactive mockup of the adaptive peer awareness facility, integrated into the Sakai platform.

approaches on the part of the system, and relate these with specific didactic approaches. After the second step we aspire to have an informed model of activity-oriented adaptive system behaviour, linked directly with didactic approaches as described below.

Modelling and employment of didactic approaches: In the context of this activity we are addressing the integration and development of ontological schemata that can represent different didactic approaches. These representations will encapsulate didactic processes, activities, actors, priorities, goals, etc. Using these schemata, different didactic approaches are being described and integrated into the system. In parallel, work is addressing the employment of these representations in the rest of the system's components. The goal is to use the didactic approaches to encapsulate adaptation strategies, which in turn will be a driving determinant in the system's adaptive behaviour. For instance, on the basis of a didactic approach that puts emphasis on rapid learn → practice → internalise cycles, an adaptation strategy could be triggered that interposes targeted informal group assignments in a group's scheduled learning activities.

Adaptive awareness: The enriched context information available to the system (as briefly described earlier) is being used to create new concepts of group awareness. These further require the development of new interactive embodiments of awareness information and the development of flexible, user-controlled privacy and security mechanisms, to allow for "progressive disclosure" of sensitive awareness information (see Figure 1).

Adaptive support for collaboration establishment: This family of services is intended to support learners in establishing ad-hoc collaboration amongst themselves (e.g., on the basis of structured activities), or in forming groups with varying life spans and learning goals. Specifically, we are exploring ways for facilitating and fostering: (a) Spontaneous interactions between learners with little or no prior social contact; this will include providing opportunities for such interactions through adaptive awareness techniques, and motivation for engaging in them (e.g., offering "collaboration points" that partially reflect a learner's social status in a learning community). (b) In-course short-lived, structured collaboration between participants. Work in this direction seeks to attain an easy to employ framework for creating brief tasks requiring the participation of multiple learners, that can then be easily introduced in the course of computer-supported teaching (e.g., instructor-prompted in-course questions randomly assigned to learners to work on in tandem).

Adaptive support for creating personal learning histories: We are investigating both automated and learner-controlled creation of personal learning histories, as well as the utilisation of these histories as a facilitator in collaboration settings. More specifically, we intend to expand upon the concept of personal blogs, introducing features such as the automatic addition of elements based on visited learning material, completed tests, communications with other students, etc. Learners will be able to manually add material to their history, as well as annotate material that has been added automatically. They will also be able to set different privacy levels for different portions of their history. Adaptivity comes into play in two forms here: firstly, using a learner's personal history to identify users with similar histories; as the basis for filtering and creating group learning histories; and, as an enabler for more traditional techniques derived from social recommenders and social software systems.

Adaptive support for ongoing collaboration / cooperation: This is, in essence, a level that integrates most of the lower- and higher- level services outlined earlier. The project aspires to utilize this level of support as an open research platform for experimenting with different approaches to visualizing and interacting with group awareness information, group history, etc.

4. Real-world case studies

The new approaches to adaptive collaboration support described herein will be tested in real-world settings through two case studies. The case studies will be built around courses offered by the Institute for Information Processing and Microprocessor Technology (FIM) of the Johannes Kepler University (Linz, Austria), in a blended learning setting. The planned case studies are as follows.

The first case study of the project will be of a targeted nature, will take place under the formative evaluation cycle of the project, and will be designed around a course that deals with legal issues in information technology. For the needs of the study, the project's infrastructure will be used to implement an adaptive generator for tests and exemplary solutions for the legal area of domain name disputes. The collaborative features that will be explicitly tested in this case study include: (a) When students make mistakes, the system will automatically recommend contacting students that have already proven their knowledge of the specific issues. (b) Students will be able to request assistance on individual problems, and the system will likewise suggest "best fit" candidates to work with. (c) Experimentation with different didactic approaches that will seek to achieve higher levels of collaboration, without obstructing the learning process through too often interruptions and diffusion of effort on the other. (d) Use of social recommendation (collaborative filtering) techniques to allow students to assess the exemplary answers provided (as well as student solutions published anonymously), and share their assessments with colleagues. (e) Experimentation with automatic generation of group histories from portions of the students' personal learning histories, in relation to the tests at hand.

The second case study will be more horizontal than the first, and will take place under the summative evaluation cycle of the project. This study will be designed around a course on system-level programming. The course syllabus will be modified to include additional on-line curricular-, practice-, and exploration- activities; the course's assignments will also be converted to group assignments. In this case study it is anticipated that the entire software infra-structure of the project will be available, which will allow for a more holistic assessment of the results of the introduction of the novel technologies on the collaboration aspects of the learning process and the learning outcomes themselves. Experimentation will continue at the levels of the employment of different didactic approaches to guide the system's adaptive behaviour, and the generation and utilisation of personal- and group- learning histories. Additional emphasis will be placed on: (a) the effects of group context visualisation on group cohesion and group work in general; (b) the facilitation of ad-hoc, spontaneous collaboration sessions within on-line class activities; and (c) the provision of guidance within structured collaboration activities.

5. Expected educational benefits

In synthetic terms, project work will result in learners being able to engage in online collaborative learning activities in ways that more closely resemble typical classroom practices than is possible today – thereby, being able to capitalise on the benefits that such practices afford. This, in turn, has a number of implications for several of the actors involved in the learning process.

To start with learners themselves, the project's grounded approaches to fostering and facilitating collaboration in an e-learning context can greatly improve social cohesion, as well as the learners' sense of community. As already mentioned, this has been shown to be a major factor in attaining study-related satisfaction, achieving successful learning outcomes, preventing student burnout, and decreasing dropout rates.

More specifically, for stable groups of learners that interact on a regular basis (e.g., students in third level education participating in a blended learning course), group awareness support will facilitate more effective and efficient interaction and communication among them. Short-term collaborating groups (e.g., online project meetings) will primarily benefit from better support in locating appropriate peers to work with, as well as better activity awareness and communication within the group. Furthermore, by enabling learners to easily locate peers that have the capacity and willingness to be of assistance in specific learning topics and tasks, we will contribute towards a culture of spontaneous, ad-hoc collaboration – something largely missing from today's CSCL systems.

The project's envisioned outcomes will also have direct implications for instructors. These will mainly revolve around the capacity to "delegate" to the system part of the responsibility of ensuring social cohesion and sustainable levels of collaboration, while maintaining personal levels of support. It is anticipated that, this way, instructors will be empowered in efficiently addressing larger groups of learners than possible today. Furthermore, through the employment of alternative didactic approaches, teachers will be able to take advantage of novel levels of flexibility in on-line group work.

The above also have direct consequences for ODL institutions (including higher education institutions, organisations and companies delivering vocational and life-long-learning services, etc.) The anticipated benefits in this case can be summarised as follows: increased capacity in supporting open-ended learning activities; capability to provide extensive "automated" support to their learners across several courses; capability to support new levels of social cohesion among learners; and, ultimately, ability to support more diverse and effective learning approaches. In order to capitalise on these new opportunities, ODL institutions will need to re-organise the way in which they offer courses. It is argued that this investment is well justified when considering the benefits it can bring about, and the fact that these organisational permutations will result in higher sustainability of the related educational processes.

6. Summary and conclusions

Technological advances and evolving social circumstances have rendered e-learning an increasingly attractive and prosperous form of knowledge acquisition in recent years. However, the benefits of flexible, online,

distance learning are in danger of being outweighed by the disadvantages resulting from reduced opportunities for group-oriented, collaborative learning.

In this paper we have reported on ongoing research work that aims to partially compensate for the lack of face-to-face contact between learners by employing adaptivity to actively support the collaborative learning process.

Adaptivity in this context is targeting not only the traditional level of course material navigation and provision, but the activities of learners themselves, especially at a group- / team- level. In this respect adaptive system behaviour will be two-faceted: on the one hand, it will enable the automation of mediation roles in collaborative learning work (e.g., team building, schedule and synchronization management, etc.); on the other hand, it will empower users to more efficiently and effectively communicate with each other by providing a cohesive learning environment, where information is filtered and tailored to accommodate the needs of a specific learner or group of learners.

Especially as far as the latter aspect is concerned, one can consider the envisioned results of the work as an advanced version of the so called "peer-help" environments (see, e.g., [15]) which promote a constructivist perspective on learning, "using" peers as the catalyst to discovering and internalising knowledge. It is exactly this process that will be supported in novel ways, as described in previous sections.

Finally, it is interesting to note that the technological infrastructure currently under development will be made available to the community as open source software, in the form of components that can be directly deployed into the Sakai platform. It is our hope that this will facilitate the direct uptake and further evolvement of our results, and lead to a new generation of collaborative learning environments.

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