RÅDET FÖR HÖGRE UTBILDNING
COUNCIL FOR THE RENEWAL OF HIGHER EDUCATION

Project number: 101/G02
Name: Department Chairman Kenneth Nilsson
Institution: Umeå University
Department of Informatics
901 87 Umeå
Tel: +46 (0)90 786 56 30
E-mail: kenneth.nilsson@informatik.umu.se

Personal technologies in user-centred design of collaborative activities for decentralised education

Abstract

Higher education has in recent years transformed towards virtual universities with students participating in courses and educational programs located outside campus. Students in decentralised education develop very strong study groups and most of the learning process takes place within these groups. Interaction between teachers and students are relatively low due to the distance between the actors and the time delay between questions and answers. Therefore most of the problem solving and interaction occurs horizontally, i.e. between students. This interaction is performed in an informal way and as a consequence, students use other media than those pointed out by the educator. For teachers the new setting challenges the way to teach since decentralised education is a hybrid form of distance and campus education. The teacher has to develop new forms of learning strategies and adopt new technologies into his work practice.

The project intends to develop pedagogical methods and models that are adapted to decentralized education. With a socio-cultural approach we will strengthen the study groups developed by the students. We will build upon existing communication behaviour and technology among students. Personal technologies are here important as well as local tutors, learning centre personnel, facilitators and technicians to include in the setting.

The project has a clear student perspective and focuses on design of learning environments supporting both a socio-cultural approach of learning and the use of personal technologies based upon students' way of interacting and communicating.

The project will focus on teaching and learning within decentralised settings and is not restricted to a specific subject or place. All universities conducting some form of decentralized education can benefit from the result of this project, e.g. pedagogical models for decentralized education, for user-centred design of learning environments, and integration of personal technologies into learning settings.

This paper deals with the use of personal technologies in decentralized university education. Decentralized education combines elements of campus and distance education and is offered to off campus students within a certain

geographical area. Personal technologies can successfully support collaborative learning in this setting. Our empirical studies show that the complexity of collaborative processes calls for a bottom up approach and participation by the students and other involved parties when designing a collaborative learning environment. The ability of the technological support to offer a broad scope of possible actions to the user is crucial. Our study indicates that integrating stationary and mobile devices provides a support that will strengthen the study groups developed by the students.

Keywords

Higher Education, Classroom Research, Instructional Innovation, Group Dynamics, Student Participation, Distance Education, Information Technology, Network Analysis

Personal Technologies in User-Centered Design of Collaborative Activities for Decentralized Education

by

Karin Danielsson Ulf Hedestig Maria Juslin Victor Kaptelinin
Olga Kopatcheva Göran Landgren Kenneth Nilsson Carl Johan Orre

Department of Informatics, Umeå University, 90187 Umeå, Sweden

Abstract

This paper deals with the use of personal technologies in decentralized university education. Decentralized education combines elements of campus and distance education and is offered to off campus students within a certain geographical area. Personal technologies can successfully support collaborative learning in this setting. Our empirical studies show that the complexity of collaborative processes calls for a bottom up approach and participation by the students and other involved parties when designing a collaborative learning environment. The ability of the technological support to offer a broad scope of possible actions to the user is crucial. Our study indicates that integrating stationary and mobile devices provides a support that will strengthen the study groups developed by the students.

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Courses and educational programs provided by universities for off-campus students have become increasingly popular in later years. The freedom for students to choose time and place for their learning activities, as well as the interest of regions and municipalities in university programs that meet the needs of the local labor markets are some factors that have contributed to this increase. This paper reports a study that focus on decentralized education, a hybrid form of education that incorporates elements from both campus education and distance education, offered to off-campus students within a certain geographical area. The conditions for off-campus students differ in many respects from those of campus students. On-campus education takes place in a setting that evolved from centuries of experience with supporting traditional classroom teaching. The setting provides a coherent context that is rich in various types of resources crucial for successful teaching and learning. Students have an access to a university library and various technological resources, e.g. computer labs, can participate in a variety of regular classes, communicate with fellow students, be engaged in student unions, and so on. These resources together with the physical presence of teachers, counselors, etc. support an enculturation process, so that students can develop different communities of interests. In the case of decentralized and distance education there is a limited access to resources, such as library facilities, teachers, computer facilities, etc. In contrast to on-campus education there is no predominant context for teaching and learning. The students have to study in a number of contexts, e.g. the local study center, at the work place, at home in the bus, etc. Since the students' learning activities are distributed over both time and space, it is more problematic to establish communities of interests. For many students in decentralized or distance education learning is a more lonely process than for on-campus students. Extending the university education beyond the campus also has implications for teachers. Many teachers have to combine traditional on-campus teaching with teaching distance and decentralized courses, which requires solving new pedagogical problems and develop a new teaching practice.

Education is currently one main area of application of information and communication technologies (ICT) and one of our concerns has been in what way ICT can support off-campus students. Many discussions related to the educational use of technology have been focusing on finding standard ways of successfully using ICT depending on certain course content. However, when education becomes more diverse other demands also come into foreground. According to Reigeluth (1999), in development of educational settings and pedagogical methods it is important to focus on customization instead of standardization. One has to recognize that the proliferation of diverse educational forms forces students and teachers to become more mobile in the sense that the context in which they act changes all the time. Teachers must also be aware that students attending their courses have different motives and prerequisites.

One more consequence of a customization perspective is that the traditional top-down approach to create learning environments, that is, an approach, according to which webmasters and technicians construct an ICT-based environment, should be replaced with an alternative "bottom-up" approach, when teachers and students are more actively involved in the design process.

"The best way to support learning is from the demand side rather than the supply side. That is, rather than deciding ahead of time what a learner needs to know and making this explicitly available to the exclusion of everything else, designers and instructors need to make available as much as possible of the whole rich web of practice- explicit and implicit, allowing the learner to call upon aspects of practice, latent in the periphery, as they are needed" (Brown & Duguid, 1993, p 13)

The point of departure of this paper and the project reported below is to discuss how everyday learning and collaboration can affect the design of learning environments. The emphasis is on exploring the possibility for design to follow a bottom-up approach, that is, to start with an understanding of students' interaction within an educational context. In earlier studies (Hedestig, Kaptelinin & Orre 2002, Hedestig & Orre 2002) we have found that students in decentralized education develop very strong study groups and most of the learning process takes place within these groups. Interaction between teachers and students are relatively low due to the distance between the actors and the time delay between questions and answers. Therefore most of the problem solving and interaction occurs horizontally, i.e. between students. This interaction is performed in an informal way and as a consequence, students use other media than those pointed out by the educator. Almost all students had mobile phones. A promising type of tool to support students in learning settings typical of decentralized education could therefore be mobile artifacts, since certain types of such artifacts have been already adopted by students and they are flexible enough to deal with the complex nature of the reality of distance and decentralized education, mentioned above.

The traditional way to use computers in education has been to make computers centrally located, e.g. in computer labs. Such an arrangement has resulted in a limited access to technology for students and isolated computers from other educational settings. Thus, the technology has been almost exclusively used for computer-oriented activities

and not for domain-oriented or subject-oriented activities (Inkpen 1999). The increased use of different artifacts in private and public situations makes it necessary to broaden the perspective of the use of these technologies. The concept of personal technologies, coined by Sharples (2000) where mobile technology and other Internet technologies are defined as subsets of technologies used in private and public situations provides a promising approach. By the concept of personal technology we are able to discuss various configurations of different subsets of technologies such as e-mail, SMS, the use and transmission of a picture taken by a mobile phone in terms of one overarching concept. This concept helps to illuminate both the structures of interaction and the relations between technologies and the situations in which they are used. Our studies (Hedestig, Kaptelinin & Orre 2002, Hedestig & Orre 2002) clearly show that students seldom use those computer resources that the department provides in computer labs. Rather, the use of personal technologies giving access to the social network determines where and which technology is used. Sitting at home in front of a computer provided with a broadband connection, or sitting idle in public places depending on the mobile phone connection, are two very common situations. Recently, a number of pilot projects have tried to find out how mobile technologies can be integrated into learning settings (Chen, Myers & Yaron 2002; Roschelle & Pea 2002, Lundby 2002, Luchini et al. 2002). Cole and Stanton (2002) present three projects where mobile applications are applied in education. Their approach aims towards task specific uses using the devices exchanging pictures, or as a support while exploring the physical vicinity and environment. Concluding that the relation between the device and the activity needs to be stressed, especially in terms of seeing the single device as collaborative tool used by many at the same time. From our perspective the device is an individual communication central giving access to resources of collaborative activities. Brown and Duguid (1991) emphasize the dimension of community. Work practice and learning within groups cannot be described as predestined in "task forces" but should be recognized as emergent communities that do not provide any clear ideas of how work or learning should be organized or accomplished.

Traditionally, the development of learning environments is characterized by a teacher-centered perspective (Carroll et al. 2002). The models are designed according to rules imposed by teacher practice or technical constraints. The potential of educational technologies appears to have been largely unexplored because of a radical dissociation between the design of technologies and the development of educational practices. The design has been typically technology-driven and oriented towards the most elementary educational activities or based on a completely new perspective that does not fit in with existing practices (Reigeluth 1999). This has also affected design methods, which have been constructed from the viewpoint that a learning setting is something that is well defined, procedural and well structured. As a result new technologies are seldom integrated into real-life education.

From these experiences we have seen it as crucial to change view to a learner-centered perspective in order to find out how a technological support can be integrated into a learning environment. Students have other communication patterns and use other media than the educator provides. This implies a focus on everyday communication patterns among students. To deal with the conditions of decentralized education students develop strong study groups for coaching each other, problem solving and brainstorming. It is important that technology will support and increase the interaction within and between study groups. Finally, it is important that one can use existing technologies and resources in order to facilitate the adoption of the technology. For example, almost all students participating in the project used mobile phones, so a promising type of tools to support the students in their learning activities seems to be mobile artifacts.

From these points of departure one needs to reconsider the design models for learning environments. This paper presents an example of how to approach the problem so that user-centered design (UCD) can be used to inform the design and to gain an understanding of the mechanisms of the students' learning context. User-centered design was developed in the 80's (Norman and Draper 1986) in order to take into consideration usability issues and stressed the importance of including the users in the development process to gain understanding of the users and their work practice. Learner-centered design (LCD) (Solowaym Guzdid & Hay 1994, Quintana et al. 2002)) is a new challenge for developing computer systems that support a learning environment. Some unique needs to be addressed when designing to support learning in contrast to the UCD framework are diversity, i.e. learners are heterogeneous, while UCD assumes that users share a common work culture. The learners' motivation cannot be taken for granted and the development of expertise must be the primary goal of computer support rather than doing tasks more efficiently as is assumed in UCD. In order to bring forward an understanding of the learning context, we have also been inspired by the approach of participatory design (PD) (Kensing 2003). In PD users are seen as experts in a specific context of development and users and designers may exchange perspectives.

A framework that helped us to approach the issue of personal technologies for collaborative learning is Activity Theory. According to Activity Theory (Vygotsky 1978) both collective and individual dimensions have to be taken

into account – how individual actions can support collaboration and develop cultural tools and how they affect the appropriation and use on the individual level. Learning or cultural development is first regarded as a social process and later on an individual process. (Vygotsky, 1978). Individuals always exist in a social context with established values, meanings, norms and experiences. Individuals do not interact in a vacuum but together with other people. Individuals learn by the interplay of own experiences of the cultural objects and the guidance of more capable peers. Even though it seems as individuals interact on their own, human interaction is a social phenomenon mediated through cultural developed artefacts, i.e. computers, telephones and language. This discussion also relate to the idea of zone of proximal development (ZPD) by Vygotsky (1978). He referred to ZPD as the distance between the actual developmental level for an individual and the level of potential development, under guidance or, in collaboration with more capable peers. This means that there exist different interpretation of cultural objects between novices and experts but with guidance and help participants can gain higher developmental levels.

For our purpose we have applied the concept of grounding processes, which can be regarded as a relevant aspect in the interplay between individual and groups. According to Baker et al (1999) grounding can play a role in collaborative learning. They refer to grounding as an interaction process that creates a shared understanding or a common ground among individuals. Beside distribution and presentation of information from a contributor to collaborators, grounding processes involves feedback and maintenance mechanisms controlling the state and status of other collaborators. Conditions for grounding among individuals, can be divided into two levels, a pragmatic level, that is a part of learning to collaborate and deals with how we understand each other's communicative intentions, and a semantic level which is connected to interaction that aims for a deeper understanding in a particular knowledge domain. Development of shared knowledge is a social and practical endeavour based on tools developed within a web of interrelations between individuals, groups and cultures. From the perspective of grounding processes different or conflicting interpretation among individuals do not necessary imply problems. On the contrary it can be beneficial where individuals have to make their interpretations explicit to each other and thereby construct more complex conceptualisations than what a single individual could have done.

Method

The students that took part in the project were a class of off-campus students located 140 km from the university campus. They attended a 3 – 4 year university program of systems analysis. During the project they studied their fourth and fifth semesters. Personal technologies for collaborative learning were tested during 3 five-week courses during the autumn semester, when they studied Informatics for their 3rd semester (C-level). The students have freely participated in the project. They were 24 in the spring and 16 in the autumn semester. Only one student that arrived later did not take part. The student group consisted of two female students and remaining students were male. Their age ranged from 23 to 48 years, where 26 years was a typical age. Also five students from the university campus took part in the project, two female and three male students. They completed their theses at the C-level and D-level (4th and 6th semester respectively of Informatics) as a part of the project.

In this project we have been able to capitalize from one of our earlier projects (Hedestig, Kaptelinin & Orre, 2002, Hedestig & Orre 2002) in which the students took part. One purpose of the earlier project was to find out how the students socialized and communicated within a group of classmates. Each student was asked to keep a diary of his or her communications, to whom and when and by what media they communicated. Single interviews and group interviews complemented the data from the diaries. A major observation was that the students develop strong study groups and that most of the learning process takes place within these groups. Most of the problem solving and interaction occurs horizontally, i.e. between students. This interaction is performed in an informal way and as a consequence, students use other media than those pointed out by the educator. In the earlier project we also studied the students exploration and practice of personal technologies, such as personal digital assistants (PDA) and mobile phones. The knowledge on existing communication patterns and use of mobile artifacts among students has been a point of departure for this project.

During the spring of 2003 conducted project activities focused on present and future learning contexts and during the autumn 2003 the activities concentrated around the design of the learning environment. The design team consisted of students and teachers and researchers at the Department of Informatics. During the spring four user meetings were held, where various scenarios were discussed concerning present and future learning settings. During the summer a prototype system was developed as a first version of a personal technology support for collaborative learning. The prototype was a web-based system accessible both through the use of desktop computers and advanced mobile devices or smart phones. Each student received a smart phone (SonyEricsson P800), which they could use during three

five-week courses during the autumn. The students could communicate via the system or via ordinary phone calls and SMS. The use of the phone was free of charge as long as they communicated within the class or with their teachers. During the autumn two workshops were held and there were also single and focus group interview. In the spring of 2004 there was a final meeting with students evaluating the project. During the autumn three campus students compared communication patterns among students during one course with a corresponding course at campus as part of their C-level thesis. Two students at the D-level extended the system with a notification function as their thesis work.

Whereas we in our earlier project were inspired by a user-centered design approach, in this project our starting point has been a learner-centered approach (LCD). LCD was developed as an argument to UCD with the goal to help learners to learn new work. In UCD computer users are considered to (a) have more expertise in their work practice and (b) mostly need tools developed to support their implementation of work. They contribute within the design process with their expertise and knowledge of work and task performance. To LCD learners on the other hand are (a) novices in a work practice and (b) need support to learn. The tools to be developed are not explicit to support task performance, rather to address the learners' lack of experience and to support them whilst acquiring the new work practice. Learners are heterogeneous in contrast to what is supposed in UCD, that users can be seen as homogenous. As the users within UCD are supposed to be sharing a common work culture, the learners might not share a common culture or level of expertise in the work practice. The learners' motivation and engagement cannot be taken for granted throughout the whole design process, in contrast to professionals that by the nature of their involvement with their work have an intrinsic motivation to contribute. The development of expertise must be the primary goal of educational software by supporting the learner to "learn by doing" rather than do tasks e.g. more efficiently.

Session 1	***Session 2***	***Session 3***	***Session 4***
Learner Interaction Scenario x 2	Vision Learning Scenario x 2	Learner Interaction and Vision Learning Scenario	Learner Written Scenario (3)
Highlighted reflections regarding the individual in a learning setting and the communication, cooperation and group learning through a Personal ICT. The students reflected upon present performance in relation to the possible interactions presented in the scenario.	Focus was on the future learning setting rather than the technology. Our interest laid on the implication regarding their support for learning and possible future learning practice.	Results from previous sessions were implemented in two presented scenarios. First focus was on the individual in relation to group communication through personal ICT. Second focus was on the future learning practice.	Here the students were divided into three groups of three to four students. They created their own scenarios and presented them to us and the other groups.

Table 1. The table presents the different scenario sessions with participants and the type of scenario

	Workshop 1	***Workshop 2***
Group participants	Learners and designers in groups of five to six persons with one designer in each.	Learners and designers. First in groups of four to five, later merged to one large group of nine persons.
Materials	Paper mock-ups on system, SonyEricsson P800 (system available through GPRS), paper (coloured, white and transparent), pen, scissor, tape, and whiteboard.	Paper mock-ups on stationary PC system, cardboard prototypes over mobile system, SonyEricsson P800 (system available through GPRS), paper (coloured, white and transparent), pen, scissor, tape, and whiteboard.

Table 2. The table presents the setting of the groups and material during both workshops.

One approach to make learners develop an appropriate and correct conceptual model of work is to use *scenarios* (cf Danielsson, Hedestig, Juslin & Orre 2003). Designers need to have a work model, an articulation of the target work practice and the experience needed to engage in the practice. Through scenarios learners can be encouraged to explore and explain their behaviour, e.g. by addressing future settings and work practice. In our case, experiences gathered from observations and previous interviews, were introduced and presented at four scenario sessions. The written scenarios were narrative designed to present future setting (vision learning scenario), the ICT support to educational task performance (learner interaction scenario), and finally by letting the students design the final scenarios (learner written scenario) (Table 1). Using scenarios gave the possibility to capture the students' thought, views and behaviours in a mobile learning setting. By interviews and scenarios we integrated their reflections in our conceptual model of the present and future learning setting. Students' participation in the design process promoted the exploration of future work context and the development of a conceptual model among the learners. The sessions gave them the contingency to connect their present learning setting to possible future settings. They were given opportunities to reflect on their present performance, benefits and problems connected to their strategies to achieve knowledge, and

the opportunity to jointly shape new ways of performance. Any changes in the scenarios were based on their remarks, and supported the development of their conceptual model of a future learning setting.

As the students to some extent had bridged the conceptual gap from learner to expert (Quintana et al., 2002) by the scenarios the possibility to include them as participants in the design was clear. Within Participatory Design (PD) the users perspectives of the present and future setting serve a more substantial role and is a significant part of the process. During appreciable time the users are included as participants. This made it possible to exchange skills, values, and perspectives on present and expectations on future settings. It facilitated a development of a joint set of requirements, needed to fulfil design that support actual work process (Kensing 2003, Carroll 1998). Previous user meetings in the project rendered possible a mutual understanding between designers, learners and pedagogical experts (cf Danielsson,

A first workshop was arranged in the autumn, one month after the students had received their smart phones and begun to use the first version of our prototype system. The time chosen for the workshop enabled the students to test the prototype in real life situations in their educational context before the workshop. Initial reflections of the prototype had also been captured in single interviews and focus groups. Students and designers were divided into three parallel groups of five to six participants. The workshop made it possible to have a more integrated meeting form supported by different materials, e.g. for making mock-ups. As the students were used to have a more prominent role in user meetings, they were at centre during the workshops. Students' proposals to improvements were merged together with the designers' implemented decisions of the interface. The students' reflections were interwoven with the designer's explanations as to why certain demanded functions had not been included and which plausible changes could be implemented in reasonable time. The students had a more prominent role than the designers in the workshop, as designers were expected to be confronted with the students' views and reflections.

This facilitated a smooth transition from their previous role, to become participants in the project. During and after the first workshop, single interviews and logs over system usage was conducted. The students' actual usage of the system could be secured both quantitatively and qualitatively. The interviews enabled an understanding why certain tools for communication were used at different times. Interviews also illuminated system function support in educational task performance (e.g. examination, group work, presentations, lectures etc.).

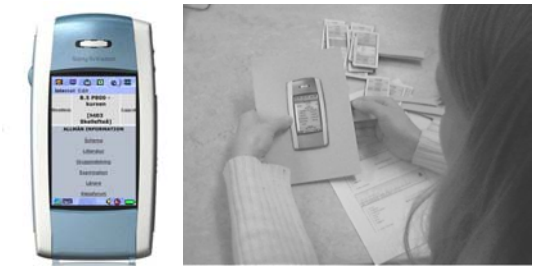

Figure 1. The figure presents the mobile interface and a prototype used by one of the students during the workshop

Figure 2. The figure presents learners and designer conducting redesign during the workshop

Two months after the first workshop, a second one was performed. The session included three forms of workshops concerning the interface of the prototype system. The class was divided into two groups of three to four learners and one designer. Group A worked on the stationary PC interface, and group B on the mobile interface. When both groups felt that they had worked through the system (approximately after one hour), the groups shifted interface. Finally, the groups were merged to one and both interfaces were handled. A mutual decision was made regarding plausible and desirable changes to the interface. This workshop complied more with the form of member activity that PD advocates. After the session, experiences from the workshop were discussed and reflected upon.

The project has followed an action research approach. The overall aim has been to understand what happens in a learning setting when students, teachers and researchers in collaboration design and use a mobile learning environment. Action research assumes that complex social settings can be understood only by a holistic approach. Action is also a key component that brings forward an understanding of the context. We have been more actively involved in the setting and become more as a participant observer since we have intervened in the setting through workshops,

scenarios and implementation of mobile devices. From these interventions we have made observations of processes through ethnographical techniques, e.g. observations, interviews, video recording, focus group interviews etc.

We will end this section by giving a short description of the prototype (cf Kopatcheva & Landgren 2003, Landgren , Hedestig & Orre 2004a, 2004b) developed in the project as a personal technology support. The system is a web-based system, consisting of dynamically created web pages. The web-content is stored in a relational database managed by a MySQL database system. The system provides different views of the same content, and different data can be combined to generate new constellations of the stored data.

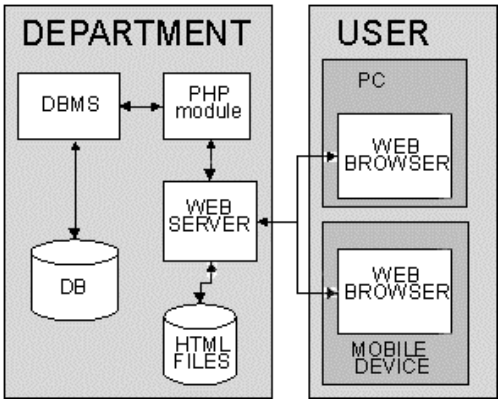

Figure 3. Illustration of the system architecture

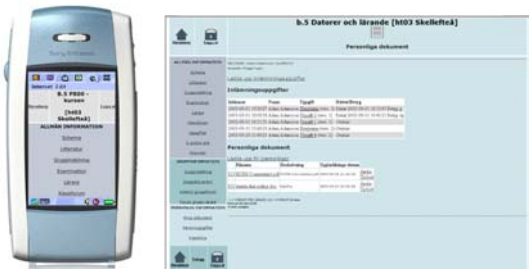

Figure 4. Illustrates the two different user interfaces, whereas the stationary interface is based on the mobile interface

The access to and from this database and the generation of the dynamic web pages is done via a PHP-module, connected to the web server. Text and binary documents up to 25 MB are also stored in the database system. These resources are presented according to the capabilities of the web-browser and existing plug-ins. Resources that are not supported by the browser, can still be downloaded and executed by other applications. The system sets few limits to what type of material the user can manage. The system is accessible both through the use of desktop computers and mobile devices, e.g. advanced mobile phones, handheld terminals etc. The connection between the mobile devices and the server is provided by the GPRS protocol.

The system takes into account both students and teachers specific practices and roles by providing two modes. The student mode, gives means for the student to access all relevant information and content of the course. Individual materials and files can be stored in a private domain, and collective resources generated through collaborative activities can be stored in a common information space. This space is managed through access control, where the students can allow teachers and other students to have read and write authorities; to text documents and other work materials. The students can upload any kind of data files and documents to the system from their own computers or mobile devices. This function is especially important for group work, where document handling can be backbreaking. The teacher mode has two dimensions. Firstly, it allows the teacher to administrate the course, e.g. upload resources, documents and other data files, that students must be able to download for the course. The teacher can also register via ready-made formats web links and resources. Secondly, the teacher is provided with means that allows him or teacher to communicate and act as a coach and a tutor towards the students. The system also provides means for her to coordinate and collaborate between teacher teams, fellow colleagues and students. Teachers and students have the possibility to edit the information content in the system. This is done via pre-defined web forms and can be done also from a mobile device. The system offers discussion forums at three levels, the class level, the study group level and the teacher-study group level. Mailing are also available and every student can add as many email addresses as he or she likes, and the system will then send the mail to that student on all those addresses. A subscription middleware, as an alternative to e-mail notification (Björk & Åden 2003) was also developed but not incorporated into the prototype. As we see it, the system must function in concert with other means of communication that exist in the specific environment, such as SMS, mobile phone calls, and instant messaging. The role of the system is to provide the users with a common information spaces and resources. Examples of these resources are bulletin boards, discussion forums, shared workspaces, contact information, and other course related information.

The user interface design is mainly based on mobile usage of the system and we have based the interface mainly on the experiences identified among the students. The mobile interface is designed for fast access, rendered possible by a text-based menu and no icon design. Also, the size of the display demands a design that supports only vertical

navigation, and no horizontal, all for easy mobile interaction. As the artifact support vertical navigation by side scroll, the interaction with the system and the usage of the artifact are interwoven. Although a stationary interface can involve a more process demanding design, based on e.g. icons and pictures, the students stated during workshops that the stationary interface should be designed according to the mobile interface. One example is the menu (see Figure 4) that the students wanted to be similar to the mobile menu. A combination of these two interfaces illuminates the importance to interweave the design so that the user is familiar to the context, despite chosen artifact of interaction. They feel that they encounter the same system, and are therefore familiar with its affordances and constraints.

Results

We present the results of the project as four themes: experiences of the design work and the co-operation of designers and students, the use of the prototype as a personal technology support, if the prototype support had been helpful for the students in their studies and the experiences of the teachers.

The design process of a prototype for personal technology support. The students stated the value of scenarios as a foundation for discussion and reflection. Mostly, they saw scenarios as a tool to structure their discussions and avoid drifting away from a given subject. The scenarios were worked out as an iterative process, i.e. the content of a scenario was affected by the discussions from earlier scenarios. This meant that they could identify the changes made from their previous remarks and it also gave them the opportunity to make connections between different discussions and include features or situations excluded in later sessions. The recognition of themselves within the narrative scenarios could also be a motivational factor. The use of the scenarios revealed the heterogeneity in point of views of the students towards learning and learning environment, not only to us as designers but moreover to themselves. This was illuminated by their identification of use situations and their concretisation of possible solutions from the scenarios that could be beneficial, both to themselves as individuals and to the group as a whole. Expressions like *"I do not recognize myself in this presentation"* and *"Ah, that is just you [Lars]!"* were common. Also notifications like: *"This sound really great, I would like to do that"* and *"This is not how we do things, we might, but then I see problems…"* were colorful remarks on the scenarios. Some of the students did not see the use of technology to the same extent as their fellow participants. Rather, for them, face-to-face meetings were stated as the ultimate solution. There was a great amount of compassion among the students for fellow participants situations: *"I don't need this, but I think its needed for NN, so why not!"* or "*this would actually be advantageous for the teachers as well*".

The students' knowledge of their everyday practice of interaction and personal technologies provided design proposals that would not have been accomplished without their participation. It gave us the position to reconsider the very foundation of using ICT tools in learning environments. *"Here it would be great to get both sound and color notification, sound to hear and color to find the change made."* or: *"To be able to check this on the bus back home, would give [me] more freedom."* are examples of comments noticed. The scenario sessions did promote to bridge the conceptual gap from learner to expert and also questioned and shaped our own conceptual model. The students, with their reflection, gave insight to whether or not our assumptions were correct. Noteworthy reflections were made regarding their present learning setting, as group and individual: *"We would meet up at Campus, wouldn't we?"* and *"I think I would study at home and then contact you through [some] technology if I had any questions"* are just two of many examples. The students also discussed ways of knowledge mediation when distributed within study groups and between student and teacher were comments as "*it's quite easy to share information by using e-mail*" or "*e-mail isn't useful when you need to mediate difficult information, like JAVA code"* came up. They recognized their learning practice in the scenario narratives and therefore they were able to reflect upon shortcomings and visions how to avoid these to support their learning. "*It might happen that it is more effective learning in a bigger group*", "*a great thing would be if communication could take place in an online forum as we comment in earlier session"* and "*a forum would open up for the possibilities for the teacher to communicate knowledge to the whole group"*.

Data from the workshops included new design suggestions made by the students and the students' experience of participation in a workshop. They stated workshops to be a more desirable form of participation, as they in previous meetings lacked views, knowledge and suggestions made by the designers. After the session, experiences from the workshops were discussed and reflected upon. Both students and designers stated workshops to be a very productive and important part of the project. A greater sense of mutual understanding regarding expectations had been attained. To ground later participation by previous ones the user meetings seemed to be of significance. Reflections on context and experience of the new system were needed before producing suggestions for change. Designers stated previous sessions to be beneficial, as they enabled inclusion of suggestions from the students, and implementation of innovative design suggestions.

The use of the prototype. The prototype was tested in 3 five-week courses. Due to the provisional character of the prototype we were not able to collect statistics of the use of e-mail sent via the system.

Course	Class Forum	Teacher-Group Forums	Group Forums	Uploads &Down-loads	Phone calls within the class	SMS within the class	Phone calls out-side the class	SMS outside the class
Algorithms and Data Structures for Problem Solving	38	121	13	156	112	35	16	30
Data Communication	6	0	7	33	83	43	26	20
Program Development	14	0	21	132	71	33	29	9

Table 3. Contributions to the discussion forums, up- and downloads of files, phone calls and SMS during the test period. (Phone calls and SMS refer only to the first 80% of the last course).

The courses were of different character and the use of the prototype also differed from one course to another. The first course contained assignments that the student groups were to solve. The teacher-group forums discussed intensively the definitions of the assignments and various problems in solving them. Each group consisted of 2 students. The second course presupposed to a much greater extent self-studies and less problem solving in groups. The students explained their passiveness during this course by the teacher's insufficient participation in the discussions. They considered the teacher's willingness to take part as very important. In the third course the students had to carry out a major project designing and programming an administrative system for a library. They worked in two independent groups with 8 students in each group. The teacher was available at place during the whole course, so the students felt no need to communicate with him via the discussion forum. In this course the students found our prototype system most useful. They stated that the system was most helpful in this last course in keeping the group together and organizing the work among the group members. The possibility to exchange documents between group members and upload and download files was one of the most appreciated features of the system. By uploading documents they could also continue to work with them at home after leaving the study center. A more detailed analysis of the communication patterns in the first course can be found in Danielsson, Larsson & Lundin (2003).

Has the prototype support been helpful to the students in their studies? Some of the student made very clear statements that the prototype system has helped them to acquire the course contents. Some citations from the students' evaluation of the project indicate this. "*It increases learning in groups. It can increase solidarity within the group, since you get to know the group, connected to the system, in quite another way than usual.*" "*You can ask the whole class, if you have any problem."* "*Group work has become easier, especially if the group consists of more than 2 – 3 persons*". There was a unanimous agreement that the possibility to share documents was extremely valuable. Some were satisfied that the availability of course material and information on the course was accessible from one place via the system. To some students mobility via the system was especially important, since they had no computer at home. It is difficult to find objective measures to which degree the personal technology support has facilitated the students' acquirement of the course contents. The examination results of the first course was not quite as good as could be expected, clearly better than expected in the second course and extraordinarily good in the third course. In the latter case all students passed with distinction. A number of other factors are clearly relevant for the outcome, but a more stimulating learning environment supported by personal technologies may have promoted successful studies.

Teachers' experiences. One testimony from a teacher states "*It can be difficult for a teacher of a decentralized course to get a grip on how the student progresses because of the lack of communication. It can also be difficult to support and maintain the social interaction. The prototype supports the teacher in both these respects as the teacher can communicate with the students as well as easier assess the student group and acquire the social awareness of the student group. All this is possible due to the communication support in the form of the different forums and the ability to send e-mail directly to the whole class or a specific group without knowing the e-mail addresses. The one function that seems to have the most impact for the students is the support for shared group documents. We believe that the ability for the student to coordinate their group assignments by using the shared workspace for their shared documents have fostered a better group dynamics*". Another teacher said that the teachers in his course had great expectations on the use of forums, but it did not work out as we thought. "*This was our fault. It was difficult to understand how it all worked. Notification facility and e-mail lists were good. Then I knew who had been informed and who hadn't.*"

Discussion

Experiences from our prototype in use indicate the viability of personal technologies for support of a collaborative learning environment. It has been used throughout three courses and been considered valuable by the students. The experiences also show that the way of using the prototype is highly dependent on the situation. In the first course a main use supported the dialogue between the teacher and the student groups, while in the third course co-ordination of work within groups and file sharing were prominent activities. Collaborative activities are complex in nature and it is difficult to foresee which tools and resources are needed to accomplish a certain collaborative task. We found that it was important that the technical support provided for a broad space of possible actions to perform communicative activities. The integration of mobile artifacts or smart phones and stationary desk computers were essential in

many situations. In one case a student group in a group room at a local learning centre, found it necessary to access resources that did not exist within the common information space. One of the students had already access to this resource within his own contact list on the mobile phone and could contact the person without leaving the learning environment. The phone call resulted in an exchange of documents between the resource person and the student, which then became uploaded into the group. The system also needs to embrace the private dimensions of the student's everyday practice. There were frequently occasions when students in study groups suddenly had to re-plan their schedules for picking up children at kindergarten, etc. This coordination activity was also obvious when members in study groups scheduled their next meeting. Also of importance is the ability of the system to provide data for a number of various applications. Communicating via a web-browser and a file sharing system was very flexible. Resources that were not supported by the browser could still be downloaded and executed by other applications.

Our experiences imply certain desirable properties of the system for an effective technology support for collaborative learning. These properties seem to be in line with the concept of semiformal system developed by Malone, Lai and Grant (2001). The characteristic of a semiformal system is that it provides the user a flexible space of possible actions. It does not prescribe ways according to which the user must handle the system. The users should be able to act in various situations and not be restrained by the system. The formalization of information concerns routine activities and information that is inevitable guiding the actors in the environment. In order to establish a foundation towards a design model of learning environments that involves mobile technologies, we need to (a) utilize Learner-centered Participatory Design approaches, where students and teachers and other actors in the setting participate in order to determine the role of technologies in current learning environment, (b) build on a contextual understanding of how these technologies are used in everyday interaction and activities, (c) balance the requirements of information processing and communication facilities, (d) determine what and which kinds of information that should be formalized or not. This implies a system architecture that can easily adapted or tailored to the special needs of the current learning environment (cf. Landgren, Hedestig & Orre 2004a, 2004b).

According to the LCD-approach learner's engagement and motivation cannot be taken for granted throughout the whole design process. However, our students have been highly motivated and engaged, although they have been participating for a long time in this and preceding projects. We think the stepwise procedure from user-centered design to learner-centered and participatory design has contributed to keeping up the students' interest. The students have been able to participate at each step according to their knowledge and also been able to develop their competence for future tasks in the process. The scenarios have had such a role in supporting the students. As one student stated: "*Scenarios have been good. Even if the scenario did not describe the way I do things myself, you get an idea how things could be. This is a good starting point for a discussion and it is easier to imagine such a scenario than thinking all for yourself*." These discussions are also of value for pedagogical reasons, since it gives the opportunity to students to reflect on their learning environment and their way of learning. The incorporation of personal technology in the learning environment is a step-by-step process. The workshops that took place at a stage when the students had experience of the prototype in use for some time have also been helpful in this process.

It is interesting to see that the teacher seems to be one key component for the success of such a system. The teachers were not always aware of their key role for how intense the communication could become on the course through the prototype system. Previous experience of other communication technologies seemed to impact on the teachers' activity in forums etc. The teacher became more reachable and could be contacted by the students either through the prototype system, or directly by mobile phone. The combination of both stationary and mobile interface of the prototype system supported a closer relation between the students and the teacher, not always possible in off-campus education. The students preferred the more regular and informal contact between teacher and students that now was supported. In cases were the teacher preferred to use other, more traditional communication technologies, the close relation was soon lost.

We will also stress the importance of the bottom up-approach. Information from the students on how they interact in their everyday learning and collaboration has affected our design in many ways. The most important problems with personal technologies are related not to the technologies themselves but to the type of coordination between personal and public artifacts and between individual and collective learning activities that can be supported with personal technologies.

The result of this project shows that there is an apparent need for personal technologies in decentralized education. The students need to get an access to course materials, to the teacher, and to fellow students when being located in a wide range of physical and social contexts. The design approach we have applied is very promising and we intend continue our efforts to develop a Learning-Centered Participatory Design approach. These efforts include the task of how to develop design models that offer a high degree of openness and flexibility for the user.

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Authors Note

Karin Danielsson
e-mail: Karin.Danielsson@informatik.umu.se
Olga Kopatcheva
e-mail: Olga.Kopatcheva@informatik.umu.se
Ulf Hedestig
e-mail: Ulf.Hedestig@informatik.umu.se
Göran Landgren
e-mail: Goran.Landgren@informatik.umu.se
Maria Juslin
e-mail: Maria.Juslin@informatik.umu.se
Kenneth Nilsson, project leader
e-mail: Kenneth.Nilsson@informatik.umu.se
Victor Kaptelinin
e-mail: Victor.Kaptelinin@informatik.umu.se
Carl Johan Orre
e-mail: Car.-Johan.Orre@informatik.umu.se

Address to the authors:

Department of Informatics
Umeå University
SE-90187 Umeå
Sweden

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