Teaching and Learning in Wallenberg Hall's Experimental Classrooms

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Abstract: In the age of telecommunications and multimedia, university teaching and learning occurs more and more in technology-enhanced environments. Scanning the current research landscape it is clear that the development of innovative pedagogies lags behind the progression of new technologies. Starting from a literature review, the authors investigate educational practices by analyzing two classes of a videotaped course conducted in one of the high performance classrooms at Stanford University to explore new ways of teaching and learning utilizing state-of-the-art technology. The study shows how technology-enhanced learning environments can be utilized to facilitate learning in activity.

1 Purpose and Context of the Study

Recent research in the science of learning (National Research Council 2000) emphasizes the importance of active, lifelong learning requiring students to be active inventors rather than passive recipients of knowledge. Furthermore, new technologies are becoming an increasingly integral part of university learning and teaching in an age of telecommunications and multimedia. Consequently, both instructors and students face new challenges, since the design of technology-enhanced learning environments as well as active learning within and outside this environment are crucial. Thus, with its high-performance learning spaces Wallenberg Hall,[1] the home of the Stanford Center for Innovations in Learning (SCIL)[2], and with CourseWork, a university-wide course management system, Stanford University provides a rich and flexible state-of-the-art learning environment facilitating innovative pedagogies and active student learning.

To learn more about how faculty and students at Stanford University meet future challenges, and how teaching and learning occur in one of the high-performance learning spaces, a single course conducted at Stanford's Wallenberg Hall was analyzed. The goal of this project is to show how the technology-enhanced learning spaces can be utilized to facilitate different learning activities and active student learning. Furthermore, conclu-

[1] Wallenberg Hall was designed to provide technology-enhanced learning spaces for university classes as well as state-of-the-art facilities for research in learning and education, both national and in collaboration with international partners.

[2] The Stanford Center for Innovations in Learning (SCIL, http://scil.stanford.edu/), a research center within the Stanford University School of Education, conducts scholarly research to advance the science, technology and practice of learning and teaching. SCIL is located in Wallenberg Hall, which has been designed to provide learning space for university classes and state-of-the-art facilities for research in learning and education. The SCIL team supports faculty and instructors to create scenarios utilizing spaces and technological advances in Wallenberg Hall to enhance teaching and learning. Hence, it offers one-to-one demonstrations and work sessions to facilitate teaching and learning utilizing new technologies.

sions for the pedagogically guided design of technology-enhanced learning environments based on successful educational practices in higher education will be provided.

This research process is guided by current research in the learning sciences and the observations of innovative educational practices of an early adopter of new pedagogies. Video of two 55-minutes classes of Richard Martin's "Poetry of Horace" course were analyzed in depth using DIVER (Digital Interactive Video Exploration and Reflection), a video analysis software tool developed by a team led by Roy Pea at the Stanford Center for Innovations in Learning[3]

In this paper we first discuss our theoretical understanding of learning and the design of learning environments based on a related literature review. In Section 3, we introduce technological innovations introduced in Wallenberg Hall at Stanford University and draw some conclusions for the design of technology-enhanced learning environments. Section 4 briefly outlines the research methodology underlying the key findings of the in-depth video analysis presented in Section 5. The paper concludes with a summary of the findings.

2 Pedagogical Innovations

The growing knowledge about the science of learning has multifaceted implications for the design of learning environments. In this chapter, we briefly present some initial thoughts regarding our understanding of learning based on a situative approach. Thereaf-

[3] DIVER has received support from the National Science Foundation in the form of a Major Research Instrumentation Grant as well as Stanford's Office of Technology Licensing. http://diver.stanford.edu.

ter, we describe four features of effective learning environments based on findings of the National Research Council (2000).

2.1 Learning in activity

Following a 'situative' approach (Brown, Collins & Duguid, 1989; Greeno, 2006), learning processes are based upon two perspectives that attempt to interrelate their strengths (Cole & Wertsch, 1996; Engeström, 1999; Salomon, 1993; Salomon & Perkins, 1998): (1) cognitive science (Piaget, 1936, 1970; Anderson, Reder & Simon 1996) focussing on information structures and individual processes, and (2) interaction approaches (Dewey, 1938; Engeström, 1999; Lave & Wenger, 1991; Vygotsky, 1978) focussing on participation structures and processes.

While cognitive, acquisition-orientated views of learning focus on the individual learner, emphasizing the acquisition of knowledge and cognitive skills (individuals' knowledge construction), the situative, participatory-oriented approach views learning "as a collective, participatory process of active knowledge construction, emphasizing context, interaction and situatedness" (Salomon & Perkins, 1998, p. 2). Therefore, one can distinguish between representations and processes as "in-the-head" cognitions, and "distributed" cognitions as jointly emerging cognitions (Pea, 1993; Perkins, 1993). However, individual learning almost always entails social mediation, whereas social learning almost always involves some learning on the part of the participating individuals. Consequently, because learning might occur within the head of the individual and/or within social interactions, both perspectives are needed.

This integrated view of the learning process together with the importance of active life-long learning and the increasing influence of technologies has implications for both learning, and the design of learning environments. Facing current and future challenges, we propose that learning has to become a holistic phenomenon requiring motivated learners, who are able to self-regulate and actively engage within a learning community utilizing new technologies. We refer to this understanding as "learning in activity" (Greeno 2006).

2.2 Perspectives on learning environments

For learning in activity to occur, an appropriate learning environment must be designed. First and foremost, a change in the nature of learning goals is necessary. Future learning aims at students who are motivated and able to plan, conduct, assess and regulate their own learning, while simultaneously actively engaging within a learning community making full use of the new technologies. Therefore, professional as well as technical, learning and social skills, on the one hand, and metacognitive skills on the other hand, are fundamental to becoming a successful learner. Moreover, effective learning environments depend on the degree to which they are learner-centered, knowledge-centered, assessment-centered, and community-centered (National Research Council, 2000). These four perspectives on learning environments will be outlined below, prior to discussing technological innovations at Wallenberg Hall at Stanford University and their impact on learning and the design of learning environments in higher education.

2.2.1 Learner-centered perspective.

"If teaching is conceived as constructing a bridge between the subject matter and the student, learner-centered teachers keep a constant eye on both ends of the bridge. The teachers attempt to get a sense of what - each student knows, cares about, is able to do, and wants to do - can serve as a foundation on which to build bridges to new understandings." (National Research Council, 2000, p. 136)

Students are not blank slates; they come to the university with cultural practices, interests, prior knowledge, skills, misconceptions, expectations, and attitudes. A learner-centered learning environment tries to build a bridge between the subject matter and the students' prior knowledge and interests. Starting from the structure of the students' knowledge, a learner-centered environment provides situations and assignments in which students' can apply preconditions, preconceptions and current knowledge and build on them to construct new knowledge. Moreover, it presents problems that engage students in cognitive conflicts that lead to the discussion of different viewpoints and finally, result in changing cognitive and participation structures.

2.2.2 Knowledge-centered perspective

"A challenge for the design of knowledge-centered environments is to strike the appropriate balance between activities designed to promote understanding and those designed to promote the automaticity of skills necessary to function effectively without being overwhelmed by attentional requirements." (National Research Council, 2000, p. 139)

Knowledge-centered environments offer a well-organized body of declarative and procedural knowledge emphasizing activities that are designed to promote learning with understanding leading to transfer of this knowledge into other contexts based on the learners' current knowledge. Learners come to understand the overall picture; that is, they can interpret the knowledge arranged in a network showing the connections of its components rather than just memorizing isolated facts. Furthermore, these environments create 'conditionalized' knowledge ensuring the development of integrated knowledge structures, information about the conditions of applicability, as well as skills to enable students to learn more about their own learning (metacognitive skills).

2.2.3 Assessment-centered perspective

"Whereas formative assessment measures the progress of learning for the purpose of providing opportunities for reflection and revision, summative assessment should be designed to measure the results of learning. Thus, formative assessment might be viewed as part of the journey of learning, where summative assessment might be viewed as a periodic destination that provides quality control and serves the important function of legitimizing credentials." (National Resource Council, 2001)[4]

An assessment-centered environment measures understanding rather than memorizing. What is assessed is connected with what should be learned (learning goals). There are many opportunities for continuously formative and summative feedback, self-assessment, and subsequent revision, reflection, and improvement in order to enhance the quality of learning. Portfolio assessment is one method of providing formative assessment; as a result, in the process of discussing the students' work, learners gain valuable information about their learning process over time.

2.2.4 Community-centered perspective

"Ideally, students, teachers, and other interested participants share norms that value learning and high standards. Norms such as these increase people's opportunities to interact, receive feedback, and learn." (National Resource Council, 2001, p. 154)

Norms that value the search for understanding encourage modes of participation and allow the freedom to make mistakes in order to learn are facilitated in a community-

[4] Quote online under http://iris.peabody.vanderbilt.edu/hpl/cresource.htm, page 4, *Assessment-Centered* Learning Environment.

centered environment since they are very important in promoting lifelong learning. Asking students to share their thinking with the class, even if the ideas are wrong, can also deepen understanding. Connections to other people or experts outside the classroom also provide students with valuable opportunities to interact and engage in learning. A way to embrace the idea of community-centered learning environments is by creating a "community of practice." (Lave & Wenger 1991)

These four perspectives form a system of interconnected components that support each other and need to be balanced and aligned with the learning goals and activities within and outside the classroom to facilitate learning in activity. Exploring classrooms from these perspectives can provide a scientifically guided framework for the design and analysis of technology-enhanced learning environments. However, there is a fifth perspective on learning environments that is becoming equally important in higher education: a technology-centered perspective.

3 Technological Innovations

Traditional classrooms at universities are often furnished with heavy, inflexible furniture, a blackboard, an overhead projector, a video projector and occasionally Internet access for instructors. As new technologies are now playing an increasingly important role in all spheres of daily and academic life, traditional "low-tech" equipment can hardly serve current and future educational challenges. However, with its state-of-the-art classrooms such as those at Wallenberg Hall, Stanford University supplies "high-tech" learning and teaching environments offering a set of general capacities to facilitate learning and teaching activities and to assist students in attaining their learning goals (Gilbert & Nash, 2003, 2004). We will highlight the following two resources: high performance learning spaces and a university-wide course management system.

3.1 High performance learning spaces

New technologies offer opportunities to extend the pedagogical possibilities of traditional learning environments. The high performance learning spaces available at Stanford since 2002, provide the "low-tech" as well as "high-tech" equipment described below:

3.1.1 "Low-tech" equipment

The classrooms at Wallenberg Hall have space for about 20-25 students. All classrooms contain lightweight, easily foldable tables and lightweight chairs on casters that can be rearranged to best suit a specific activity. It is possible to easily reconfigure the physical space, e.g., push furniture to the side or to the middle of the room, so that students can work on the big whiteboards on the sidewalls or circulate around the rooms. Furthermore, the furniture can be switched quickly for whole class, group, or discussion settings and therefore, support different learning and teaching modes. Some of these classrooms have large glass windows and partially retractable blinds on one side, which enable visitors/researchers to observe classroom activities. There are multiple big whiteboards mounted on the walls in every classroom, as well as 2' x 3' lightweight port- and hangable smaller whiteboards ("huddleboards") stored in groups of five on mobile racks. Complementing the whiteboards are two CopyCams,[5] wall-mounted scanners that can store

[5] A copy cam takes high-resolution photos of small whiteboards (huddleboards) and converts them to images that can be saved and printed. CopyCam is a commercial product available from Polyvision: http://www.polyvision.com/.

work done while creating digital images and save them to a website or floppy disk, or print a hard copy. In addition, there are breakout areas near the classrooms (in- and outside the building) providing physical spaces (e.g., student lounges, benches, nooks), and network connections for small groups to create collaborative work.

3.1.2 *"High-tech" equipment*

The Wallenberg Hall classrooms also provide cutting-edge technology, such as SmartPanels,[6] collaborative iSpace software,[7] collaboration stations (flat screen displays on carts that support group work), video cameras, and microphones. Moreover, the classrooms are supported by an integrated building technology infrastructure providing high-speed wireless network connectivity, centralized audio- and video-capture and computer disk storage for every course. Each classroom has its own dedicated wireless network. In addition, two large screen displays that function as digital whiteboards can project an in-room-computer, a laptop, a DVD/VCR player, or a videoconference. These two screens, known as Websters[8] also enable fast and easy Internet access and annotation techniques (using a special stylus as a "marker" to take notes on the screen or to mark-up web-pages, documents etc.).

Beyond this, each classroom has a mobile cart of wireless-enabled laptop computers that support individual student work and interact seamlessly with the larger display screens in

[6] A SmartPanel is a technical device, which includes simple on/off switches, volume controls, a technology selector and a DVD and VHS player.
[7] This software allows users to push files from one computer to another, share control of the big screen computers, and deliver synchronized multi-screen presentations.
[8] Webster LT Interactive is a commercial product available from Polyvision: http://www.polyvision.com/.

the class. These technical devices run Microsoft Windows or Apple Macintosh OS X depending on the classroom setting.

3.2 Course Management System

With "CourseWork," a campus-wide course management system, released in Winter 2002, Stanford University offers a platform which helps to manage university courses, facilitating testing and grading procedures, organizing and distributing learning content, as well as providing additional communication and discussion possibilities. To facilitate learning and teaching, CourseWork makes online-features like syllabi, course materials, email-announcements, online-assignments, schedules, and grading tools available. Instructors as well as students have ubiquitous access to various structured course materials and online resources inside and outside the classroom. For example, students can easily upload online-assignments and tests, and look up events and grades.

A recent online survey among over 2500 users at Stanford (Hoidn & Mai, 2006) revealed that the users – instructional staff and students - are very satisfied with the usability of CourseWork. However, among other things, the analysis shows that there are tools that are (much) more valued, i.e., applied and rated as (very) satisfactory (e.g., course materials, schedule) than others (e.g., discussion fora, grades tool). The analysis reveals the potential for improvement as well as key areas for further development and provides many concrete suggestions for further development from the user's point of view. Overall, the findings show that CourseWork is considered to be an important tool in supporting and fostering a technology-enhanced pedagogy throughout the campus.

3.3 Consequences for the design of learning environments

Traditional lecture-based classes have an extremely simple and stable structure because the instructor is in charge of planning, managing and guiding all the classroom activities as well as presenting the subject matter. In contrast, the technology-enhanced classrooms in Wallenberg Hall provide a much more complex structure, allowing innovative modes of learning that place students and their learning activities in the foreground. The general design approach is to modularize key resources so that they can be flexibly reconfigured to accommodate various teaching and learning styles and activities. The simultaneous presence of a variety of technical and human resources, all available to be incorporated into classroom activities, present opportunities for learning in activity and innovative pedagogies.

"*So there are resources out there that instantly enable them [the students] to get the authority and to either question me or to propose alternatives. In a funny way it comes back to the alternative question because they now have at their disposal this library and they can pop it up on the screen." (Prof. Richard Martin)*

However, the use of new technologies must be driven by pedagogic principles; technology serves the science of learning and not vice versa. The technology itself moves into a supporting role, while (joint) activities of instructors' and learners' utilizing new technologies move into the foreground. Taking technological innovations into account, we propose that the design of technology-enhanced learning environments, facilitating learning in activity, incorporates a fifth perspective on learning environments: technology centeredness. On one hand, this technology-centered feature is altering and enhancing traditional class activities. On the other hand, it is also influencing, or rather expanding the four perspectives proposed by the National Research Council (2000). The following drawing illustrates the five perspectives on learning environments based on Bransford et al., 1998):

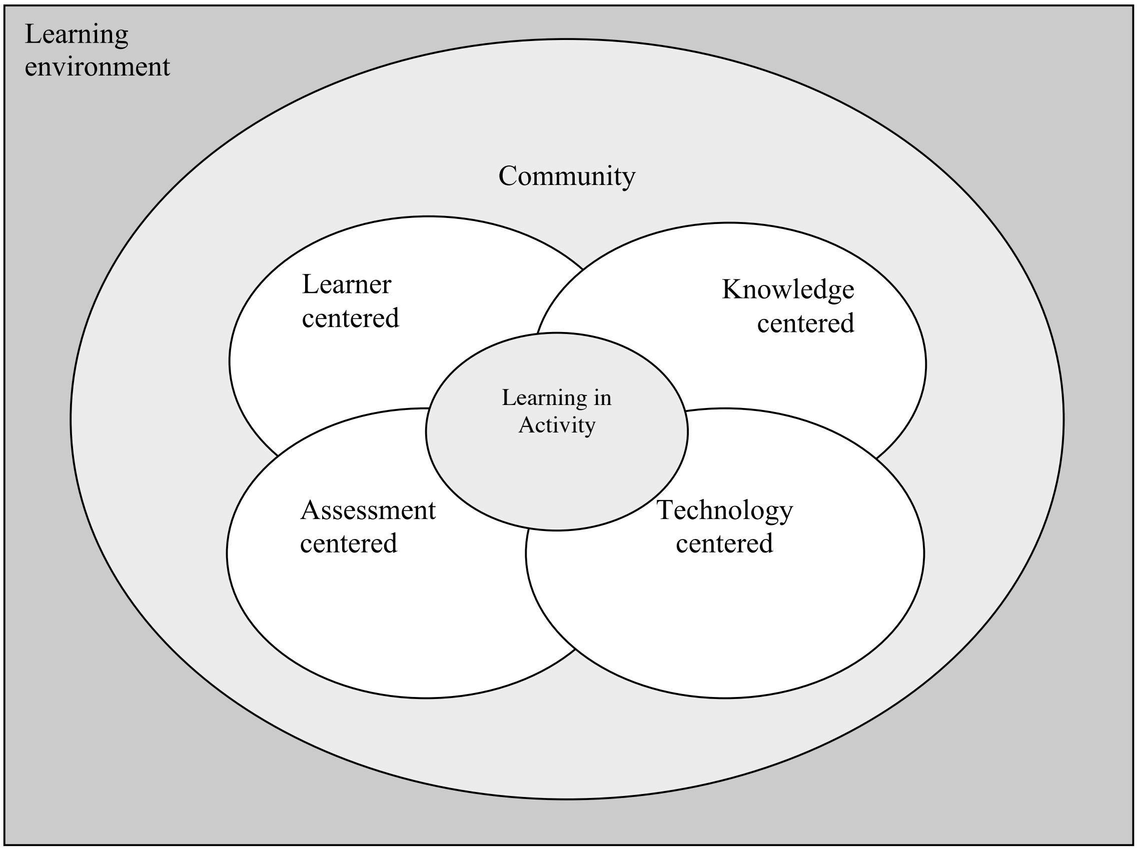

Fig. 1: Five perspectives on learning environments (based on Bransford et al., 1998)

4 Research Methodology

Researchers in the field of learning sciences have explored the nature and conditions of learning and teaching in educational environments. For instance, video recording is increasingly used to advance this research. As a data collection method, it provides the opportunity to investigate learning and teaching activities mediated by social interaction and cultural artifacts within the context of the socio-cultural environment in which it occurs. Therefore, it is possible to gather more reliable data about social interaction than with traditional methods, such as field notes or interviews (Pea, 2006).

The analysis of this study is based upon an in-depth video study in which two 55-minute classes of Richard Martin's "Poetry of Horace" course were analyzed using the DIVER tool (Digital Interactive Video Exploration and Reflection), an analysis software to conduct expert analysis of video data.[9] This course was videotaped throughout the quarter. For this report we provide an in-depth analysis of two classes we selected as an exemplary set of classroom activities practiced in technology-enhanced environments.

The results of the study were derived from analysis of shared video records from four different camera angles to generate more powerful analytic conclusions. In addition, one of the two researchers also did some non-participant observations in the two classes under study; the other was only given the video-taped classes as a basis for analysis. The latter

[9] DIVER is a trademark of Stanford University for DIVER software and affiliated services with patents pending. The DIVER project work has been supported by grants from the National Science Foundation and the Hewlett Foundation. Roy Pea served as lead developer with contributing developers Ken Dauber, Michael Mills, Joseph Rosen, Wolfgang Effelsberg, and Eric Hoffert.

conducted the first round of analysis providing a structured content log of events as they occur on the tape to create and annotate small digital video clips from the original video records. The research goal as well as current research on learning design functioned as a starting point and reference framework for the research and analytic process. During several rounds of analysis of the empirical data, patterns were found which seem to characterize the teaching and learning activities in the single course in the experimental Wallenberg Hall classrooms. These findings were reinforced by two interviews with Prof. Richard Martin. Some original quotes from the interviews will be provided in the following chapters.

5 Findings

Professor Richard Martin's "Poetry of Horace" course aims to give undergraduate students the skills to translate and understand Horatian Odes using strategies of the discipline as well as web resources. In an interview, conducted by Academic Technology Specialist Dan Gilbert from SCIL, Richard Martin describes the typical mode of his classes as follows:

I would display a text of the poem in the original Latin on one screen. This would become the arena (to use a Roman word) for translation. In turn - sometimes in teams - the students, who had for homework read the poem and tried to work out its meaning, would come up, stylus in hand, and "perform" their understanding. By that I mean, they would translate live, pointing out to me and other students the syntactical connections between subject and verb, what words went with what, and so on, as they translated. And all this could be highlighted - even using different stylus marker colors. So at the end of a few minutes, the class as a whole had a clearly visible "map" or 3-D image of the inner workings of the Horatian Ode. We could debate the fine points of translation, of image, of meaning all sharing the same digital whiteboard.

The following findings attempt to connect both the theoretical foundations outlined earlier and educational practices applying technological innovations. In this chapter we first present five guiding questions for the analysis and design of learning environments (following the National Research Council, 2000). Thereafter, we provide a summary of the key findings of the video analysis of two 55-minutes classes conducted in high performance learning spaces at Stanford University.

5.1 A scientifically guided framework

Learning and teaching in Wallenberg Hall presents challenges and opportunities for both instructors and students. To make full use of high performance learning spaces, the importance of designing classrooms around the kinds of activities that instructors are likely to do or would want to do is essential. Pedagogy drives the use of the technologies, which means that technology is not used because it is there; rather, the specific activity is altered and enhanced by its use. Leading with the pedagogy also makes the rationale clear to the students as to why they are in an advanced space in the first place: namely, they want to do something there, that they cannot do in a regular classroom. When students understand that rationale and understand that the professor expects to do things differently, they are more likely to participate more in the learning experience.

The analysis of the class activities is guided by the following five questions related to the five perspectives on learning environments (following National Research Council, 2000):

1) "Has the instructor discovered something of each learner's background knowledge, interests, and social and cultural values, and has he helped them become aware of how these things impact their opinions and perspectives"?

2) *"Has the instructor provided rigorous content and helped students to learn with understanding rather than merely commit things to memory"?*

3) *"Has the instructor required high standards along with frequent opportunities for feedback, reflection and revision in order to enhance the quality of learning"?*

4) *"Has the instructor developed course values or norms that foster lifelong learning, and has he made his goals and assumptions for the class explicit, and are these in line with their needs"?*

5) *Has the instructor integrated the resources provided by technology-enhanced classrooms in a pedagogically valuable way and thus, facilitated effective teaching and learning?*

The findings of the in-depth video analysis of two classes at Wallenberg regarding learning goals and learning and teaching activities within a technology-enhanced environment are presented below.

5.2 Findings of the video analysis

Overall, the technology-centered perspective shows how technology-enhanced environments can alter, enhance, and enrich traditional class activities and, concurrently, what new kinds of activities and possibilities for the design of learner-, knowledge-, assessment- and community-centered learning environments they offer.

(1) Learning goals/outcome

The analysis shows that the instructor fosters not only professional competencies but also technical, learning, social, and metacognitive skills. Furthermore, students frequently produce “learning products” which they present to the whole class. As a result, students

- are active inventors while creating knowledge individually or jointly and apply and/or regulate their learning process by implementing different strategies of a discipline to solve problems utilizing web resources;
- work together in groups, share their knowledge with others, ask meaningful questions and participate in class discussions;
- review and reflect upon their own and others’ learning processes and products and revise their work to improve the quality of learning.
- produce and present meaningful and applicable learning products;
- learn how to use laptops, annotation and presentation techniques, a course management system, and online-communication tools.

(2) Class activities

This study provides ideas for an innovative technology-enhanced pedagogy. Learning in activity and the pedagogically guided design of technology-enhanced learning environments involve the following learning and teaching activities: (a) The instructor

- fosters professional competencies and also technical, learning and social skills
- provides an organized course and knowledge structure as well as possibilities for formative feedback. Specifically, the instructor:

- provides information about the goals and tasks of the next and/or actual class
- demonstrates and explains strategies how to make use of websites as study aids
- orchestrates the class activities giving clear instructions
- utilizes new technologies like a course management system or huddleboards and shows presence during students' work
- summarizes key findings of students work
- provides permanent opportunities for feedback for student work (experts, peers, instructor) and praises students' answers

• creates a learning environment where students play an active role and have to take responsibility for their learning process within both individual and group activities. The instructor
  - challenges students' knowledge, provokes questions and fosters higher order thinking and discussion so that the learning process is guided by students' questions and comments as well as by instructor's questions
  - provides opportunities where students take an active part, for example students are in charge of preparing some questions for the next class
  - picks single students to make a contribution or to answer a question while others can jump in
  - integrates students' prior/actual knowledge/questions as single students are in charge of translating and explaining chunks of the poem to the class using annotation techniques or students are asked to email grammatical questions as a starting point for the next class

- integrates the resources provided by technology enhanced classrooms in a valuable way and thus, functions as role model. The instructor
  - is comfortable applying the new technology and using web resources
  - verbally expresses his conviction of the usefullness of new technologies
  - alternates computing resources for teaching and learning provided by the high performance learning spaces
  - makes also full use of “low-tech” equipment like the flexible furniture or the breakout spaces

(b) The students

- are active originators of their learning and actively engage within the learning community utilizing new technology. The students are participating actively in collaborative practices while
  - asking many meaningful questions,
  - expressing their understanding,
  - providing arguments and hypotheses, propose alternatives, show critical thinking (for example, questioning the instructors solution and defending one’s own solution),
  - discussing their own ideas and leveraging their knowledge of the broader field
- are engaged in self-study forms in order to create knowledge and understanding (knowledge production) while applying the methods and strategies of a discipline.
- perform and share their thinking and understanding in representational practices, compare their solutions with expert interpretations and with one another within class

discussions guided by the instructor using annotation techniques and as a consequence create joint knowledge (complementing one another)

- actively reviewing and improving their own understanding (metacognition) while
  - getting opportunities to revise thinking continuously while working on a task
  - having opportunities to use feedback immediately in order to improve the quality of learning
- making full use of environmental resources like cultural artifacts (e.g. media) and social mediators within and without the classroom (distributed intelligence)
  - every students can use either a laptop with wireless internet connection and therefore has ubiquitous access to web resources and books or papers
  - the instructor is available for questions

6 Conclusions

Referring to the National Research Council (2000) new developments in the science of learning have important implications for the design of learning environments. Moreover, the exploration of successful educational settings also reveals valuable insights to bridge theory and practice. It is obvious that there is a strong need to intertwine pedagogical as well as technological innovations wherein the use of new technologies is guided by pedagogical principles.

"A new set of tools for doing any craft, I suppose, makes you rethink the craft itself. The learning space combined with the technology - and I think they are both related and valuable tools - made me and I think will make others rethink what it is to transmit and apply our knowledge of the ancient world. It also offers the promise, paradoxically, of making that distant world much closer to us, through the ability to unite image, sound, text, cultural information, in an integrated surrounding - sort of a virtual time machine." (Prof. Richard Martin)

We argue that learning in activity, that is, motivated students, who are able to learn in a self-regulated manner and to actively engage within a learning community utilizing new technologies, is crucial. Learning in activity at a university seems to interrelate four components: motivation, self-regulation, participation and utilization to foster lifelong learning. As a result, we propose that it is an important goal in higher education to facilitate learning in activity, and thus, to create a learning environment that enables students to acquire knowledge, which is applicable and transferable and facilitates lifelong learning. Consequently, the learning environment has to be designed, that means, it has to be student-centered, knowledge-centered, assessment-centered, community-centered, and technology-centered.

The high performance learning spaces at Stanford University seem to provide useful tools and new practices that could be exported to more fixed, less fully staffed locations used across Stanford as well as to higher education institutions around the world.

"I think the main goal should be establishing learning communities through the most creative use of learning spaces and technological tools. I am convinced that this really gets students to do their best work - not that I want to throw out good old-fashioned lonely study in one's room late at night. But a class is for gathering not segregating." (Prof. Richard Martin)[10]

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[10] The authors thank Roy Pea, Joseph Rosen and the DIVER and Wallenberg Hall teams for their support and interest in this project.

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