Support online social interaction with Context-Awareness

Yanlin Zheng*

School of Media Science,
Northeast Normal University, China
E-mail: ZHENGYL539@nenu.edu.cn
*Corresponding author

Luyi Li

School of Educational Science,
Northeast Normal University, China

5268, Renmin Avenue, Changchun City,
Jilin Province, 130024, China
E-mail: LILY857@nenu.edu.cn

Hiroaki Ogata and Yoneo Yano

Faculty of Engineering, Tokushima University, Japan

2-1, Minami-Josanjima, Tokushima 770-8506, Japan
E-mail: ogata@is.tokushima-u.ac.jp
E-mail: yano@is.tokushima-u.ac.jp

Abstract: Social interaction is critical to knowledge building and sharing in online learning. This paper identifies knowledge, social and technical contexts as the three essential elements of the *context space* for online social interaction, and accordingly proposes a three-dimensional context-awareness (CA) model to support online social interaction, including *Awareness to Knowledge Context*, *Awareness to Social Context*, and *Awareness to Technical Context*. The activity context, the mediator in the *context space*, is highlighted in CA implementation. CA map is employed to visualise CA information. A case study (caLDT) is provided to test if the CA model is helpful for online social interaction.

Keywords: online social interaction; context space; activity context; context-awareness; CA, CA map.

Reference to this paper should be made as follows: Zheng, Y., Li, L., Ogata, H. and Yano, Y. (2007) 'Support online social interaction with Context-Awareness', *Int. J. Continuing Engineering Education and Life-Long Learning*, Vol. x, No. x, pp.xxx–xxx.

Biographical notes: Yanlin Zheng is currently a Researcher at the School of Media Science, Northeast Normal University, China. She received her BE and ME Degrees from the Department of Educational Technology, Northeast Normal University, China, in 1997 and 2000 respectively, and her PhD Degree

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from the Information Science and Intelligent Systems Department at the Faculty of Engineering, the University of Tokushima, Japan, in March, 2006. Her current interests are in social interaction and knowledge management in computer supported collaborative learning.

Luyi Li is currently a Researcher at the School of Educational Science, Northeast Normal University, China. He received his BE and ME Degrees from the Department of Educational Technology, Northeast Normal University, China, in 1997 and 2000 respectively, and his PhD Degree from the Information Science and Intelligent Systems Department at the Faculty of Engineering, the University of Tokushima, Japan, in March, 2006. His current interests are in ubiquitous learning and computer-supported collaborative learning.

Hiroaki Ogata received his BE, ME and PhD Degrees from the Department of Information Science and Intelligent Systems, Tokushima University, Japan, in 1992, 1994 and 1998, respectively. Currently, he is an Associate Professor in the Faculty of Engineering, Tokushima University. He was a Visiting Researcher at the Center of Lifelong Learning and Design, the University of Colorado at Boulder, USA, from 2001 through 2003. His current interests are in computer supported collaborative learning. He is a member of IPSJ, JSiSE, IEEE, ACM and AIED. He received the best paper award from JSiSE in 1998 and from WebNet in 1999.

Yoneo Yano received his BE, ME and PhD Degrees in Communication Engineering from Osaka University, Japan, in 1969, 1971, and 1974, respectively. He is currently a Full Professor at the Faculty of Engineering, Tokushima University, Japan, and also a Dean of the same Faculty. He was a visiting research associate at the Computer-Based Education Research Lab, University of Illinois, USA. His current interests are in the intelligent CAI, human interfaces and groupware. He is a member of the IPSJ, IEICE and JSiSE, Japan Society for Educational Technology, AACE and IEEE.

1 Introduction

A technology-mediated online learning space is not a technology-shielded island. Human learning is facilitated by technology, but it should never be detached from social and cultural contexts (Conceicao, 2002; Vygotsky, 1980). According to current theoretic frameworks for learning, such as Knowledge Creation theory (Nonaka and Takeuchi, 1995), Activity Theory (Engeström, 1991), and Situated Learning theory (Lave and Wenger, 1991), researchers argued that effective social interaction was critical to knowledge building (Stahl, 2002) and knowledge sharing (Soller, 2001; Cho et al., 2002) in Computer Supported Collaborative Learning (CSCL) environments. As social individuals, learners need to communicate and collaborate continually with the teachers, peers, and experts to increase their knowledge and competence (Brook and Oliver, 2003). However, the distribution of resources complicates social interaction in online learning settings.

This research proposes the use of Context Awareness (CA) to support online social interaction. Awareness is widely used to increase collaboration opportunities and efficiency in Computer-Supported Cooperative Work (CSCW) (Dourish and Bly, 1992;

Gutwin and Greenberg, 2002) and CSCL (Ogata and Yano, 1998). CA and context-aware computing (Dey et al., 2001) have received increasing attention from the Mobile Learning and Ubiquitous Learning research communities, where CA is often imposed on human-machine interfaces, supported by mobile devices or sensing technologies, and tends to highlight the interaction between the human and the physical environments. For the current study, CA is visualised in contextual online learning environments, and focuses on its ability to facilitate social interaction between human beings.

This research first discusses the *context space* for online social interaction, including three essential elements: knowledge context, social context, and technical context to assess CA in online social interactions. Accordingly, a proposed three-dimensional model in which *Awareness of Knowledge Context, Awareness of Social Context,* and *Awareness of Technical Context* is considered. CA compares the knowledge, social aspects, and technical aspects of the two parties in an interaction. In distributed online learning environments, CA provides support for social interaction by helping learners locate the right individual for collaboration with the right knowledge, at the right time, and in the right way (Zheng et al., 2004a, 2004b). This paper uses this theoretical framework to describe the functional model of CA in supporting online social interaction.

With respect to the CA implementation, this research highlights the importance of Activity Context, regarded as the matrix of the context space, and is promising as an explicit clue for mining the other three fundamental contexts (knowledge, social and technical). This research presents a CA enabling mechanism based upon a mining activity context, which includes four basic steps: context modelling, context monitoring, context filtering, and CA information visualising. In particular, a five-dimensional representation approach (i.e., who, what, how, where, when) of model activity context is described. The CA map is employed to visualise CA information. Additionally, a case study is presented to assess the validity of the proposed three-dimensional CA model in supporting online social interaction, and the feasibility of the CA implementation by dealing with activity contexts of learners in online learning settings.

This paper has five sections:

- Section 1: presentation of Context Space for online social interaction
- Section 2: the three-dimensional CA model and discussion of its functions
- Section 3: introduction of the CA enabling mechanism
- Section 4: case study and Context-Awareness (CA) supported Lifelong Development for Teachers (caLDT)
- Summary and suggestions for future research.

2 Context space for online social interaction

According to Dey et al. (2001), the *Context* in computing applications is defined as

> "any information that can be used to characterize the situation of entities (i.e., whether a person, place or object) that are considered relevant to the interaction between a user and an application, including the user and the application themselves."

The context for social interaction in online learning environments broadly encompasses all aspects that will shape the interaction: from physical settings to virtual space; from individual interests to social culture; from explicit conversations to tacit cognition; from technical media to human emotions, etc. This examination has attempted to capture the most essential issues. A background survey of 200 university students with online learning experience was conducted to examine what inducements would possibly motivate active social interaction between online learners and, especially, to ascertain what factors could encourage learners to seek communication with collaborators. Thus, the question highlighted in the survey was "Why did you select this person as your collaborator?" On the one hand, knowledge, social, and technologies were regarded as the three key elements in online learning (Zheng et al., 2004c, 2004d). The participants were asked to answer the question considering three dimensions (knowledge, social and technical). On the other hand, the participants were encouraged to give open answers.

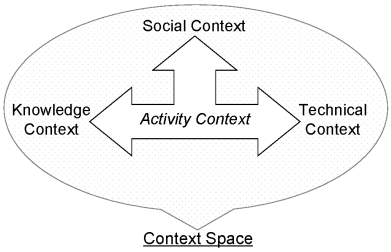
The results of the survey are listed in Table 1. The survey suggested that the inducements and influencing factors for effective online social interaction could be categorised into three dimensions: knowledge, social, and technical. For example, in the knowledge dimension, the influencing factors include knowledge interests, task, problem, expertise, and so on. In the social dimension, the influencing factors were friendship, social conformity, familiarity, illumination, and so forth. In the technical dimension, the influencing factors include the preferences for media, time coincidence, etc.

Table 1 Inducements for active social interaction

		Sample question and answers
Categories	*Sub-factors*	(*Q: why did you select him/her as your collaborator?*)
Knowledge dimension	Knowledge interest	I have the same knowledge interest as he/she does
	Knowledge problem/task	I want to share my new idea with others
	Knowledge expertise	I met a knowledge problem, but I cannot solve it myself. Moreover, he/she has the expertise
	Knowledge experience	I have a collaborative knowledge task with him/her
Social dimension	Friendship	He/she is my friend. He/she invited me to discuss
	Social conformity	My friend asked me to help him/her
	Social familiarity/influence	He/she is the expert I admire. I will pay attention to every topic he/she posted
	Social role/responsibility	I think he/she is a good communicator with good conversational skills
		I found many learners were willing to discuss with him/her
		As the group mentor, I should help him/her
Technical dimension	Technical preferences	We prefer the same media
	Time coincidence	We were in the same media space
		I found only he/she was online

Accordingly, a concise context space for online social interaction was specified, as in Figure 1. The context space consists of three basic components: knowledge context, social context, and technical context. Activity context is the adhesive element in the entire context space indicating what should be explored in the three fundamental contexts.

Figure 1 Context-space for online social interaction



2.1 Knowledge context

Knowledge is not only the strategic resource for learning practice, but also the object of learning efforts. Knowledge context deals with knowledge objects and their associated relationships and embraces knowledge-related implications for influencing the knowledge backgrounds of interacting participants, knowledge needs, knowledge expertise, and knowledge interests.

Human knowledge is created and expanded through the social interaction between tacit knowledge and explicit knowledge. In addition, the creation of knowledge is not confined to an individual; instead, it is a social process between individuals, groups and organisations (Nonaka and Takeuchi, 1995). Polanyi (1997) first introduced the concepts of tacit and explicit knowledge in his *magnum opus*, *Personal Knowledge*. Explicit knowledge, or articulate knowledge, expressed in words, diagrams, or formulae are easily codified, represented and shared asynchronously. On the other hand, tacit knowledge, or inarticulate knowledge, is ineffable, contextual, based on personal experience, directly related to personal cognitive skills, embodies personal beliefs, and values, and is communicated most effectively through face-to-face encounters. Obviously, the knowledge context in online learning environments is complicated by the coexistence of explicit and tacit knowledge and the distribution of knowledge resources. In contrast to the knowledge context in traditional learning, the knowledge context in online learning is much more distributed, dynamic and difficult to evaluate.

2.2 Social context

In recent years, many researchers have increasingly embraced Vygotsky's sociocultural theory (Vygotsky, 1980) in evaluating and understanding online learning environments. This theory postulates that individual mental functioning is inherently situated in social interaction influenced by cultural, institutional and historical contexts, and learning occurs through social interaction with peers, mentors and experts. Knowledge increment takes place in effective sharing with honesty, trust, responsibility and openness (Palloff and Pratt, 1999).

When a computer network connects people or organisations, it is a social connection based on friendship, co-working, information exchange, and so forth (Garton et al., 1997). Computer Mediated Communication (CMC) systems promise to reduce the transaction costs of initiating and maintaining interpersonal ties (Pickering and King, 1992). Weak ties created by CMC expand the channels of information sources for individuals and possess the potential to become strong ties.

Social context considers mainly social, cultural, psychological, and emotional influences on online social interaction, such as the social-cultural backgrounds of the participants, social distances in online social networks, online social roles/responsibilities, and online social prestige or affinity. Social context has an important role in online interpersonal communications, which directly determines if the two parties can communicate and collaborate with honesty, trust, and openness.

2.3 Technical context

Technology overcomes barriers of time or space in distributed learning settings. More practically, technical media are used to facilitate the personal or collaborative learning processes of learners, or to assist instructors or learning services providers to perform relative management. Technologies are indispensable to building online learning environments. The reliable technical promise is the necessary mediator for effective social interaction in online learning settings.

Technical context refers to those technical factors that will influence online social interaction, such as the characteristics and functions of technical media spaces themselves, media preferences of learners, skills or time proximity in the use of media. Particularly, when considering the preferences and skills of learners, the definition of technical context becomes twofold: the preferences and skills for using media for knowledge representation, and the preferences and skills for using media for interpersonal communications. For example, some learners favour using figures to express their ideas, while others favour using words to express their ideas. Similarly, some learners prefer to communicate synchronously in Chat Rooms and some learners favour asynchronous forums. Therefore, it becomes necessary to consider the technical context for eliminating technical barriers for online social interaction.

2.4 Activity context

Activity context is not only the background setting that will shape an activity itself, but also the dynamic changes in the activity. Learning activities provide important clues for understanding the knowledge context, social context and technical context in online learning environments.

First, a learner's activity contexts can reflect his/her own profile in knowledge, social, and technical dimensions. For example, if a learner frequently searches or discusses a topic, it is presumed that he/she is interested in this topic. Similarly, if a learner often uses one media space as opposed to others, it is inferred that he/she prefers or excels at using this medium. Additionally, the activity contexts of a learner can reflect or affect profiles of other learners. For example, if many learners ask for assistance from a specific learner in problem solving, it indicates that the focused learner has relative expertise in the area queried or enjoys general popularity in the learning community. Finally, a learner's activity contexts may induce changes in the activity contexts of other learners. For example, if one learner posts a new knowledge topic, other learners may pay attention to this topic and interact by offering comments, asking questions, searching relative resources, and so on.

As a result, it is necessary to stress the importance of activity contexts. Further discussion of Activity Contexts will be found in Section 3.

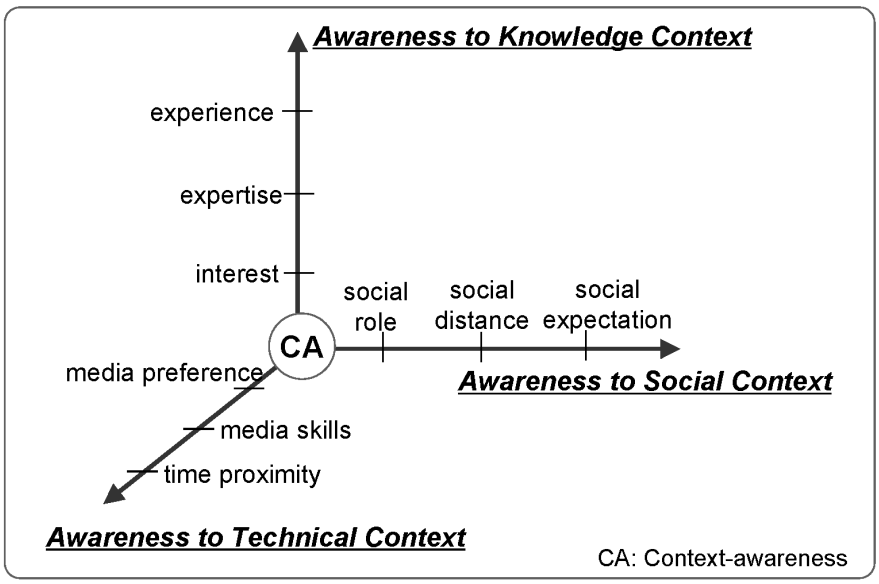
3 Context-Awareness (CA) for online social interaction

A popularly cited definition of *Awareness* is the "understanding of the activities of others, which provides a context for your own activity" (Dourish and Bly, 1992). Awareness helps people to move between individual and shared activities, provides a clue with which to interpret the statements of others, anticipating the actions of others, and reduces the effort needed to coordinate tasks and resources, then, enables group members to work together more effectively (Gutwin and Greenberg, 2002).

For this study, CA is defined as the awareness of the whole context space for online social interaction, which is mediated by the understanding of the activity contexts of learners. CA assists learners in acquiring a relational understanding of themselves and others from knowledge, social and technical dimensions, thus eliminating or reducing possible obstacles to fruitful interactive communication and collaboration.

Figure 2 illustrates a three-dimensional CA model for outlining online social interaction. *Awareness of Knowledge Context* regarding those knowledge factors that possibly influence online social interaction, such as the characteristics of knowledge itself, the knowledge interests, expertise and experiences of the communicating parties. *Awareness of Social Context* includes those social factors that possibly influence online social interaction, such as the social roles of learners, social distances, or social expectations. *Awareness of Technical Context* consists of those technical factors that possibly influence online social interaction, such as preferences, skills and time proximity in utilising technical media of learners.

Figure 2 Three-dimensional CA model for online social interaction



A typical role of CA for social interaction is to support learners in locating the right individual for collaboration on the right knowledge, at the right time, and in the right way. For example, CA is useful as an aid for those confronted with knowledge problems to find suitable helpers. Figure 3 depicts a three-dimensional, balanced, functional model of CA in helping learners find suitable helpers. There are some exemplary questions for CA investigations in this study in the Table 2.

Figure 3 The functional model of CA

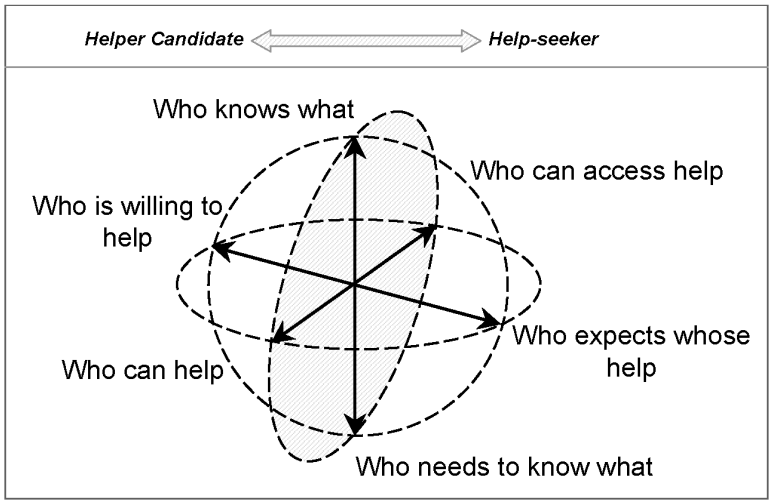


Table 2 Sample questions for CA investigations

Dimensions	*Sample questions for CA investigations*
Knowledge context	Is he/she interested in the same knowledge as the help-seeker?
	Does he/she possess the expertise that is needed by the help-seeker?
	Does he/she have experience with the knowledge problem needed by the help-seeker?
Social context	What is his/her influence upon the entire learning space?
	What is his/her influence over the person seeking help?
	Is he/she good at communicating?
	Is he/she familiar to the help-seeker?
	Is he/she the helper that the help-seeker is expecting?
Technical context	What media does he/she prefer?
	What media is he/she comfortable with using?
	Does he/she prefer synchronous/asynchronous communication?
	Is his/her preferred media same as the help-seeker's?
	When is he/she online?

Annotation: 'He/she' refers to the investigated helper candidate

In the knowledge dimension, CA is used to match "who needs to know what" (help-seeker) and "who knows what" (helper candidate). CA inspects whether the helper candidates have the same knowledge interest as the help-seeker, and whether they have the expertise or experience of a knowledge topic or problem. For example, a learner with a higher score or more discussions on a knowledge topic has more potential in the knowledge dimension.

In the social dimension, CA intends to pair "who expects help" (help-seeker) with "who is willing to help" (helper candidate) to ensure social harmony. Typical investigations in this dimension include the influence of candidates in online learning environments and his/her social familiarity with the current help-seeker, such as his/her activity in 'social' affairs in the learning community, if he/she is willing to help others, or if he/she is familiar with the help-seeker.

In the technical dimension, CA facilitates the alliance between "who can technically help" (helper candidate) and "who can technically access help" (help-seeker) to ensure technical proximity. CA considers the best communication media and method for collaboration between the two parties. If both parties are experienced in the same media and method, communication efficiency is improved. For example, what media does the helper candidate prefer? What media is the helper candidate good at using? Is the preferred media of the helper candidate the same as those of the person seeking help?

4 Context-Awareness (CA) providing mechanism based on mining activity contexts

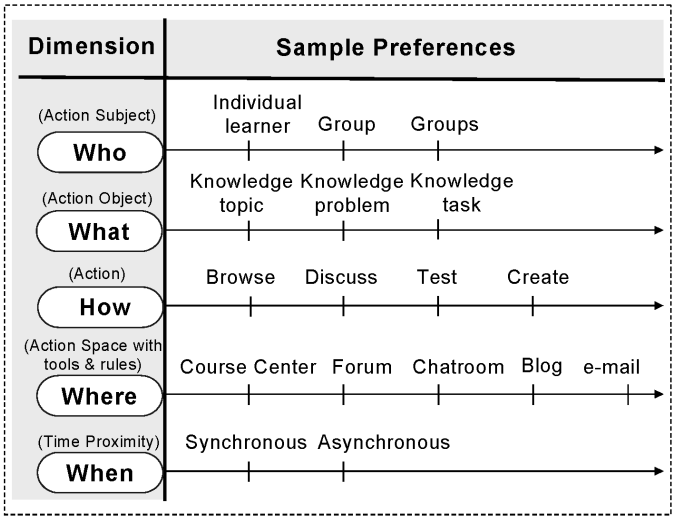
CA provides mechanisms based on the mining of the activity contexts of learners in online learning environments and contains four basic modules: Context Modelling, Context Monitoring, Context Filtering, and CA information visualising. CA implementation highlights the usage of activity context.

4.1 Activity context modelling

The Activity Theory (Engeström, 1991) states that an activity is an action directed toward an object, which is transformed by a subject in a community through tool mediators and, correspondingly, results in an outcome. More concretely, according to Kaptelinin et al. (1999), any activity is object-oriented, has a hierarchical structure (motivated activity, practical action and automatic operation), maintains constant transformation between external and internal actions, is mediated by tools, and is reformed and shaped by historical development. Obviously, no activity is an isolated action, but rather is directly connected to the profiles of its subject, object and tool mediators. Learning activities provide important contexts for understanding an online learning environment.

This utilises the activity context to provide CA information to support online social interaction. For this purpose, clearly articulating the activity context is very important. A rational articulation will help to computationally model and manage the context information. As shown in Figure 4, a five-dimensional (who, what, how, where, when) representation approach is proposed for activity context description.

Figure 4 Five-dimensional representation to activity context



Who (Action subject): an individual learner, a group of learners, or all learners

What (Action object/outcome): processed knowledge objects/outcomes, such as topics discussed in forums, created new knowledge, or knowledge objectives in a systematic course; in which domain ontology attempts to explicitly represent, model, and manage knowledge objects

How (Action): learning actions conducted by learners, which are differently classified in different media spaces, such as "post/browse/comment/link" in blogs, and "request/read/accept/cancel/reject/forward" in e-mail systems

When (Time proximity): a given period when actions transpired, typically divided into synchronous and asynchronous types

Where (Action space): the media space where learning actions are conducted, such as Course Center, Forums or Blogs that are directly related to tools, media, and according rules.

4.2 Context monitoring

Two basic strategies are used to monitor activity contexts in online learning environments. One is to track the learning (personal or collaborative) action logs of learners. Action Logs have been widely used by many researchers in the analysis of conversational skills (Soller, 2001). The other is '*Activity Context Report*' strategy. This strategy suggests that learners provide a clear report on their own activity contexts. The five-dimensional representation approach of the activity context is promising to facilitate the report process. On the one hand, this strategy will increase the reliability of detected context information and decrease the burden of monitoring. More importantly, this strategy is likely to cultivate the individual social responsibility of learners in online environments, to strengthen trust among learners, and to activate the self-awareness, self-direction and self-management of his/her own learning activities.

4.3 Context filtering

The meaning of *Context Filtering* is twofold. Firstly, the source for filtering is the activity contexts of learners. Secondly, the goal of filtering is to acquire the knowledge context, social context, and technical context in online learning settings. In other words, Context Filtering is to filter out the knowledge, social, and technical contexts by mining the activity contexts of learners. There are no uniform criteria or fixed rules for context filtering because of the complications of activity contexts in different media spaces. There are different activities in different media spaces and, on the other hand, even the same activity may indicate different implications in different media spaces. Some sample strategies for context filtering based on the activity contexts from web logs will be discussed in a later case study.

4.4 CA information visualising

Concept Map (Novak and Gowin, 1984), and Knowledge Map (Kim et al., 2003) have been extensively applied to information visualisation. This research employs CA map to display CA information graphically. CA map permits learners to clearly grasp the relative contexts, classified into four sub-types:

- Domain ontology based *Knowledge Map* illustrating the intrinsic characteristics and relations of knowledge contents
- *Knowledge-Human Map* detecting the relations between knowledge topics and learners
- *Human-Human Map* is used to discover social networks in the learning community to help *Awareness of Social Context*
- Human-Media Map used to reveal Awareness of Technical Context.

5 A case study

The case study in this paper is titled CA supported Lifelong Development for Teachers (caLDT), which is primarily used to improve Instructional Design (ID) ability of teachers. The caLDT was developed from an existing web-based system, LDT, which had been operating in Northeast Normal University (NENU) since 1999. As a CSCL community, LDT allows learners (trained teachers) to:

- learn systematic courses on ID
- obtain video-cases for instructional skills training based on streaming media technology
- cooperative design instructional plans or solve problems in instructions.

This case study is designed to answer the following questions:

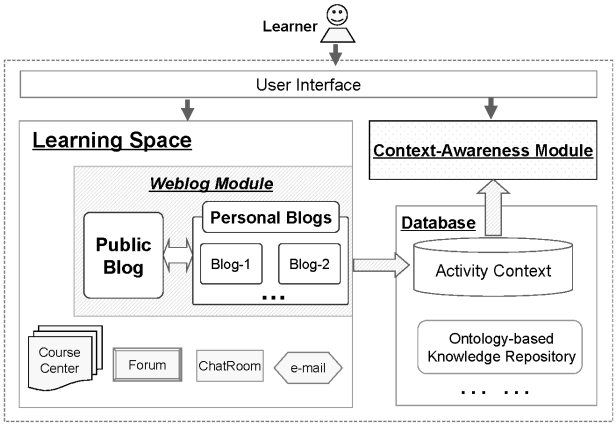
- Is the three-dimensional CA model helpful for supporting online social interaction?
- Is it feasible to get CA information by mining activity contexts of learners?

5.1 System configuration

As shown in Figure 5, caLDT comprises three main modules: learning space, system database, and a newly added CA providing module. The data of activity contexts from the learning space is used in the CA module to provide CA information.

Learning Space consists of many functional sub-modules, such as the Course Center for systematic course learning, forums or chat rooms for discussing e-mail services for private communication, and Blogs for community/personal knowledge management.

Figure 5 System configuration of caLDT



At present, the Blogs are selected as the test bed for CA implementation in caLDT. Blogs can be regarded as simple knowledge management tools with identities and openness (Zobel et al., 2003). A blog system is used in caLDT, in which there is a public blog, and a number of personal blogs. Based on a strict ranking procedure (e.g., an experts' assessment, or a collaborative filtering approach), the public blog serves to post academic papers from learners, and links the most recent personal blogs or up-to-the-minute posts in some blogs. In addition, there is a special section in the public blog for posting representative questions (from learners) and corresponding answers (from experts or learners). Personal blogs can hyperlink with each other according to the preferences of bloggers. A blogger can post in or browse his/her own blog, and comment in or browse others' personal blogs. To facilitate learners' communications and context management, knowledge topics frequently are structured by shared domain ontology (Gruber, 1995; Zheng et al., 2003).

5.2 Context filtering strategies

To simplify the discussions, the 'help-seeker' and the 'help-candidate' were used to denote the two parties in an interaction. Accordingly, the five dimensions of the activity contexts in the case study include:

- *Who*: the help-seeker, the investigated helper candidate, and other learners
- *What*: academic Paper/Knowledge Topics/blogs (as linked objects)
- *How*: Link/Post/Comment/Browse

- *When*: not time sensitive
- *Where*: public blog/the help-seeker's personal blog/the investigated helper candidate's
- Personal blog/others' personal blogs.

Table 3 indicated the basic strategies for context filtering in knowledge and social aspects. In the knowledge dimension, the candidate's knowledge interest, expertise and experience are considered. In the social dimension, the candidate's social influence and social familiarity with the help-seeker are focused upon.

Table 3 Basic strategies for context filtering

Context Awareness		*Basic strategies for context filtering*
Knowledge dimension	Interest	In all personal blogs, if the candidate has contributed more posts/comments on some topic, he/she has more interest in this knowledge topic
	Expertise	If a candidate has more academic papers on current knowledge topics posted in a public blog, he/she possesses higher academic expertise
	Experience	If the candidate once asked the same or a similar question in a public blog, he/she has more experience on the current knowledge problem of the help-seeker; if the candidate has higher academic expertise, he/she has higher experience
Social dimension	Influence	If the candidate's blog is linked with the public blog, he/she has more public influence; if his/her blog is linked by more personal blogs, he/she has more public influence; if his/her blog is visited by more people, he/she has more public influence; if his/her blog is linked by the help-seeker's blog, he/she has more influence than the help-seeker
	Familiarity	If the candidate comments more times in the help-seeker's personal blog, he/she has more familiarity with the help-seeker

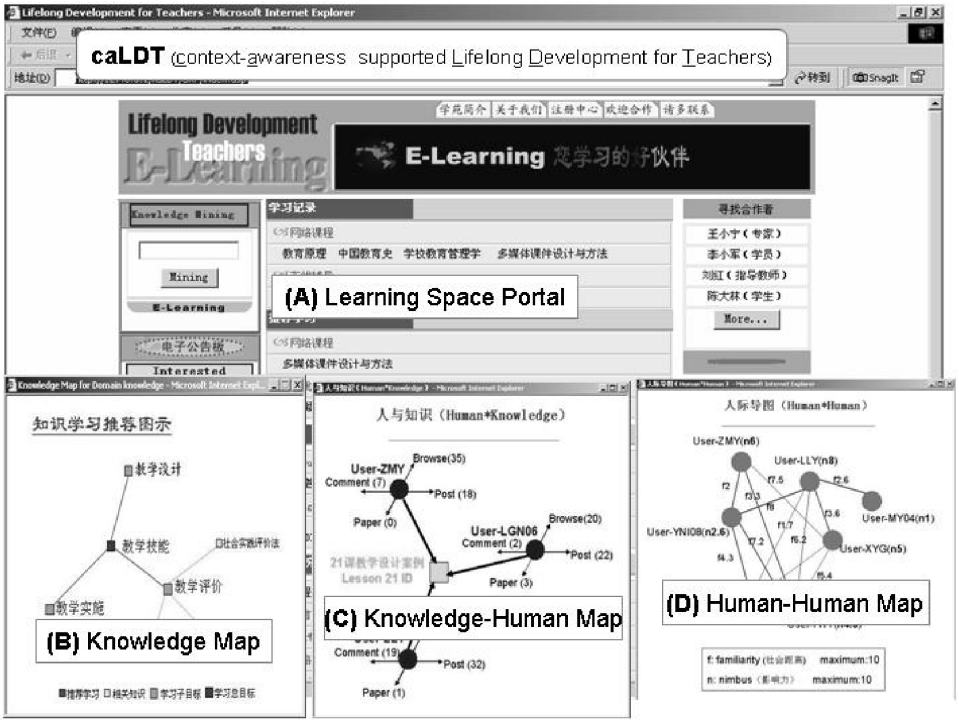
5.3 System interfaces

Screenshots of caLDT are illustrated in Figure 6. A Knowledge Map aims at displaying the internal context of multiple knowledge objects, and at helping learners understand the whole knowledge architecture and identify their own learning objectives, or problems. A Knowledge-Human map directly shows learners' processes on knowledge topics, such as who has posted/commented how many times on some topic, and who has published how many papers on some topic. A Knowledge-Human map indirectly reflects the knowledge interests, expertise and experiences of learners. A Human-Human map is used to reveal the relations between learners, including every learner's degree of social influence, and the social distances between learners.

This research did not try to develop a coverall CA map, but tended to provide learners with open choices. For example, if a learner regards the knowledge dimension as the most important preference, he/she may choose an expert for querying, even though he/she does not know the expert. In this case, the learner can only use the Knowledge-Human map, rather than browse all the CA maps. Similarly, if a learner just likes to discuss problems with his/her own friends, even though he/she knows that his/her friend does not

know how to solve some knowledge problem, he/she may still prefer discussing the problem with his/her friend for problem exploring. Then, he/she can only visit the Human-Human Map.

Figure 6 Screenshots of caLDT



5.4 System evaluation

Participants. caLDT was opened to 50 trainees for two weeks, who were previous users of the past learning system (LDT). All the participants had utilised the online training on Educational Technology by using LDT.

Procedure. First, in order to structure the experiment environment, some concrete knowledge topics within the scope of ID were prescribed, and the users were requested to clearly mark out subjects based on the prescribed topics which they posted or commented, or asked questions. Secondly, according to the basic filtering strategy described in the above, relative data from blogs were collected. The collected data included information regarding who had posted/commented how many times on some knowledge topic, who had asked questions on some knowledge topic, whose blog was linked by the public blog, and so on. Thirdly, the CA map was formed based on the data analysis, and was fed back to the participants. Finally, a questionnaire was designed to collect the participants' evaluations on the effectiveness of the CA map in supporting online social interaction. The questionnaire included six questions as shown at the left of Table 4. At the same time, the participants were suggested to give some sample reasons for their grading.

Table 4 Results of questionnaire

Question	*Ave.*
(1) Do you think the CA map can help you find new knowledge topics?	4.6
(2) Do you think the CA map can help you find interesting knowledge topics?	4.7
(3) Do you think the CA map can help you identify next learning objectives?	4.4
(4) Do you think the CA map can help you find experts?	4.2
(5) Do you think the CA map can help you find new friends in learning?	3.1
(6) Do you think the CA map can help you strengthen the relationship between you and your friends?	2.8

Results of questionnaire. The questionnaire used a 1-to-5 Likert Rating Scale, with the options of 'strongly agree (5 points)', 'agree (4 points)', 'undecided (3 points)', 'disagree (2 points)', and 'strongly disagree (1 point)'. For every question, all the valid scores were averaged. The median score was three points. Therefore, an average score under three points represented disagreement or the tendency to disagree, while an average score above three points represented the tendency to agree, and an average score above four points represented obvious agreement. The average scores of all the questions are listed at the right of Table 4.

According to the scores of questions 1–4, it was found that the CA map was helpful for exploring knowledge context. Most users gave high scores to these questions and supplied the following explanations: "The Knowledge Map gives me a clear view on the internal relations between knowledge topics", and "the Knowledge-Human map lets me know other learners' interests and expertise on some knowledge topic". Questions 4–6 indicated that the CA map is beneficial to the maintenance and evolution of social context. However, it seemed that the present CA map was/is more useful in the knowledge dimension rather than in the social dimension. The typical positive answer to question five was: "From Human-Human map, I can find who has extensive contacts with others, then I can select him/her to help me solve problems. If he/she replied me, I will be pleased". To question 6, the positive answer was: "From Knowledge-Human map, I will know if my friend also is interested in the same topic as what I am interested in, then I can contact with him/her, and he/she will reply me". While the negative answer to question 5 and 6 was mostly: "I don't think the Human-Human map is able to truly reveal the closeness between me and my friend".

6 Discussions

- Immature online learning systems are often technology-intensive rather than knowledge-intensive or human-oriented, and depend too much on explicit knowledge, expert knowledge, and knowledge storage instead of tacit knowledge, practical knowledge of each learner, and knowledge flow. The proposed three-dimensional CA model is based on the recognition of the knowledge context, social context and technical context, which may be helpful for us, as a learner or a learning services provider, to get a comprehensive consideration of online learning settings from knowledge, social, and technical aspects. For an online learning system, it may be helpful to add a CA module.

- The three-dimensional CA model is promising to eliminate or reduce possible obstacles in online social interaction from knowledge, social and technical aspects. The CA map is proved useful for helping learners' awareness of the whole learning space, and useful in supporting online social interaction.
- The activity context is promising to be an explicit clue for mining other three fundamental contexts (knowledge, social and technical). It is feasible, therefore, to mine the CA information to support effective online social interaction by dealing with the activity contexts of learners. The development of reasonable context filtering strategies is the key for effective CA implementation.
- Within the three dimensions of the proposed CA model, the Awareness of Social Context is most challengeable. Generally and ideally, the influence of a person within a social environment, and the familiarity of two persons should be evaluated by Social Network Analysis (SNA). SNA is increasingly used to capture and describe interpersonal interaction patterns, to trace information and knowledge flow within the network scope, and to reveal how the relations and ties within the network affect interpersonal communications (Garton et al., 1997; Ogata et al., 2001). Ties and relations in a social network are critical to the transfer of tacit and explicit knowledge in collaborative knowledge building. The strength of ties can be used to assess the degrees of influence and familiarity. The current case study in this research attempted to simplify the complicated SNA approach into operable activity context investigations. Correspondingly, the techniques used in mining social context are still limited, and should be further emphasised and polished.
- Because the focused case study used only the activity contexts from blogs (public or personal), the filtering strategy for *Awareness to Technical Context* was skipped in the above discussions. To acquire the CA information in the technical dimension, it is necessary to investigate the action histories of learners in all media spaces, such as the course centre, forums, and chat rooms. Overall, a learner's degree of preference for synchronous media or asynchronous media can be numerically assessed. Synchronous media space refers to spaces such as chat rooms and video-conferencing. Asynchronous media space indicates e-mail, forums, blogs etc. A basic principle for evaluating a learner's media preference is to assess which medium a learner uses more frequently, and to what extent he/she prefers to use that medium.

7 Conclusions and future studies

This paper focused on how to make use of *CA* to support online social interaction. Taking knowledge, human and technical aspects into account, this paper proposed a three-dimensional CA model, involving *Awareness to Knowledge Context, Awareness to Social Context, and Awareness to Technical Context.* Furthermore, the functions of CA also were presented in a three-dimensional balance model featuring the balance between "who needs to know what" and "who knows what", the leverage between "Who expects whose help" and "who is willing to help", and the matching between "who can technically help" and "who can technically access help". Practically, the importance of Activity Context is highlighted. A five-dimensional representation approach (who, what,

how, when, where) was presented for activity context description. The mechanism for providing CA encompasses Context Modelling, Context Monitoring, Context filtering, and CA Visualising. The CA Map was employed to graphically display CA information. Finally, this paper also provided a case study (caLDT). The case study lent support to the value of the CA model in supporting online social interaction, the feasibility of obtaining CA information by mining the activity contexts of learners, and revealed the existing problems in dealing with Awareness to Social Context.

For future studies, further exploration and refinement of the CA mechanism are in order. For example, although we proposed the 'Activity Context Report' strategy, we did not adopt it in the present case study. In addition, more attention should be paid to the implementation of the Activity Context Report strategy. Possible filtering strategies in different media spaces can be explored as well. In particular, more advanced SNA techniques should be applied to increase the efficiency in mining the CA information in the social dimension.

Acknowledgement

This research is supported in part by the grant-in-aid for Youth Scientific Research 2001 from NENU, China and in part by the grant-in-aid for Scientific Research (B)(2) No. 13480047 from Japan Society for the Promotion of Science.

References

Brook, C. and Oliver, R. (2003) 'Designing for online learning communities', *Proceeding of ED-MEDIA 2003*, June 23–28, Honolulu, Hawaii, USA, pp.1494–1500.

Cho, H., Stefanone, M. and Gay, G. (2002) 'Social information sharing in a CSCL community', *Proceeding of CSCL2002*, January 7–11, Boulder, Colorado, pp.43–49.

Conceicao, S. (2002) 'The socialcultural implications of learning and teaching in cyberspace', *New Directions for Adult and Continuing Education*, Vol. 2002, No. 96, Winter 2002, pp.37–46.

Dey, A.K., Abowd, G.D. and Salber, D. (2001) 'A conceptual framework and a toolkit for supporting the rapid prototyping of context-aware applications', *Human-Computer Interaction*, Vol. 16, pp.229–241.

Dourish, P. and Bly, S. (1992) 'Portholes: supporting awareness in a distributed work group', *Proceeding of CHI'92*, Monterey, CA, USA, pp.541–548.

Engeström, Y. (1991) 'Activity theory and individual and social transformation', *Activity Theory*, Vol. 7, pp.6–17.

Garton, L., Haythornthwaite, G. and Wellman, B. (1997) 'Studying online social network' *Journal of Computer Mediated Communi*cation, Vol. 3, No. 1, Available from http://www.ascusc.org/jcmc/vol3/issue1/garton.html.

Gruber, T.R. (1995) 'Toward principles for the design of ontologies used for knowledge sharing', *International Journal of Human-Computer Studies*, Vol. 43, No. 5, pp.907–928.

Gutwin, C. and Greenberg, S. (2002) 'A descriptive framework of workspace awareness for real-time groupware', *Journal of Computer Supported Cooperative Work*, Vol. 11, Nos. 3–4, pp.411–446.

Kaptelinin, V., Nardi, B.A. and Macaulay, C. (1999) 'The activity checklist: a tool for the representing the 'space' of context', *Interaction*, Vol. 6, pp.27–39.

Kim, S., Suh, E. and Hwang, H. (2003) 'Building the knowledge map: an industrial case study', *Journal of Knowledge Management*, Vol. 7, No. 2, pp.34–45.

Lave, J. and Wenger, E. (1991) *Situated Learning: Legitimate Peripheral Participation*, Cambridge University Press, Cambridge, UK.

Nonaka, I. and Takeuchi, H. (1995) *The Knowledge Creating Company*, Oxford University Press, New York.

Novak, J.D. and Gowin, D.B. (1984) *Learning How to Learn*, Cambridge University Press, New York.

Ogata, H. and Yano, Y. (1998) 'Knowledge awareness: bridging learners in a collaborative learning environment', *International Journal of Educational Telecommunications, AACE*, Vol. 4, No. 2, pp.219–236.

Ogata, H., Yano, Y., Furugori, N. and Jin, Q. (2001) 'Computer supported social network for augmenting cooperation', *Journal of Computer Supported Cooperative Work*, Vol. 10, pp.189–209.

Palloff, R.M. and Pratt, K. (1999) *Building Learning Communities in Cyberspace*, Jossey-Bass Publishers, San Francisco, CA.

Pickering, M.J. and King, L.J. (1992) 'Hardwiring weak ties: individual and institutional issues in computer mediated communication', *Proceeding of CSCW'92*, ACM Press, October 31–November 4, Toronto, Canada, pp.356–361.

Polanyi, M. (1997) 'The tacit dimension', in Prusak, L. (Ed.): *Knowledge in Organizations*, Butterworth -Heinemann, Woburn, MA, pp.135–146.

Soller, A. (2001) 'Supporting social interaction in an intelligent collaborative learning system', *International Journal of Artificial Intelligence in Education*, Vol. 12, No. 1, pp.40–62.

Stahl, G. (2002) 'Contributions to a theoretical framework for CSCL', *Proceeding of CSCL 2002*, Boulder, Colorado, January 7–11, pp.62–71

Vygotsky, L.S. (1980) *Mind in Society: The Development of Higher Psychological Processes, Harvard University Press*, Boston, MA.

Zheng, Y.L., Li, L.Y., Ogata, H. and Yano, Y. (2004a) 'Using knowledge awareness to support learning services in collaborative e-learning environments', *Proceeding of International Conference of Web Intelligence'04*, Beijing, China, Sep.20–24, pp.694–698.

Zheng, Y.L, Li, L.Y., Ogata, H. and Yano, Y. (2004b) 'Toward awareness services in CSCL: classifications and contextual providing mechanism', *Proceeding of ICCE 2004*, Melbourne, Australia, Nov.30–Dec.03pp.803–808.

Zheng, Y.L, Li, L.Y., Ogata, H. and Yano, Y. (2004c) 'Using knowledge awareness to support knowledge building in virtual learning community', *Proceeding of E-Learn 2004*, Nov.01, Washington DC, USA, pp.2258–2265.

Zheng, Y.L, Li, L.Y., Ogata, H. and Yano, Y. (2004d) 'A framework of Context-Awareness support for collaboration recommendation in e-learning environments', *International Journal of Japanese Information for Information and Systems in Education*, Vol. 2, No. 1, pp.40–48.

Zheng, Y.L., Li, L.Y., Ogata, H., Matsuura, K. and Yano, Y. (2003) 'Ontologies: structure e-learning from information-based to knowledge-based', *Proceeding of E-Learng'03*, Phoenix, Arizona, USA, Nov.7–11, pp.833–840.

Zobel, A.M., Hupfer, M., Wendler, A. and Schuber, U. (2003) 'Cooperative maintenance of a content pool for learning', *Proceeding of ED-MEDIA 2003*, June 23–28, Honolulu, Hawaii, USA, pp.283–290.