Preface

ABSTRACT

It is broadly admitted that collaboration can facilitate and augment learning in many ways. Accordingly, collaborative learning models, tools and technologies should receive increasing attention. Aiming at further contributing to this directive, this chapter elaborates a series of issues related to the current state, objectives and future trends of collaborative learning. Particular attention is given to the identification of requirements imposed by contemporary communities and learning contexts, as well as to the consideration of approaches that could significantly contribute to their fulfillment.

INTRODUCTION

The proper exploitation of Web-based technologies towards building responsive environments that motivate, engage, and inspire learners, and which are embedded in the business processes and human resources management systems of organizations, is highly critical. Accordingly, the research field of technology-enhanced learning continues to receive increasing attention. However, as widely admitted, learning evolves, and this is only partly due to the reduced cost of the related software and hardware. The changing nature of our society and organizations, being more and more knowledge-based (Holmapple & Joshi, 2002), has a major impact on how individual and organizational learning is - and will be - delivered or experienced.

In this evolving context, it is broadly considered that collaboration is a highly desirable and effective action towards learning. More specifically, argumentative collaboration, conducted by a group of people working towards solving a problem, can admittedly facilitate and augment learning in many ways, such as in explicating and sharing individual representations of the problem, maintaining focus on the overall process, maintaining consistency, increasing plausibility and accuracy, as well as in enhancing the group’s collective knowledge (Koschmann, 1999; Andriessen et al., 2003; Ravenscroft & McAlister, 2006).

According to the above, learning and teaching technologies should further focus on (i.e. exploit and augment) the collaboration among learners. Such technologies should support self-directed and personalized learning through the engagement of learners in collaborative learning settings and scenarios (Dillenbourg, 1999; Stahl et al., 2006). Formal and informal learning should be considered in parallel, together with the overall social and organizational context. The appropriate management of the related knowledge resources and user-generated content is another critical issue to be addressed during the development of the contemporary collaborative learning technologies. In any case, these technologies
should make it easier for learners to follow the evolution of an ongoing collaboration, comprehend it in its entirety, and meaningfully aggregate data in order to resolve the issue under consideration.

In the context sketched above, this chapter elaborates a series of issues related to the current state, objectives and future trends of collaborative learning. Particular attention is given to the identification of requirements imposed by contemporary communities and learning contexts, as well as to the consideration of approaches that could significantly contribute to their fulfillment.

**SUPPORTING COLLABORATION**

Recent advances in computing and Internet technologies, together with the advent of the Web 2.0 era, resulted to the development of a plethora of online, publicly available environments such as blogs, discussion forums, wikis, and social networking applications (Summerford, 2008). These offer people an unprecedented level of flexibility and convenience to participate in complex collaborative activities, such as long online debates of public interest about the greening of our planet through renewable energy sources or the design of a new product in a multinational company. Information found in these environments is considered as a valuable resource for individuals and organizations to solve problems they encounter or get advice towards making a decision. In any case, people have to go through some type of sorting, filtering, ranking and aggregation of the existing resources in order to facilitate sense-making. Yet, these activities are far from being easy. This is because collaboration settings are often associated with ever-increasing amounts of multiple types of data, obtained from diverse sources that often have a low signal-to-noise ratio for addressing the problem at hand. In turn, these data may vary in terms of subjectivity, ranging from individual opinions and estimations to broadly accepted practices and indisputable measurements and scientific results. Their types can be of diverse level as far as human understanding and machine interpretation are concerned. They can be put forward by people having diverse or even conflicting interests. At the same time, the associated data are in most cases interconnected, in a vague or explicit way. Data and their interconnections often reveal social networks and social interactions of different patterns.

The above bring up the need for innovative software tools that can appropriately capture, represent and process the associated data and knowledge. Such tools should shift in focus from the collection and representation of information to its meaningful assessment and utilization. They should facilitate argumentation, i.e. discussion in which reasoning and disagreements exist, not only discourse for persuasion, logical proof and evidence-based belief (Kunz & Rittel, 1970), the ultimate aim being to support collaborative sense-making (and/or decision-making), and accordingly enhance learning. This can be seen as a special type of social computing where various computations concerning the associated context and group’s behavior need to be supported.

Designing software systems that can adequately address users’ needs to express, share, interpret and reason about knowledge during an argumentative collaboration session has been a major research and development activity for more than twenty years. Technologies supporting argumentative collaboration usually provide the means for discussion structuring and visualization, sharing of documents, and user administration. They support argumentative collaboration at various levels and have been tested through diverse user groups and contexts. Furthermore, they aim at exploring argumentation as a means to establish a common ground between diverse stakeholders, to understand positions on issues, to surface assumptions and criteria, and to collectively construct consensus.
While helpful in particular settings, the above solutions prove to be inadequate in cognitively-complex situations.

RELATED WORK

Existing approaches to support argumentative collaboration vary in terms of the problem dimension they principally address and the context they particularly target. One category, focusing on a meaningful representation of the related items and their interconnections, builds on the concepts of IBIS (Issue Based Information System), introduced back in 1970 (Kunz & Rittel, 1970). For instance, gIBIS (Conklin & Begeman, 1989) is a pioneer argumentation structuring tool that allows users to create issues, assert positions on these issues, and make arguments in favor or against them. QuestMap (Conklin et al., 2001) resembles to a ‘whiteboard’ where all messages, documents and reference material for a project, together with their relationships, are graphically displayed, the aim being to capture the key issues and ideas during meetings and create a shared understanding in a knowledge team. Hermes (Karacapilidis & Papadias, 2001) builds on concepts from the areas of Decision Theory, Non-Monotonic Reasoning, Constraint Satisfaction and Truth Maintenance, and offers an integrated consideration of classical decision making and argumentation principles. Compendium (http://www.compendiuminstitute.org) is a tool that supports dialogue mapping and conceptual modeling in a meeting scenario, and can be used to gather a semantic group memory. In the same context, Belvedere (Suthers et al., 1995) is used for constructing and reflecting on diagrams of one’s ideas, such as evidence maps and concept maps. It represents various logical and rhetorical relations within a debate and supports problem-based collaborative learning scenarios through the use of a graphical language.

In the context of argumentation theory, systems supporting the visualization of argumentation have played a considerable educational role by supporting the teaching of critical thinking and reasoning skills. For instance, Araucaria (Reed & Rowe, 2004) supports the contextual analysis of a written text and provides a tree view of the premises and conclusions, also reflecting stereotypical patterns of reasoning. In the same line, ArguMed (Verheij, 2003) builds on a formal argumentation approach to addresses the issues of argument mapping. The Reason!Able argumentation tool (van Gelder, 2002) provides a well structured and user-friendly environment for reasoning. Through the use of an argumentation tree, a problem can be decomposed to its logically related parts, whereas missing elements can also be identified. MindDraw (http://info.cwru.edu/minddraw/) is another educational software providing assistance in the creation and sharing of visual images of ideas; it enables users to produce maps of causal relationships, and has been proven to be useful for students and learners of all ages. Athena Standard and Athena Negotiator (http://www.athenasoft.org) are two more examples of argument mapping software. Athena Standard is designed to support reasoning and argumentation, while Athena Negotiator is designed to facilitate analysis of decisions and two-party negotiations. The last two systems are efficient argumentation structuring tools, but do not employ any knowledge management features.

As derives from the above, the majority of existing argumentative collaboration support systems mainly focus on the expression and visualization of arguments. Generally speaking, existing approaches provide a cognitive argumentation environment that stimulates reflection and discussion among participants. However, their features and functionalities are limited, they pay no or limited attention to data and knowledge management issues, they are mostly tested in academic environments, they are not interconnected with other tools, and they do not efficiently tackle the technological and social dimensions of
cognitively-complex collaboration. They receive criticism related to their adequacy to clearly display each collaboration instance to all parties involved (usability and ease-of-use issues), as well as to the formal structure used for the representation of collaboration. In most cases, they merely provide a sort of threaded discussion forums, where messages are linked passively. This usually leads to an unsorted collection of vaguely associated positions, which is extremely difficult to be exploited in future collaboration settings. Also important, they do not integrate, in most cases, any reasoning mechanisms to (semi)automate the underlying decision making processes required in a collaboration setting. Thus, there is a lack of alternative formalization, consensus seeking and decision-making support abilities. It has been also admitted that these solutions often require that users carry out activities that do not naturally belong to their work, or they support activities which are infrequent in normal work; thus, such activities are often considered artificial or insignificant by users. As a result, traditional argumentation software approaches are no longer sufficient to support contemporary communication and collaboration needs (de Moor & Aakhus, 2006). There is a need to provide alternative representational features in order to demonstrate a significant effect on the users’ collaborative knowledge building process.

REQUIREMENTS TO BE MET

Design of a smart solution to augment individual and organizational learning during a cognitively-complex argumentative collaborative session is certainly a big challenge. Towards addressing it, we have performed a series of interviews with members of diverse communities in order to identify the major issues they face during their ordinary practices. Twelve communities, coming from three distinct work environment types (management, engineering and learning), and ranging in size from a few decades to a few hundreds of members, were involved (7 of these communities were moderated). In total, 37 people went through a semi-structured interview (the vast majority of them were ‘early adopters’ with more than 5 years hands-on experience with collaborative technologies). All people selected were highly active members in their communities and/or they were having a moderator role. Major issues identified were:

- **Cognitive overhead and management of information overload:** This is primarily due to the extensive and uncontrolled exchange of diverse types of data and knowledge resources. For instance, such a situation may appear during the exchange of numerous ideas about the solution of a public issue, which is accompanied by the exchange of big volumes of positions and arguments in favor or against each solution. In such cases, individuals usually have to spend much effort to conceptualize the current state of the collaboration and grasp its contents. The need to consider an overwhelming amount of resources may ultimately harm a community’s objectives. To avoid that, functionalities for scalable filtering and timely processing of the associated big amounts of data need to be offered.

- **Social behavior:** The representation and visualization of social structures, relationships and interactions taking place in a collaborative environment with multiple stakeholders are also of major importance. This is associated to the perception and modeling of actors, groups and organizations in the diversity of collaborative contexts. A problem to be addressed is to provide the means to appropriately represent and manage user and group profiles, as well as social relationships. However, neither relationships nor contexts are static; they are emerging and change over time, which necessitates the development of adaptive services.
- **Collaboration modes:** Interviews indicated that the evolution of collaboration proceeds incrementally; ideas, comments, or any other type of collaboration objects are exchanged and elaborated, and new knowledge emerges slowly. When members of a community participate in a collaborative session, enforced formality may require them to specify their knowledge before it is fully formed. Such emergence cannot be attained when the collaborative environment enforces a formal model from the beginning. On the other hand, formalization is required in order to ensure the environment’s capability to support and aid the collaboration efforts. In particular, the abilities to support decision making or estimation of the present state benefit greatly from formal representations of the information units and relationships. Generally speaking, solutions to the problem under consideration should be generic enough to address diverse collaboration modes and paradigms.

- **Expression of tacit knowledge:** A community of people is actually an environment where tacit knowledge (i.e. knowledge that the members do not know they possess or knowledge that members cannot express with the means provided) predominantly exists and dynamically evolves. Such knowledge must be efficiently and effectively represented in order to be further exploited in a collaborative environment.

- **Integration of legacy resources:** Many resources required during a collaborative session have either been used in previous sessions or reside outside the members’ working environment (e.g. in e-mailing lists or web forums). Moreover, outcomes of past collaboration activities should be able to be reused as input in subsequent collaborative sessions. The inherent issues of liability and preservation of intellectual rights need particular attention in such cases.

- **Data processing and decision making support:** In the settings under consideration, timely processing of data related to both the social context and social behavior is required. Such processing will significantly aid the members of a community to conclude the issue at hand, extract meaningful knowledge and reach a decision. This means that their environment (i.e. the tool used) needs to interpret the knowledge item types and their interrelationships in order to proactively suggest trends or even aggregate data and calculate the outcome of a collaborative session.

The above issues delineate some categories of crucial requirements to be met during the development of contemporary collaborative learning models, tools and technologies. At the same time, it was made obvious that argumentative collaboration, as a particular social computing type, is also knowledge-intensive, in that access to and manipulation of large quantities of knowledge is required.

## DESIGN ISSUES

This section elaborates a series of issues to be thoroughly considered during the design of contemporary collaborative learning solutions. These concern diverse collaboration aspects and should be taken into account together with the overall collaboration context.

### Incremental Formalization

When engaged in the use of existing technologies and systems supporting argumentative collaboration, users have to follow a specific formalism. More specifically, their interaction is regulated by procedures that prescribe and - at the same time - constrain their work. This may refer to both the system-supported...
actions a user may perform (e.g. types of discourse or collaboration acts), and the system-supported types of argumentative collaboration objects (e.g. one has to strictly characterize a collaboration object as an idea or a position). In many cases, users have also to fine-tune, align, amend or even fully change their usual way of collaborating in order to be able to exploit the system’s features and functionalities. Such formalisms are necessary towards making the system interpret and reason about human actions (and the associated resources), thus offering advanced computational services. However, there is much evidence that sophisticated approaches and techniques often resulted in failures (Shipman & Marshall, 1994; Shipman & McCall, 1994). This is often due to the extra time and effort that users need to spend in order to get acquainted with the system, the associated disruption of the users’ usual workflow (Fischer et al., 1991), as well as to the “error prone and difficult to correct when done wrong” character of formal approaches (Halasz, 1988).

Complex contexts imply additional disadvantages when using formal approaches. Such approaches impose a structure which is not mature enough to accommodate the management of huge amounts of data coming from diverse sources. They do not allow users to elaborate and digest these data at their own pace, according to the evolution of the collaboration. Instead, a varying level of formality should be considered. This variation may either be imposed by the nature of the task at hand (e.g. decision making, deliberation, persuasion, negotiation, conflict resolution), the particular context of the collaboration (e.g. medical decision making, public policy making), or the group of people who collaborate each time (i.e. how comfortable people feel with the use of a certain technology or formalism).

The above advocate an \textit{incremental formalization} approach. In other words, formality and the level of knowledge structuring should not be considered as a predefined and rigid property, but rather as an adaptable aspect that can be modified to meet the needs of the tasks at hand. By the term formality, we refer to the rules enforced by the system, with which all user actions must comply. Allowing formality to vary within the collaboration space, incremental formalization, i.e. a stepwise and controlled evolution from a mere collection of individual ideas and resources to the production of highly contextualized and interrelated knowledge artifacts, can be achieved.

\section*{Visualization and Reasoning}

It has been widely argued that visualization of argumentation conducted by a group of experts working collaboratively towards solving a problem can facilitate the overall process in many ways, such as in explicating and sharing individual representations of the problem, in maintaining focus on the overall process, as well as in maintaining consistency and in increasing plausibility and accuracy (Kirschner et al., 2003). Moreover, it leads to the enhancement of the group’s collective knowledge. For the above reasons, visualization issues should receive much attention while shaping the proposed innovative collaborative learning solutions.

Alternative \textit{projections} of a virtual collaboration space may constitute the ‘vehicle’ that permits incremental formalization of argumentative collaboration (Karacapilidis & Tzagarakis, 2007). A projection can be defined as a particular representation of the collaboration space, in which a consistent set of abstractions able to solve a particular organizational problem during argumentative collaboration is available. With the term abstraction, we refer to the particular data and knowledge items, relationships and actions that are supported through a particular projection, and with which a particular problem can be represented, elaborated and be solved. The foreseen solutions should enable switching from one projection to another, during which abstractions of a certain formality level are transformed to the appropriate
abstractions of another formality level. This transformation should be rule-based (and context-specific); such rules can be defined by users and/or the facilitator of the collaboration and reflect the evolution of a community’s collaboration needs. It should be up to the community to exploit one or more projections of a collaboration space (upon users’ needs and expertise, as well as the overall collaboration context).

Each projection of the collaboration space should provide the necessary mechanisms to support a particular level of formality (e.g. projection-x may cover only needs concerning collection of knowledge items and exploitation of legacy resources, whereas projection-y may provide decision making functionalities). The more informal a projection is, the more easiness-of-use is usually implied; at the same time, the actions that users may perform are intuitive and not time consuming (e.g. drag-and-drop a document to a shared collaboration space). Informality is associated with generic types of actions and resources, as well as implicit relationships between them. However, the overall context is more human (and less system) interpretable. As derives from the above, the aim of an informal projection of the collaboration space should be to provide users the means to structure and organize data and knowledge items easily, and in a way that conveys semantics to them. Generally speaking, informal projections may support an unbound number of data and knowledge item types. Moreover, users may create any relationship among these items; hence, relationship types may express agreement, disagreement, support, request for refinement, contradiction etc.

While such a way of dealing with data and knowledge resources is conceptually close to practices that humans use in their everyday environment, it is inconvenient in situations where support for advanced decision making processes must be provided. Such capabilities require resources and structuring facilities with fixed semantics, which should be understandable and interpretable not only by the users but also by the tool. Hence, decision making processes can be better supported in environments that exhibit a high level of formality. The more formal projections of a collaboration space come to serve such needs. The more formal a projection is, easiness-of-use is usually reduced; actions permitted are less intuitive and more time consuming. Formality is associated with fixed types of actions, as well as explicit relationships between them. However, a switch to a more formal projection is highly desirable when (some members of) a community need to further elaborate the data and knowledge items considered so far. Such functionalities are provided by projections that may enable the formal exploitation of collaboration items patterns and the deployment of appropriate formal argumentation and reasoning mechanisms. A switch to a projection of a higher level of formality should disregard less meaningful data and knowledge items, resulting to a more compact and tangible representation of the collaboration space. This effect is highly desirable in cognitively-complex situations.

Information Triage

Concepts originally coming from the area of spatial hypertext and the information triage process (Marshall & Shipman, 1997), i.e. the process of sorting and organizing through numerous relevant materials and organizing them to meet the task at hand, should be also exploited towards the proposed collaborative learning solutions. According to the above, users must effortlessly scan, locate, browse, update and structure knowledge resources that may be incomplete, while the resulting structures may be subject to rapid and numerous changes. Information triage related functionalities enable users to meaningfully organize the big volumes of data and knowledge items in a collaborative setting.

Spatial hypertext is admittedly a promising approach to address issues in argumentative collaboration environments, as it introduces a visual language in an attempt to take advantage of the humans’
visual memory and their ability to recognize patterns. Exploiting these human capabilities can greatly reduce the negative impacts of cognitively-complex environments. Spatial hypertext removes the barrier between reading and writing processes enabling articulation of tacit knowledge and ambiguity, as well as establishment of emerged problem-solving strategies. Thus, users are incrementally processing information and are not forced to predefined structural commitments. The corresponding features and functionalities should enable users to create and organize information by making use of spatial relationships and structures, giving them the freedom to express relationships among information items through spatial proximity and visual cues. Such cues could be related to the linking of collaboration items (e.g. coloring and thickness of the respective links) and the drawing of colored rectangles to cluster related items.

As highlighted above, the foreseen solutions should permit an ordinary and unconditioned evolution of data and knowledge structures. Such solutions should also provide abstraction mechanisms that allow the creation of new abstractions out of existing ones. Abstraction mechanisms may include:

- annotation and metadata (i.e. the ability to annotate instances of various knowledge items and add or modify metadata);
- aggregation (i.e. the ability to group a set of data and knowledge items so as to be handled as a single conceptual entity);
- generalization/specialization (i.e. the ability to create semantically coarse or more detailed knowledge items in order to help users manage information pollution of the collaboration space);
- patterns (i.e. the ability to specify instances of interconnections between knowledge items of the same or a different type, and accordingly define collaboration templates).

**Exploitation of Legacy Resources**

The foreseen solutions should also reduce the overhead of entering information by allowing the reuse of existing resources. Generally speaking, when legacy resources have to be reused during a collaborative session, complexity is increased. This is not only due to the additional amount of data involved, but also to the conceptual overhead and distractions imposed to the user from switching among applications and environments. One way of dealing with this situation is to enable the ubiquitous access of legacy resources from within the collaboration environment by seamlessly integrating the systems involved. Towards this direction, interoperability among various applications should be carefully considered.

**Social Networking**

Management of social structures, interactions and relationships is also critical in a contemporary collaborative learning framework. Applications and projects dealing with social relationships mainly support explicit and abstract structures. However, social structures may gain from the expertise of structure domain research, including various structure abstractions or ways for implicit structuring. Another issue to be addressed concerns the elaboration of social relationships in their contexts, that is, how they relate to assets, locations, or change over time. Social network analysis (Castells, 2004) has to be extensively used to find who is depending on whom in a network. Such an analysis will also help to detect hidden hierarchy of social networks. Other requirements of this category concern the (semi)automatic role-
specific cognitive mapping for each participant, based on his/her overall behavior, and the development of artifacts-related collaboration metrics.

The foreseen solutions should integrate a sophisticated user and role modeling module to tackle the above issues. This module should build on an explicit representation of the notion of user/group, which in turn should be based on a predefined attribute hierarchy. The associated attributes can be domain-specific. They can be categorized, depending on how they are populated and who may modify them, as explicit (their values are provided by users themselves and include personal data such as name, address, birth date, preferences, competencies, skills etc.) or implicit (their values are not provided by users explicitly, but implicitly, by observing their behavior within the system). User/group modeling should be also associated with mechanisms for the acquisition of the abovementioned implicit information of users/groups. These mechanisms will observe and log the operations and discourse moves of users within the system and record them in the user’s profile. Finally, such a sophisticated user and role modeling module should integrate an inference engine. The role of such an engine is to analyze all data present in the profile, together with data from the collaborative workspaces, in order to extract meaningful information about social structures, interactions and relationships. Contrary to most user modeling approaches, this approach pays much attention to community-related aspects (i.e. relationships between individual users and relationships between users and artifacts).

CONCLUSION

This chapter has elaborated a series of issues related to the collaborative learning paradigm, the ultimate aim being to sketch the appropriate tools and technologies that will facilitate and augment it. A series of critical requirements imposed by contemporary communities and learning contexts have been identified, while approaches that could significantly contribute to their fulfillment have been discussed. We argue that the proper tuning and integration of these approaches is able to fully support the evolution of a cognitively complex (and/or data intensive) collaboration, while it provides the means for addressing the issues related to formality in collaborative knowledge building and learning systems. The foreseen solutions support argumentative collaboration between people and groups, enable social feedback, and facilitate the building and maintenance of social networks.

By no means, one would argue that the list of issues discussed in this chapter covers fully the diversity and complexity of the research field under consideration. Related works, derived from other perspectives, should be also taken into account during the development of innovative collaborative learning systems (see, for instance, (Amy, 2003), (Dimitracopoulou, 2005) and (Kamtsiou et al., 2006)). Furthermore, the improvement of collaboration among learners should not be considered as the sole research direction towards further enhancing web-based learning. The augmentation of the quality (not the quantity) of e-learning material and the establishment (and global adoption) of e-learning standards consist two other essential directions to be thoroughly investigated.

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