A framework to support knowledge sharing and construction in virtual learning communities

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Abstract. This research aims at the development of a computational framework to support knowledge construction and sharing in Virtual Learning Communities. The distinctive characteristic of the framework is that the support will be tailored to the community *as a whole*, rather than adapting to particular individuals. A key component in the framework is a community knowledge model, which will be derived from monitoring the knowledge sharing process and will be used to support the building of transactive memory and shared mental models, as well as to identify cognitively central and peripheral members. These issues are important in Virtual Learning Communities (both in educational and organisational context), as they promote the processes of knowledge/information sharing, collaborative learning, and development of collective efficacy among community members.

1 Introduction

During the last decade, academics and practitioners have been searching for techniques to support knowledge extension and sharing (Puntambekar, 2005). Online communities appear to be an exceptional approach which brings together people from diverse backgrounds, provides support for collaboration, and – through collective knowledge sharing – provides a basis for the creation of shared understanding (Lewis and Allan, 2005, Puntambekar, 2005). The term Online Community, is an umbrella term for a number of others like Virtual Community, Community of Practice and Learning Community. There are common characteristics applied to all of the subsets of an online community but each subset has its own distinctive characteristics. Learning communities are altering the way people learn and work collectively: groups of professionals and practitioners, often from the same or related background, are coming together to share ideas and experience and to tackle common problems and issues.

Authors coming from different disciplines vary in their perception of what constitutes a 'community' (Preece et al., 2003). For this study, we consider Virtual Learning Communities (VLCs) that may exist in either organisational or educational context and have the following characteristics: common purpose, identified by the participants or a facilitator; commitment to the sharing of information and generation of new knowledge; shared resources; participants are more likely to be at different stages of their professional/academic life; high level of dialogue, interaction and collaboration; equal membership and leadership; knowledge construction. The above characteristics can be part of both learning communities (Lewis and Allan, 2005), and communities of practice (Lewis and Allan, 2005, Wenger, 2001). Learning is a very important process of today's organisations. It is defined as "an issue of sustaining the interconnected communities of practice through which an organisation knows what it knows and thus becomes effective and valuable as an organisation" (Wenger, 2001). Furthermore, a community of practice is not far from what others call a learning community, as long as practice and learning continue staying in tension (Lewis and Allan, 2005, Wenger, 2001) [1]. By VLC in this study we refer to both learning communities and communities of practice.

2 Problem Statement

Extensive research has been done on studying the theories behind electronic communities, learning communities, and communities of practice (Allen, 2005, Hung and Der-Thanq, 2001, Jones and Issroff, 2005, Laurillard, 2002, Puntambekar, 2005). As Lewis and Allan point out, theorists agree that learning takes place as a result of interactions within a particular social context, e.g. work, programme of study, or learning community (Lewis and Allan, 2005). They also argue that theories regarding cognitive, social and emotional development are not mutually exclusive but are closely linked, and some conflict and overlapping exist between them. One of the main theory that hold the foundations for a community collaborative learning is the theory of social constructivism (Piaget, 1954). Social Constructivism postulates that individuals gradually build their own understanding of the world through experience, maturation, and interaction with the environment (Rovai, 2004). Collaborative learning, which happens when a group of people work together on a shared goal (Dillenbourg, 1999), has been commonly linked to social constructivism. The benefits of

[1] In fact, Lewis and Allan (2005) discuss that most of the learning communities that they came across in their studies have the characteristics of communities of practice.

collaborative learning are that people bring divergent ideas in a collaborative environment and work towards the development of a shared understanding and common knowledge building (Puntambekar, 2005). Interactions in a community can involve novices and more experienced (or knowledgeable) learners, which can lead to a higher level of potential development and can be linked to Vygotsky's 'zone of proximal development' (Vygotsky, 1978). Furthermore, an important theory, which is closely related to communities, is that of cognitive apprenticeship. This theory states that a novice learner can develop new skills and construct knowledge by observing and learning from more experienced peers (Lewis and Allan, 2005, Silverman, 1995, Wenger, 2001). In this way, expert community members offer mental scaffolding that helps less-knowledgeable members to move forward in their understanding and knowledge building.

Although the theories suggest that communities lead to knowledge sharing and construction, studies show that these processes don't just happen, they have to be supported (Fischer and Ostwald, 2001). Learning within online knowledge management systems may be hindered by a number of factors, from technological (e.g. communication barriers, diverse technical background, technological constraints) to social (e.g. different background, interests, understanding of the problem). A common misconception is to believe that VLC will be effective when people and technology are present. As stressed by Fisher and Ostwald (2001), appropriate support for the effective functioning of the community is needed. The key challenge for the support is to understand what is happening within the community as a whole and how individuals influence each other during the learning processes. A paradigm shift towards building personalisation technologies that adapt to a community as an entity, as opposed to adapting to each individual independently (which is the common case at the moment), is called for. Our work aims to make a step in this direction by developing a framework for analysing the knowledge processes in a community and providing support for the effective knowledge sharing and construction within the community.

2 Underlying Theories

In this section, we will discuss the processes that are considered as crucial for the effective functioning of a community, and therefore should be supported in a VLC. The issues of building transactive memory, shared mental models and cognitive centrality have been widely examined in the context of teams and groups operating in the boundaries of an organisation (Hollingshead, 2000, Hollingshead and Brandon, 2003, Ilgen et al., 2005, Kerr and Tindale, 2004, Mohammed and Dumville, 2001, Wegner, 1986). These issues underpin the design of our framework and will be summarised here.

Shared Mental Models. Shared mental models are defined as the "team members' shared, organised understanding and mental representation of knowledge about key elements of the team's relevant environment" (Mohammed and Dumville, 2001). Many studies confirm that the effectiveness of a group, in terms of collaborative knowledge exploitation activities, can be improved if the group members have a shared understanding of the environment, situation and task (He, 2004). In addition, the development of a shared understanding regarding the areas that are investigated by the community members is one of the main objectives of community formation (Merali and Davies, 2001, Puntambekar, 2005).

Transactive Memory. Wegner defines that, transactive memory is concerned with "the prediction of group and individual behaviour through an understanding of the manner in which group processes and structures information" (Wegner, 1986). Transactive memory helps group members to divide responsibilities for different knowledge areas and be aware of one another's expertise. Groups perform better when they have a transactive memory system in place. Wenger also argues that a community of practice is a "living context", as it can give newly joining members access to knowledge and expertise already accumulated within the community (Wenger, 2001); through the transactive memory system newcomers will be able to quickly identify who knows what and to promote what they know themselves.

Cognitive Centrality and Cognitive Consensus. Cognitive centrality deals with how much information a member shares with the rest of the group. If a member shares a lot of information that is of a certain importance to the rest of the group, then this member is cognitively central. When this is not the case, the member is cognitively peripheral (Kerr and Tindale, 2004). In addition, cognitive consensus deals with similarity among group members comparing how specific issues are defined and conceptualised (Mohammed and Dumville, 2001). Cognitive centrality and cognitive consensus are both important elements of the smooth functioning and successful performance of a community.

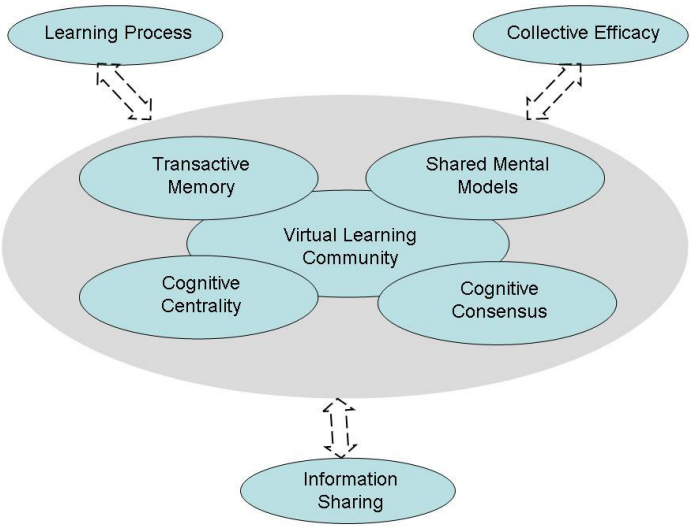

Figure1 – Theories and their Relation to the VLC

The above issues are strongly related to knowledge processes in communities, which is the focus of our work (Figure 2). Knowledge processes will be considered are Learning Processes inside the community; Information Sharing among members; and Collective Efficacy (the collective belief that they can be effective as a group). There are other issues, for example, social networks, trust and motivating participation. They are important for the overall functioning of the community but they have been studied within the context of VLC (e.g. Comtella[2], EduTella[3]). Distinctively from these systems, we focus on modelling and support of knowledge processes and in this respect our framework is original and can be considered as complimentary to work on social factors within communities.

3. Methodology

Our study will follow the conventional methodology for building intelligent learning environments based on the integration of theoretical and empirical approaches, as described in (Self, 1999). The methodology includes the following steps: (1) thorough understanding of the phenomenon to be modelled and the underpinning theories; (2) develop a formal description of the processes, in our case this includes how to model the community and how to decide what adaptation is needed; (3) build a demonstrator to validate the theoretical framework; (4) evaluate the demonstrator to examine the educational benefit.

Stage 1: Understand the phenomenon to be modelled

Tthis stage is being currently conducted based on material outlined in sections 1 and 2. We are currently reviewing the area of communities of practice and are identifying the processes linked to knowledge construction and sharing. The issues on Section 2 are the initial step in this direction. We are also looking at studies from Psychology and Social Sciences reporting on what support will be needed for communities.

Stage 2: Define the framework

The computational framework will consist of two major parts. The first deals with the development of a community model, which will represent the whole community and will focus on issues related to shared mental models, transactive memory, and cognitive centrality and consensus. The second deals with what adaptive support can be offered to improve the functioning of the community.

Firstly, for the development of the community model, we will focus on analysis of the tracking data and implicit interactions with the users to clarify certain aspects. We will be analysing data from two existing VLC applications. We have two years' tracking data from an existing VLC of some 25 researchers with common interests working together on virtual research projects and sharing documents with the BSCW (Basic

[2] http://svaroy.usask.ca:8080/comtella/

[3] http://www.l3s.de/english/projects/edutella.html

Support for Cooperative Work)[4] system that supports resource sharing and collaboration over the web. The BSCW data consists of information on who uploaded what resource on the community's space; who accessed which resource and when, who ranked and modified it; which members joined and left the community and when. This information is in an xml like format and will be processed with appropriate tools, e.g. JAXP or Xcerpt**.** We also have the tracking data from 15 groups of students (each group includes 4-5 people) working together to create educational resources on a particular topic with the help of the ConDOR (Construction of Dynamic Open Resources)[5] system. The tracking data from ConDOR, which is stored in a MySQL database, includes details about shared resources uploaded by the group members and all versions of the collaboratively developed resources (ConDOR provides a version control support).

The tracking data that we already have will be analysed and examined to see what information can we get to identify existence of transactive memory, shared mental models, and/or cognitively central or peripheral members. Learning or knowledge construction, information sharing and collective efficacy (i.e. how much the group members believe that they can be successful as a group) will be examined in relation to the development of shared mental models and the existence of transactive memory systems. Having this done, we will enhance what we have with semantically enriched information such as metadata of the objects, considering the specialisation area of the person who posted that object and keywords provided. We will also use existing ontologies of areas relevant to our community (for example, the VLCs we are analysing are focusing on issues related to the Semantic Web for which example ontologies have been developed[6]) to compare against the data that we have.Ontological reasoning techniques will be used to identify relations between topics and to decide what interventions from the system may be needed.

Only analysing tracking data will not be sufficient to find consensual knowledge and shared mental models. To model these, we will use in addition a system-user dialogue to get additional information and complete the community model. The dialogue approach has been successfully used in our research group to gather knowledge of individual users (Denaux et al., 2005) and can be adapted to capture collective knowledge. Dialogue can be used to clarify when conceptual discrepancies between community members can be detected and can be used to help the community identify the similarity and differences in individual members' viewpoints.

Once the community model is developed, it will be used to provide support to the community and to help its members improve the transactive memory system of their community, develop shared understanding between them and become aware of cognitively central or peripheral members. This will help us point at issues that support information sharing, learning and development of collective efficacy, and to help the community build a good transactive memory system and a shared understanding of the domain they are working in.

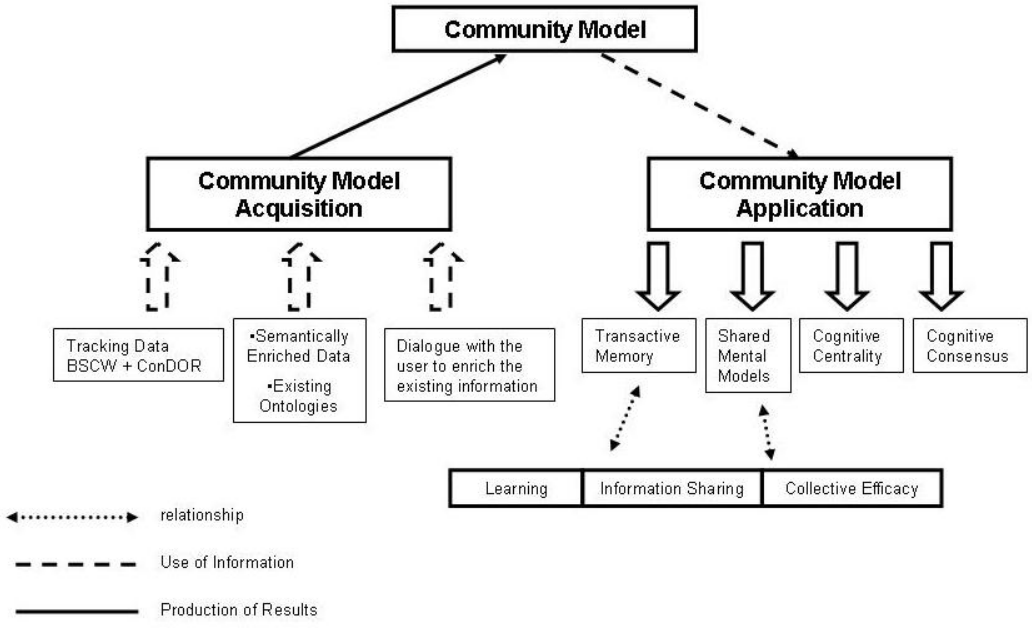

Figure 2 – General structure of the community modelling and adaptation framework.

[4] http://bscw.fit.fraunhofer.de/
[5] ConDOR was developed within the EU funded Edukalibre project and is available from http;//edukalibre.org
[6] For example, https://wiki-sop.inria.fr/wiki/bin/view/Acacia/KnowledgeWeb

Figure 2 illustrates the architecture of our framework following the general architecture of user-adaptive systems defined by Jameson (2004).

Stage 3: Develop demonstrator

To illustrate the framework, we will extend the ConDOR system which was developed at Leeds University as part of the Edukalibre project, funded by the European Commission's Socrates/Minerva program. The Edukalibre project examined the translation of the uses and procedures of the free/open source software development to the creation of content suitable to be used as material for education (Gonzalez-Barahona, 2004). Among the final deliverables of the project is ConDOR through which groups of people (teachers or students) can collaborate, share resources, engage in discussions, and jointly develop educational materials (Gonzalez-Barahona et al., 2005). The main idea is to mimic processes that happen in open-source communities within a VLC. With this study, we aim to extend ConDOR's functionality, in a way to support knowledge sharing and construction, focusing on the issues discussed in Section 2.

Stage 4: Evaluation

Once we have an extended version of ConDOR, we will be able to deploy it in educational settings. We are considering university environments, where ConDOR has been used and where a number of problems related to transactive memory, shared mental models and cognitive centrality and consensus have been observed. There is also a possibility to use ConDOR with a community of IT teachers in secondary schools in Leeds. We will be able to examine the benefits of ConDOR by comparing the functioning of the community by using two different versions of ConDOR – with and without the adaptive community support framework proposed here.

Current State and Future Work

This paper outlines a PhD project being conducted by the author at the University of Leeds. The studies began in January 2006 following work by the author on the Edukalibre project. Based on that project we have identified issues which have to be supported within a VLC and which will be the core of this PhD. We are currently analysing the tracking data from BSCW and ConDOR to extract community models, for which we are examining the application of data mining techniques (Paliouras et al., 2000). Our next step will be to include metadata and to use existing ontologies working on stage 2 of the methodology. We will then extend ConDOR to validate the framework and examine the benefits of the approach.

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