PEDAGOGICAL INFRASTUCTURES IN E-LEARNING ENVIRONMENTS AS INVISIBLE BRIDGES BETWEEN NAVIGATION ELEMENTS

Tiiu Tenno
MSc, Med, Senior Lecturer
Oulu University of Applied Sciences
School of Vocational Teacher Education
e-mail: tiiu.tenno@oamk.fi

Abstract

In ICT, the pedagogical design of technology-enhanced learning should start by building basic supporting structures in learning environments. Some recent studies have given a central focus to the notion of infrastructure in discussing the pedagogical design of knowledge-creation practices. Furthermore, Finnish researchers have started to use the notion pedagogical infrastructures, consisting of *technical*, *social*, *epistemological* and *cognitive* components. In this study pedagogical infrastructures will be seen as a collection of *invisible mental bridge*s between *navigation elements* in e-learning environments. Principally, these infrastructures should be totally invisible supporting elements. The guidance of students can be made possible only through the visible elements such as links and icons. They support the navigation act as meeting points or knots of infrastructures. Whether the pedagogical infrastructure guides the student into the desired direction or not, is dependent on the position and organization of those elements.

The aim of this study is to investigate pedagogical infrastructures within the guidelines of user psychology, which applies psychological knowledge in analyzing and designing *human - device interaction processes*. Achievements of user psychology research are based particularly on the outcomes of the research in Finland. The study consists of three parts: 1) constructing the theoretical basis of research and defining the concept of infrastructure; 2) analyzing the infrastructures and the availability of the elements in the present learning environment, and 3) creating an improved learning environment and analyzing the infrastructures and elements in it.

Preliminary background information for planning design-based research was collected by a statistical analysis tool in WebCT (BB) e-learning environment. It appears that students had problems to find essentially necessary elements such as instructions written by the by tutor, and learning resources. The findings from these studies also show a clear connection between using navigation elements and their placements in e-learning environments. In the case of negative connection the pedagogical infrastructure didn't work.

Keywords: pedagogical design, pedagogical infrastructures, e-learning, user psychology.

Introduction

In recent years research on learning has examined various applications of ICT (Information and Communication Technologies) from the viewpoint of online tutoring, content production and social aspects. The basic question in constructing an online course is still: What added value is obtained

through transferring a course to the web? The choice of online learning environment should be based on learning theories and well argued pedagogical needs which are realized and supported by the learning environment. According to Rossett (2002), online learning has many promises, but it takes commitment and resources. One aspect is that tutoring can be included in the structure of the learning environment. The structure is often understood as the technical or physical features of the learning environment. On the conceptual level the structure of the learning environment as infra structures is a metaphor of the model and cultures of operations in online learning environment. Infrastructure means different things in different situations and for different people; infrastructure is seen as an ecology of tools, action and built environment. An infrastructure is part of technological, material and social conditions of practices. As Star and Bowker expresses, "communication infrastructures include printing, telegraph, radio, television, the Internet and the web, and movie production and distribution" (Star & Bowker, 2002, 151).

Researchers have described the infrastructures for learning with technology since a dozen of years (Star, 1999; Bieaczyc, 2001, 2006; Paavola, Lipponen & Hakkarainen, 2002; Paquette, 2003; Lakkala & Lipponen, 2004; Guribye, 2005; Lipponen & Lallimo, 2004, 2006; Lallimo & Veermans, 2005; Lipponen, Lallimo & Lakkala, 2006; Lakkala, 2007; Lakkala, Muukkonen, Paavola & Hakkarainen, 2008). The research on infrastructures seems to be connected to the problems of structuring and tutoring social learning (e.g. Dillenbourg, 2002). Lipponen, Lallimo & Lakkala (2004) have started to use the notion *pedagogical infrastructures* in the connection of describing the structures in social learning. The researchers argue their views by pointing out that the social structures of learning in the environment resemble human action in everyday life. Pedagogical infrastructures tend to describe the practices that support learning in the environment. The practices referred to follow daily human action and are possibly transferred from daily activities to learning environments. The practices are culturally bound and differ from each other in different educational units, learning environments and courses by different teachers. In conclusion, infrastructures for learning, in other words pedagogical infrastructures are a collection of instructional tools designed and used by a variety of actors.

In the research of learning and learning environments attention can be given to their physical structure, action culture and contents or examine their mutual relationship. In an online learning environment the attention is focused on the conceptions of "technical", "social" and "pedagogical" infrastructures. The notion of the relationship and order of importance between the infrastructures described varies among researchers. The researchers in Finland see that all the infrastructures of learning environments could be regarded as part of pedagogical infrastructures. For instance, Lakkala, Muukkonen, Paavola & Hakkarainen (2008) try to find theoretical arguments and explanations for profiting from pedagogical infrastructures in promoting learning and tutoring in technology-supported environments. Other researchers (e.g. Paquette, 2003) consider pedagogical infrastructures an independent issue.

In this study the conception of pedagogical infrastructures is widened to describe, besides the practices of learning, also web learning environment and its content elements. As a tool in making the infrastructures visible the researcher has used the examination of the infrastructural content elements as well as the organization of the elements.

Theoretical Basis

The aim of the next chapter is to take a general survey on the educational usage of the conception of infrastructure and to introduce the first conceptual framework for the present study.

The pedagogical design of technology-enhanced learning could be seen more as providing basic supporting structures to users. The concept of *infrastructure* refers to technical or physical aspects that are built in society to provide for smooth functioning of people in their everyday life processes (Star, 1999). To study infrastructure in relation to practice, means doing inquiries into practices, students' experiences, and media. Star (1999, 387-388) identifies three different ways to interpret infrastructure: a) a material artifact constructed by people, with physical properties and pragmatic properties in its effects on human organization, b) a trace or record of activities, and c) a veridical representation of the world. Drawing on Star conceptualization of infrastructure, infrastructure is embedded in the system and is transparent, meaning that it need not be adjusted for each task, but it invisibly supports those tasks. In recent studies, *computing infrastructure* will be seen as an integral part of the infrastructure for learning. "The notion *infrastructures for learning* encompasses technologies designed to support, manage, organise and/or deliver training or learning activities, and the specific instances can vary between everything from groupware for use in collaborative learning, discussion forums, web based simulation games, to online tutorials. Still, all of these tools link into and are inseparable from an installed base and other technological and nontechnological arrangements, and become infrastructures for learning in relation to practice." (Guribye, 2005, pp. 64.) Lipponen, Lallimo & Lakkala (2004) have started to use the notion *pedagogical infrastructures* to illustrate how the pedagogical design of collaborative learning practices resembles the construction of basic physical infrastructure. Pedagogical infrastructures used to refer to the elementary preconditions designed to shape and support collaborative knowledge practices in educational settings. *Pedagogical infrastructure* mediates cultural practices and directs students' activity both explicitly and implicitly (Lipponen, Lallimo & Lakkala, 2006). "In a complex learning setting, the elements that build affordances for students' actions, designed by the teacher or based on the conventions of the educational institution can similarly be said to consist of components that form a *pedagogical infrastructure* to afford and facilitate certain types of learning activity"(Lakkala et al., 2008).

The next summary reflects different theories of infrastructures for learning, especially infrastructures in on-line learning environments. In the field of computer-supported learning the central component of learning environment is technical infrastructure. Technical infrastructure bases on the technology that enables and facilitates co-construction and elaboration of common knowledge artefacts. Kling (1992) sees computing infrastructure as a *collection of resources* that support working computing arrangements. These resources can be physical, technological or social. "Physical resources include the space to place equipment; technological resources include electricity and communication lines. The social resources include people skilled in using and repairing equipment and practices for allocating resources" (Kling 1992, pp. 366). Computing infrastructure is an integral part of the infrastructure for learning.

Bielaczyc (2001) argued that in educational change, through collaborative technology, the central challenge lies in building the appropriate social infrastructure around the technical infrastructure. Lipponen (2002, pp. 77) criticises Bielaczyc's model of being too focused on the technological infrastructure. According to Lipponen & Lallimo (2004), infrastructures are too often understood as some kind of technological structures. Social infrastructure is based on the explicit arrangements to advance and organize communication and collaboration. Bielaczyc (2001) was the first to use the notion of *social infrastructure* associated with designing and analyzing technology-enhanced learning environments. She stated that characteristic of successful technology-enhanced collaborative learning is the fact that an appropriate social infrastructure is built to support the use of technology. Bielaczyc

(2001, pp. 107) sees the social infrastructure as the "supporting social structures enabling the desired interaction between collaborators using the same tool". She proposed three levels of social infrastructure important for successful implementation and use of CSCL. The levels include a) cultural level (the philosophy and norms established among educators and students), b) activity level (practices), and c) tool level (technology). Lipponen and Lallimo (2004) have elaborated on Bielaczyc's idea and they proposed that establishing social infrastructure should be the primary objective. They propose that the distinction between collaborative technology and collaborative use of technology is useful for the future development of technology-supported collaborative learning. Further, Bielaczyc (2006) proposed to include a *cultural beliefs* dimension and an *interaction with the "outside world"* into social infrastructure framework. Social infrastructures as social components of learning and learning environments are basic components of well structured environments. According to previous views, the key is to see social and technical infrastructure as aspects of infrastructure in general, not as two separate entities - one built around the other.

Paavola, Lipponen and Hakkarainen (2002) stated that educational settings should also be examined from the viewpoint of the relationship to *knowledge* that the practices reflect. Scardamalia and Bereiter (2003) pointed to the expectations of education that stem from the beliefs that future knowledge society requires not only content mastery but competencies of working with knowledge. Learning and development of knowledge occurs in heterogeneous socio-technical networks which both technical factors and social actors take part in (Lipponen & Lallimo, 2004). Paavola, Lipponen, and Hakkarainen (2002) pointed out that besides technical and social infrastructure, educators and researchers should also pay attention to the *epistemological* infrastructure of the learning community. Epistemological infrastructure is based on the role of knowledge sources used and students' and teachers' role in creating and sharing knowledge (Paavola et al., 2002). The main role of content materials seems to be to contribute to the building of the *epistemological infrastructure* in the educational setting (Lakkala, 2007). In a research by Lakkala et al. (2008) epistemological infrastructures were categorized according to the *epistemic nature of activities* (task-accomplishment, the sharing of ideas or purposeful inquiry) and the *structuring of activities* (rigidly structured activity, open inquiry, or scaffolded inquiry).

In addition to designing an educational setting to provide students with relevant technological tools (technical infrastructure), encourage them to collaborate effectively (social infrastructure), and direct them to treat knowledge as something that can be shared and developed (epistemological infrastructure). Lakkala et al. (2008) proposes that educational settings should also be designed to include explicit *cognitive infrastructure*. In the research by Lakkala et al. (2008) c*ognitive infrastructure* is based on explicit modeling of the strategies of inquiry and collaborative knowledge work. Specific learning materials can have a role in building the *social and cognitive infrastructures* of an educational learning setting (Lakkala, 2007).

Lakkala et al. (2008) proposes a *Pedagogical Infrastructure Framework*, including technical, social, epistemological, and cognitive components, to be used as a conceptual tool in design-based research studies. The most important benefit of the framework is that it will help structure an overview of various design features in a concise form which facilitates the examination of the interplay between the critical components. The applicability of the framework was tested by using it retrospectively to describe a long-term design-based research effort involving four consecutive undergraduate university courses. They were traditional lecture courses enriched by introducing the elements of inquiry supported by a collaborative software system. (Lakkala et al., 2008)

Table 1. Application of Pedagogical Infrastructure Framework in practice (* Lakkala et al., 2008) and **Lakkala, 2006).

Component*	Definition,* features shaping the infrastructure	Question**	Answer**
Technical	Providing technology and technical advice; the appropriateness of tools for the desired activity; and organizing the use of technology.	What kind of technology and tools are in use?	Providing technology and technical advice; the appropriateness of tools for the desired activity; organizing the use of technology.
Social	Explicit arrangements to advance and organize students' collaboration and social interaction; openness and sharing the process and outcomes; and the integration of various social spaces, such as face-to-face and technology-mediated activity.	How collaboration is organized and supported?	Explicit arrangements to advance collaboration; social interaction and working practices; sharing the process and outcomes.
Epistemo-logical	Ways of operating with knowledge; conceptions of knowledge that the practices reflect; nature of knowledge sources used; actors' and content materials' role while sharing and creating knowledge.	Why, how and by whom knowledge is produced?	Ways of operating with knowledge; nature of knowledge sources used; participants' and content materials' role while creating and sharing knowledge.
Cognitive	Supporting students' awareness and independent mastery of the critical aspects in the desirable practices; timely guidance provided for the students; scaffolding embedded in tools; and methods used to promote metacognitive thinking and meta-level reflection of the practices.	How to explicitly support and scaffold activity?	Providing models, templates and conceptual tools; promoting metacognitive reflection; scaffolding embedded in tools and technology.

By Paquette (2003), the architecture of an online course can be viewed as three-level. It consists ideally of a pedagogical infrastructure, a media infrastructure and the information technology infrastructure that supports the other two infrastructures. The real concern for teaching and learning concentrates in the pedagogical infrastructure where the pedagogical strategy guides the course toward a content-based or activity-based approach.

The infrastructures of learning and the environments of learning have been examined to the extent that this study can find a theoretical basis which is sufficiently well reasoned. Still there remain issues which should be sharpened, as for instance: how are the infrastructures for learning separable from other infrastructures? Resources that support learning practices can also be used to support other working arrangements.

The starting point of this study is that computing infrastructure will be seen as an integral part of the infrastructure for learning. Infrastructures for learning are a collection of conceptual instructional tools and explicit structures of action. Pedagogical infrastructure mediates cultural practices and directs students' activity. In practice, pedagogical infrastructure may be seen as a collection of physical or

non-physical, visible or non-visible resources that support students. The pedagogical infrastructure is embedded in the system. At the same time part of tutoring the learning has been immersed into the system.

In this study the central objects of examination are the conceptual and pedagogical counterparts of pedagogical infrastructure, like technical, social, task-oriented and resource elements in learning environment. Technical infrastructure means in this study the so called second level technical infrastructure which is constructed by the teacher through organizing the contents of the environment and making use of available technological resources. The study of technical, social, cognitive and epistemic solutions is operationalized into studying the elements of learning environments and their organization. This is how the structure of infrastructures becomes physical and open to research.

Research Context, Data Gathering and Research Methods

This study is being carried out in 2007-2008 in The School of Vocational Teacher Education in Oulu, which is the northernmost of Finland's five vocational teacher education institutes. It is responsible for the pedagogical education (60 ECTS) of teachers for secondary and tertiary vocational education, but gives a general pedagogical competence for teaching the majoring subjects. The present study examines the way in which the student teachers (here called students) make use of their e-learning environment. The aim of the research is to illustrate and develop the infrastructures of the learning environment to make it match the typical action models of the students in the e-learning environment. The learning environment concerned was built to support the compulsory pedagogical studies (15 ECTS) of vocational student teachers.

In this study a design-based research approach will be used. Design research is a strategy spreading since the 1990´s with the aim to study and develop both the theory and practice of learning in authentic learning situations (Collins, Joseph & Bielaczyc, 2004). There are five characteristics that describe the design research: 1) the purpose is to develop educational theories; 2) it uses a wide variety of methods; 3) it creates conditions to inquire about unique educational phenomena; 4) the process of the design is essentially iterative; and 5) it produces solutions directly applicable in practice (Edelson, 2002; Collins, Joseph & Bielaczyc, 2004). Design research is not a methodological unity, but a research strategy that can be used in the connection of both qualitative and statistical methods (Bereiter, 2002; Collins et al., 2004). In design research it is important to reflect the relationships among theory, designed artifacts, and practice. "Research can also result in context-specific knowledge and can serve a problem solving function" (Richey & Nelson, 1996, pp. 1216). Design research should produce a design solution that outlasts the design research study and can be used by others.

Design methodology provides guidelines for the procedure to find a successful design solution. Design research processes are complex and continue in steps. In each step, the emphasis is on different research objectives. The present study consists of three parts: 1) constructing the theoretical basis of research and defining the concept of infrastructure, 2) analyzing the infrastructures and the availability of the elements in the present learning environment, and 3) creating an improved learning environment and analyzing the infrastructures and elements in it.

Results of the first part of the design research: The infrastructures and the availability of the elements in the present learning environment

Analyzing the infrastructures in the present learning environment was started in autumn 2007 by analysing the learning environment, i.e. Blackboard Learning System - CE Enterprise License (WebCT 6.1.1) or BB 6.3.2 (WebCT were updated to BB in April 2008). The purpose of collecting preliminary information was to explain what action structures there are in the present learning environment. The infrastructures of the learning environment were observed at the critical points like the information of courses, location of resources and evaluation of courses. In the target learning environment there were technically two kinds of practices in organizing the contents: focusing by the tools and focusing by the themes. In addition, in the learning environment there was a central information forum and other non-grouped elements.

When the preliminary information for the research had been collected, the examination of technical, social, cognitive and epistemic solutions was reduced to examining the organization of the elements in the learning environment. Also Lallimo and Veermans (2005, pp. 53) operationalized the examination of pedagogical infrastructures by concentrating them into the form of the elements needed in the learning environment. The elements consisted of study material, instructions, tasks, timetable and different opportunities of interaction. The examination was carried out by first outlining the different elements of individual courses. After that the elements were studied from the viewpoints of cognitive, social and epistemic infrastructures. In addition to the characteristics of the elements in the learning environment, this study also tried to explain to which infrastructure the elements mainly belonged to. The elements were study materials, instructions, tasks, timetable and different interaction opportunities. Lallimo and Veermans (2005) observed the targets first by outlining the characteristic of the course elements individually, then by examining them from the viewpoints of cognitive, social and epistemic infrastructures.

In the present study, in addition to the elements of the learning environment (n=9), the aim was to explain which infrastructure the elements mainly belonged to. The data were collected during the time of eight months 1.5.2007 – 31.12.2007. The forums observed were

- the tutor´s forum for supervision,
- the students´ forum for personal introduction,
- two public forums for returning the assignments called My Learning Experience and The Analysis of a Peer´s Learning Experience, and
- two private forums for returning the assignments named My Learning Portfolio and Peer Evaluation of the Portfolio.

In addition, the usability of the following files were observed:

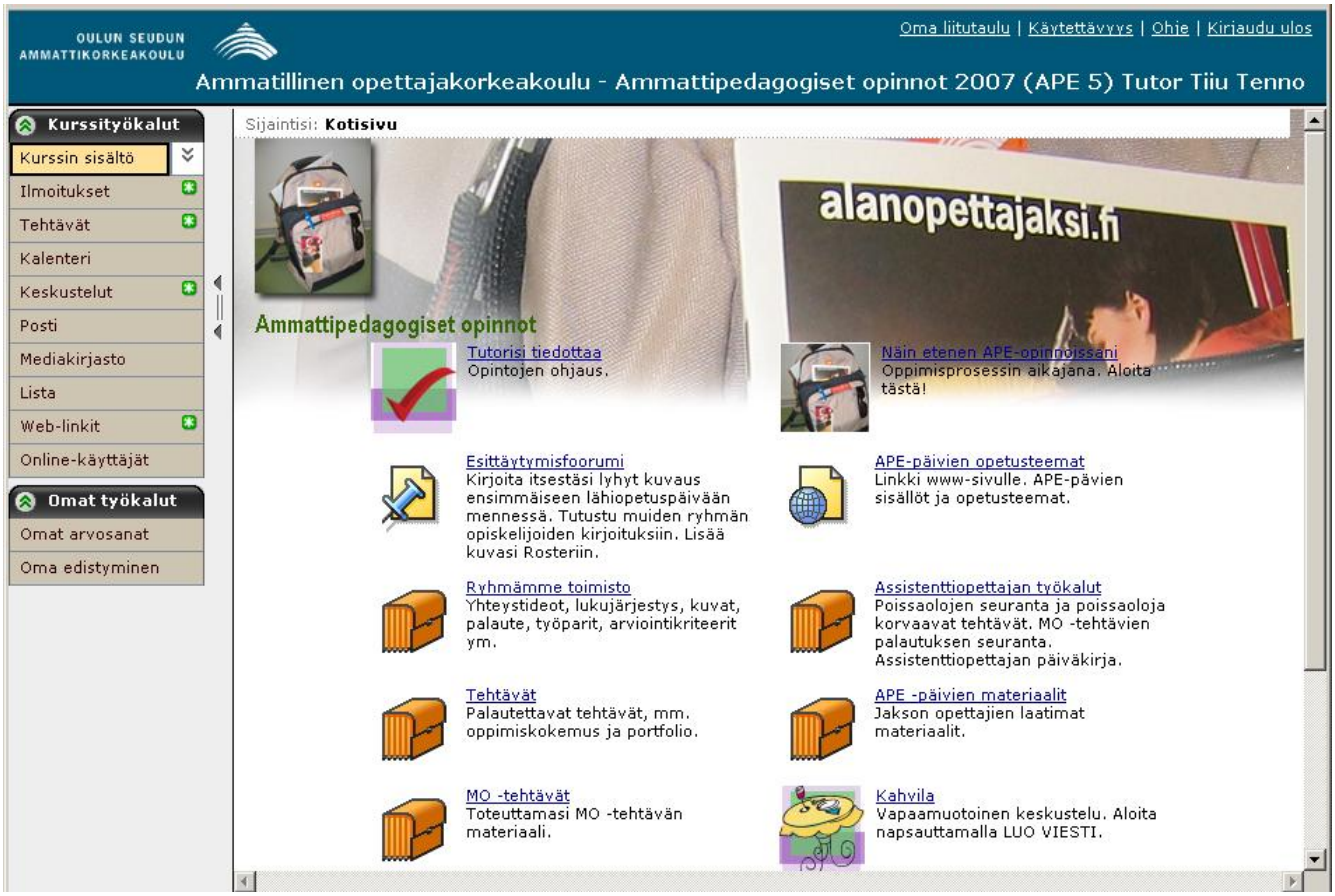
- Material Folders (n=10),
- the office folder called Our Office (n=1), and
- the data Files (n=5).

The learning environments had links and attachments whose use was not observed. The results of the pre-study were not dealt with statistically. The BB analysing tool presents the results of the inquiry also as percentages and figures. They were considered sufficiently exact for the results of the pre-study.

Examining the learning environment was started by an inventory list of the contents. The elements of the learning environment to be examined, and the linking of these elements with various infrastructures were written down. Students´ activities concentrated around these elements which was presumable. Statistical data of their usage were also written down, i.e. about:

- openings or loadings
- reading and writing messages in the forums, and
- information to the support services on the problems concerning an element.

The elements which were opened fewer times than there were students in the learning environment were marked as critical points of the learning environment.



Picture 1. The entrance page of the learning environment with its technical infrastructure. The contents of the course has been classified according to the tools (to the left) and themes (to the right).

The central tools, forums and materials are present on the main page of the learning environment (Picture 1). Charting the structure of infrastructures was started by observing the organization of the elements representing the infrastructures, i.e. the technical, social, task/assignment and resource elements. The preliminary data of the infrastructure were gained through examining the statistical information of the usage of the elements. The active usage of the learning environment took place in 15.5. – 15.10. 2007. Important meeting points of the infrastructures were the elements which were used actively through the whole time of observation. The dynamics of student activity revealed the structures of activity in the environment. The inner analysing system of the BB learning environment

gives a picture of the content usage in the environment classified according to the tools, i.e. from the viewpoint of the technical infrastructure.

The picture modelling of the results by the BB analysing tool reveals how student action concentrated round certain elements of the learning environment. Round Discussions and Who´s Online there was active participation. Almost equally often students used the resources represented by File Upload/ Download and media Library. An essential tool was also Assignments.

The students were very different actors and used the learning environments in different ways. Part of them were interested in social tools and were interactive in the forums of the learning environment, in sending e-mails and working with chat tools. The way how they used the forums showed that a) the assignments were returned to the forums immediately before the deadline, and b) the students replied to each others´ messages mainly when it was suggested in the instruction. The students opened each others´ messages 1,5 times on average. The first messages on the forum were opened more actively that the later ones, 2 – 3 times on average. Messages written by co-students were read, but comments on them were given seldom. For instance, on the forum of introduction of APE5 (19 students) and APE8 (19 students) the only one to reply to the introduction message was the teacher tutor. There were 995 openings of the introduction forum in group APE5. It means that each introduction of a student was read 19 times on average.

Social activity of the students was different on different forums. Activity was probably influenced by the advice they were given about the use of the forums. Part of the forums acted also as the forums of delivering the assignments. Consequently, the social infrastructure was difficult to distinguish from the whole. For instance, in learning environment APE5 “My learning Experinece” the assignment of a co-student was opened 1 – 6 times. The assignment was designed to be a pair work, and reading all the messages was not necessary.

Before delivering the second part of the assignment “The Analysis of a Learning Experience”, the students in APE5 were advised to become familiar with each others´ essays and comment on them. Now students opened each others´ messages 9 – 41 times. There appeared discussions on the forum especially due to those message chains in which the tutor asked an activating question. In the forum “My Learning Experience” there lacked common social infrastructure. If this issue is seen as pedagogically argued, uniform social infrastructure round these two forums is possible to be developed by the means of supervision.

Summing up student activity in all learning environments to be examined reveals that the groups of students were very similar (Table 1). It was interesting that a student had passed the studies by writing only the minimum of messages (4). All students did not open all the messages written by the tutor. The minimum openings on the tutor´s forum were 4 in APE5. The message concerned the tutor´s days off (“Tutor´s vacation”). The students seldom commented on the tutor´s messages. For instance, on the tutor´s forum of APE5 there were 47 messages which gained only 4 student replies. On the tutor´s forum of APE8 there were 8 messages with no comments from the students. The tutor´s forum of supervision did not appear to be a central part of the social infrastructure of the learning environment. Social practices moved the discussion to topical forums of assignments and tasks. The problem seemed to be that sometimes discussions moved to the e-mail from the forums. Then the social infrastructure was cut and became unapproachable to other students.

How students left the learning environment was observed as a part of social practices. About 22% of the students left through the main page. Other last places were “Who is on-line”, a message on the discussion forum (“Discussion”), talk forum “Café” or an e-mail. The structure of student social activity will be continued in the second phase of the design study.

Table 2. Summary of Activity Report (1.5.2007-31.12.2007)

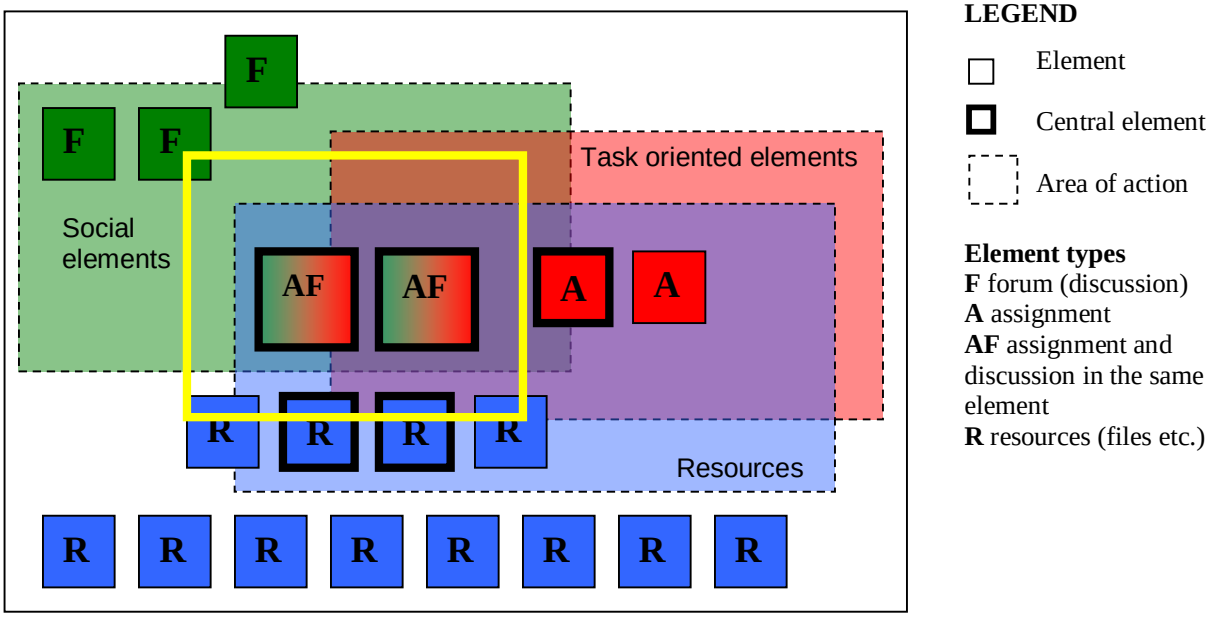
Statistics	**Group APE 5/ 19 students**	**Group APE 6/ 15 students**	**Group APE8/ 19 students**
Students sessions			
min	32	25	27
max	283	144	171
Overall	1745	1024	1549
Average user session length	22:30	17:39	13:25
Most active hour of the day	20:00-21:00	21:00-22:00	21:00-22:00
Discussions, read messages per student			
min	61	80	70
max	2914	983	3056
Overall	11305	5407	16496
Discussions, posted messages per student			
min	4	4	4
max	35	13	40
Overall	225	119	194

Cognitive and epistemic infrastructures can be examined in two ways, either as a characteristic of the elements or as a matter of organizing the elements. The aim was to observe cognitive and epistemic infrastructures through resource and assignment elements. During the preliminary study mainly the accessibility of the elements was observed. A clearly distinguishable problem in learning resources appeared to be the difficulty of finding the data files in the environment. There were data in files, in Media Library and in the attachments of the forums. The tutors of different groups had different ways to deliver material. Students tried to find resources either in the tutor´s information forum, or in the file named according to the assignment They looked for data more seldom in the central “Office” file which was the place of topical information. The material of the contact days had been gathered into the main files of the learning environment. The opening times of these files were in APE5 environment 60 – 338. Every file was opened at least three times per student. There were some technical problems concerning the data of the files. The assignments of the learning environment were decentralized on assignment and discussion forums. The cognitive challenge of the tasks was added by secondary reasons, such as the technical problems of the environment or finding the decentralized resources. Solving the problem of placing the resources will be one of the tasks in the following phase of the design study.

The results of the preliminary study show that active action in the learning environment concentrated round social infrastructures (Figure 2). Social and assignment elements were difficult to distinguish

from each other. Thus it is well argued to create pedagogical and guidance infrastructures round social and assignment elements. The most important characteristic of resources is their placing in the technical infrastructure. It must be coherent with the infrastructure of activities. Unlike the realities of the real world, developing social infrastructures in online learning environment involved guidance. Since the students find the necessary support mainly in the social forums, structuring thematic discussion forums is well argued. On the other hand, these thematic social forums may increase the tutor´s work load through repeated questions. The challenge of the infrastructure designer will thus be to examine how to guide the students to task resoures.

Cognitive and epistemic infrastructures as such were difficult to observe. There seemed to be a connection between the organization of the elements in the learning environment, the concentration of activities and their rhythm. Cognitive and epistemic factors can also be examined applying the view of Lakkala et al (2008). In their study epistemic infrastructures were categorized according to the epistemic nature of activities and the structuring of activity. Cognitive infrastructure, again, could be observed through the quality of knowledge and the challenges of information processing. 'What is the connection like' will be examined in the next phase of the design study.



Picture 2. The result of the preliminary research: the elements representing infrastructures and guiding the action in the learning environment to be examined.

Next step of the Design research

In the next phase of the design study the infrastructure of the learning environment will be clarified. Starting from the results of the preliminary research a questionnaire for the students will be designed. The inquiry will concentrate on finding out how the *students experience the structure of the learning environment* and if the structure *corresponds* to *their needs*.

The action models of the students are influenced by their personal characteristics, culture and earlier experiences. This background information will also be charted by the questionnaire. Online learning can cater for *individual differences* and provide appropriate learning activities based on the learner's style. Since the students chart their learning styles as a part of their teacher studies, they are asked to give the results of the learning style tests to the researcher. For example, *individual cognitive* style refers to the characteristic manner in which the student responds to and processes information. Part of the questions will be designed in the guidelines of user psychology, which applies psychological knowledge in analyzing and designing human - device interaction processes.

References

Bereiter, C. (2002). Design Research for Sustained Innovation. *Cognitive Studies: Bulletin of The Japanese Cognitive Science Society*, 9 (3), 321-327.

Bielaczyc, K. (2001). Designing social infrastructure: the challenge of building computer-supported learning communities. In Dillenbourg, P., Eurelings, A. & Hakkarainen K. (Eds.), *European perspectives on computer-supported collaborative learning* (pp. 106-114). Maastricht: Maastricht McLuhan Institute.

Bielaczyc, K. (2006). Designing social infrastructure: Critical issues in creating learning environments with technology. *Journal of the Learning Sciences*, 15 (3), 301-329.

Collins, A., Joseph, D., & Bielaczyc, K. (2004). Design Research: Theoretical and Methodological Issues. *Journal of the Learning Sciences*, 13 (1), 15-42.

Dillenbourg, P. (2002). Over-scripting CSCL: The risk of blending collaborative learning with instructional design. In Kirschner, P. A. (Ed.), *Three worlds of CSCL: Can we support CSCL* (pp. 61-91)? Heerlen: Open Universiteit Nederland.

Edelson, D. (2002) Design Research: What we learn when we engage in design. *The journal of learning sciences*, 11(1), 105-121.

Guribye, F. (2005). Infrastructures for learning: Ethnographic inquiries into the social and technical conditions of education and training. Department of Information Science and Media Studies. Thesis. University of Bergen, Norway.

Kling, R. (1992). Behind the terminal: The critical role of computing infrastructure in effective information systems development and use. In W. W. Cotterman & J. A. Senn (Eds.), *Challenges and strategies for research in systems development* (pp. 365-413). New York: John Wiley & Sons Ltd.

Lakkala, M., & Lipponen, L. (2004). Oppimisen infrastruktuurit verkko-oppimisen tukena. In V. Korhonen (Ed..), *Verkko-opetus ja yliopistopedagogiikka* (pp. 113-134). Tampere: Tampere University Press.

Lakkala, M. (2006). *How to design classroom practices for collaborative inquiry?* Inquiry Learning, building bridges to practice: Workshop May, 29-31, 2006 University of Twente, The Netherlands. Retrieved May 20, 2008, from http://www.helsinki.fi/science/networkedlearning/material/InquirySIG_Case_History.doc

Lakkala, M. (2007). *The pedagogical design of technology enhanced collaborative learning.* Published in E-Learning Europa Portal, June 20, 2007. Retrieved May 20, 2008, from http://www.elearningeuropa.info/out/?doc_id=11958&rsr_id=13028

Lakkala, M., Muukkonen, H., Paavola, S., & Hakkarainen, K. (2008). Designing pedagogical infrastructures in university courses for technology-enhanced collaborative inquiry. *Research and Practice in Technology Enhanced Learning*, 3(1), 33-64. May 20, 2008, from http://www.helsinki.fi/science/networkedlearning/texts/Lakkalaetal2008.pdf

Lallimo, J., & Veermans, M. (2005). Yhteisöllisen verkko-oppimisen rakenteita. Helsingin yliopiston Avoimen yliopiston julkaisusarja 1/2005. Helsinki: Yliopistopaino.

Lipponen L., & Lallimo J. (2004). From collaborative technology to collaborative use of technology: Designing learning oriented infrastructures. *Educational Media International*, 41(2), 111-116.

Lipponen, L. (2002). Exploring foundations for computer-supported collaborative learning. In G. Stahl (Ed.), *Computer support for collaborative learning: Foundations for a CSCL community* (pp. 72-81). Hillsdale, NJ: Lawrence Erlbaum Associates.

Lipponen, L., Lallimo, J., & Lakkala, M. (2006). Designing infrastructures for learning with technology. In D. Fisher, & M. S. Khine (Eds.), *Contemporary approaches to research on learning environments: Worldviews* (pp. 449–460). Singapore: World Scientific Publishing.

Paavola, S., Lipponen, L., & Hakkarainen, K. (2002). Epistemological foundations for CSCL: A comparison of three models of innovative knowledge communities. In: G. Stahl, (Ed.), *Computer Support for Collaborative Learning: Foundations for a CSCL community*. Proceedings of CSCL 2002 (pp. 24-32). Hillsdale, NJ: Lawrence Erlbaum Associates.

Paquette, G. (2003). «L'ingénierie cognitive des systèmes de téléapprentissage », Alain Senteni et Alain Taurisson (dir.). Pédagogies.net : l'essor des communautés virtuelles d'apprentissage [Résumé en ligne], Presses de l'Université du Québec. (Éducation-recherche)

Richey, R.C., & Nelson, W. (1996). Developmental Research. In D. Jonassen (Ed.), *Handbook of Research for Educational Communications and Technology* (pp. 1213–1245). New York: Macmillan Simon & Schuster.

Rossett, A. (2002). Waking in the night and thinking about e-learning. In A. Rossett (Ed.), *The ASTD e-learning handbook* (pp. 3-18). New York: McGraw-Hill.

Scardamalia, M., & Bereiter, C. (2003). Knowledge building. In *Encyclopedia of Education* (2nd ed.), New York: Macmillan Reference, 1370-1373.

Star, S. L., & Bowker, G. C. (2002). How to Infrastructure. In Lievrouw, L. A., & Livingstone, S. L. (Eds.), *The Handbook of New Media* (pp. 151-162). London: SAGE Publications.

Star, S. L. (1999). The ethnography of infrastructure. *American Behavioral Scientist,* 43(3), 377–391.