British Journal of Educational Technology (2009)
doi:10.1111/j.1467-8535.2009.00973.x

From mindtools to social mindtools: Collaborative writing with Woven Stories

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Abstract
The rapid development of computer-supported collaborative environments has highlighted the need for collaborative knowledge construction devices. Because most available mindtools do not promote collaboration, there is a need for social mindtools that can be used in collaborative learning situations. We have used activity theory as a conceptual framework to define the requirements of social mindtools as awareness of other participants, communication and the ability to edit common objects together. We present the concept of Woven Stories and use it as an example of an effective social mindtool. We also describe a case study in which Woven Stories software was used as an online debating forum. This case study reveals the potential inherent in the concept, compared with other text-oriented Web 2.0 tools, such as wikis.

Introduction

Because of the continuous flow of powerful new technologies, research in the field of educational technology tends to concentrate on the use of mobile technologies, virtual worlds, and other relatively complex tools and technologies. Given the popularity of technology-driven developments of this kind in research, it is easy to overlook the fact that learning is inextricably bound up with thinking and that simple solutions can often be crucial in the evolution of educational research. Jonassen (1992) notes: 'Rather than developing more powerful teaching software, we should be teaching learners how to think more efficiently'. If we are to accomplish what Jonassen recommends, we need to develop a range of simple and generic thinking tools that can be taught to learners. The development of simple tools of this kind is predicated on the realisation that the primary purpose of learning is not how to use the tool but how to think efficiently.

While developing educational tools and software, it should be borne in mind that contemporary scholarly communities all exist in a web of international contacts, and that it is important to be able to support collaboration among these communities. In modern-day educational institutions, for example, online teaching and learning are being used ever more widely. This ubiquity of online teaching and learning in education presupposes a need for effective methods of collaborative knowledge processing. Internet facilities, such as email, discussion forums and usenet news, have become so widely used for collaboration and information delivery that they seem to have become indispensable (Memmi, 2006), even though they are not equally effective for learning in all situations.

The development of Internet-based tools from the traditional Web to Web 2.0 (Ullrich *et al*, 2008), and from information delivery to interpersonal collaboration and group-based knowledge construction and creation, indicates the direction that developers of educational software should be taking. In order to provide an example of a simple and generic tool, we present the Woven Stories (WS). WS is based on a simple and generalisable concept that permits a high degree of original collaborative work. Although WS originated as a means for writing stories, it subsequently proved its usefulness as a *mindtool* (Jonassen, 2000) in several other application areas such as progress reporting, collaborative learning of programming and corporate strategy planning (Myller & Nuutinen, 2006; Nuutinen, 2006; Nuutinen, Liinamaa, Sutinen & Vanharanta, 2004; Salo, 2006). WS provides a supreme example of a useful methodology that is characterised by simplicity, generalisability and collaborative dimensions.

This paper introduces a conceptual framework for understanding *social mindtools*. Social mindtools are tools that enable and facilitate collaboration and communication among—in this case—users in learning communities. We focus on the requirements of mindtools in general and on the requirements of social mindtools in particular. In order to clarify the factors that affect the actions of users when they are using social mindtools, we utilise activity theory as our framework. We especially concentrate on text-oriented social mindtools that allow hypertext-based collaborative writing.

As our main research problem, we investigate *how WS differs from other text-oriented Web 2.0 applications*, namely, wikis, and *how WS works as a debating tool from the viewpoint of activity theory*. Wikis and WS look similar from the viewpoint of activity theory, and they share the basic idea of utilising hypertext (in different ways though); because of this, these tools are an interesting pair to compare. In order to answer the questions, we compared the WS to wikis and carried out a case study, where an application based on WS was used for online debating.

In the remainder of this paper, we will first introduce and describe the concept of WS. After that, we will discuss mindtools in general. We will then formulate activity theory as a conceptual framework and propose a description of social mindtools on the basis of that framework, and compare WS with wikis. This will be finally illustrated by a case study.

Woven Stories

Woven Stories facilitates collaborative work in general and collaborative writing in particular. It incorporates the concepts of *flow charts* (Chapin, 1970), *collaborative writing*

(Lowry, Curtis & Lowry, 2004), *graphs* (Berztiss, 1975, pp. 119–164) and *finite automata* (Hopcroft, Motwani & Ullman, 2003, pp. 37–81). Representationally, it is reminiscent of *concept mapping* (Novak & Gowin, 1984), although it supports serial rather than holistic thinking. Even though WS incorporates features from several other techniques, it is quite unlike any of those techniques. The distinctive feature of WS is that it is a collaborative product in which a woven story is visualised as a graph that contains nodes and links similar to those that one would find in a graph or a concept map. Each node of a collaborative story contains a piece of text and the links which demonstrate the possible directions of flows of the story. Such an approach to representation makes it possible to include several storylines simultaneously in one document.

When creating a document with WS, the users draw the structure of the document on the screen with boxes (sections) and arrows (links). An arrow between two boxes represents the order in which the boxes should be read. At any stage of drawing the structure, users can write content to the boxes. The application allows the users to write an unlimited amount of text to the sections they write. It is up to the group to formulate a common rule for proper length for the text of a node. In all the cases for which we have been using the WS, the lengths of the sections have ranged from just one word to several paragraphs. Boxes do not need to have any arrows to other boxes. Visualising the structure of the document makes it easy to maintain the topology of the document, which can be difficult in wikis (Désilets, Paquet & Vinson, 2005). Also, the visualised structure makes it easy to grasp the relations between different pieces of the document, which is again difficult in wikis (Désilets *et al*, 2005). Moreover, even the composition process of the woven story can be animated based on its structure.

WS, as the name implies, was originally meant for collaborative story/narrative writing. However, during the development process, several unexpected application domains have emerged. In order to allow its use in different application areas, the functionality of the application has been kept as simple as possible. However, the background as a story-writing tool has influenced the features of the concept. For example, the links that connect the pieces of text together are directed, because it is essential that there is the possibility to represent the flow, the direction, of the story in a natural way.

Figure 1 offers a simple example of the structure of a document produced with WS. The figure shows the latest version of WS application called WS@Web, a pure Web application written with JavaScript and PHP. The document itself is a simple set of travel stories. The document contains three possible storylines: to travel to Finland and see Joensuu, to travel to Finland and see Helsinki or to travel to Sweden and see Stockholm.

If users like to share more about their related excursions on their trips, they simply add new boxes to the screen, add relevant contents and create required links.

The first section is the *anchor* for the process because it influences the subsequent thoughts of the other members of a group, however, it is also possible to add alternative beginnings. The rules of WS prohibit a user from modifying an existing section unless

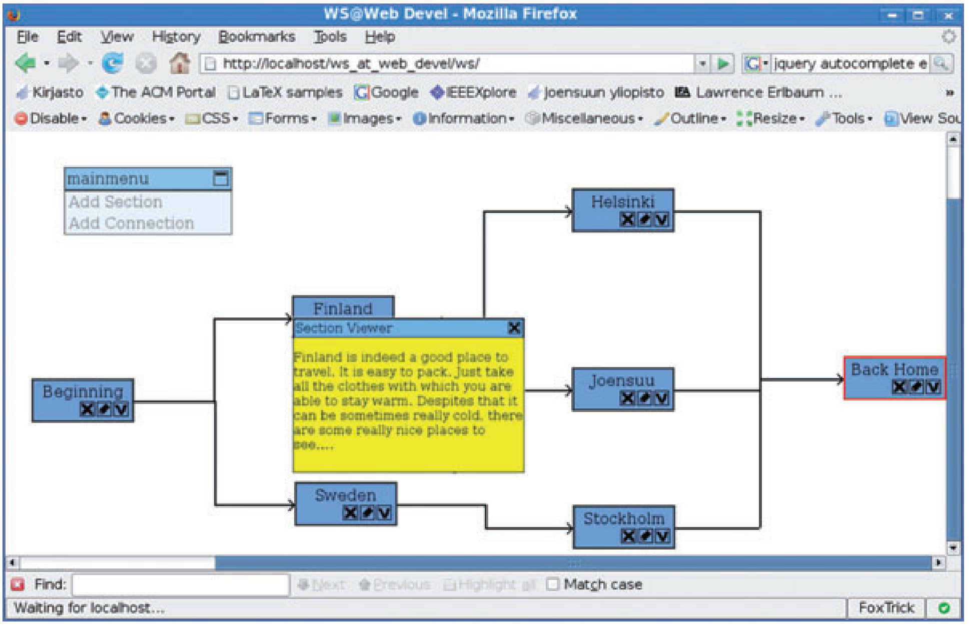

Figure 1: Illustration of WS@Web with a simple travel plan. Contents of the box Finland has been opened

he/she is its original author. This requires the members of a group to contribute their own ideas and opinions if they disagree on the content that has already appeared in existing boxes. The reason for this is that it is necessary for the completed work—the final woven story—to represent the knowledge and opinions of all the members of the group, and even the knowledge formation process. This prevents a problem often related to wikis, namely, *edit wars* (Bryant, Forte & Bruckman, 2005), where people keep changing each other's contributions. Similarly, the possibility to add alternative content instead of editing or removing existing content lowers the threshold to participate in the knowledge construction process, while in wikis, this can be a problem (Bryant *et al*, 2005). It should be noted that the WS method can be used to construct any kind of text-based, or any other media-based, document in which the structure of the knowledge is important, that is, documents where the order of the information is important.

A computer application that utilises the WS concept is called Loom. Because this application has been constructed in the Java programming language, it can be used on almost any commonly available computer. Loom is based on the client-server architecture and allows a virtually unlimited number of users to edit the same WS document. The application, whose interface is presented in Figure 2, implements the basic features of the WS concept: the story space for constructing the document (area 1 in Figure 2), and the content viewer (area 2 in Figure 2) that allows participants to read the content of the sections and links. The toolbar (area 3 in Figure 2) gives utensils for interacting

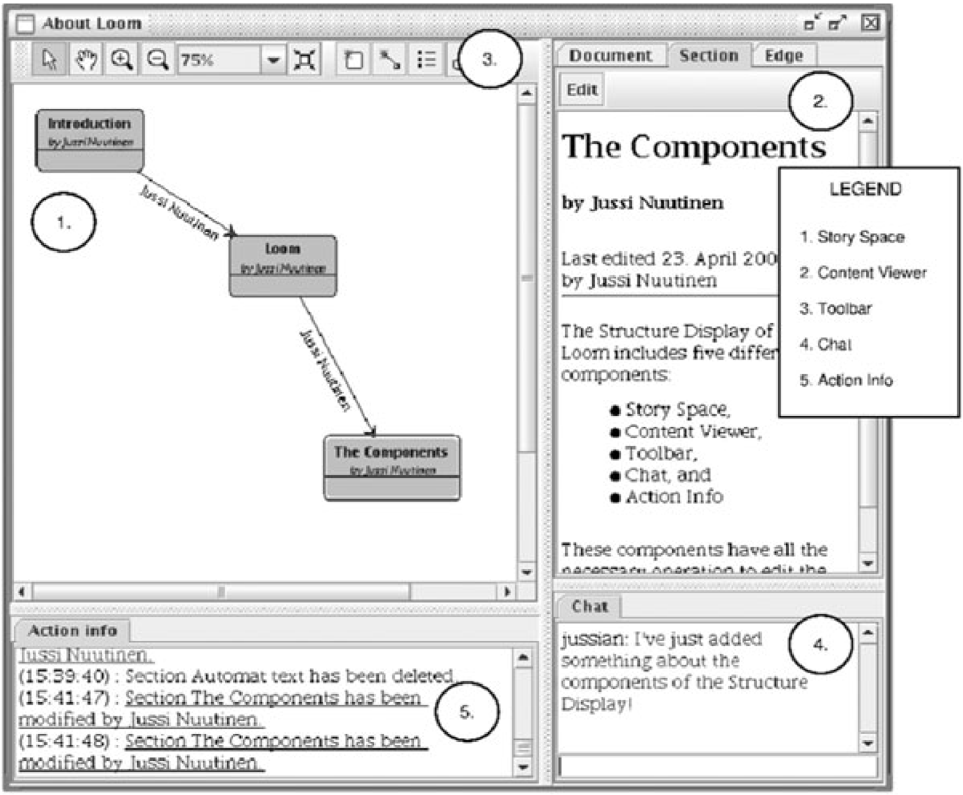

Figure 2: User interface of the Loom—an application based on the concept of Woven Stories

with the story space, the chat (area 4 in Figure 2) allows communication with other users and action info (area 5 in Figure 2) to stay informed about the changes made by other authors to the current document. This version of the tool was used in the experimental case presented in this paper. In order to make the use of the WS even easier, a new web-based version of WS, WS@Web, is currently being developed and is available for experimenting at http://cs.joensuu.fi/wovenstories.

In this paper, we use the case of debate as an example of a potential application of the concept. It is important to note that WS is not just a tool for argumentation/debating. Until now, the different versions of WS application have been used for story writing in various forms, collaborative concept mapping, forest growth simulation reporting, debating, text-based adventure game scripting, corporate strategy planning, mapping research topics and structuring a PhD thesis.

Mindtools

Jonassen notes that 'learning is mediated by thinking' (Jonassen, 1992), and Bereiter states that 'people learn from what they process' (Bereiter, 2002, p. 274). Both these points of view presuppose that a learner is cognitively active in the acquisition, processing and construction of new skills and knowledge. Most learners can only become active in the acquisition and construction of their knowledge and skills if instructors and designers have created and organised appropriate learning activities by means of which they can learn. Thinking is activated by learning activities, and learning activities are mediated by instructional interventions (Jonassen, 1992). While it is the responsibility of educators to design appropriate activities and provide proper input and feedback for the guidance of learners, it is essential for learners to process the material themselves so that their new knowledge will be built on the basis of what they already know. One way of achieving this is by utilising discovery learning (Bruner, 1961). When the learners make use of discovery learning, they follow the same procedure as scientists (van Joolingen, 2000). They generate hypotheses, they set up experiments and tests, and they interpret data—all of which are activities that are traditionally associated with empirical research. Discovery learning encourages learners to discover concepts for themselves rather than to have them presented as a predetermined dogma (Ausubel, Novak & Hanesian, 1978, p. 24). A methodology such as discovery learning requires the kinds of tools, called mindtools (Jonassen, 2000), that support learners as they endeavour to construct and process their own knowledge. Loom is one such useful tool.

One of the features of mindtools is that they can be used for different purposes and in various domains. All mindtools facilitate the construction and processing of knowledge by learners because they extend the range of the learner's mind (Jonassen, 1992) and force the user to think constructively and empirically. Mindtools are thus devices or techniques that help a learner to focus and refine the analytical and experimental processes of learning (Mayes, 1992).

Applying Jonassen (1992) and Mayes (1992), we define a mindtool as *a generalisable knowledge construction device or technique that helps learners to focus their analytical processes*. While this definition is strongly influenced by the fact that mindtools are used mostly for learning, mindtools can be used for other purposes as well. For example, a chief executive officer of a company could benefit from using such a tool when making strategic decisions.

Jonassen (2000, p. 18) presents a list of features or characteristics that a tool or application should have if it is to qualify as a mindtool. These features have been compiled in Table 1 in the column labelled Characteristic. Jonassen's elaboration of these characteristics is contained in the column labelled Necessary features of a mindtool according to Jonassen. A short description is provided in the column labelled Remark. It should be noted that Jonassen's input (Jonassen, 2000, p. 18) implies that all mindtools are computer applications.

Table 1 suggests the following four characteristics of mindtools: accessibility, engagement, multi-purpose utility and usability. *Accessibility* stands for the extent to which the tool is available to its users and the cost of using the tool. Usage should ideally be free. If it is not free, fees for usage should be as low as possible. When mindtools are distrib-

Table 1: Characteristics of a mindtool

Characteristic	*Necessary features of a mindtool according to Jonassen (2000)*	*Remark*
Accessibility	Application is available. Application is affordable.	Funds limit what educational institutions can do. It is therefore important that mindtools are easily available and affordable.
Engagement	Intended for knowledge construction. Supports critical thinking.	These tools assist learners to think and construct knowledge on the basis of their previous knowledge and experience.
Multi-purpose utility	Generalisable. Transferable to other forms of learning.	When students master just one good tool, they can use it to all of their subjects.
Usability	Based on a simple, powerful formalism. Easy to learn.	When students find it easy to master a mindtool, the spin-off is that they will gain at least some acquaintance with technology in education. A good mindtool helps users to focus on the subject rather than on the tool itself.

uted as freeware, they are often able to benefit far more educational institutions than expensively priced software. *Engagement* means that a tool should be designed in such a way that it serves the purposes of knowledge construction and supports critical thinking. *Multi-purpose utility* signifies that an efficient mindtool needs to be generalisable. This means that it can be applied in several application areas and a number of subject domains. Tools of this kind should also facilitate the transferability of whatever skills have been learned. *Usability* intends that it is easy to master the use of a particular tool and to apply it in practice. This criterion takes into account not only the formalism or the concept of a tool, but also its technical quality. The interfaces of the best mindtools have been carefully and thoughtfully conceptualised, designed and developed.

Mindtools are also useful because the skills that are used in their application are easily transferable from one subject domain to another, and from formal to informal learning and vice versa. The use of mindtools promotes the integration of technology and education when little time is available to master the navigation of a technology and to apply its benefits to new subject areas.

Activity theory as a conceptual framework

If mindtools are to be developed to a point where they support collaborative knowledge construction, it is first necessary to analyse the factors that affect users (and learners) as they use such tools. For such an analysis, we use activity theory as a conceptual

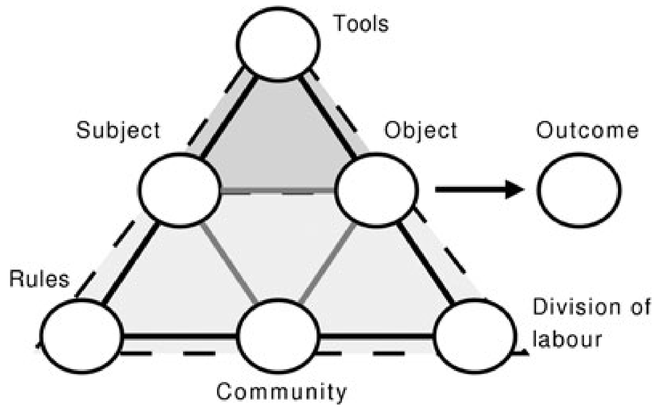

Figure 3: The activity theory model (as elaborated by Engeström, 1987)

framework. We have selected activity theory because it elegantly illustrates important aspects of collaborative activities as well as activities in general.

Several researchers (Bodker, 1989; Kaptelinin & Nardi, 2006; Kuutti, 1995; Nardi, 1995) have proposed the use of activity theory as a conceptual framework for understanding mediated work practice. Engeström (1987) notes that activity theory had its foundations in classical Russian psychology, according to which the human mind is understood in the context of meaningful, goal-oriented interactions between human beings and the environment in which their actions take place (Kaptelinin, Kuutti & Bannon, 1995). Kaptelinin and Nardi (2006) use activity theory to explain how people act with tools and how such tools are both designed and used in the context of intentional actions. This theory defines people as subjects who construct and give form to their intentions and desires in the shape of objects. Activity theory describes this relationship between people and tools as one of *mediation*. Engeström extended the scope of the activity theory model in the way that is presented in Figure 3.

In Engeström's model, the relationship between the object and the community is mediated by the division of labour, and the relationship between the subject and the community is mediated by rules. While tools are used in the transformation process, the rules by which they work are the explicit and implicit norms and conventions that determine the social relations within a community. Division of labour refers to the ways in which a community is organised (Scanlon & Issroff, 2005).

The activity theory posits that conscious learning arises out of action (Jonassen & Rohrer-Murphy, 1999). While activity theory is not the only model that can be used to frame WS, it accounts for most, if not all, of the factors that affect individuals when they engage in such an activity. Because learning and using a computer application are also activities, it is possible to analyse them in terms of activity theory. It is important, when designing and developing software for learning, to ensure that the applications concerned are able to support the activities of learners. It is possible to use mindtools to do this because they are specifically designed to support the thinking activities of learners.

In Figure 3, mindtools are represented in the upper (darker grey) part of the triangle, where they offer a means for individual learners to process information in order to achieve an objective. As a conceptual framework, activity theory emphasises the importance of the surrounding community in which learning takes place. The context of the community is especially important for learning because, as Jonassen points out (Jonassen, 1999), learning occurs most naturally wherever teams of people work together towards a particular goal. Wherever individuals engage in learning activities together, they automatically constitute a learning community. Before learning communities can be supported with knowledge-processing tools, the mindtools themselves first need to be developed and refined with features that enable, support and engage learners as they collaborate on learning tasks.

Social mindtools

There are available mindtools which serve individual processing needs, and existing collaborative systems which serve needs such as communication and data sharing. Even though effective collaboration requires people to share information as they communicate (Ellis, Gibbs & Rein, 1991), there is still more that can be achieved to improve collaboration. If we want to improve the thinking capacity of communities, as well as their ability to process data and construct knowledge, we need to introduce social mindtools into the equation. *Social mindtools* are those mindtools that enable communities of learners to work together efficiently to process data and undertake collaborative activities. Social mindtools could therefore be defined as *generalisable and collaborative knowledge construction devices or techniques that help learners to focus their analytical processes in order to achieve a common objective*. While this definition allows for the definitional requirements of mindtools, it also adds those dimensions that are necessary for collaboration. Obviously, there are several Web 2.0 tools that meet the requirements of social mindtools.

The activities of individuals in a learning community are essentially dialogue and collaboration, and the members of a learning community use tools to mediate their work and achieve their common goals and objectives. It is during the process of using such tools for various activities that the community develops and constructs a shared body of knowledge. Because all members of a learning community are able to contribute to this shared body of knowledge, all of them are able to participate in the common task of knowledge building. Through the process of gathering, collating and systematising opinions and information from different individuals, social mindtools are able to offer the benefits and advantages of mindtools to a community. Because social mindtools require learners to be able to explain and give reasons for whatever data and opinions they offer to a community, they force learners to think about their contributions and to process the information, knowledge and opinions that they propose to offer to the community. One may compare the transformation from mindtools to social mindtools with the transformation from the traditional Web to Web 2.0. Instead of an

Table 2: Additional requirements for a social mindtool

Characteristic	*Requirements*	*Remarks*	*Relevant aspect in activity theory*
Access	Preferably web based.	Web-based applications are easier to access. Maintenance of the software can be minimised for the end-user.	Community
Engagement	Provides awareness information. Offers a channel for communication.	If communication is to take place, learners must first be in contact with one another. Contact of this kind allows learners to be informed about what other learners are doing. Communication is an indispensable requirement for collaboration.	Community Rules
Multi-purpose utility			
Usability	Enables editing a shared object.	If they are to collaborate efficiently, learners must be able to edit a common object.	Community Division of labour

emphasis on raw information and the importance of individual contributions, there is a definite focus on the processing of collaborative information. There are tools that can be classified as social mindtools; a common example would be the wikis. Generally, the aim of the Web 2.0 trend seems to be, more or less, to offer tools that provide users with the possibility to share knowledge and collaboratively construct new knowledge. These tools encourage participation and are social and open (Ullrich *et al*, 2008). However, many of these tools are meant for one specific use and thus cannot be utilised outside their original application area.

While the way in which a social mindtool supports collaborative work is, of course, tool-specific, it is possible to make general inferences on the basis of activity theory. Although the basic features of mindtools are present in the case of social mindtools, social mindtools need to support collaboration in particular. Table 2 sets out the supplementary requirements of social mindtools (Table 2 is constructed in the same way as Table 1 in order to facilitate comparison between the two tables).

A community of learners has to be able to construct common knowledge as they communicate. By using common features for communication, the community is able to set rules and organise the division of labour in advance. But if a community of learners wants to undertake activities in a more comprehensive and thorough way, it needs to be empowered with features that support *awareness* (see, for example, Gutwin & Greenberg, 1996). It is only possible for learners to construct knowledge together if they are clearly aware of the thoughts, activities and opinions of other members of their learning community before, during and after the learning construction process. It is this kind of knowledge that creates the feeling of community that makes the process collaborative. We observed the importance of this kind of awareness in our experiments, as in the user case that is presented later in this paper.

When we examine WS in the light of Jonassen's characteristics in Table 1 and the requirements presented in Table 2, we cannot but come to the conclusion that WS is a social mindtool. While WS engages learners in the construction of their knowledge, it also supports critical thinking. It allows users to create their own knowledge on the basis of their own and their peers' existing knowledge. It gives learners opportunities to reflect on their own knowledge as well as that of their peers, and it enables them to engage in collaborative knowledge building. Participation in WS requires users to analyse and understand the existing knowledge in order to contribute new information and make a relevant and meaningful contribution. It can be seen that the *modus operandi* of WS facilitates those activities that precede learning, that is, efficient thinking and information processing. WS can also be used for various other purposes. Once learners have learned how to use this tool within one subject or task, they are in a position to utilise their newly acquired skills for other subjects or tasks as well. The fundamental concept of WS is simple but powerful. Our tests of the product have also indicated that it is easy to master.

Woven Stories and wikis

Wikis provide an example of a commonly available text-oriented Web 2.0 application and were selected to this comparison in order to introduce the concept of WS in contrast to a more familiar tool. Furthermore, WS and wikis fundamentally share the same idea of collaboratively editing hypertext, although the ways these tools represent the knowledge make their look and feel totally different. They have been set high exceptions especially as a support mechanism for collaborative learning. However, research has identified several shortcomings in the usability of wikis (Bryant *et al*, 2005; Désilets *et al*, 2005). The comparison shows how WS can overcome many of the limitations of wikis.

In this section, we compare WS and wikis in terms of 10 attributes represented in Table 3. These attributes have emerged from this analysis, but are related to characteristics of accessibility, engagement, multi-purpose utility and usability presented in Tables 1 and 2. The characteristic related to each attribute in shown in parenthesis after the attribute name. Attributes are divided to five categories that compile closely related attributes together.

The first attribute, *accessibility*, comes directly from the requirements of social mindtools. Both WS and wikis are freely available. However, the drawback of the Loom is that it is based on Java and thus needs an installed program for users. However, the new WS@Web solves this problem. The next attribute, *purpose*, describes the expected function of the tools. In wikis, this is to produce all kinds of documents, but the WS is meant for writing documents where the structure of the document is important. A typical product of WS is a collection of a student group's variants of a given folklore tale.

Table 3: Summary of the differences between Woven Stories and wikis

Category	*Attribute*	*Woven Stories*	*Wiki*
Accessibility	Accessibility (A)	Available for free	Several implementations available for free
Purpose	Purpose (M)	To write a document where the structure is important (eg, stories)	To write any document
Usage	Representation (U)	The structure of the document is visualised as a graph	No visualisation available Documents are hypertext pages
	Synchronicity (E, U)	Semi-synchronous: allows both synchronous and asynchronous activities	Asynchronous
Structural aspects	Structure (U)	Simple, sections form linear 'storypaths' Links represent the order of the storyline	Complex, links form non-linear paths Links are independent of the order of the storyline
	Topology (U)	Visible in user interface	Hidden from the user
	Maintenance of topology (U)	Easy to maintain Graphical maintenance	Typing errors and similar problems can make it difficult Sometimes needs transition diagrams (eg, before writing stories)
Ownership/ access	Ownership (E, U)	Everyone can create new storylines (boxes with links) Only the creator can edit his/her storylines (individual boxes)	Everyone can create new content and links Everyone can edit all content
	Tolerance (E, U)	Low threshold to add new data No need to change existing content	High threshold to add new data, especially for novices Often need to edit existing content
	Conflicts (E, U)	Because of organised ownership, no conflicts are possible	Possibility for edit collisions Possibility of edit wars

A, accessibility; E, engagement; M, multi-purpose utility; U, usability.

Two attributes are related to the usage of these tools. *Representation* describes how the information stored by the tool is shown for the users. In wikis, the representation is a somewhat traditional web page, while WS visualises the structure of the document as a graph in the user interface. Thus, WS emphasises the meaning of the structure even in the user interface. *Synchronicity* refers to which extent the application allows simultaneous usage. This is divided into three levels. *Synchronous* applications are tools where simultaneous users can work with the same content at the same time. *Asynchronous* applications do not allow simultaneous usage, and *semi-synchronous* applications can be used in both ways.

Three attributes are related to the structural aspects of the documents. Attribute *structure* refers to the structure of the document as well as to the linking between different parts of the document. Because of the plain linking system of WS, the structure of the documents remains simple. In wikis, however, the links can be placed anywhere in the text, allowing extensive additional data and vast possibilities of traversing the document at the expense of comprehensible structure. Because of the simple structure of the WS, it is possible to visualise the *topology* of the document for the users in the user interface. In wikis, the topology could be visualised with proper scripts based on the wiki links, but because of the complex nature of the structure, it is normally hidden from the user. *Maintenance of topology* then refers to how the topology and the structure of the documents are maintained in these systems. In WS, the topology is maintained in the graphical user interface by adding boxes and links. Thus, the maintenance is a natural part of the workflow. In wikis, the topology is maintained by adding link tags to the document text, which can cause problems, for example, because of typing errors (Désilets *et al*, 2005). Similarly, in the study of Désilets *et al*, (2005), the users drew a state transition diagram of their story before writing it to the wiki; with WS, this would have not been necessary.

The last three attributes are related to the ownership and access of the documents. *Ownership* refers to the role of the creator versus user and browser, that is, who is in control of the contents stored in the application. In wikis, everyone has a full control over all the data. Anyone can add new content and edit existing content. In WS, however, anyone can add new content, but only the original author can modify existing data. Ownership also relates to the *tolerance* of the system, by which we mean how easy it is for novices to add new data to the system. Research has reported that especially novice users of wikis are reluctant to make drastic changes when starting to use Wikipedia (Bryant *et al*, 2005), and we do believe that this holds in all wiki use cases. WS requires the users to add new content instead of changing existing content. In this way, the collaborating group can decide which pieces of alternative information are important. Furthermore, the restricted access to content—the approach used in WS—reduces *conflicts*, such as edit collisions (Désilets *et al*, 2005) and edit wars (Bryant *et al*, 2005).

Table 3 thus summarises the differences between the WS and wikis. Furthermore, Table 3 presents a classification which can be used to evaluate text-oriented social mindtools. It is not surprising that most of the attributes which emerged in this analysis are related to characteristics of *engagement* and usability; it is highly important that these types of tools can efficiently be used for collaborative knowledge construction, that they engage users for knowledge contributing and that they are easy to learn and use. Based on this analysis, we claim that WS can help to overcome the shortcomings of wikis especially in situations where the structure of the document produced and the thinking which it captures is important. Similarly, the approach used in WS can lower the threshold for novices to start contributing knowledge.

When compared with other text-oriented Web 2.0 tools, such as GoogleDocs or blogs, WS offers a totally different approach to writing documents. GoogleDocs is just another collaborative text editor, while in contrast, WS allows the users to create, see and edit a shared document from a totally different perspective, in a graphical way. Furthermore, because of the graphical representation of the structure, WS-based applications are highly generalisable for various application areas.

Case: debates with Woven Stories

Problem and setting

In the spring of 2007, we designed an experiment that would allow us to observe how users used WS to engage in debate. We were specifically interested about the utility of the tool in relation to debating. Whether students learned better was intentionally left out from this study, the emphasis was on the process how they learned. The main problem was to analyse *how does WS work as a debating tool from the viewpoint of activity theory?* Furthermore, we were interested in how WS might differ from wikis in this context. This case study concretises and exemplifies WS in relation to activity theory, and in contrast to other text-oriented Web 2.0 tools in the context of online debating.

The case was selected for this study because it could have been carried out with other text-oriented Web 2.0 tools as well, for example, with wikis or blogs. The users in this case represented various cultures with different backgrounds. The case was also known to generate data that is strongly dependent on the structure, because in debates, most arguments are based on previous input. A downside of this case was the fact that the debate arguments of the students were quite brief. Also, because of the spatial and cultural distribution of the users, the case was challenging.

The participants, presented in Table 4, were students from the University of Joensuu (Finland), the University of Montana (USA) and the Akaki Tseretely State University (Georgia), all of whom were invited to participate in a debate on two topics. While the students from Montana were all majors in subjects such as Communications and Political Science, those from Georgia were majoring in American Studies. The first claim of the debate was 'Globalization through the use of information and communication technologies is creating cultural homogenization along Western Lines'; the second was 'The mass media has been instrumental in creating an informed global public'. Each of these debates lasted for 2 weeks.

Table 4: Participants in the case study

University	*Major*	*Number of participants*	*Number of respondents*
University of Joensuu, Finland	Computer Science	25	14
University of Montana, USA	Various, but mostly Communications and Political Studies	9	2
Akaki Tseretely University, Georgia	American Studies	4	3

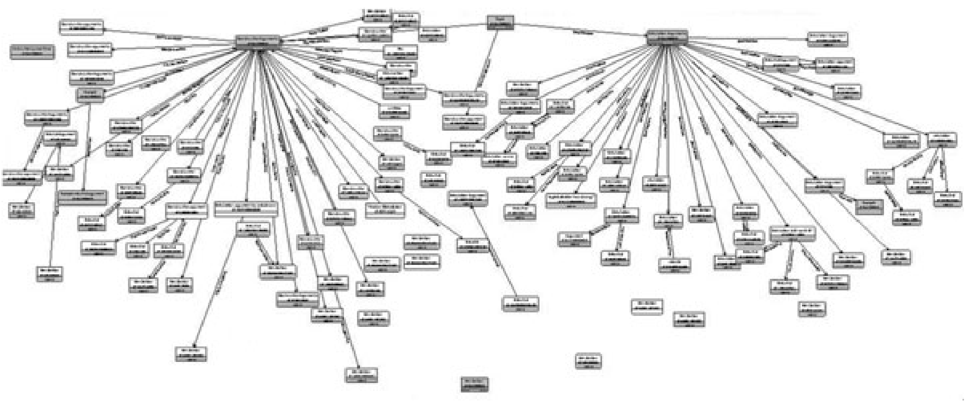

Figure 4: Screenshot of the structure of the final document after the first claim of debate

In order to provide a starting point for the students, we introduced three sections (boxes) into the preliminary woven story. One section contained the debate claim. The two subsequent sections were entitled constructive arguments and *refutation arguments*. All the students were required to express their points of view under these headings. In addition to this, each student was required to construct at least one rebuttal for any comment made by any other student. These three preliminary sections are visible on the top of the story space in Figure 4 (they are shaded somewhat darker than the other sections). The tool used in this experiment was the Loom. The setting in this case was rather constrained, which naturally affected the flow of the debate. It might have been better to let the students use the tool freely, but in order to ease the assessment, this approach was selected.

Method

After each round of the debate, a questionnaire was sent to each of the participating students. User IDs were created for a total of 51 students. Out of these 51 registered students, a total of 38 participated in the actual debate and 19 answered the first questionnaire (on which this analysis is based). The user IDs were created based on the course enrolment lists, so we assume that the 13 missing students had dropped their course before the actual debate. The final answer rate, 50%, was moderate, but enough for our analysis.

The questionnaire took the form of a web-based form, and the link to the questionnaire was sent to the participants by means of email. The questionnaire was divided into two parts. The first part dealt with the usability of the tool, and the second part dealt with the perceived utility of the tool as an online debating forum. Both parts were again divided into two parts, where the first part included the multiple-choice questions and the second part included open-ended questions. All multiple-choice questions were formulated as statements, such as 'T*he Loom is a useful tool for debating*', and all had a Likert scale range of *strongly agree*, *agree*, *disagree* and *strongly disagree*. The format of the statements was altered through the questionnaire in such a way that some of the questions were negative statements and some were positive statements. Whether the statement was positive or negative was randomly selected.

Open-ended questions were presented as pairs in such a way that we asked for both positive comments and negative comments in different questions. In the utility part, we asked first '*In what ways was the Loom good for debating, and why?*' and right after it '*In what ways was the Loom bad for debating, and why?*'.

The results of the questionnaire were analysed both quantitatively as well as qualitatively. Histograms were constructed from responses to multiple-choice questions, and the Weka (The University of Waikato, Hamilton, New Zealand) data mining software (Witten & Frank, 1999) was used to determine any surprising or strong dependencies between the answers. The open-ended answers were grouped together and considered as 'mini interviews'. Then, features of the grounded theory approach were used to analyse the answers. All answers were split to smaller, meaningful parts, and classified to various categories. Examples of categories include *community*, meaning the other users, and *structure*, meaning the way Loom represents the structure of the document. After classification, the categories were related to terms of activity theory and analysed in order to see what students saw as important aspects.

Before the students were involved in the research, they were asked to fill out an electronic informed consent form and to agree to participate in the research. Alternatively, they were given the right to refuse permission for their data to be used for the purposes of research.

The analysis that follows is based mostly on the answers to the second part (questions about perceived utility).

Analysis

This experiment proceeded smoothly, and students and teachers alike seemed to enjoy using Loom for the debates. It was evident to us that Loom and the use of WS offered a functional visual format for debate because it offered participants an easy way to refer to several parts of an argument in one post.

Student C: Simple, quick to learn, creates a good overall picture of a debate.

Most of the participating students did not have much experience of debate in educational settings prior to the case study. Ten of them had no experience of debating at all, and seven described themselves as having participated in debates from between one and five times before the commencement of the research. Only two students could be described as experienced in the art of educational debating. Despite the relative absence of debating experience among the participants, the online debate indeed resembled a real, although not very excitable, debate. Fifteen students expressed the opinion that the Loom was a useful tool for online debating.

Students also agreed that the visual representation of the storyline (which in this case was the topic of debate) was 'quite good'. It should be noted that without visual representation, the control of the structure of the debate would have been difficult. Because of this reason, we believe that WS is a better tool for debates than, eg, wiki or online forum. Fourteen students were of the view that it was easy to follow the debate in Loom. An interesting finding was that four of the five students who generally did not like Loom said that it was easy to follow the debate. Negative feedback related mostly to problems of navigation within the document itself. Several students complained that the document had become too big and that this had made it rather difficult to find the sections that they were looking for. This defect is observable in Figure 4. It shows how large the structure of the final document had become after the first round of debate.

Student B: Its a nice way to see the everyone's debate. But I don't know. If the number of people was a little bit larger, it's gonna be a mess.

Student C: If there are a lot of arguments from which only few are interesting, it might be hard to find those good ones.

Although each of the debates commenced in an atmosphere of relative calm, more and more students began to offer their contributions as the deadline approached. While most students did only as much as was expected of them, a few of them offered additional comments. Some of these students expressed the wish that there had been more activity and engagement:

Student A: It felt more like people just adding their 2 cents. Perhaps this may be because of the inexperience of the participants.

The above quote seems to highlight the fact that the task given for the students was too closed. Requirement to post certain types of arguments forced the students to come up with arguments that might have not been natural enough. Figure 4 represents the structure of the woven story document at the end of the debate. As can be seen from Figure 4, the structure indeed represents a tree which suggests that students have done only what they were required to do. If, however, it had been possible to continue the debate, the structure could have been ended with a more graph-like nature. It would be possible to add emergent ideas and arguments to the document without linking them to the existing content. The application does not require the user to create the links.

Furthermore, even though the author of the text would not see where to link the argument posted, there can be another user who could do it.

The tendency of the document to grow to an unmanageable size could be resolved either by limiting the number of debaters or (obviously a better solution) by implementing features that would allow debaters to easily find the arguments that fit their needs. Effective information retrieval methods would make it possible for users to locate relevant sections and even story paths. Such methods would provide a necessary scaffold for users as they prepare their input.

One surprising finding was that some students were actually using other tools that were not part of Loom's interface. Some students, for example, used Microsoft Word or other word processors to construct their arguments before they added them to Loom. The most probable explanation for this is that some of the students were not native speakers of English and they wanted to check their spelling before making their contributions public. It is also possible that the typing feature offered by the Loom was not adequate (although no one specifically complained about it). But students did complain about other tools. Several students described the difficulty they experienced when they tried to paste text into Loom from another text editing tool. We regret to say that there was indeed a problem with the copy/paste feature. However, without this problem, we would not have obtained the information about the use of other tools from the students.

It seems that the students did not create any specific rules for the debates but merely tried implicitly to follow the kinds of rules that conventionally govern online debating. As has already been mentioned, the majority of the participants had little prior experience of online debates. This might, to some extent, explain why the debates started so slowly. Even though the communication features of Loom were not all that sophisticated, it seems that they were adequate enough to allow the students to feel that they were part of a community. A few Computer Science students, for example, were worried about the ability of the other students to use the tool. Several other students also mentioned that they would have preferred to know more about the other participating students and the circumstances of their lives. While this may indicate that it is important for students to know something about the background of all the other users, such knowledge was not essential for participation in the debates. The tasks that the students were required to perform did not actually require any kind of collaboration. But the expressed needs of the students mentioned above support the claim that a good collaboration tool should create a format that allows participants to acquire knowledge about the circumstances of other users (as we already have indicated in Table 2). With WS, this could have been implemented as a parallel story though.

Discussion

Figure 5 summarises the characteristics and findings of this case study in terms of activity theory and in contrast to our second research problem. As can be seen, it is possible to explain the activities of the subject, ie, as an individual learner participating in the debate, with terms of activity theory. Because the debate was an exercise in a

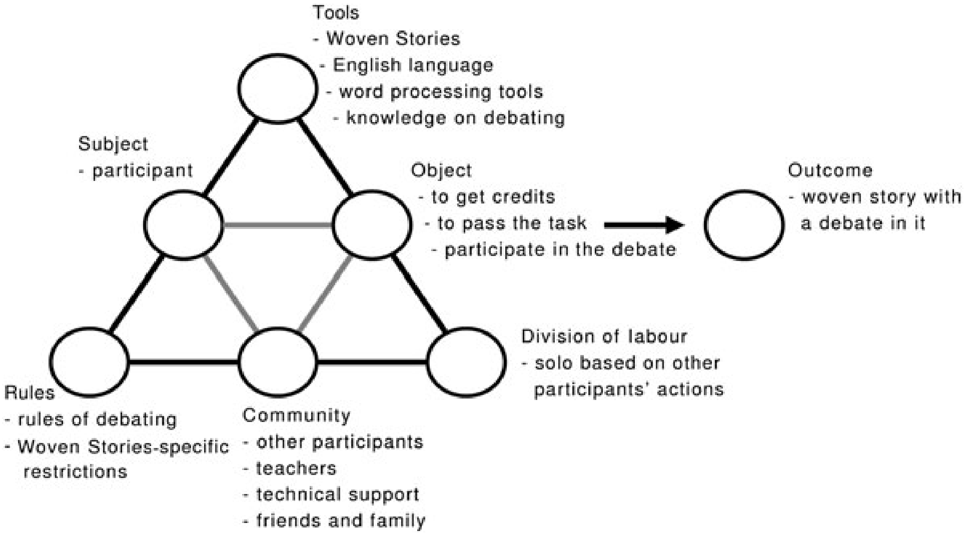

Figure 5: Activity theory and debates with Woven Stories

course, the purpose of the participants was to pass the course and obtain the credit units. Making participation in the debates an obligatory part of a course for which they had enrolled provided the students with the necessary motivation to take part. The subjects used various available tools to perform actions. These tools included the WS application, skills in English language and an aptitude for debating. The final analysis of the data made it clear that some of the subjects also used other applications such as word processing tools to write their statements.

Figure 5 maps the activities of the debates from the viewpoint of the individual learner. Because the students were using a social mindtool in this experiment, we were able to place an emphasis on the collaborative requirements of the task. 'Community' in this context includes fellow participants, teachers, technical support staff, and the friends and families of the participants. While it might, at first, seem odd to include friends and families in our definition of community, these people had to be included because they exercised a strong determining effect on the opinions and knowledge of the participants in the experiment.

It is easy to describe the division of labour in this experiment because each of the participants was required to undertake certain specific tasks alone and unaided. It was inevitable that input from other participants in a procedure such as this would affect the work of individual subjects. A debate cannot, by definition, be carried out alone, and the rules that were applied in the community were those acquired from previous experience and convention. All the participants were briefed in their universities on debating procedures before the activity actually commenced. The WS used in the activity also

Table 5: Debate case summarised relative to attribute categories of Table 3

Attribute category	*Debate case with Woven Stories*	*Wiki (hypothetical)*
Purpose	Debating online	Debating online
Usage	Graphical representation allows easy understanding of the flow of the debate	In the wiki format, the flow of the debate would be difficult to understand
	Users are able to attend the debate simultaneously	If done on one page only, a big risk for edit conflicts exists
Structural aspects	Continuing the debate is easy, as the structure can be easily maintained	It is possible to create too complex structures
	Every argument of the debate is based on previous argument(s)	Difficult to present the flow of the debate in a sensible manner
Ownership/ access	Require users to contribute their own arguments, instead of editing others' arguments	Users could edit each others' arguments, instead of posting their own

affected the rules. Thus, for example, participants were not allowed to change any part of what other participants had already written.

If we base our evaluation on activity theory and WS, it seems that a certain amount of information about other participants is essential for the proper functioning of a social mindtool. This kind of information enables participants to understand the context and situation of other participants, and therefore, to communicate better. Information about other participants also engenders a sense of belonging to a group, and this in turn strengthens the motivation of participants.

It is clear that WS has its strength especially in situations where the structure of the document and information are critical issues. A debate is an example of such a case, because arguments stated by participants are (almost) always based on previous arguments. Table 5 concludes this case in terms of the four categories presented in the section *Woven Stories* and *wikis* and in Table 3. We also hypothesise how WS performs better in debating than wiki.

Based on the feedback from the students in this case, it was obvious that the graphical presentation of the document made it easy to understand the flow of the debate. As a downside, with such many students, the structure got eventually complex. Adding new arguments and linking them to previous arguments was found to be easy. Furthermore, the fact that WS does not allow users to edit other students' arguments forces the students to contribute their own opinions.

The task in this particular case was a rather closed problem with certain requirements students had to fulfil. This led to a tree-like structure (see Figure 4) with primarily *deductive* reasoning: students were expected to compose arguments and counterarguments related to only *one* existing section. We believe that the full capacity of the WS would emerge in the context of a longer and less restricted debate. This allows the participants to draw upon arguments of other participants in an *inductive* way: they can compile synthesised arguments by links to *several* existing sections. That will enrich the debate and lead to a collaborative knowledge creation process.

From the point of view of the activity theory, the items categorised under usage in Table 5 are related to *tools* and *rules*. Ability to easily understand the debate makes it possible for the users to debate by using WS. The possibility of attending the debate simultaneously reduces the needs of rules. Items under the structural aspects are related to *tools*, *rules* and *community*. By being able to easily continue the debate, users share their arguments with the community; similarly, they obey the rules by following the standards created by the tool. Ownership and access-related items are related to *rules*, *community* and *division of labour*. WS forces the users to contribute their own arguments, thus, it defines an important rule for the division of labour and the role of a member of a community.

Even this simple case shows the strengths of WS in a situation where the groups need to produce a document that strongly relies on structure. The visual approach of WS allows users to see the structure of the document easily, thus making it easy to grasp the flow of the debate. At the same time, it is possible to easily link own arguments to existing arguments, thus referring to several previous arguments, something that is difficult in online forums and wikis.

If the debate had been carried out as a wiki, there would have been a risk that instead of posting their arguments, students might have changed each other's arguments, thus posing a threat of an edit war. The possibility to freely edit a shared content is beneficial in some contexts, but not always.

There are plenty of tools for argumentation and debating available at the Internet (see, eg, Cho & Jonassen, 2002). These tools, because specifically developed for these activities, offer naturally a more versatile collection of features for this purpose. The advantage of the WS approach is that with the same tool, it is possible to do plenty of different things. It is up to the imagination of an individual user or instructor how the WS is used. This is exactly the reason why we have kept the application as simple as possible. The new version of the application, WS@Web (http://cs.joensuu.fi/wovenstories.), makes the tool easily accessible and useable for various tasks.

Conclusions

Properly designed social mindtools are ideal but rare instruments for supporting collaborative knowledge processing and construction. These tools extend the scope and capacity of mindtools by adding features for collaboration and communication, and by facilitating thinking and knowledge building in a learning community. We have shown that WS is an example of a functional mindtool. We used activity theory to define social mindtools and their requirements. While activity theory may not be the only theory to support the use of social mindtools, it did enable us to take into account the most important features that needed to be considered in the context of collaborative applications.

Social mindtools are tools for constructing knowledge by means of collaborative effort, and they can be used to focus and give form to a community's analytical processes. In order to qualify as a social mindtool, any individual tool must meet the requirements of mindtools which were presented in Table 1, as well as those of social mindtools presented in Table 2.

In order to analyse how WS differs from another text-oriented Web 2.0 applications, we compared WS to wikis. Results of this analysis and a classification that can be used to evaluate text-oriented social mindtools are shown in Table 3. Furthermore, we analysed how WS works as a debating tool from the viewpoint of activity theory, and compared that with a hypothetical case of debating with wiki. Results for this analysis are represented in Figure 5 and Table 5. Our analysis indicates that WS is a potential instrument for debating, among other purposes, and that it solves several shortcomings of other text-oriented Web 2.0 tools, particularly wikis. Most important advantages were that maintaining and understanding the structure of the document was easier with WS, and that the approach used in WS can lower the threshold for novices to start contributing knowledge. This is also a starting point for several new research questions and challenges for developing exciting text-oriented social mindtools.

Acknowledgements
We would like to thank Dr Phyllis Ngai of the University of Montana-Missoula and Dr Irakli Tskhvediani of the Akaki Tsereteli State University for their collaboration during this case study.

References

Ausubel, D. P., Novak, J. D. & Hanesian, H. (1978). *Educational psychology: a cognitive view*. New York: Holt, Rinehart and Winston.
Bereiter, C. (2002). *Education and mind in the knowledge age*. Mahwah, NJ: Lawrence Erlbaum Associates.
Berztiss, A. T. (1975). *Data structures theory and practice*. New York: Academic Press Inc.
Bodker, S. (1989). A human activity approach to user interfaces. *Human-Computer Interaction*, *4*, 3, 171–195.
Bruner, J. S. (1961). The act of discovery. *Harvard Educational Review*, *31*, 21–32.
Bryant, S. L., Forte, A. & Bruckman, A. (2005). *Becoming Wikipedian: transformation of participation in a collaborative online encyclopedia. Proceedings of the 2005 International ACM SIGGROUP Conference on Supporting Group Work* (pp. 1–10). New York: ACM.
Chapin, N. (1970). Flowcharting with the ANSI standard: a tutorial. *ACM Computing Surveys*, *2*, 2, 119–146.
Cho, K. L. & Jonassen, D. H. (2002). The effects of argumentation scaffolds on argumentation and problem solving. *Educational Technology, Research and Development*, *50*, 5–22.
Désilets, A., Paquet, S. & Vinson, N. G. (2005). *Are wikis usable? Proceedings of the 2005 International Symposium on Wikis* (pp. 3–15). New York: ACM.
Ellis, C. A., Gibbs, S. J. & Rein, G. (1991). Groupware: some issues and experiences. *Communications of the ACM*, *34*, 1, 39–58.

Engeström, Y. (1987). *Learning by expanding: an activity-theoretical approach to developmental research*. Helsinki: Orienta Konsultit.
Gutwin, C. & Greenberg, S. (1996). *Workspace awareness for groupware. CHI '96: Conference Companion on Human Factors in Computing Systems* (pp. 208–209). New York: ACM Press.
Hopcroft, J. E., Motwani, R. & Ullman, J. D. (2003). *Introduction to automata theory, languages, and computation*. Upper Saddle River, NJ: Pearson Education International Inc.
Jonassen, D. (1999). Designing constructivist learning environments . In C. M. Reigeluth & NJ Mahwah (Ed), *Instructional-design theories and models* (pp. 215–239). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.
Jonassen, D. & Rohrer-Murphy, L. (1999). Activity theory as a framework for designing constructivist learning environments. *Educational Technology, Research and Development*, *47*, 1, 61–79.
Jonassen, D. H. (1992). What are cognitive tools? In P. A. M. Kommers, D. H. Jonassen & J. T. Mayes (Eds), *Cognitive tools for learning* Vol. F 81 of NATO ASI Series (pp. 7–18). Berlin Heidelberg: Springer Verlag.
Jonassen, D. H. (2000). *Computers as mindtools for schools* (2nd Ed.). Upper Saddle River, NJ: Merrill Prentice Hall.
Kaptelinin, V., Kuutti, K. & Bannon, L. J. (1995). Activity Theory: Basic Concepts and Applications. In B. Blumenthal, J. Gornostaev & C. Unger (Eds), Human-Computer Interaction, 5th International Conference, EWHCI '95, Moscow, Russia, July 3–7, 1995, Selected Papers (pp. 189–201). Berlin Heidelberg: Springer.
Kaptelinin, V. & Nardi, B. A. (2006). *Acting with technology: activity theory and interaction design (acting with technology)*. Cambridge, MA: The MIT Press.
Kuutti, K. (1995). *Activity theory as a potential framework for human-computer interaction research* (pp. 17–44). Cambridge, MA: Massachusetts Institute of Technology.
Lowry, P. B., Curtis, A. & Lowry, M. R. (2004). Building a taxonomy and nomenclature of collaborative writing to improve interdisciplinary research and practice. *Journal of Business Communication*, *41*, 1, 66–99.
Mayes, J. T. (1992). Cognitive tools: a suitable case for learning. In P. A. M. Kommers, D. H. Jonassen & J. T. Mayes (Eds), *Cognitive tools for learning* Vol. F 81 of NATO ASI Series (pp. 1–6). Berlin Heidelberg: Springer Verlag.
Memmi, D. (2006). The nature of virtual communities. *AI & Society*, *20*, 3, 288–300.
Myller, N. & Nuutinen, J. (2006). JeCo: combining program visualization and story weaving. *Informatics in Education*, *5*, 2, 255–264.
Nardi, B. A. (Ed.) (1995). *Context and consciousness: activity theory and human-computer interaction*. Cambridge, MA: Massachusetts Institute of Technology.
Novak, J. D. & Gowin, D. B. (1984). *Learning how to learn*. New York: Cambridge University Press.
Nuutinen, J. (2006). *Designing a computer supported collaborative mindtool: Woven Stories* (Licentiate thesis, University of Joensuu).
Nuutinen, J., Liinamaa, K., Sutinen, E. & Vanharanta, H. (2004). Woven Stories as a tool for corporate strategy planning. In P. Kommers, P. Isaias & M. B. Nunes (Eds), *Web based communities 2004* (pp. 438–441). Lisbon: IADIS Press.
Salo, M. (2006). Woven strategies (PhD thesis, Tampere University of Technology).
Scanlon, E. & Issroff, K. (2005). Activity theory and higher education: evaluating learning technologies. *Journal of Computer Assisted Learning*, *21*, 6, 430–439.
Ullrich, C., Borau, K., Luo, H., Tan, X., Shen, L. & Shen, R. (2008). *Why web 2.0 is good for learning and for research: principles and prototypes. Proceeding of the 17th International Conference on World Wide Web* (pp. 705–714). New York: ACM.
van Joolingen, W. R. (2000). *Designing for collaborative discovery learning. ITS '00: Proceedings of the 5th International Conference on Intelligent Tutoring Systems* (pp. 202–211). London: Springer-Verlag.
Witten, I. H. & Frank, E. (1999). *Data mining*. London: Academic Press.