An idea-centered, principle-based design approach to support learning as knowledge creation

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Abstract: While the importance of viewing learning as knowledge creation is gradually recognized (Paavola, Lipponen, and Hakkarainen, 2002; 2004), an important question remains to be answered - what represents an effective instructional design to support collaborative creative learning? This paper argues for a need to move away from efficiency-oriented instructional design to innovation-oriented instructional design if learning as knowledge creation is to be pursued as an important instructional goal. The rationale in support of this argument is discussed from four different theoretical perspectives and an idea-centered, principle-based design approach as an example is proposed for discussion.

In her work, Sfard (1998) distinguishes two metaphors of learning, which are learning as acquisition and learning as participation. Building on this work, Paavola, Lipponen, and Hakkarainen (2002; 2004) suggest a third metaphor—learning as knowledge creation. They identify Carl Bereiter's (2002; Scardamalia & Bereiter, in press) knowledge building theory, Nonaka and Takeuchi's (1995) knowledge-creating theory, and Yrjo Engestrom's (1999) expansive learning theory as three prominent models in support of the knowledge creating community conceptualization. While the argument for "learning as knowledge creation" as a new pedagogical approach to schooling and education is well justified in their articles, an important issue remains to be explored - what represents an effective instructional design to support learning as knowledge creation? The purpose of this paper is to discuss two general types of instructional design approaches—efficiency-oriented and innovation-oriented. It is posited that if learning as knowledge creation is to be pursued as a new pedagogical approach, instructional design will need to move away from an efficiency-oriented to an innovation-oriented approach. We discuss some design differences between the three learning metaphors in relation to these two types of instructional approaches from four theoretical perspectives to support this argument, and then propose an idea-centered, principle-based design approach as an example to support learning as knowledge creation.

Pedagogical Underpinnings

Of the three learning metaphors, learning as acquisition represents a traditional view according to which learning is "mainly a process of acquiring desired pieces of knowledge" (Paavola, Lipponen, & Hakkarainen, 2002, p. 24). It highlights a psychological concept of knowledge (cf., Hyman, 1999) and sees knowledge as possessed within an individual's mind-as-a-container (cf., Popper, 1972). Learning as participation suggests learning is a process of participating in various cultural practices and shared learning activities (e.g., Brown, Collins, & Duguid, 1989; Lave & Wenger, 1991). In this view, activities are regarded as the center of learning and knowledge is seen as distributed over both individuals and their environments (Hutchins, 1995). In other words, the focus of learning is on activities ("knowing") more than on outcomes ("knowledge"). The creation metaphor, however, emphasizes the innovative process of inquiry where "something new is created and the initial knowledge is either substantially enriched or significantly transformed during the process" (Paavola, Lipponen, & Hakkarainen, 2002, p.24).

Consistent with the view of learning as acquisition, a conventionally held belief in education has been to learn first (e.g., through K-12 schooling), and to innovate later (e.g., during graduate study). Under this view, "efficiency" in maximizing an individual's personal knowledge becomes an important criterion in judging whether instruction is effective. To this end, early instructional design models have strongly emphasized the importance of employing well-defined procedures, clear scripts and rules, and componential tasks (cf. Reigeluth, 1999) in order to help students master certain pre-specified knowledge/skills. Such instructional design examples include task-driven instructional design models (Dick & Carey, 1990), Criterion Referenced Instruction (Mager, 1975), Gagne, Wagers and Briggs's (1992) Principles of Instructional Design, and Component Display Theory (Merrill, 1983). Growth of individual knowledge is usually the chief goal. Although "innovation" may still be considered important under the learning-as-acquisition view, for most conventional instructional designs, it is clearly not their primary design focus.

Moving away from cognitive reductionism and overemphasizing mental "efficiency", instructional designs based on the view of learning-as-participation have been shifting the design focus to activity and collaboration, for example, problem-based, project-based, and inquiry-based instructional activities (see Barron, Schwartz, Vye, Moore, Petrosino, Zech, Bransford, & CTGV, 1998; Edelson, Gordin, & Pea, 1999; Hmelo-Silver, 2004; and Krajcik, & Blumenfeld, 2006). Although procedures and routines are still an unavoidable part of instructional design, the primary design interest is clearly in meaningful constructivist activities to support situated learning and knowing. The design of such activities and practices are often characterized as student-centered (e.g., self directed learning, Hmelo-Silver, 2004), situated (e.g., cognitive apprenticeship, Brown, Collins & Duguid, 1989), and culturally relevant (e.g., Lee, 2001). Despite success in facilitating knowing through participation, most instructional designs based on this view still fall short of seeing knowledge as a collective social product and designing activities accordingly to promote knowledge "innovation". This can be seen in the tendency of many of these approaches to formulize learning as a set of procedures that a group of students can follow. For example, in the problem-based learning approach students move through a clearly defined cycle of activity as follows: 1) identify the facts of a problem scenario; 2) generate hypotheses about the problem solution; 3) identify what knowledge needs to be gained in order to solve the problem; 4) apply the newly gained knowledge to solve the problem; and 5) abstract the knowledge gained from the entire cycle of problem solution through reflection (Hmelo-Silver, 2004; see also White, Shimoda, & Frederiksen, 2000).

Arguably, in a knowledge creating community, the knowledge goal is not merely to achieve individual knowledge growth or to promote distributed knowing, but to collectively advance community knowledge as a public product (Bereiter, 2002). Of the three knowledge-creating theories referenced above, a commonality among them is their emphasis on pursuing sustained knowledge advancement through collective effort. Under the learning-as-knowledge-creation view, the function of a knowledge creating community is very much like that of a research or science community (Latour & Woolgar, 1986; Merton, 1973) where sustained collective public knowledge advancement is treated as the primary knowledge goal while personal learning and individual knowledge growth become a natural byproduct of such endeavors (Bereiter, 2002). Doing so, however, requires a rethinking of the nature of designed instructional activities. We argue that rather than pre-defined activity structures (e.g., clear division of labor and the following of a set of procedures), more emergent, self-organizing activity structures (Barab, Cherkes-Julkowski, Swenson, Garrett, Shaw, & Young, 1999) are necessary in order to engender learning as knowledge creation. We provide more reasons below.

Psychological Underpinnings

In a review, Brown, Bransford, Ferrara, and Campione (1983) describe a classic view of a two-process approach to thinking. One is an automatic process (often referred to as automaticity), which represents a fast, parallel process of mental activity, requiring less subject effort. Such a process is commonly associated with cognitive mechanisms such as schemas (Anderson, 2000) and scripts (Schank & Abelson, 1977). The other is a controlled process, which is a comparatively slow, serial process that requires a large degree of subject control. While they are both indispensable mental mechanisms, the roles played by these two thinking processes are very different for efficiency and innovation as knowledge goals.

When efficiency is regarded as a primary knowledge goal, facilitating the development of automaticity becomes more essential as an end in and of itself. Towards this end, a controlled process needs to serve as a means to fostering automaticity. For example, in learning to drive (or to cook), effortful thinking in order to integrate necessary knowledge and know-how of driving (or cooking) must function as a means to gradually accomplish the automatization of driving (cooking). Once a learning goal of being efficient is achieved to form certain automatic procedures, controlled processes become less essential as a means of accomplishing the goal. Apparently, well-defined procedures (such as those described in a manual for driving or a recipe for cooking), or authentic cooking activities or practices (such as craft apprenticeship), can help with such mental practice; and with considerable cognitive and/or socially embedded practice it is possible for people to become adept at performing certain routines (e.g., driving or cooking) with great efficiency (Hatano & Inagaki, 1986). Hence, both component-based and activity-based instructional designs are useful in developing automaticity or routine expertise in a given domain.

However, when innovation is prized as a primary knowledge goal, facilitating the development of a controlled process in service of innovative thinking becomes more essential as an end in itself. To accomplish this, any previously acquired automatic processes must be re-invested as a means to serving a higher goal of knowledge advancement. Doing so not only sustains knowledge creation but also helps with the gradual attainment of adaptiveness, that is, being more effective in activating and utilizing the controlled thinking process. As a related example, for professional drivers (or cooks), achieving routine efficiency in driving (or cooking), that is, automaticity, is not an end of itself. The goal is to achieve a higher-level of adaptive capacity, that is, to be able to drive (or to cook) adaptively regardless of any kind of road conditions (or cooking conditions), or in other words, to be able to problem-solve creatively across different contexts (Hatano & Inagaki, 1993). To do so, however, requires a metacognitive habit of mind (Black & Wiliam, 1998; Zessoules & Gardner, 1991) and progressive problem solving (Bereiter and Scardamalia, 1993); that is, to persistently subject oneself to a controlled thinking process for tackling gradually more difficult problems in order to advance one's expertise (rather than reducing problems to previously learned, familiar routines), and more importantly, for going beyond creative problem solving to a mode of sustained problem finding or defining. We argue that in order to achieve higher-levels of adaptiveness, a more flexible instructional design framework that can go beyond scripted procedures and ritualistic mental activities, and allow more emergent and self-organizing activities to occur is required.

Epistemological Underpinnings

The two types of knowledge most frequently discussed are know-that and know-how (Ryle, 1949). In various terms, they are also referred to as learning and use (Brown, Collins, & Duguid, 1989), replicative and applicative knowledge (Broudy, 1977), or declarative and procedural knowledge (Anderson, 2000). An example of know-that may be learning the multiplication table, number facts, or chemistry formulae and that of know-how may be using the multiplication table to answer a math question or using the chemistry formulae to solve a scientific problem. There is, however, a third type of knowledge, which all too often is neglected in formal schooling. This knowledge is broadly referred to as "tacit knowledge" (Polanyi, 1967; Nonaka, 1994) or perhaps more specifically, knowledge of "promisingness." Such knowledge is found to be especially important as a resource of creative experts. For example, after continuously solving many problems in their area of expertise, experts are found to possess a stronger sense of what is promising (or problematic) as a solution to a problem, and/or of how to improve, refine, or re-design that solution in order to better solve that problem.

There are important relationships between the above three types of knowledge. According to Hatano and Inagaki (1986) know-how can be categorized into two sub-categories. One is routine know-how and another is adaptive know-how. An example of routine know-how is being able to solve a science problem by applying a set of well-specified, textbook-defined procedures. In contrast, an example of adaptive know-how may be solving the same science problem by trying to design a better solution and keep improving, refining, or re-designing it. In correspondence with these two types of know-how, the role of know-that can be very different. When routine know-how is pursued as an important knowledge goal, know-that is more likely to be specifiable content knowledge that can be used to fulfill the routine know-how. As such, know-that and know-how are both ends of learning, and typically in many school settings they are reified as textbook knowledge guided by a well-structured and circumscribed curriculum. Normally, when curriculum is structured in this way (with routine know-how and specifiable know-that), little room is left for students to develop the third kind of knowledge of "promisingness".

On the other hand, when adaptive know-how is the primary knowledge goal, know-that becomes less likely to be specifiable. As such, know-that and know-how become emergent knowledge and their content can only be gradually defined in a developing course of knowledge building. Arguably, knowledge practice, as such, would give more opportunities for students to develop the kind of knowledge of "promisingness" that is important for knowledge creation. Correspondingly, the kind of curriculum required would be a progressive one (Caswell & Bielaczyc, 2002) that would be allowed to unfold and emerge as inquiry progresses, so as to foster the development of such knowledge of "promisingness". Thus, while it is important to refer to curriculum guidelines when designing instruction, it will be equally important to allow more design flexibility so that instructional activities can be more adaptive and can go beyond curricular and disciplinary boundaries. If knowledge creation is to be pursued as an essential instructional goal, design flexibility is needed to foster the kind of knowledge of "promisingness".

Socio-Cultural Underpinnings

Where the emphasis of instructional design is placed on knowledge acquisition and distribution rather than on knowledge innovation in a community, a culture that facilitates efficiency in mastery of a corpus of knowledge predefined in the curriculum becomes essential. To initiate members into such a culture, it is necessary to create a well-organized community that favors effective division of labor and well-structured activities in facilitating such a process. An example of collaborative learning through repetitive activity structures in the classroom is the jigsaw method (Aronson & Patnoe, 1997). As the authors note in their book, "The Jigsaw Classroom":

> Every member of every group was responsible for learning all the curriculum material, but individual students had direct access to only their part of the material—the part they were to teach others. Since they had to depend on groupmates for access to the rest of the materials, it became essential for all groupmates to do a good job of communicating their parts of the material…In essence, the students in each group were putting their knowledge together a piece at a time, each student contributing a piece of the jigsaw puzzle of material. (p.91)

As another example, the importance of repetitive activity structure is also highlighted by Brown and her colleagues (Brown, Ash, Rutherford, Nakagawa, Gordon, & Campione, 1993). As they argue,

> The repetitive, indeed, ritualistic nature of these activities is an essential aspect of the classroom, for it enables the children to make the transition from one participant structure

(Erickson & Shultz, 1977) to another quickly and effortlessly. As soon as students recognize a participant structure, they understand the role expected of them. Thus, although there is room for individual agendas and discovery in these classrooms, they are highly structured to permit students and teachers to navigate between repetitive activities as effortlessly as possible. (pp. 200-201)

The chances are the more defined a community's division of labor, the more likely a community will be aligned with an efficiency-oriented instructional design and be able to achieve an overarching goal of knowledge acquisition and distribution. Arguably, this typifies a learning community (Brown, 1997) and the kind of culture valued in such community is a culture of knowledge sharing and construction based on a pre-defined curriculum. Although innovation may still be held with high value within such a community, the focus of innovation is likely to be on the process of how to best achieve knowledge acquisition and distributed knowing (e.g., learning how to learn individually or collaboratively), but not necessarily community knowledge advancement. For example, in a discussion of the anchored instruction design model, collaboration is seen not only as allowing students to "…discuss and explain, and hence learn, with understanding," but also to serve a monitoring function "Students in groups can also monitor one another and thereby help keep one another from going too far off track." (CTGV, 1990 p. 68). The monitoring function of collaboration seems to be viewed as a strategy for achieving knowledge acquisition.

On the other hand, when a community not only values efficiency in the growth and exchange of individual knowledge, but highlights a higher aim of creating an innovative community (Hargreaves, 1999), a culture that facilitates innovativeness by means of having members collaboratively contribute knowledge to the community, and persistently build-on and improve one another's individual knowledge for advancing collective knowledge in a community, become more imperative (Hong & Scardamalia, 2008). To initiate members into such a culture is to create a community, whose chief function is not just to define optimal learning procedures and/or foster meaningful distributed social activities for the growth of individual knowledge, but also to encourage members to work with knowledge creatively by allowing knowledge building processes and activities to emerge. And the more adaptive and flexible a community's activity structure, the more likely members would be allowed to design their own course of knowledge work and work opportunistically in connecting with diverse ideas and collaborating with one another for sustained knowledge advancement (see Hong, Scardamalia, Messina, & Teo, 2008; Hong, Scardamalia, & Zhang, 2007; Zhang, Scardamalia, Reeve, & Messina, 2006, for example). Arguably, this represents a knowledge-creating community and the kind of culture valued in such a community is similar to the kind of knowledge-innovating culture that is commonly observed in research, science, technology, and business communities (Evans & Wolf, 2005; Gloor, 2006; Latour & Woolgar, 1986; Merton, 1973; Nonaka, 1994; Nonaka & Takeuchi, 1995), where community knowledge is held with high esteem, while learning as acquisition and participation is still seen as an essential part of, and as complementary to, community knowledge advancement. For example, new technologies are increasingly created by self-organizing knowledge workers (Rycroft, 2003) such that the open source operating system, Linux, has been developed and continues to evolve through an essentially volunteer, self-organizing community of thousands of programmers who collaborate on diversified ideas through constant exchange of open source code (Evans & Wolf, 2005).

Needless to say, the two kinds of communities (learning community vs. knowledge-creating community) described here are very different in nature and would require different instructional design support. It is evident that an efficiency-oriented design is a better candidate than an innovation-oriented design for sustaining a culture that values efficiency for knowledge acquisition and/or distributed knowing in a learning community. On the other hand, to foster a knowledge-creating community would require a high degree of flexibility and adaptability in the design of activity structures in order to support self-organization of knowledge. It is therefore posited that an innovation-oriented design is a more effective design approach to supporting learning-as-knowledge-creation. Table 1 summarizes key design differences between the three learning metaphors, examined from four theoretical lenses.

Table 1: Design differences between the three learning metaphors.

	Learning as acquisition	Learning as participation	Learning as knowledge creation
Peda-gogical Under pinnings	> Enhancing efficiency in knowledge appropriation as a primary instructional design goal > To learn in order to, potentially, innovate	> Facilitating participation and distributed knowing as a primary instructional design goal > To learn through participation	> Promoting knowledge innovation or creation as a primary instructional design goal > To innovate is to learn
Psycho-	> Placing more emphasis on	> Placing more emphasis on	> Both controlled & automatic

logical Under-pinnings	automatic process (as ends) than controlled process (as means)	controlled process (as ends) than automatic process (as means)	processes integrally regarded as means to progressive problem solving & finding/ defining; there is no end to this process.
Epistemo-logical Under-pinnings	> Towards more routine know-how and pre-defined know-that > Pursuit of knowledge of promisingness not emphasized > Pre-determined curriculum (with clear instructional procedures)	> Towards more adaptive know-how with still largely pre-defined know-that > Pursuit of knowledge of promisingness less emphasized > Pre-determined curriculum (with more flexible learning process/activity)	> Towards adaptive know-how and emergent know-that > Pursuit of knowledge of promisingness highly supported > Progressive curriculum necessary
Socio-cultural Under-pinnings	> Community not emphasized > Social activity not necessarily emphasized > Knowledge appropriating culture > Construction of individual knowledge highly valued; community knowledge advancement not emphasized	> Community of learners > Structured social activity (e.g., division of labor; scripted cooperation, reciprocal teaching, group-based collaboration) > Knowledge exchanging and collaborating culture > Social participation as means to support distributed knowing and individual knowledge growth; community knowledge advances not necessarily valued	> Knowledge-creating community > Emergent, opportunistically-structured activity > Knowledge innovating and creating culture > Sustained community knowledge advancement and individual knowledge growth are both valued

An idea-centered, principle-based design approach

As an example of design that supports learning as knowledge creation, below we describe an idea-centered (Scardamalia, 1999), principle-based (Hong, Scardamalia, Messina, & Teo, 2008) approach that is based on knowledge-building theory and pedagogy (Bereiter, 2002), and supported by Knowledge Forum (KF), a computer-supported knowledge building environment (Scardamalia & Bereiter, 2006). Knowledge building is a social process focused on the production and continual improvement of ideas of value to a community (Scardamalia & Bereiter, 2006), and guided by a set of knowledge-building principles (see Scardamalia 2002, for detail). For example, the principle of 'Epistemic Agency' highlights the importance of setting forth ideas and negotiating a fit between personal ideas and ideas of others (Hong & Scardamalia, 2008; Hong, Teplovs, & Chai, 2007), using contrasts to spark and sustain knowledge advancement rather than depending on others to chart that course for them. As another example, the principle of "community knowledge, collective responsibility" emphasizes that contributions to shared, top-level goals of the community be prized and rewarded as much as individual achievements and that team members produce ideas of value to others and share responsibility for the overall community knowledge advancement. In a knowledge-building environment, knowledge advancement usually starts with idea generation, for example, using authentic problems and scaffolds to help students form ideas. Once generated, ideas can be contributed to a KF database in the form of a note and become public, and once recorded in the database, they are treated as conceptual objects/artifacts for further collective improvement (Bereiter, 2002; Popper, 1972). Figure 1 shows some selected design features in a KF note in relation to idea generation.

Arguably, ideas can be improved in two dimensions: depth and breadth (Hong, Scardamalia & Zhang, 2007; see Figure 2). From a social perspective, the former is a function of how knowledge workers (epistemic agents) collaborate together in improving ideas, i.e. the intensity of collaboration or co-elaboration; whereas the latter is a function of how ideas (conceptual/epistemic artifacts) interact with each other, i.e., the extent of knowledge-interaction between ideas. Building on evolutionary epistemology (Popper, 1972) and social epistemology (Fuller, 1988), ideas can be improved by means of two fundamental evolving trajectories: idea co-elaboration and idea diversification. Depending on how ideas are transformed, ideas may be substantially refined by means of co-elaboration or significantly enriched by means of idea diversification. Neither, however, represents an optimal approach to sustained idea improvement. For example, research has indicated that withholding ideas as valuable intellectual properties (e.g., a business secret) without sharing with, and/or obtaining new perspectives from others (e.g., other disciplines) can hinder knowledge innovation. On the other hand, simply exchanging ideas (e.g., information-sharing) does not guarantee the transformation of ideas into deeper understanding. Ideally, the process of idea-improvement requires transformation both in depth and breadth, and there is no end to this evolutionary, collaborative, and innovative process, i.e., a self-organizing process initiated by the two simple communal behaviors of idea co-elaboration and idea diversification to form a complex system of ideas—what Popper (1987) calls the third world.

To sustain this endless process, knowledge-building principles are employed as ideal conditions that constitute an optimal knowledge-building community (see Scardamalia, 2002, for detail). Using only principles as guidance without pre-specifying activity structures, a "design space" (e.g., a KF View, see Figure 3) is intentionally created as a meta-design scheme to allow community members (e.g., the teacher and students) to collectively improve (i.e., to design, perform, and re-design/refine) their knowledge works (e.g., theories) in order to advance community knowledge. Accordingly, knowledge-building activities become adaptive rather than routine or ritualistic. For example, in one of our recent studies in a grade 5/6 knowledge-building class where students were collectively inquiring about "human body system" "long jump" (Hong, Scardamalia, Messina, & Teo, 2008), we have observed a more opportunistically structured activity pattern. At a quick glance, it appears that students are involved in activities similar to an ordinary student-centered class, for example, small-group or whole-class discussion, watching videos, computer use, library search, reading, writing, conducting experiments, and working in front of a computer, etc. However, these activities do not fall into any ritualistic practice. Instead, students work around ideas, by opportunistically forming collaborations and by employing any meaningful activities considered beneficial at the moment when in need of idea improvement. Further, it was also observed that the increasing agency and collective responsibility (as guided by the principles of "Epistemic Agency" and "Community Knowledge, Collective Responsibility") for students to design, perform, and re-design/refine their knowledge work, increased their progressive problem-solving ability, as well as their knowledge or sense of "promisingness." For example, in investigating how human body functions as a system to perform a long jump, a student summarized the process of his idea improvement along the course of his knowledge building as follows:

> My original theory wasn't very successful. For my normal jump [as compared with the experimental jump] I got 2.20 m and for when I used running in the air my results were 1.48 m. So don't run in the air... but it might only be for me so you could try it…so I am going to try something the opposite of that. I am going to try not moving in the air. Also I am going to keep my legs tucked in too (but at the end stick them out so I will go higher. I think that is going to work because I will go high and you want to go high because then you won't touch the ground sooner. (by IJ)

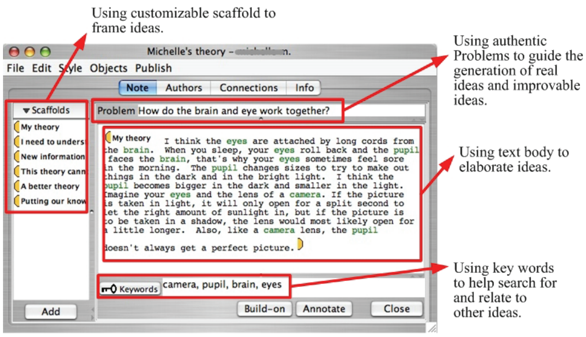

Figure 1. Some design features in a KF note.

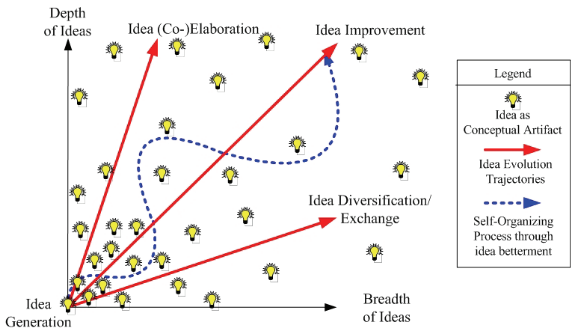

Figure 2. An evolutionary view of idea improvement.

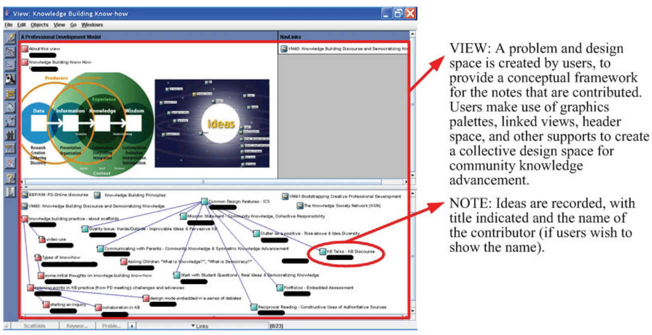

Figure 3. An example of a KF View (design space).

Discussion

In this paper, we have identified the need for a new, innovation-oriented, instructional design framework that addresses the conceptualization of learning as knowledge creation. To highlight the need for this new idea-centered and principle-based framework, we have contrasted it with efficiency-oriented instructional design frameworks including component-based and participation-based models. We have argued for the need for the innovation-oriented framework from pedagogical, psychological, epistemological and socio-cultural perspectives. In the following paragraphs, we discuss areas of future research from these four perspectives that will aid in the development of innovation-oriented instructional designs.

The learning as knowledge creation metaphor represents not only a shift in conceptualizing how people learn, but also in what the outcomes of learning should be and what conditions are best for fostering such learning outcomes. The idea-centered, principle-based instructional design approach emphasizes self-organization as a guiding pedagogical principle for engendering innovation and knowledge creation. Research agendas that focus on the classroom conditions, pedagogical approaches and policy decisions that affect self-organizing activity in a classroom are needed to advance our understanding of how to create innovation-oriented instructional designs for knowledge creation. An important psychological aspect of innovation is adaptiveness, meaning developing the capacity to perform at a high level in any situation through metacognitive control processes. Investigating more fully the mechanisms and conditions that make possible adaptive expertise (Hatano & Inagaki, 1986) is a particularly important area of future research for those interested in creating innovation-oriented instructional designs. We have theorized that in order for students to develop the knowledge of "promisingness" they would need to be immersed in a curriculum that holds adaptive know-how as the primary learning goal. In such a curriculum, know-that, or declarative knowledge, becomes less specifiable ahead of time. Therefore, the curriculum would need to be spacious enough to allow the know-how and know-that knowledge needs to emerge as a function of collective inquiry. The role of the teacher in facilitating movement through such a spacious curriculum is an important area of future research. Finally, our conceptualization of the knowledge creation community highlights the importance of the public advancement of community knowledge. This view of collaboration goes beyond small group work and whole class discussions, to the notion of a professional research community where an individual's interests are pursued through evolving and continuing intellectual relationships with others (Hong, 2005; Hong & Lin, 2008) towards the end of advancing public knowledge. Understanding how to create the conditions for such relationships to develop overtime in a classroom is an important area of future research.

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