Requirements Development in Loosely Coupled Systems: Building a Knowledge Management System with Schools

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Abstract

The diffusion of computers, local area networks and Internet connections in schools and the increase of instructional software and online resources is a challenge for the school system. Appropriate tools to store, access, distribute and to use those resources in schools are still in their infancy. In order to understand why schools as learning institutions are struggling with knowledge exchange, existing models for knowledge management will be described and adopted to the school context. Based on this framework, the specific functional requirements for key stakeholders in schools are derived. In order to integrate the requirements into system development for a computer-based knowledge management system, a participatory design process was initiated with three schools. The empirical findings during the process of requirement analysis are documented, focusing on key organizational aspects in schools. Based on empirical evidence, it is suggested that participatory design can be used not only as a method for user-oriented system development but also as a catalyst for reflecting the new role of technology for teaching and learning within an organizational change process.

1. Introduction

The extensive initiatives on federal, state and district level to bring computers, local area networks and high-speed Internet connections into schools and the increasing number of instructional software and online resources for students and teachers have significant organizational impacts on the school system. The technology is partially shaping how and where teaching and learning is taking place, questioning the traditional roles of teachers and learners ([1], [2]). But as we know from educational research, change processes in schools are slow and the system is effective in absorbing and ignoring innovations ([3], [4], [5]). Technology-oriented reform efforts which were naively driven by the idea that information and communication technologies might change the way teaching and learning happen in institutions such as schools are becoming less dominant. The focus is now moving from specific technology plans to whole-school reform and comprehensive education plans including technology, following the suggestion of RAND consultants in 1996: “Technology without reform is likely to have little value; widespread reform without technology is probably impossible“ ([6]). The new approaches include new forms of collaborative teaching and student-centered learning in authentic and virtual environments (‘blended learning’), digital content production and quality control, embedded in a stronger framework of accountability ([7]).

With more information and communication technologies in classrooms, computer labs and libraries, including mobile devices, the number of digitalized teaching and learning materials in schools has already increased to such an extent that effective and efficient ways of storing, indexing, retrieving, evaluating and sharing information are required. In business literature, the underlying management structures, workflows, the necessary technical infrastructure and professional development needs are subsumed under the term ‘knowledge management’. The goal is to identify systematically all relevant information resources and knowledge potentials in an organization and to deliver them to all relevant stakeholders with the help of groupware technology for computer-supported cooperative work (CSCW). Depending on the school of thought, knowledge management is also regarded as an organizational learning process that includes all stakeholders, regardless of the level of technology integration.

Until a few years ago, knowledge management has not been a major issue in educational contexts. Research was focused on technologies for teaching and learning in universities and business (computer support for cooperative learning, CSCL, e.g. [8]). The reasons are mani-
fold: schools are not a big business, there are difficult contextual factors, and there is a group of end-users (teachers) who are rather technophobe. Only recently, schools have become targets for the discussion about knowledge management as a comprehensive strategy ([9]), sometimes repeating the platitudes from the early days from business enthusiasm ([10]).

Starting with an overview of different approaches to knowledge management, a multifaceted perspective on knowledge management in schools is suggested. In order to model the processes in schools and on the classroom level to elicit the user’s requirements, we use an extension of Rowley’s four-level framework for information management ([11]). Within this framework, the requirements from all stakeholders (students, teachers and administrators) will be derived. Accordingly, this paper will describe the first phase of a participatory design process that was conducted together with three schools (secondary, vocational, adult education). The underlying research question is, why schools as learning institutions are struggling with organizational learning, using knowledge management strategies. It will be shown, that schools are types of organizations in which knowledge management supported by digital media can play an important role when they are embedded into organizational structure and slowly changing school culture. The key interest is providing information about the specific context in which knowledge management is placed in schools and suggesting requirements for system development, which are derived from a participatory design process. It will be suggested, that participatory design plays a double role for the target groups in schools: enhancing the functionalities of the system and increasing the acceptance by its critical users.

2. Knowledge Management in Schools – Information Management or Organizational Learning?

As often discussed in knowledge management literature, the terms ‘information’ and ‘knowledge’ are often naively used as though they were interchangeable, when in practice their management requires very different processes. According to Nonaka and Takeuchi, information “is a flow of messages, while knowledge is created by that very flow of information anchored in the beliefs and commitment of its holder. This [...] emphasises that knowledge is essentially related to human action” ([12]). For Drucker, “knowledge is information that changes something or somebody – either by becoming grounds for actions, or by making an individual (or an institution) capable of different or more effective action” ([13]). Davenport and Prusak define knowledge as “a flowing mixture of structured experiences, value concepts, context information and expertise which provides a structured framework for judging and integrating new experiences and information” ([14]).

Reflecting those assumptions about knowledge, we can identify a certain terminological sequence from data (isolated facts and values that are used to describe and construct reality) to information (linked data which is connected to some sort of meaning) and knowledge (information that is processed individually, linked to one’s own experience and is becoming grounds for action). This sequence can be regarded as a continuous network building process with increasing subjectivity and relevance for action. Apart from individuals, organizations have knowledge, too. “Knowledge is developed and used in the head of the knowing person. In organizations, knowledge often is not only included in documents or stores, but it is gradually embedded in organizational routines, processes, practices and standards” ([14]).

Historically, there are two theoretical streams, which are merging into the concept of knowledge management: (a) information management as effective information processing (the IT perspective) and (b) organizational learning (the behavioral perspective). Information management entered business and management literature two decades ago when information was first regarded as a new commodity. It was seen as a means to use the potential of information for reaching strategic goals and transforming it into company success by creating and maintaining a suitable information infrastructure ([15, 16]).

The concepts of organizational learning have emerged from earlier approaches on organization development, focusing on individual learning processes and the required training to obtain the necessary skills. The term ‘organizational learning’, however, has a more comprehensive meaning. The dynamics of an organization require a continuous learning process within the organizational structures and procedures. Nonaka and Takeuchi shifted the attention from information to knowledge as the key competitive factor ([12]). Their underlying assumption is that unlike other resources knowledge is a resource,
which grows by use and increases continuously its value.

Knowledge management is a fast growing paradigm in both research and practice. Earl identified in his analysis three different schools (with sub-schools) of knowledge management ([17]) with different aims, focus, units and philosophies: the technocratic, commercial and behavioral schools.

In summary, knowledge management is about planning, implementing and controlling information technology to support data and information flows to help meeting the strategic goals of an organization. In this paper, a specific educational organization, i.e. schools, is selected in order to understand why a learning institution has such difficulties to manage its knowledge. Schools as places for institutionalized learning should be a perfectly suitable domain for knowledge management. As it is a thrilling idea making knowledge about teaching and learning methods as well as quality-proven material available to all teachers and learners. If we take a closer look at the core processes in schools, we have to make a distinction between four levels, which comprise different stakeholders and a different scope of knowledge management (for an overview see table 1).

<table>
<thead>
<tr>
<th>Level</th>
<th>Stakeholders</th>
<th>Scope of Knowledge Management</th>
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<tbody>
<tr>
<td>Classroom</td>
<td>– Teachers</td>
<td>– Teaching and learning</td>
</tr>
<tr>
<td></td>
<td>– Students</td>
<td>– Cooperation, collaboration and communication</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Documents (material, lesson plans etc.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Media technologies (instructional software, websites etc.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Student portfolios and test scores</td>
</tr>
<tr>
<td>School</td>
<td>– Principal</td>
<td>– School administration</td>
</tr>
<tr>
<td></td>
<td>– Teachers</td>
<td>– Professional development</td>
</tr>
<tr>
<td></td>
<td>– IT Coordinator</td>
<td>– IT management</td>
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<td></td>
<td>– Professional development coordinator</td>
<td>– Accountability / test scores</td>
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<tr>
<td></td>
<td>– Administrators</td>
<td>– Cooperation, collaboration and communication</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Documents (timetable, curriculum etc.)</td>
</tr>
<tr>
<td>School Environ</td>
<td>– Parents</td>
<td>– Information and participation</td>
</tr>
<tr>
<td>ment</td>
<td>– Local community</td>
<td>– Cooperation and communication</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Documents (lesson plans, timetable)</td>
</tr>
<tr>
<td>District</td>
<td>– Superintendent</td>
<td>– Professional development</td>
</tr>
<tr>
<td></td>
<td>– IT Department</td>
<td>– IT management</td>
</tr>
<tr>
<td></td>
<td>– Curriculum development department</td>
<td>– Accountability / test scores</td>
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<tr>
<td></td>
<td>– Professional development department</td>
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This distinction is crucial as it demonstrates that objectives, processes, quality and quantity of data differ significantly. In school practice and education research, we can find different areas where knowledge management is already in place: (a) Teacher training as a means for knowledge exchange; (b) school development planning and curriculum development as a basis for organizational learning; (c) empirical research on learning to help teachers to understand better the cognitive processes and to support learners; (d) data-driven decision-making based on student test scores as a new focus in educational research ([18, 9, 19]); or (e) e-learning systems as a means for new forms of teaching and learning and knowledge exchange.

In this paper, a different perspective on knowledge management is taken. Our focus is the classroom and the cooperation between teachers, students and administrators within and between schools. These are the core processes in schools and aspects of individual information retrieval, organizational context and the school environment come into play.

In order to systematically analyze the requirements for this view on knowledge management in schools, Rowley’s four-level framework of information management is adopted and extended (see figure 1). The four layers of the framework can be described as follows:

- **Information Retrieval**: individuals’ abilities using the information systems to meet specific information needs. This includes actions, methods and procedures to recover information from stored data using indexing and search languages, interfaces as well as learning and cognitive frameworks.
- **Information Systems**: applications and IT infrastructure, i.e. invisible tools designed to
enter information, store it and facilitate effective retrieval.

- **Information Contexts**: factors influencing systems design, which are the direct environment for the user – including internal and external communication channels.
- **Information Environments**: surrounding factors, such as political, legal, regulatory, economic framework like intellectual property rights, social exclusion, security and privacy.

Transferred to schools, that means that the organizational structure of schools and the internal and external forms of cooperation and coordination (information contexts) have to be taken into account. With regard to schools as public institutions, the curricular and legal framework conditions, e.g. accountability, are of equal importance (information environments). Finally, addressing and adapting to students’ and teachers’ media literacy skills, i.e. identifying their information needs and methods to use the stored information (information retrieval) will be a necessary condition for a successful system implementation. This framework builds the model for system development.

As an extension to Rowley’s model, information management in an educational setting has to cope with a tacit normative pedagogical framework in which all actions are embedded. This influences the individual decision-making process as well as the contextual factors and the environment. Similar to strategic goals in corporate organizations, goals and objectives for ‘good education’ can be manifold. They are interpreted flexibly by individuals and not always shared within the school nor the system. In order to understand the specific conditions of schools for introducing a computer-supported knowledge management system a closer look on their complex social structures is required.

3. Organizational Context – Schools as Loosely Coupled Systems

Since the 70s, innovation research in education has extensively examined their shape as complex social organizations, finding ways to improve, to change and to develop ([4, 20]). Generally speaking, the school system can be described as a hierarchical organization with strong functional differentiation in school levels, grades, and age groups. Besides the hierarchical structure the members are relatively independent from each other, i.e. on the level of the work in the classroom, teachers act autonomously. They are controlled only to a limited degree, the range of control is relatively large, and success and failure can only hardly be determined. Lortie identified this as the “cellular structure of schools” ([21]), which manifests itself in the classroom. In his studies he observed isolated staff; teachers did not identify themselves with the school as a whole because they exclusively focused on their class and on the subjects they taught. Especially the division into different teaching subjects and school levels is a barrier for cooperation as much as the lack of team structures. Coordination is only possible in the form of school committees and instructional conferences or through top-down decisions by the school management. Depending on the country and/or state, curricula and standards build a more or less strong means for coordination. These curricula, which vary between strong standards enforced by achievement tests and loose frameworks, leave much action space to the individual teacher. Hierarchy and autonomous cells together build what Weick has called ‘loosely coupled systems’ ([22, 23]). Those kind of sys-

![Figure 1. A framework of information management in schools](image-url)
tems consist of partly autonomous units which themselves create their own borders, cultures, and contexts. They are characterized by a high degree of autonomy of its elements implying low controllability and predictability as well as a high flexibility. Controlling the individual elements within the system does not necessarily have an effect on the system as a whole. Overall, cooperation is no strength of schools and the organizational structures do not support it. Teachers are often 'isolated workers' who are rarely sharing their expertise because it is either not transferable or the team structures are not supportive. In this context, the idea of taking off this expertise (process knowledge) and making it generally available sounds compelling. The problem of eliciting process knowledge has already been the crucial point in all technology-driven knowledge management approaches. Extracting, modeling or retrieving “tacit knowledge” as named by the Hungarian philosopher Polanyi ([24]) is hardly possible. The endeavor in schools is to make the expertise of teachers (and students) explicit, finding ways to formalize, to store it and to make it accessible to others.

What does this mean in regard to the use of knowledge management systems or cooperative teaching and learning systems in schools? The pessimistic answer could be to ignore schools as being too difficult. The more optimistic and pragmatic answer is to encounter these aspects as early as possible in the system development process. What needs to be taken into account when developing a system for schools? (a) The specific context of autonomous cells in a loosely coupled system in which top-down approaches do not work and incentives are difficult to offer; (b) the information context of three different user groups, from teachers that are mainly interested in teaching not technology, to enthusiastic students and bureaucratic administrators.

4. Requirements Engineering

Requirements analysis is the least technical, but the most important phase of system development. If the analysis is not made completely and adequately, the consequences are more serious than in the other phases, as the information not collected in this phase cannot be collected later without starting the whole process over again ([25]). On the other hand, adjusting the development continuously to randomly changing interests (tastes) of the users will cause problems and slow down the development process, especially since it will not be possible to fulfill all demands. Additionally, users often do not have a complete understanding of their tasks nor the options and functionalities. It is important to have in mind existing language barriers between systems designers and end-users. As we know from research on participatory design, user involvement is desirable but difficult. In any given context, users are part of a micro-political process in which issues of representation are central; they (and the systems developers) build categories which are constituted by systems development; the users’ ability to speak for the organization is usually limited; and users need to be wary of how information technology is represented to them by developers ([26]). The more the requirements analysis is using example tasks from the real life of users, illustrated with functional prototypes, the more the resulting document and later the product fits into their information context, which has been described in the theoretical framework. In order to cope with these problems, there is a growing interest in developing systems in cooperation with end-users. During the last decade, participatory design has become a more popular method in software engineering ([27, 28]). Research suggests that later in the development process there is hardly a remedy for the consequences of neglecting, misinterpreting or even ignoring the user requirements. Requirement analyses are built on social and communicative abilities, which are normally not developed adequately by system designers nor are they part of computer science education. In our case studies, a team of advanced students of computer science worked closely together with three pilot schools including their teachers, students and administrators. So far, there is only little research on participatory design with school stakeholders. For example, Carroll et al. conducted a long-term study around the implementation of the virtual high school ([29]). Concerning students, there is no documented effort for participatory design although this group is not only comfortable in using the technology but also a highly relevant information resource.

Similar to knowledge workers in other organizations, teachers (and students) have no definite workflows that could be analyzed with existing process models. Teachers’ knowledge about their students and teaching and learning methods is mostly tacit, process-oriented and driven by experience, embedded in their understanding of the normative pedagogical framework of ‘good teaching and learning’.
4.1 Research Methodology

As we know from research in CSCW, technical solutions cannot be separated from social and organizational issues. Ackerman called it the ‘social-technical gap’ ([30]) and Orlikowski and Hofman emphasized the necessary combination of change processes and technological solutions ([31]). In order to develop a comprehensive picture of the system requirements within the organizational setting, it is necessary to understand the objectives of key stakeholders in schools (see table 1). To capture the complexity of this undertaking and to determine what factors deter and promote its use for multiple stakeholders within the given framework, a mixture of methodologies is needed to collect both qualitative and quantitative data. We have selected three schools (secondary, vocational and adult education) in a city school district with different histories in using technology and sharing information among teachers and students (see following boxes).

<table>
<thead>
<tr>
<th>School A</th>
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<tr>
<td>School A is a comprehensive school (grades 5 to 10) with 47 teachers and 840 students in the heart of the city. The school has a strong pedagogical focus on integrating the local community in the school’s learning environment. As a basic philosophy, the school believes in constructivist learning processes, allowing students to self-direct their learning, changing the role of teachers. IT plays a vital role in this concept. With the visionary leadership of the school management, the school was one of the first with laptop classes and computers in the classrooms. Based on a local area network, teachers and students have already started to exchange documents (homework, student presentations). E-mail is used as a normal way of communicating between students and teachers as well as with parents. Given this, the school has a high interest in extending the file server system to a knowledge management system.</td>
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<tr>
<th>School B</th>
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<tbody>
<tr>
<td>School B is a special school for adult education with 117 teachers and 1000 students in a non-residential area. The students have usually failed in the normal school system for different reasons, worked for a couple of years and later attend to classes in which they can redo their exams for the traditional school degree (after 9, 10 or 13 years of school). Courses are offered both in the morning and in the evening, allowing the mature students to follow their work and/or family obligations. Hence, attendance rates vary due to different reasons. Given that, the principal and a school team have been involved in setting up a technical system that enables exchange of digital material between students and teachers in a much easier way than before. The school has already built up a web server that can be accessed from outside the school. Their interest is to extend this system to a full groupware and information exchange server.</td>
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In order to model workflows of students and teachers, classroom activities as well as after-school activities have been observed. With the help of semi-structured interviews and participant observations, teachers’ practices and collaborative activities and their attitudes toward the introduction of a knowledge management system were highlighted. The role distribution of informants interviewed is shown in table 2:

<table>
<thead>
<tr>
<th>School C</th>
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<tr>
<td>School C is a large vocational school with 80 teachers and 1000 students in a poorer suburban area. Students work in different clerical professions (banking, insurance, accounting) and are part-time attendees (sometimes 3 months a year, sometimes alternating 2 days a week for 2 years). With input from the businesses where the students work and with which the school cooperates, a small group of teachers in the school was interested in e-learning projects from the very start. Nevertheless, there are only few faculty members who are actively involved, reducing the size of the team to about 10 teachers. The school management is planning to extend the use of the existing groupware system, making it more accessible for untrained teachers. The major goal was to allow students to access all information and teaching materials from home, informing them about changes in the lesson plans and to make administrative use of the system.</td>
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### Table 2. Number and distribution of interviewees

<table>
<thead>
<tr>
<th>Number interviewed</th>
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<tbody>
<tr>
<td>School A</td>
</tr>
<tr>
<td>Teachers</td>
</tr>
<tr>
<td>Students</td>
</tr>
<tr>
<td>Administrators</td>
</tr>
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These kinds of ethnographic methods are rarely used in systems design ([32, 33]). They are time consuming, their effectiveness cannot be easily measured and most system designers do not have the necessary skills to conduct them.
Another way we have used to elicit end-users attitudes and requirements is the scenario-method (e.g. [34]). This hands-on experience lowers the barrier for most teachers to talk aloud about their requirements and expectations about the systems’ functionalities. Supplemented with a vertical prototype, students and teachers could actually explore the system. From our case studies in all three schools we found, that students had an exploratory approach to the systems technical functions due to experiences they already made at home. Nonetheless, the system's objective was to support the teaching and learning process. In this regard, teachers are (still) the experts. And students have to be regarded as temporary participants with changing roles and interests.

4.2 Functional requirements

According to literature ([35]), four basic tasks accessible via a user-friendly interface are key to learning support systems:

- Information distribution (homepage, calendar, meetings, projects)
- Management of learning material (upload/download, search engine)
- Multiple communication facilities (e-mail, chat, newsgroups, videoconferencing, shared whiteboards)
- Class management (user management, groups, security and privacy)

Teachers and administrators in our case studies added two more necessary features they wish to be integrated:

- Content management (for easy content production, test and assessments)
- Asset management (managing scarce resources like video projectors, software licenses, hardware etc.)

In order to elicit the functional requirements from our schools, we developed a role model that builds the contextual framework for the on-site interviews (see fig. 2).

In all our interviews with teachers, ease of use and easy navigation (with school-relevant metaphors) was mentioned as a necessary condition to motivate non-expert users. In order to operationalize this requirement, the system must comply the standards of software ergonomics (as in ISO 9241) and web content accessibility guidelines (as in WCAG 1.0). If the latter is ignored, users with all different kinds of disabilities might be excluded. The potential of a teaching and learning support system expands when it respects a wide range of individual learning styles, preferences, and abilities.

During the interviews it became obvious that students, teachers and administrators have different priorities. While students especially in schools B and C emphasized the importance of
communication tools, teachers were reluctant to use e-mail or chat as means for communication. For them the exchange of documents, online delivery of homework and, in school B, student-directed tests were mentioned as key functions. From the perspective of administrators, necessary functions are both asset management and electronic tools for one-to-many information distribution including a group calendar. The target group for information and communication differs - for school C, communication with the sending companies (for vocational training) is important; for school A communication with parents. Most of these functional requirements are realized in commercial and open source groupware tools. As schools cannot afford commercial products, open source products seem to be the only way unless the school district is willing to pay for commercial software. Beside the obvious functional requirements, we found empirical evidence, that the integration of a knowledge management system is dependent on different contextual factors, which are examined in the following chapter.

4.3 Contextual factors

There is evidence from our interviews with teachers in schools B and C that they would rather share their knowledge (their materials and lesson plans) with teachers of schools in other regions (or even countries) than with colleagues within the same school. In both schools, cooperation and communication structures were not well developed; they were limited to smaller groups of teachers. In contrast, teachers in school A reported that the general school climate was very much supporting exchange of lesson plans and classroom experience. Teachers visited frequently lessons of their colleagues and the school management offered enough space for exchanging ideas.

During our classroom observations, all teachers equivocally complained about teaching resources and practical examples of curriculum integration on the Internet. It would be too difficult to transform them into the individual teaching practice, as they were often too sophisticated (‘orchid projects’) or below a certain level of quality. As quality, validity and reliability of data is crucial for most teachers, adequate structures and processes for quality control have to be built up. In order to reach a certain level of quality, all entries have to be checked regularly, otherwise there is the danger of a vicious circle that data is not used because it is too difficult to access, and no one invests in making it easy to retrieve because it is not used. Likewise, data is not trusted because many errors have been found, and no one cares about verifying the accuracy of the data because it is not trusted. Only in school A, there is some evidence that there is an organizational structure ensuring that knowledge which is built up with great efforts, is suitable for everyday teaching.

In order to attract users to provide material as well as controlling its quality, a system of incentives needs to be established. In schools A and C both teachers and school management have been thinking about this. In that respect, experience from corporate organizations show ambivalent results, as managers and workers might not share the same reward structures ([36]). Orlikowski found in her study about the introduction of the ‘Notes’ software, that if incentives are only based on individual performance, the participation in collaborative activities is less likely ([37]). What kind of incentives work best in schools is not yet clear neither to teachers nor to school managers. Teachers in school B emphasized that saving time to prepare new lesson plans by using other teachers’ material, i.e. not ‘re-inventing the wheel’, should be sufficient. But, as our classroom observations revealed, teachers in other schools tended to use basic materials that were freely available and produce new lesson plans around them, in order to make their own teaching process more interesting. It was also obvious that in schools with a high involvement of the principal (like schools A and B), the opportunities to build a ‘community of practice’, in which ideas and material would be shared are more likely to exist.

Analogously to corporate organizations, there appears to be a critical mass problem ([38]). In school C, there was an insufficient number of users and material that prevents other teachers to access the system (negative network effects). As there is a certain minimal threshold of active users, in the context of teaching and learning, there is also a maximal threshold: teachers in schools B were unsure when there are too many users at the same time, the system might become too confusing to handle, as individual search strategies as well as ways to organize meta data are not yet established.

Institutionalized education is strongly connected with measuring student achievement therefore different kinds of assessments are used (from standardized tests, students' portfolios to open team and project work). On the bottom line, students get grades from their teachers. Apart
from school A with their very open teacher-student relationship, teachers in the other schools are anxious about the fact, that the more digital material has been produced and the better the search engines get, the more the students will build a “copy-and-paste-culture” of plagiarism. As there is no effective technical solution to prevent copying paragraphs or even full presentations, the teachers are looking for social regulatory structures. Mature students in schools B and C did not see any advantages in using the Internet as a large-scale database for copying existing coursework. The younger students in school A admitted indirectly that they are currently using such databases – without teachers’ knowledge.

In interviews with teachers who are not yet feeling very competent using digital media in the classroom, they mentioned individual barriers for using a computer-based knowledge management system. Apart from the expert users in schools, this is still a big issue about necessary skills to use computer and Internet among teachers and also deficient media literacy skills of students. Some teachers, especially in school C, mentioned a fear of losing power over the classroom and the teaching and learning process - both through ‘virtualization’ and stronger control options (as one teacher pointed out: ‘data is stored on the machine, spoken words are invisible’). They do not trust electronic networks (technically) and fear the loss of face-to-face contacts.

Obviously, cultivated routines have to be modified, which is a long-term organizational change process that can only be initiated and supported by information technology. As revealed in interviews, teachers’ arguments against the usability of the technology could be seen as a pretext to block any changes of teaching and learning styles as well as roles of teachers and learners. Overall, only with adequate support structures, teachers in all three schools feel confident in experimenting with such a digital tool. Students, especially mature students in schools B and C are even more enthusiastic as they see a great potential in changing the way school works.

5. Conclusions

Research about the use of computer-supported knowledge management systems in schools is still in its infancy. It is still too early to generalize results from the first pilot projects. More systematic research is needed in order to transfer existing findings in the field of CSCW and CSCL to schools. The increase of digital teaching material and students’ work will push forward the development of such systems in many schools. Additionally, many efforts are in place to produce electronic assessment technologies (e.g. students' portfolios, the digital fieldbook) as well as making standardized test results electronically available for teachers, parents, principals and districts. Therefore it is important to make a distinction between the levels of the school system and the objectives that are underlying the concepts of knowledge management.

The gap between social requirements and technical feasibility is particularly big in schools. If knowledge management systems should have a future in schools, they need to be embedded in a larger framework. As shown in this paper, individual information needs and retrieval methods have to be taken into account as well as the contextual factors of the school as an organization and the environment of the school system.

Thus, at the core, knowledge management is a process, which has to be embedded in the entire organizational development of schools. The current ‘hype’ about digital media could give the impetus and motivate teachers and learners to participate. But without an organizational structure, where rules, conventions, and reliable decisions are negotiated and which are mandatory to all, the implementation of such a system will be difficult.

Due to the loosely coupled system, a cross-departmental task such as knowledge management is difficult to establish. But to fully utilize and exchange the process knowledge in schools, the school culture has to change, moving toward a learning organization. In the long term, schools must shift from the current teacher-oriented instructional process of whole-class teaching in traditionally structured classrooms to learner-centered, project-oriented and team-oriented learning. It is important to create a culture where both teachers and learners are feeling free to exchange and share their knowledge. In such an organizational context, the implementation of a web-based knowledge management system can be effective. As shown, participatory design can play an important role in this process, serving both as catalyst for better system design and increasing the acceptance by its users.

6. Acknowledgments

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6. References