Integrated Tool Support for Learning through Knowledge Creation

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Abstract: In this symposium we discuss pedagogical design involving technology that aims to support and foster learning through object-bound collaboration. The designs employed have emerged from the knowledge creation approach (Paavola & Hakkarainen, 2005), which depicts learning as a collaborative activity aimed at creating shared knowledge objects. Technology-mediation has a prominent role in supporting collaboration processes, iterative development of products, and reflection of knowledge practices. The KPE environment (http://www.knowledgepractices.info) is an integrated, modular open source software. It is designed to enable various visual views on the collaboration process and the related knowledge practices. In this symposium we present four empirical studies that examine ways of supporting higher education and professional learning, and learning through development of knowledge objects (e.g., designs, software applications, research reports). The four research studies attempt to explain how the different functionalities of the KPE can enhance collaboration and development of shared knowledge objects.

General Introduction

In this symposium we will present and discuss pedagogical design involving technology that aims to support and foster learning through object-oriented collaboration and knowledge creating inquiry. The aim of the symposium is to understand how the participating students, teachers, and professionals engage in knowledge work and the development of shared knowledge objects with the technology-mediation provided by the Knowledge Practice Environment (KPE). The KPE is a Web 2.0 application that provides participants with integrated tools. Activities supported by the integrated tools are, for example, co-construction of knowledge, collaborative and iterative writing, conceptual modeling, and reflection of knowledge practices (Lakkala et al., 2009). The four research studies presented in this symposium attempt to present an integrated investigation approach, and to explain how the tools and functionalities of the KPE environment can enhance and support different aspects of the aforementioned activities.

In the current knowledge society many problems are of an open-ended character. To solve such open-ended problems collaboration both in groups, but also across groups, with various expertise is a presupposition. In current work practices, multi-professional collaboration is typically organized around long-term efforts for developing shared, tangible knowledge objects such as products, models, articles, or practices (Paavola & Hakkarainen, 2005). In the educational system, this creates a challenge for design of the curriculum and tasks: on the one hand learners should develop systematic understanding of their specific knowledge domains, and on the other hand they should develop expertise that prepares them for taking part in work life processes around the development of complex epistemic objects (Knorr-Cetina, 1999; Miettinen &Virkkunen, 2005). Designing for knowledge creation calls for a new mindset for educational institutions and educational activities. To promote such changes is a long term effort. The EU-funded project "Knowledge Practices Laboratory" (KP-Lab) is a response to the described challenge. The KP-lab project now entered into its last phase, and we can present empirical findings and reflections on the theoretical foundations, and the pedagogical and technological design.

One of the leading ideas in the project has been to explore how theoretical claims put forward by the knowledge creation approach to learning (Paavola & Hakkarainen, 2005) can be materialized in the educational practice and, consequently, what are the implications for pedagogical and technology design. The knowledge creation approach has its origin in Bereiter and Scardamalia's work (2003) on expertise and knowledge building communities, while the object-orientation builds on the 'turn towards objects' in activity theory (Engeström, Miettinen, & Punamäki, 1999). The knowledge creation approach emphasizes epistemic and pragmatic dimensions of object-oriented inquiry and technology-mediated collaboration in social practices. It depicts learning as a collaborative activity aimed at the creation and advancement of knowledge objects by making use (work with, manipulate, modify) of various kinds of artifacts. In these processes, individual and collaborative

learning are seen as intertwined. The knowledge objects convert joint idea development and knowledge creation efforts into resources that can be re-used and modified in new learning and working contexts.

The theoretical claim underlying the knowledge creation perspective is that new meaning and understanding of the domain arises through the externalization of knowledge and collaboratively creating knowledge objects that emerge and become transformed over time. In the knowledge creation approach an explicit theoretical account of the social interaction is included, which was not theoretically accounted for in the knowledge building approach (Ludvigsen, 2009). The mediated nature of human activity (see Vygotsky, 1978) is acknowledged in the knowledge creation approach particularly by emphasizing multiple types of technology-mediation; including support for pragmatic, social, epistemic, and reflective types of activities (Lakkala et al., 2009; Paavola & Hakkarainen, 2005; Rabardel & Bourmaud 2003). In this context, technology plays an important role as a mediating element, since it enhances the social interaction between participants and (shared) knowledge objects, and the development of innovative knowledge practices.

The added value of KPE is in the integration of various functionalities to build a multipurpose and flexible collaborative virtual environment, which is designed to support complex activities, both at the epistemic and procedural levels. In KPE, individual and collective shared (work) spaces can be created, e.g., by a project team, students attending a class or members of a multifunctional development team in an organization. Different visualizations are possible: a view of the *process*, a view of the *content*, a *community* view, an *alternative process* view, and a *tailored* view. Within these views KPE focuses on supporting the sustained activities around shared objects through offering flexible tools for: a) joint elaboration, versioning and visual organization of content; b) object-bound commenting and chatting; c) use of semantics in content specific searching, conceptual modelling, tagging, and explicating relationships between various knowledge items; d) awareness of other users' participation and status in knowledge creation processed supported by KPE, and e) management and organization of the groups' practices (see images in Figure 1). KPE also provides analytic tools for automatic analysis of collaborative work and development of shared objects. The analytic tools offer possibilities for students, teachers, and researchers to visualize and reflect on the knowledge creation processes and provide reference points for practice transformation.

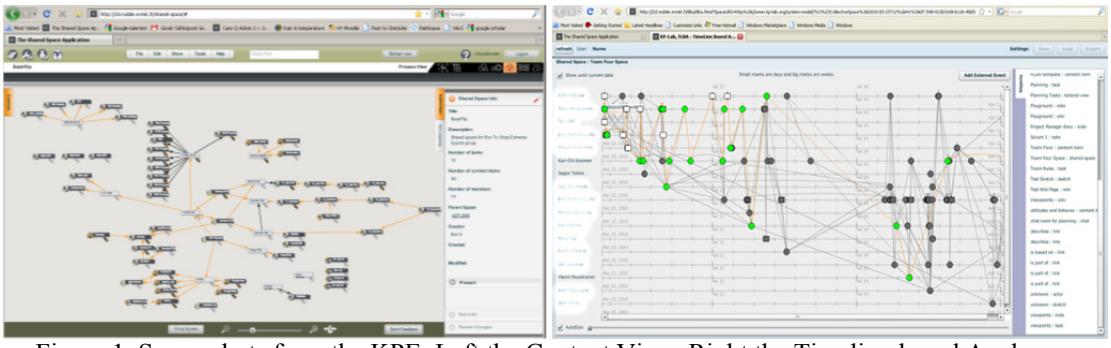

Figure 1. Screenshots from the KPE: Left the Content View; Right the Timeline-based Analyzer.

In the four cases, we examine ways of pedagogically designing and supporting higher education learning and teaching activities, and professional practices where participants develop knowledge objects (designs, software applications, research reports). Three themes are taken up by the presentations: collaborative and iterative development of knowledge objects, conceptual modeling, and identifying patterns of collaborative object-oriented inquiry. The symposium setup stimulates interaction between the presenters and the audience by 1) presenting the findings of the research studies, 2) depicting the tools and functionalities employed and 3) by inviting discussion focused by these three themes. We will provide a brief introduction to the symposium and then organize the presentations and the discussion around the aforementioned themes. We intend to engage the audience in the discussion of the contributions, using the three themes to structure the interaction.

Iterative Co-construction of Knowledge Objects by Student Teachers

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Introduction and Theoretical Considerations

In this contribution we investigate how teacher students work in collaboration to create and develop knowledge objects that will be employed at their internship places. We examine the processes revolving around collaborative and iterative knowledge object development and the way student groups employ features of technology designed to support this type of activities. We focus on identifying collaborative mechanisms across

groups and we provide a more detailed insight into how knowledge objects are developed by a number of groups.

Exposing students to knowledge practices they will perform as professionals seems to be a challenging task in higher education. In this study, the prevalent idea in the KP-lab project is that problems with an open-ended character entice students to engage with knowledge and make their own knowledge explicit. This involves theoretical and practical knowledge being materialized into objects (e.g., in educational material, evaluation instruments, research reports, etc.), where this knowledge becomes transparent for the participants involved. Nevertheless, becoming actively involved and successful in such complex processes, and creating sophisticated knowledge objects, is a challenging task for students. The knowledge creation approach to learning (Paavola & Hakkarainen, 2005) can serve as a guide to develop new practices of learning and instruction, which places collaborative creation of knowledge objects at its core. Knowledge creation processes not only shape the knowledge objects constructed but are also transformed by the actions that are performed on these objects (Stahl, 2006). Pedagogical designs should explicitly scaffold these practices through incorporating collaborative co-construction activities revolving around knowledge objects. This involves also providing various types of technological support. Whilst various studies showed how (online) technology features enhance dialogic interaction for learning (see for a review Ludvigsen & Morch, 2010), technology that supports interaction through knowledge objects received less attention.

Empirical Setting, Methods and Data

This one-year study was conducted at a University of Applied Sciences and Teacher Education in the Netherlands that prepares teachers for lower secondary education. The curriculum is based on Professional Situations (PS) wherein students are stimulated to mobilize knowledge and skills during projects conducted at their internship schools. Twenty groups formed from 73 mixed-age students, enrolled in three randomly selected PS's, participated in the study. Learning was enhanced by participation in collaborative knowledge creation activities, where groups of students developed and reported on authentic knowledge objects, such as didactic materials, guidelines or manuals for teachers. Supporting activities and materials were provided, such as workshops on object-oriented collaboration, document templates with topics for work plans, and training sessions for using KPE (for both teachers and students). In the KPE, each group had its own shared workspace. Inside these spaces, students were expected to employ functionalities that supported organization and management of the collaborative process (i.e., task creation and planning functionalities) and iterative development of knowledge objects (i.e., versions, commenting, sources display through web links, linking and chatting). We collected a rich set of data, consisting of: a) interaction data; b) knowledge objects, and c) reflection data. The analyses include frequencies of individual contributions to the collaborative work, coding of groups' interactions, and a detailed analysis of knowledge object development and iterations by one group.

Findings

Results indicate that groups employed different strategies to organize their work – division of labor was frequent. In terms of object development, there are a number of aspects that stand out. Co-construction moments occurred in some groups' work, such as discussing ideas and concepts, and then following up and materializing these ideas into object iterations. Elaboration of object sections was often done individually, and the outcomes were placed in the group's shared space, where the other group members could read it and provide it with feedback. However, some groups had difficulties to collaboratively expand their knowledge on the matter and to build on it together, or to concretize this knowledge into the objects in-progress. Most recurrent situation in these groups was that ideas were discussed but not taken-up and not materialized. In these groups, mutual feedback and revisions on iterations of the objects were less common. Of the 20 participating groups 17 used the shared work spaces provided in KPE. Groups that employed co-construction strategies registered were also registered to be most active in using KPE, and received a positive final assessment of their final product by their tutor. Majority of groups used the shared spaces to store and organize their knowledge objects. Twelve of the groups used the Process view and task creation functionalities to plan and organize their collaboration, and reported on these functionalities as being good support for this purposes. The types of items mostly created were document files, web links (to online sources), and comments on document versions. Twelve groups used the system to visualize versioning of their knowledge objects, and indicated this functionality as supporting well the work on the knowledge object. These results show that most students became engaged in co-constructing shared knowledge objects, but individual elaboration and strict division of labor without much feedback on object iterations occurred too.

To conclude, the study indicates that the challenging task of managing and constructing knowledge objects and the use of complex web-based technological support suits students who are able to employ productive strategies, but that other students need more intensive support. Hence, these findings call for attention to students' understanding of this pedagogical setting and of technology; also, to how these types of designs can provide more clear scaffolds for students when entering the knowledge co-construction process.

Furthermore, more focused studies are needed especially on how tools can support collaborative elaboration of textual objects.

Modeling Professional Practices and Object-bound Knowledge Creation in a Higher Education Customer Project

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Introduction

The rapidly evolving knowledge practices of present professional settings generate novel demands for education. The knowledge creation approach to learning (Paavola & Hakkarainen, 2009) provides theoretical background to address learning and teaching organized around authentic problems and the development of shared knowledge objects, such as reports, products, and new practices. This approach focuses on the development of shared objects in addition to the pursuit of personal learning and collaborative discourse interaction.

The study examines a higher education course which involved students, teachers, and customers in a complex tryout of knowledge creation. Multidisciplinary student teams from three degree programs, media engineering, industrial management, and communication, were asked to develop a business idea and make it happen for real. Teachers from these degree programs and customers from four companies were participating in the process for six months. Students were provided with various analytical, reflective and managerial documents (Omicini & Ossowski, 2004) that functioned as templates. The documents were intended to promote professional practices and object-bound knowledge creation (Eckert & Boujut, 2003; Paavola & Hakkarainen, 2009). We investigated how these documents (e.g., status report, customer presentation template) and related guidance (specifically during steering group meetings) from teachers and customer representatives contributed to student teams' advancement. The advancement was expected to manifest itself in the produced business ideas and plans, user stories, and mock-ups as well as in the management of workflow and project reporting, creation of functioning technical solutions, and communication with potential end-users. Further, we examined how the various collaboration tools were used and what kind of mediation for joint activities they provided.

Research Methods

A total of 50 students from 3 study programs of the Helsinki Metropolia University of Applied Sciences participated in the course for 6 months. The Knowledge Practices Environment (KPE) software was used as the shared environment, but student teams utilized several tools for their teamwork (e.g., GoogleDocs and Dropbox) in parallel. The course was one of the Finnish test sites in the EU-funded Knowledge Practices Laboratory project (see http://www.kp-lab.org).

From the originally 11 student teams, 5 teams that most actively used the KPE environment were examined. In addition, 2 teams were randomly selected for an intensive follow up at the onset of the course (one team included in the former analysis). The following data were collected: video recordings of teacher and customer guidance during weekly steering group meetings from the two intensively followed teams, as well as weekly self-reports on project advancement and KPE data on the versioning of central knowledge objects from all teams. Interviews with teachers, and the students and customer representatives of the 2 teams were conducted at the end, including questions about the use of collaboration tools, team functioning, and the advancements of team productions.

Qualitative data analysis of the video recorded steering group sessions was carried out to examine what the mentoring focused on. A second qualitative content analysis focused on the progress reports and major editions found in the project documentation. The results of these two analyses were compared to gain an understanding of how the comments were observed to influence the iteration of knowledge objects. Further, a thematic examination of the interviews provided evaluations of the strengths and weaknesses of the course design, the tools used, and reflections on the process and its outcomes.

Findings

The templates provided a starting point for project documentation. Teams faced difficulties related to focusing their business plans and coordinating the engagement of students from multiple domains. The customers and teachers facilitated especially turning attention to the end-user needs and explaining team's ideas to potential clients of their business solution. Successive versions of the business ideas and software applications could be observed to undergo considerable changes based on work on the intermediate documents and related guidance. Overall, 3 teams accomplished all the steps involved in designing and implementing an application and engaging clients for their business. Most other teams accomplished either the application or acquiring the client.

KPE was found to mediate participants' epistemic and regulative actions. Such functionalities of KPE as uploading files, and creating notes and links were mostly used to organize work around the documents and

their subsequent versions (epistemic mediation). Several functionalities were found to serve regulative purposes (pragmatic mediation): creating tasks and links between them; the object-bound chat tool; and the note editor for creating meeting memos and defining team members' roles and responsibilities.

Theoretical and Practical Implications

The findings suggest that the teams were faced with demands for efficient practices in analytical business procedures, work flow management, and coordination and communication with the customer representatives and potential clients. Similar collaboration and knowledge creation challenges have been reported in relation to global virtual teamwork in professional practices (e.g., Faraj & Sproull, 2000). The use of KPE provided epistemic and pragmatic mediation by allowing the student teams to organize their tasks and show visually interdependencies of documents and their iteration.

Making Use of Artifacts in Processes of Object-bound Inquiry

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Introduction and Theoretical Considerations

This contribution focuses on creating and utilizing artifacts in processes of object-bound inquiry. We investigate how project teams create and make use of various kinds of artifacts in order to solve complex design task and how their utilization is shaped by the properties of the artifacts chosen.

Even though the importance of shared artifacts for learning and knowledge creation has been stressed by various scholars (e.g. Stahl, 2006; Bereiter, 2002) and is also at the core of the KP-Lab project, the affordances and materiality of different kinds of artifacts in processes of object-bound inquiry has hardly been investigated yet. While shared artifacts have been studied as means for grounding and coordination of collaborative efforts, there potential role as objects of joint exploration and inquiry is only poorly conceptualized and understood. Building on the work of Gedenryd (1998) and Knuuttila (2005) we conceptualize artifacts as dynamic entities, which can fill multiple roles depending on the type of activity they are used in, while yet being constrained by their material and sign-related properties. Rather than treating artifacts as mere representations or carriers of information and ideas, we are particularly interested in their material and sign-related qualities with regard to fostering and impeding their utilization for epistemic processes. From a pedagogical perspective artifacts are particularly interesting as they provide important means to scaffold and support but also to monitor learning processes. Therefore a better understanding of the properties of artifacts and their utilization for different activities can provide for better guidance in the complex endeavor of object-bound inquiry.

Empirical Setting, Methods and Data

This study was carried out in a project-based course at the University of Applied Sciences in the bachelor program “Communication and Knowledge Media”. In a compulsory first-year bachelor course, project teams of 3-6 students were asked to develop an educational scenario drawing on existing web 2.0 technologies. The course was meant to promote an understanding of design as a process of object-bound inquiry. All in all 26 students in 8 teams took part in the study. To support the design process students were introduced to Knowledge Practices Environment as well as a variety of techniques and design artifacts to document their understanding of the design space at stake. Typical design artifacts included journey frameworks, conceptual models of the designs space, various types of prototypes for probing as well as reports.

The set of data used for this study consists of: a) project-logs on students’ activities filled in by each team, b) periodic interviews with the teacher on her intentions and experiences with the different interventions, c) retrospective group interviews with each team at the end of the course, d) log files from KPE and VME, e) artifacts and documents uploaded or linked to KPE. The analysis is focused on the contents of the various artefacts and the kind of activities they were created in and used for.

Results

Even though the design task and instructions have been the same for all groups, we found considerable differences in the overall flow of activities and in the utilization of the design artifacts. While most of the teams apparently worked in a rather linear fashion, basically refining and building on their initial ideas, two teams revised their initial ideas significantly in the course of their project. Comparing the contents of the different artifacts produced by each team, we found that the conceptual overlap across artifacts was often rather low, even for those artifacts submitted as project results. This finding seems to indicate that the students conceived the artifacts indeed as complementary, fulfilling different functions. With regard to the different types of artifacts introduced by the teacher we found differences both between teacher’s intentions and actual use but also between the different teams. While for example the teacher’s intent for using conceptual models had been to

foster articulation and scrutinizing of students' assumptions, the models were rather used as means for documentation. Comparing the prototypes created by the teams we found them to be used as means to describe and communicate ideas on the user interface level, to explore different design options but also to test for usability problems and probe experiences. The way the artifacts are used appears at least partly due to the particular kind of material and format chosen.

Tool use turned out to be heavily dependent on the actual tasks at hand. While the KPE was primarily used to collect, document, and organize, links, notes, and documents, as well as to create visual models of the design space, most other artifacts were created by third party tools such as Indesign, MS Word and Excel but also pen, paper and scissors to create prototypes. It is obvious that students like to use flexible tools such as Word and paper-based notes, as they can easily edit, reuse, and share the artifacts created.

Theoretical and Practical Implications

The results of this study suggest, that processes of object-bound inquiry draw on a multiplicity of artifacts each of them providing unique affordances and constraints. Besides its content, the epistemic use of an artifact is also shaped by its material and sign-related properties. From a pedagogical perspective it appears important to be sensitive to the way these artifacts are appropriated by the students and the actual purpose(s) they are used for. From the perspective of tool development, these findings point to a major limitation of collaborative learning environments currently available. While existing collaborative learning environments usually provide a broad array of functionalities to share, comment, and trace resources as well as documents, they are often quite restricted in their capability to collaboratively create and work with artifacts beyond text, conceptual models and or simple sketches.

Using the Knowledge Practices Environment (KPE) to Support Collaboration in a Systems Development Project at a Hospital

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Introduction

The knowledge creation approach to learning has a particular interest in collaborative knowledge creation processes in which concrete artifacts and practices ('knowledge objects') are created and developed. The roles of external representations in mediated discourses have been studied extensively in research areas such as CSCL, e.g. (Rogers et al. 2002); CSCW, e.g. (Scaife et al. 2002); and distributed cognition, e.g. (Hutchins 1999). Artifacts have varying roles in collaborative work processes, and perhaps especially so in design and development teams. The meaning of design representations are not carried by artifacts (such as sketches) themselves but are made meaningful through accompanying design activities (Tholander et al. 2008).

The project under study concerned a systems development project, focusing on the creation of a new medical information system at a large hospital. The project explored and suggested new solutions for collecting and presenting data about patients and treatments. The core team consisted of an IT specialist, a physician, two nurses from different clinics and a researcher (KK). The hospital's management, represented by the CEO and three head doctors, also took part in some meetings. The team met monthly over a 12-month period. Early interviews with each project member revealed that existing project tools and practices were considered unsupportive or constraining; good ideas produced during meetings were often forgotten, not pursued between meetings, and ideas were systematically dependent on particular individuals, e.g., documentation was kept on individual members' computers, resulting in a lack of collaborative elaboration. Moreover, planning and coordination of work was typically driven by factors external to the project rather than based on the development of new ideas deriving from the team. With these problems as a background, and based on 'work-pedagogical' ideas of fostering knowledge creation practices, the Knowledge Practices Environment (KPE) was introduced into the project. The team members were given training and the project had a "shared space" in KPE. An aim was to manage the flow of project information and tasks, and to see their mutual dependencies. The members had equal rights to create, modify, comment, and delete items. The space was organized to include project tasks, the relevant project documents, and items to support documenting and commenting of ideas. Dependencies were marked by linking tasks, items and persons.

Aim, Methods and Analyses

The aim of this study was to examine the roles of KPE in supporting the knowledge creation processes of the development project. A rich set of data was collected: reflective data through interviews, interactions at meetings (video recordings), and artifacts stored in KPE. For analysis, a protocol for exploring tool-mediated knowledge creation processes was used consisting of three dimensions: epistemic (e.g., elaborations, creating awareness), regulative (e.g., planning, organizing) and transformative (e.g., formalizing collaboration).

Findings

KPE was primarily used during meetings for structuring various items, e.g., tasks, ideas, background material, reports, notes, comments, sketches, links, and pictures of whiteboard notes. Between meetings it was used mainly for catching up, uploading materials, and sometimes for commenting. KPE was projected on a large screen and its contents referred to in the discussions. KPE had a central role of giving an overview of materials that were produced and collected and supporting reflection and planning of further work. Team members asked for items to be stored in KPE to make them available for all and sometimes explicitly asked for comments.

KPE served an awareness-creating role by reminding of previously discussed ideas and uploaded materials and showing participants' contributions, supporting the elaboration of items. The risk of ideas being left unattended to was lowered. During meetings whiteboards, pen and paper were also frequently used and sometimes the results were photographed and uploaded to KPE. Planning and organizing collaboration was done in the Process view by creating tasks and linking them to individuals. KPE thus had a regulative function; having the tasks presented reminded of tasks still to be done or information that needed to be collected. Conversely, KPE also served an awareness-creating role by reminding and bringing into focus already carried out tasks but which had not been reviewed in the meetings. Participants expressed that the team's planning became more prominent and directly connected to the specific objects/tasks that were currently worked on. KPE's functionality for presenting events that can be followed on a timeline as work progresses (Timeline Based Analyzer) was occasionally used to get an overview of progress in the project. KPE's abilities to provide overviews of work 'at a glance' were appreciated. However, moving between items in different parts of the system was considered challenging. The degree to which material was uploaded or tasks were defined for users in KPE varied between participants.

Theoretical and Practical Implications

KPE served a regulative function in planning further work, channeled the joint discussion, helped documenting new ideas, and had an awareness-creating role by representing what had been done and reminding of planned tasks. KPE thus appeared to in part resolve some of the pre-existing problems hindering knowledge-creation processes. Between meetings individual users would not use the tools extensively which may in part be explained by usability challenges. Also, there were individual differences as to how much material and tasks were posted - knowledge creation practices do not develop automatically by introducing KPE – and an implication for development projects is to carefully consider and explicitly decide on strategies and routines for documenting work and managing tasks in order to get the most of a system supporting collaboration.

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