VISCI Virtual Intelligent Space for Collaborative Innovation - Project Description

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Abstract

This paper introduces the Virtual Intelligent Space for Collaborative Innovation (VISCI) multidisciplinary research project. The project has commenced in 2009 and continues until the end of 2012. The main goal for the research is the investigation of virtual collaborative spaces, which allow for rich interaction in innovation activities. The project aims to achieve this through multidisciplinary collaboration and iterative prototype development. The paper will present the background, main objectives, way of implementation and expected results stemming from the research.

1. Introduction

As education and businesses today are increasingly globalized, new challenges are facing communication, interaction, and collaboration for the advancement of innovation. This concerns both education and business sectors. There is a clear need to develop virtual tools and spaces to facilitate socially shared interaction and innovation processes that take place in distant locations without the need for a physical presence from the participants. Moreover, there is a need to identify current gaps and needs in virtual inter-organizational learning and innovation processes, and to explore how these needs can be fulfilled through the use of intelligent virtual tools and pedagogical solutions. We need new knowledge about communication and knowledge co-construction processes in virtual teams as well as about the possibilities of modern ubiquitous computing to support knowledge co-creation and innovation in business and educational settings.

Virtual Intelligent Space for Collaborative Innovation (VISCI) is a research project, which studies the interaction of virtual teams in innovation activities, and designs and develops prototypes of tools and environments to support their collaboration. Due to the complex and dynamic nature of collaborative virtual interaction and innovation processes, we have recognized the demand for multidisciplinary research approach for the advancement of scientific and pedagogical understanding of interaction and innovation processes in

virtual collaborative spaces. The project team is comprised of researchers from three different university units and integrates disciplinary knowledge grounded in information technology, interaction design, business, education and studies of language and culture.

2. Background

Current technologies have shown to be insufficient for supporting rich interaction, seamless collaboration, and innovation in virtual teams. At present, there is a great gap in understanding the unique nature of collaborative virtual innovation processes and their special requirements. Questions, such as how to support productive asynchronous working modes and how to facilitate innovation processes in virtual teams require further examination. Moreover, as virtual teams seem to interact and innovate in different ways than face-to-face teams, they are likely to need different kinds of support for their innovation processes. This project aims to tackle these challenges via a multidisciplinary research approach by carefully analyzing the interaction and innovation processes constructed into being in virtual collaborating teams located in business and educational settings. In this research project, special attention is paid to the enabling and supporting role of technological ubicomp solutions. The project applies a user-centered approach that aims at supporting human interaction and innovation with novel, intelligent technologies. The enabling technology to be developed in this project includes:

- Second life -type solutions for virtual interaction and collaboration spaces with avatars
- Advanced information retrieval tools for facilitating synchronous and asynchronous interaction
- Intuitive user-interfaces, affordances, context-sensitivity, and personalization - all supporting collaboration and innovation in virtual teams

Technology and culture evolve so rapidly that it has become impossible to confidently predict the future and conditions for our existence. In fact, the prominent futurist Kurzweil [1] has predicted that by the end of this century, the non-biological portion of our intelligence will be trillions of times more powerful than unaided human intelligence. In his provocative argument Kurzweil stresses the fact that technological and cultural evolutions are not linear and in this way accumulative but rather exponential, self-amplifying phenomena. This is a serious challenge for any educational system that historically has been based on the premise that it is possible to anticipate what learners will need in their future lives. As researchers, practitioners and policy-makers, we should be seriously concerned with how ill-prepared our educational institutions are in today's complex society characterized by growing diversity and ubiquity of communication and knowledge creation.

Despite the success of the Finnish educational system in the international PISA ratings, Finland needs to further develop powerful educational solutions that support and enhance students' social, mental and intellectual well-being, motivation and life-long interest to education and learning. This includes helping students to develop abilities and skills related to learning-to-learn as well as interacting and working with others in local and distant spaces. How to integrate the informal, everyday worlds and their tools to the social practices of formal schooling are also fairly unsolved questions. At the same time, the Finnish education system is challenged by emerging "innovation society" requirements. Educational researchers, practitioners and policy-makers are invited to create educational practices that support creativity and collaborative knowledge building. The future innovation society requires competencies that develop through participation in the practices of working with different forms and types of information and solving real-world complex problems. In this process, learning can be seen as an innovation process of inquiry where a new object or artifact - be it a concept, plan, or product- is communally created and the participants' initial understanding is either substantially enriched or significantly transformed. Scardamalia and Bereiter [2] have examined schools as knowledge-building communities in which both teachers and students work as a community of learners in order to build and innovate new knowledge and understanding. Moreover, applying this knowledge to a different setting, the virtual design studio has become more common in recent years in various design fields. This refers to technology-supported environments that allow communities separated by time and space to work in collaboration with shared design ideas [3,4]. Through these collaborative tools, the designers as well as students are able to rely on socially distributed intellectual resources in conducting their joint innovation projects.

Social sciences have contributed to the research on innovation with Anthony Giddens' [5] seminal work on social structuration, the communities of practice theory by Wenger [6,7] and learning theories as collaborative inquiry and knowledge construction [8,9,10]. In the last decade, research on collaborative innovation has contributed to the emerging multidisciplinary research area of knowledge management [11,12,13]. Especially, research has shifted its focus towards the collaborative creation of new knowledge in different kinds of groups and communities. The concept of innovative knowledge communities defines learning as knowledge creation activity in parallel to the more traditional views of learning as a process of information acquisition or participation in a social community [14,15]. Furthermore, the role of boundary objects in groups' and communities' knowledge sharing and creation has been widely researched, e.g. in multi-professional negotiations [16], distributed work groups [17], innovation processes [18], new product development [19], strategic change and reorganization [20], and organizational memory [21]. Boundary objects enable knowledge sharing and co-operation between groups and group members by providing a shared context [22]. According to Wenger

[23], these shared and common artifacts, discourses, and processes may promote social learning in the communities of practice. However, more research is needed to better understand how boundary objects could be utilized to promote new knowledge creation and innovation in groups and communities supported by advanced technological systems.

The traditional models of teaching and learning do not account for the richness and complexity involved in innovation. Research on social creativity suggests that the core of humans' intelligent performance is not the individual mind but a group of minds mediated and connected by interactions with one another and with the tools offered by the sociocultural setting [24]. Experiences of collaborative innovation appear to cultivate both participants' creativity and agency for exploring with fellow inquirers' different innovative ideas. Thus, an engagement in collaborative innovation appears to provide access and elicit generative and creative potential that does not often emerge in traditional school settings. The complex skills and practices that collaborative working and innovation requires are not often present or cultivated in education. Empirical research on learning through collaborative working and designing indicates that it can enhance learning of complex problem-solving skills. Many abstract principles that are difficult to learn from textual resources become easier, more engaging, and motivating when approached through a collaborative design process [25,26]. Students who are themselves designing and exploring artifacts tend to have deeper understanding of their working principles. Collaborative innovation is not only about pedagogical processes but it defines social practices as well. The pursuit of design problems, developing design ideas and defining design constraints are social practices that are grounded in an activity system, and cultivated, exercised and crystallized within a community. An advanced learning-by-design inquiry culture cannot be transferred from one community to another without undergoing through a laborious process of establishing optimal design and inquiry practices and developing pedagogically sound "ritualized activity patterns" [27]. It is these patterns that research in the VISCI project aims to make visible.

Many researchers assert that using new technologies is a powerful means to support the development of practices and skills in students that they need in today's complex society. Yet, they have concluded that the technology as such does not automatically change educational practices. Deliberate efforts need to be made for the development of fruitful technological, pedagogical and social infrastructures. In this research, collaborative working modes in the Virtual Intelligent Space are seen to have a special significance in promoting creativity and innovation. Human beings have a specific capacity to transform their plans and ideas into the form of shareable artifacts that embody meanings. The process of designing artifacts represents a vast continuum of abstract ideas and inter-related realities mediated by social, cultural and educational values. The design of these objects is an active, distributed meaning-making process. All activity, including meaning-making is social and distributed between agents as well as physical and cultural tools. Virtual Interactive Spaces specifically designed for educational use can have an important role in promoting people's creativity, collaboration and life-long learning.

3. Objectives

The starting point of this research project is the hypothesis that modern intelligent modeling technologies, guided by recent pedagogical knowledge, create far-reaching possibilities for enhancing innovation and learning processes in virtual teams, leading to new and more efficient working and learning practices.

The VISCI project investigates two groups of users: (a) comprehensive education and university students as well as (b) representatives from private and public organizations. The research project develops prototypes integrated in an intelligent web-based virtual space (VISCI) that is designed to support collaborative innovation in these user groups. Novel features of the system include tools for intelligent, personalized information retrieval, team forming tools and intelligent monitoring tools.

This computational platform allows the investigation of the following research objectives.

1. Communication and interaction in and for innovation in virtual teams
   - How does collaborative innovation take place in virtual teams?
   - Modeling and analyzing collaborative innovation processes in virtual teams, including interaction, communication, and the enabling role of technology
   - What kind of boundary objects can support collaborative virtual innovation?
   - What pedagogical approaches, social practices, and technological solutions support and enhance collaborative interaction and innovation?
   - User and use situation analysis and requirements specification for the development of a user-centered virtual innovation space

2. Technology as an enabler of interaction and innovation in virtual teams:
   - How does technology affect and support communication, interaction, and innovation in virtual teams?
   - What kind of technical features, functionalities, and affordances can facilitate collaborative innovation processes in virtual teams?
   - How can associative, semantic-based information retrieval tools be utilized as a "virtual facilitator" in the collaborative virtual interaction and innovation process?
   - How can the requirements of context sensitivity and

personalization of the enabling technology be realized for productive virtual collaboration and innovation?

In sum, this research project will address the main objectives by:

- Creating valuable new scientific knowledge for the information society via a multidisciplinary research approach focusing on communication, interaction, and enabling technology for the advancement of collaborative innovation in virtual teams
- Developing and testing novel technologies that facilitate social interaction and collaborative knowledge creation for innovation in educational and work place settings
- Exploring how adaptive and personalized technology works as an enabler in learning and innovation processes, encouraging creativity and self-expression among individuals
- Producing new knowledge of the ways in which individuals from different backgrounds interact, communicate and collaborate in virtual spaces when co-constructing knowledge and when creating innovations through emerging technologies
- Fostering innovativeness and high scientific quality

These goals require multidisciplinary competence in the areas of educational sciences, interaction design, business and management sciences and computer science. The research consortium of this project has expertise in all of these disciplines.

4. Implementation

During the project, the team will implement in an iterative manner several prototypes of a web-based virtual space that is designed to support collaborative innovation. The VISCI systems will offer novel and innovative features that will be initially specified in detail during the first phase of the project. Acknowledging existing user studies and feedback, additional unforeseen features will also emerge during the later stages of the project.

The project implementation will take place via the following three working packages:

Table 1: Work Packages

Work packages	Key data sources and research methods
Specification and planning	-Analyzing and modeling collaborative innovation processes -Specifying and planning innovation processes -Running simulations to analyze innovation and knowledge-construction dynamics
Implementation and testing	- Deployment of probabilistic modeling techniques - Implementing an intelligent support system and tools - Software engineering via prototyping, testing and validation
Empirical validation and user studies	- Analysis of virtual interaction and innovation processes -Analyses of participants reflections

It should be emphasized that as the project will employ novel technologies, many of which have not been used in this context, it is not possible to foresee which of the technologies turn out to be most successful, or what type of new user requirements emerge during the project. Therefore, the project will be implemented using a rapid prototyping model, where the focus of the project work is iteratively switched forth and back between the three work packages, and the whole cycle over the work packages is iteratively repeated several times so that already during the first year of the project at least one full cycle will be completed. The realization of this plan requires intensive collaboration from the research consortium in every work package.

Work package 1: Specification and planning

One basic question in design, be it design of products, services or business models, is the simultaneous existence of multiple viewpoints and the need for new solutions which are coherent across divergent viewpoints. In her seminal studies on problem solving among different scientific communities, Star [22] found that scientists managed to cooperate by creating boundary objects that allowed joining of heterogeneous information. They were defined as “objects that are both plastic enough to adapt to local needs and constrains of the several parties employing them, yet robust enough to maintain a common identity across sites”. The main boundary object that SimLab has been using in its research on process innovation has been the visual process model [28]. One of the objectives of the research is to develop new boundary

objects that can support collaborative innovation in virtual interaction.

The SimLab™ process simulation method is an interactive, participative group simulation of business processes. The method is targeted towards supporting the creative co-development of business processes and business models of case organizations [29,30]. The method has been developed at Helsinki University of Technology TKK into a systematic action research method for process development (see http://www.simlab.tkk.fi). The SimLab™ method culminates on a carefully prepared process simulation, participated by the stakeholders and facilitated by SimLab's researchers. The goal of the process simulation is on one hand to provide a holistic, shared understanding on the process in question, and on the other hand to further develop the process collaboratively. This includes both sharing the existing knowledge and constructing new knowledge, i.e. innovating and expansive learning. Since 1998, more than 100 SimLab process simulations have been conducted as empirical research phases in several research projects. They have concerned e.g. e-learning, order-to-delivery processes, new product development, customer relationship management, human resource management, knowledge management, welfare services, and urban planning processes. Since the year 2000, the focus has shifted towards networked inter-company and public-private processes, with an increasing weight on service processes.

The research results have shown repeatedly, that SimLab™ business process simulations create a holistic process understanding, raise important development ideas, and create motivation for process development and change. In addition, organizational learning is achieved, and the lead-time of process innovations is shortened [31,32,33,34,35,36,37]. In the simulations of collaborative networks, we have found that the method supports the construction of inter-organizational communities of practice and common understanding between the collaborators and their customers. The method increases communication and knowledge sharing on the business goals and develops common understanding and trust between the collaborators [38]. Visualized process models are used as boundary objects and facilitators of the process simulation, creating possibilities for common understanding, as well as collaborative learning and knowledge construction.

Until now, the SimLab™ method has been applied in face-to-face settings that have required physical presence in the process simulation event. This has become challenging as organizations tend to operate globally and in different kinds of business networks. There is a need to develop the process simulation method towards a virtual one enabling participation from several locations and supporting participants' collaborative knowledge sharing and innovating over distance. In this research project, the VISCI systems to be developed will be tried out in the context of virtual SimLab™ process simulations. Moreover, information from analyzing the collaborative innovation and facilitation processes taking place in the current, face-to-face SimLab™ process simulations will be used in specification and planning of the VISCI systems. This will be realized in several phases as the iterative VISCI system development and research project proceeds. First, the current process simulations and their facilitation processes will be modeled and analyzed to produce requirements and other information for planning the VISCI systems. Second, feedback and user experiences will be collected and analyzed when testing the VISCI systems for process simulations in virtual settings. This includes both the international "virtual global project course" for university students and the SimLab™ process simulations for representatives from private and public organizations.

Work package 2: Implementation and testing

During the project, several prototypes of a web-based virtual space for supporting collaborative innovation will be implemented and tested. The VISCI systems will offer users novel, innovative features based on intelligent modeling techniques that will be initially specified during the first phase of the project and further developed according to user feedback and evaluation. Initially, we can envision the following feature sets:

Tools for intelligent, personalized information retrieval

In innovation processes, the ability to quickly access information relevant to the project is of central importance. The VISCI system will offer a standard query-based document search engine, but based on novel statistical document retrieval methods developed by one of the partners, we will be able to offer also novel, semantic-based ranking of the retrieved documents, allowing queries such as "Find documents which discuss concept X, without necessarily containing the word X". Furthermore, this methodology offers also novel information retrieval methods not possible with traditional keyword-based techniques, such as document search based on a paragraph or even a whole document or a group of documents ("Find more documents like this."). It should also be noted that these types of features can also be used for locating past or existing innovation processes that are similar to a new projects in planning stages. It can be expected that these types of "associative" semantic-based information retrieval tools will turn out to be valuable in offering interesting, nontrivial stimulus for innovation processes assisted by the VISCI system.

The technological platform is based on existing semantic search techniques, but the tools are to be developed further to meet the specific requirements of the VISCI project. An obvious direction in this respect is to develop personalized information retrieval methods based on user models and collaborative filtering techniques. User models can initially be based on manually created profiles, but the main goal is to use statistical machine

learning techniques for automatically constructing models from available observations. These contain implicit information such as what type of data the users feed in or search for, how do they use the system and who do they work with. Personalization will be used both in determining what information to give to the user and in determining how to present it.

Team forming tools

One of the key issues for successful innovation processes is to get the right team of people together, forming a group with profiles that complement and support each other. The VISCI system offers functionalities for locating new potential members for an existing team ("Find users or groups of users that are similar to this group of users."), or for a user to find a group that matches with the user's profile ("Find a group where this user would fit in.").

Intelligent monitoring tools

It is expected that many of the processes run in the VISCI system will involve people living in different time zones, and that the virtual innovation teams may be quite large. Therefore it is not possible to restrict the use of the system to short, synchronized sessions when all the team members are online at the same time. Therefore, the system will offer monitoring tools that can be used, e.g., for setting up automatic alarms that will notify the user when new, relevant information can be found in the system. This may include either information related to a specific single process, to a group of processes, or in general involving all available information. These types of tools will help the users to be actively involved in several simultaneous projects.

Technically, two different interfaces are planned for the system. The first interface creates a virtual space based on interface solutions found in most current web-based systems, while the second interface will be more ambitious, based on a three-dimensional, virtual-reality-type interface. In both cases, the basic functionalities are based on the same underlying engine, but the virtual reality space sets additional requirements not present in the first system.

Work package 3: Empirical validation and user studies

There will be two empirical user studies in this research project. The other case study will be carried out in a comprehensive school setting (grades 5-9) in the metropolitan area of Helsinki. In this case study, student groups engage in collaborative innovation processes with their peers from another school in California. The innovation processes deal with the topic of Space and Time.

The other case study group of students is based in a university setting. SimLab at TKK Helsinki University of Technology, University of Columbia in New York and Indian Institute of Technology in Madras will organize a new international "virtual global project course" between the three universities. The design of the course has been started and the course will be organized the first time during spring semester 2009. While designing the course the teachers and technological experts from all three universities aim at creating technologies and processes of teaching, studying, learning, and interaction for collaborative learning in international student teams. During the virtual global project course the student teams from the collaborating universities solve together given case problems of networked business processes: they analyze the case data, solve the problems, and develop the process. In this way, the students can experience virtual collaboration, collaborative development and innovation activities. The course will be accomplished by using existing virtual collaboration tools as well as a telepresence system for synchronous video- and audio-conferencing. This virtual global project course will serve as a user study for the VISCI system development. User studies will also be conducted with the business users from public and private sector organizations participating in the SimLab™ process simulations that will be implemented in virtual settings with the help of the VISCI systems.

The complexity of researching the multifaceted collaboration processes in virtual teams calls for a diversity of approaches with different levels of analysis and different methodologies. For that reason, we will use a variety of sources in data collection; ethnographically-grounded observations (videotaped, audiotaped), interviews, artifacts produced by the participants (such as weblogs, wikis and on-line discussions). The basic investigative approach will be the combination of a variety of qualitative methods in order to provide a multifaceted and comprehensive picture of the research objects and task in question (see [39]). We shall draw on sociocultural, ethnographic, sociolinguistic and discourse analysis, as well as critical perspectives. Further, various units of analysis will be used. One special focus is to combine micro and macro level analysis to better understand the complex, reciprocal and co-evolving nature of individual, communal, and organizational transformations.

5. Timetable of the research

The project will run for four years, from January 1, 2009, to December 31, 2012. As discussed earlier, the project will iterate between the three work packages within every year. In addition to this, we can outline the following additional milestones to take place during the project:

Table 2: Timetable of the Research

Year 2009	-Critical literature reviews in the field of pedagogy, design, management, and technology -Designing and piloting pedagogical and managerial models, and technological tools -Refining pedagogical, managerial and technological solutions based on pilot studies
Year 2010	-Further refinement of solutions -Researching diverse learners and innovation communities using VISCI prototypes
Year 2011	-Meta-analyses of the value of research for the advancement of new understandings about collaborative interaction and innovation in VISCI.
Year 2012	-Final reporting of the research project and its findings in international and national scientific journals and books. The dissemination of the project also includes conference and seminar presentations for diverse audiences, also for non-academic communities.

6. Expected research results

The information society of tomorrow will face an increasing need for virtual tools and spaces to facilitate productive socially shared interaction and innovation processes that will take place synchronously and asynchronously in geographically distant locations and without requiring physical presence from the participants. In this project we will identify current gaps and needs in virtual inter-organizational learning and innovation processes, and explore how these needs can be fulfilled through the use of intelligent technological tools and pedagogical solutions. As a result, we will produce valuable new knowledge about communication and knowledge co-construction processes in virtual teams as well as about the possibilities of modern ubiquitous computing techniques in supporting knowledge co-creation and innovation. We believe that the results can be used for promoting creativity, collaboration and life-long learning.

In summary, the research project will have several scientific and practical outcomes impacting both science and society:

- New scientific knowledge on models and principles for supporting technology-enabled innovation processes in virtual teams
- Experimental research knowledge on creation of a virtual collaboration spaces, innovation facilitating technologies, and their design
- Practical experience on user requirements for virtual collaborative innovation spaces, students' collaboration and learning in virtual teams, and inter-company innovation in virtual teams
- Dissemination of acquired knowledge through doctoral dissertations, journal articles, scientific conferences, books and a scientific multidisciplinary steering group
- Intensive international and national research collaboration
- New improved technology for virtual collaboration and innovation, distributed as open-source software

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