eSTEP AS A CASE OF THEORY-BASED WEB COURSE DESIGN

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Introduction

This chapter explains the design of eSTEP, an innovative, experimental web-based course in the learning sciences[2] for pre-service teachers. I will describe instructional approaches that integrate interactive study of classroom video and learning science text, supported by an online multimedia environment called a Knowledge Web (KWeb), with collaborative lesson design, supported by an online environment for Problem-based learning (PBL). I will also address the question, why do it that way? While the answer includes a number of practical considerations, this chapter will focus largely on how theory about learning and transfer is reflected in course activities and the website that the eSTEP team designed to support them. The theoretical question addressed is how to make the conceptual systems (e.g., learning sciences) taught in college truly useful in students' future professional lives (e.g., teaching). This chapter reflects several years' thinking about this problem and about course and website designs for transfer.

For purposes of grounding this discussion, I will think of both learners and practitioners as people experiencing a social and physical learning environment through cognitive processes of recognition and pattern matching that are essentially perceptually based. From this perspective, I believe that professors and managers of large professionally-oriented courses will make the ideas they teach useful for their students' later practices to the extent they can create course designs that cause students to repeatedly *mesh* (e.g., Glenberg, 1997) (1) patterns of activation associated with conceptual systems taught in courses with (2) families of perceptual patterns resembling events learners will experience in practice. I think of these learned meshings, which I call conceptual/perceptual fields, as potential future patterns of activation. To help students be able to bring perceptual/conceptual fields to bear on practice, they must also be meshed with cognitive patterns representing useful planning heuristics (Suchman, 1987) that can guide later reflective, adaptive action in practice. I will argue that this complex form of pattern meshing is most likely to occur when learners are motivated, through learning environment design -- which includes material, social, and facilitation structures -- to actively use course concepts to develop and evaluate multiple goal-based plans in the context of studying a library of cases that realistically represent a range of patterns that will be experienced in the field of practice. My chapter will further elaborate this view.

The Activity Field Hypothesis

This theoretical framework, which is guiding and evolving with our work, assumes existence of a continuously organizing *activity field*, a complex system of cognitive activation representing human experience of an activity that can be thought about and analyzed at the individual or group level. The *learning* activity field is a virtual "space" where, when instruction is well designed and facilitated, cognitive patterns activated by more perceptual aspects of instruction (e.g., video study) mesh with interpretive patterns generated through more conceptually based aspects (e.g., text study) as well as "embodied" patterns of planning and problem solving (Glenberg, 1997) representing authentic professional activity. This concept of mesh within a dynamic cognitive field is related to Clancey's (1997) ideas about perceptual-conceptual organization and coupling.

Conceptual/Perceptual Mesh

Although all forms of learning probably promote both perceptual and conceptual activation, some forms, such as study of video, are regarded as more perceptual, whereas others, such as reading or explanation, are typically more conceptual. The challenge of instructional design is to create activity fields in which learners repeatedly mesh conceptual knowledge with perceptual visions of practice to which those concepts apply.

Repeated meshing is important. To illustrate this point, consider the following: students in sixth-grade mathematics often manifest an operational rather than a relational view of equality, and the future teacher must learn to recognize a range of perceptual patterns through which students reveal this developmental phase. Behavioral patterns demonstrating operational or relational views vary widely, but share family resemblance (Wittgenstein, 1953). Not all possible patterns can be experienced during instruction, but if a sufficient number of patterns are experienced, such as through video study, new patterns within a family might later be appropriately identified by a human perceptual system even if never seen before. However, pattern activations are only meaningful if they simultaneously activate concepts relevant to practice.

Importance of Planning Activity

The AFH suggests that for many forms of professional practice, including teaching, an important mechanism promoting both mesh and transfer is adaptive planning in action. That is, 'perceptualized' concepts learned in a course must become *useful* tools for guiding practice, not just passive interpretive lenses (Kozulin, 1998). This idea is based partly on current theory and research on event perception (Zacks & Tversky, 2001), which suggests that events of professional practice are experienced as unfolding, nested goal-based plans—basically cause-and-effect structures—that are adapted in action (Suchman, 1987). As an example of a nested plan, consider that a teacher in an inquiry science classroom may ask students questions with the immediate goal of surfacing current understandings, a proximal goal of challenging misconceptions if detected, and a longer range goal of preparing students to participate meaningfully in an inquiry science experience. Hence, our teacher education courses attempt to promote meshing of perceptualized learning science concepts to professional activity, through discussions that employ those concepts as a cause-and-effect language of goal-based planning. The validity of this argument is supported by Dewey (1933), and Schon (1983) and (Lemke, 2002)

Entering Student Characteristics

In addition, as the substantial body of research studying the effects of prior knowledge on learning documents, what students bring to the instructional environment is also important. As a whole, we characterize the learning activity field as a generalized cognitive *attitude*, a representation of experience that includes not only patterns of activation representing organization and meshing of perceptual and conceptual experience with general plans for future action, but also the prior attitudes, feelings, beliefs, and dispositions that learners activate during the learning activity. As part of the learning activity field, these neural patterns can exert biasing influences on professional learners' goals, on what they perceive and how such perceptions support learning new conceptual systems. Such biasing cognitions may be either compatible or incompatible with the conceptual and planning material being taught, and so may either help or hinder learners' receptivity and ability to "see" and operate using concepts being offered. For example, if a teacher-learner tends to believe that a child's environment is mostly responsible for whether a child learns, that teacher may easily learn to see and plan in terms that help engineer that environment, but may have more difficulty learning to see and develop the child as a self-determining cognitive agent. Understanding and challenging or building on such cognitive attitudes is part of the instructional design problem.

Social Interaction

Much social interaction can occur within learning environments, including online ones. Students in our courses discuss readings, participate in collaborative lesson study, and engage in small-group lesson design projects. The activity field within a learning environment is both highly influenced and revealed by social interactions, which can be studied for how such interactions promote meshings that may or may not relate to targeted learning goals. Following Wertsch (e.g., Wertsch & Kazan, 2003), we view social interaction online as a dialectical struggle to mesh (1) learners' perceptual and prior-knowledge activations that occur within the course's activity field with (2) the language (e.g., learning science concepts) of a new semiotic community they are asked to appropriate, within (3) task and social structures imposed by the course. There is the struggle of using learning science terminology to help articulate and represent thoughts to others in the class; and there is the struggle of trying to mesh personal understandings with signs for ideas and goals, expressed in learning materials and assignments and by others. Beyond this problem of understanding and being understood in the course context—as Greeno's (2001) analysis reminds us—there are social achievements related to being able to carry course ideas and practices into the future professional social problem-solving environment. Thus, the learning activity field must also help students activate and mesh patterns of social interaction, including attitudes and behaviors that will support carrying forward and sustaining practices advocated by the course. From the goals of classroom participation to sustained participation in professional practices, learning is a very complex form of social coordination involving such issues as status, competence, agency, and personality within social environments (Clancey, 1997; Greeno, 2001). By focusing on the learning activity field revealed through social discourse as a dependent variable, research may uncover ways that group composition, activity design, tool design, and forms of facilitation work together online as factors that help or hinder achieving desired forms of mesh through social learning (e.g., Chernobilsky, Hmelo-Silver, & DelMarcelle, 2003; DelMarcelle & Derry, 2003).

Summary

In very brief summary, the basic idea is that instructional design for useful conceptual learning should attend to the activity fields created through learners' participation. To promote transfer, learning environments must create fields characterized by mesh between families of perceptual patterns representing events of practice and the conceptual systems taught in their courses. There should also be mesh with causal structures that can guide reflective action in practice, and dispositions and beliefs that support conceptual thinking during practical activity. Here, we propose that such learning fields are likely to be produced if learners are motivated, through "designed" social interaction, to use and combine concepts in developing and evaluating multiple goal-based plans in the context of varied authentic situations that are presented perceptually, as with video study. By conceptualizing activity fields as virtual complex systems that can be described and manipulated, we open the door for new ways of thinking about such ideas as transfer and authenticity. For example, rather than judging the authenticity of a classroom learning activity in terms of its physical match to a professional environment, one might ask whether the learning activity fields and professional activity fields match in critical ways.

Toward a Deeper Understanding of Mesh

An Event-Perception Analysis

A typical way of thinking about professional education is that it helps learners acquire conceptual systems (e.g., the learning sciences) that can flexibly be assembled and imposed as interpretive lenses upon events of practice (e.g., classroom teaching), to guide and inform it (e.g., Spiro, Feltovich, & Coulson, 1992). Presumably, such flexible cognition increases the professional's power to see multiple possible interpretations and solutions, leading to better decision-making. However, a relevant concern not addressed in many such analyses is how the events of professional practice, upon which conceptual systems are flexibly imposed, are naturally segmented and structured by the physical world, including the physiological systems of human event perception. This issue is important, for event perception in professional environments is a cognitive and physical process strongly influenced by the "bottom-up" mechanisms of human perception that have evolved to reflect how humans interact with events in situ. We argue that instructional designers should give more consideration to how humans connect with their environment through the meshing of perceptual patterns triggered by the environment and those triggered by conceptual memories learned through courses.

In classroom teaching, the professional landscape teams with hundreds of complexly interwoven events occurring simultaneously in three-dimensional space and continuously over time. The teacher at the center must refine, select, edit and impose order on what would otherwise be an overwhelmingly complex experience. Fortunately there are features of the physical world that form patterns and gestalts, and human perceptual systems have evolved means of taking advantage of them. Zacks and Tversky (2001) synthesized a large body of literature concerned with perception of events in a dynamic environment. Events as perceived tend to be structured by certain objective physical properties, such as change in an actor's behavior or direction of movements, and have beginnings and endings that are reliably detected across observers. These perceived patterns very often correspond to chunks of activity representing systems of physical causality: For example, an agent (e.g., the teacher) acts on objects (e.g., writes on a transparency) with particular, usually multiple, physical consequences (e.g., a display appears and students stop talking and look toward the display). There is evidence that such episodes are perceived as objects that have parts (agent, action, ground, direction) and are themselves parts of hierarchical event structures (Zacks & Tversky, 2001). For example, the transparency event is part of a larger daily activity that is a part of a lesson that has particular event outcomes in the context of a larger instructional unit and course, all associated with learning goals and expected outcomes for students.

Although events are perceptually cued by objective physical properties and individuated on the basis of physical properties of motion and causality, they may also activate conscious meaning through mesh with prior knowledge. Teachers interpret events, drawing inferences about classroom plots, students' understandings and motives, problem solving processes, etc. Many researchers and theorists have noted that the ordinary language that people use to talk about, and draw inferences regarding, the meaning of events is shaped by physical properties of events themselves and reflects how the human body interacts with them. For example, Zacks and Tversky (2001) suggest that the basic syntactic and semantic structures of all languages reflect the hierarchical and causal nature of events. Highly regarded theorists such as Hofstadter (2000) and Lakoff and Johnson (1980) propose that all thinking is fundamentally analogical and metaphorical (terms used interchangeably), grounded in our embodied experiences with the environment. Informal professional discourse about teaching practice thus reflects a universal human tendency to interact naturally with events as physically structured and perceived. This is why teachers *cover*, *skip*, *skim*, *go through*, *go over*, and *throw around* the ideas they teach.

This viewpoint has implications for professional education. One is that practitioners' comfort with a new conceptual discourse, such the *learning sciences*, will likely be tied to how naturally that language maps to events in the world of work. Those involved in teacher education are well aware that teacher learners often expect and gain little from the theories to which their curricula expose them (Simon, 1992). Scientific theory talk might be too far removed from the events of classroom practice, either because the foundations of educational science were not historically grounded in classroom practice in the first place, or because even grounded theories have evolved away from practice through out-of-classroom professional discourse (e.g., talks and discussions at academic conferences, in journals, in university classrooms). If theory isn't well matched to student teachers' perceptions of the kinds of events it is supposed to explain, it won't be bought, especially if teacher-learners are immersed in classroom experiences while studying.

However, an event that can informally be described as the teacher presenting material and students receiving it can also be seen as the teacher talking in a way that uses <u>instructional tools and artifacts</u> that help direct students' <u>attention</u> to what is most important for them to <u>process</u>. An instructional objective is characterized, not merely in everyday terms as a goal to cover material or pass a test, but as a goal of helping students <u>construct understanding</u> of important <u>concepts</u> in a way that will help them <u>transfer</u> that understanding into new situations within <u>communities of practice</u> outside of school. These sentences are examples of using learning sciences terms (underlined) in a way maps naturally on event perception, but that expands and deepens it in useful ways. Note that most terms that mesh natural events to the science of learning are also metaphors. Also note that these metaphors serve as tools in teaching, that is, they serve useful functions, such as describing goals for teaching and learning and actions, including mental ones, for achieving them. Teachers who understand the metaphors of learning science can unpack them further for deeper insights into the causal nature of instructional goals and actions, including hidden "thinking" actions that facilitate goal achievement.

In sum, this drives home the point that *which* learning science concepts taught in education courses, as well as the *way* they are taught, should respect the shape of the perceptual landscapes of practice. Such concepts must not only "make sense" metaphorically in helping teachers describe a complex professional world that is structured by event perception, but also serve as useful tools for flexible goal-based planning and action within that world.

Instructional Design for Enhancing Mesh

In recent years, many researchers and educators have proposed innovative designs for learning environments that strengthen the connection between the conceptual world of classrooms and real-world practice. Some examples include Cognitive Flexibility Hypertext systems (Spiro et al., 1992), Problem-Based Learning (PBL) (Barrows, 1988; Koschmann, Glenn, & Conlee), Understanding by Design (Wiggins & McTighe, 1998), and Contrasting Cases Instruction (Schwartz & Bransford, 1998). All of the aforementioned methods can be characterized as proposals for creating forms of conceptual mesh that we see as necessary for conceptual transfer, and we have in fact incorporated all of them into our work. However, we believe that each of these approaches, at least in the versions implemented so far, is in some sense incomplete in that it has dealt with only part of the mesh that needs to occur within the learning activity field. Some proposals focus on connecting practice with planning; others center on creating mesh between conceptual analogies and the landscape of event perception, or on the connection between the learning of new concepts and prior knowledge. In our work we have borrowed from and adapted these approaches, creating and testing hybrid blends of them in an attempt to motivate more complex forms of mesh within the learning activity field. In the following sections we will describe how we have adapted and blended several of these approaches in the context of an experimental online course.

A Course Experiment

For several semesters, my colleague Cindy Hmelo-Silver and I have collaboratively designed, taught and studied learning within two courses for pre-service teachers at UW-Madison and Rutgers. The two courses, called the eSTEP (Elementary and Secondary Teacher Education Project) courses, have similar goals: to help pre-service teachers acquire *useful* knowledge of learning science concepts. The courses employ similar methods consistent with the AFH viewpoint. Briefly, these methods include integrated study of learning science text and video cases of lessons, coordinated with small-group projects involving adaptive lesson design following a problem-based learning (PBL) format (Barrows, 1988; Hmelo-Silver, 2002).

The courses must be adapted to the different sites and student populations. For example, the UW-Madison course is taught to a socially cohesive cohort of upper-division students who have completed their majors and been selected into a competitive secondary teacher education program. The Rutgers students are not in a cohort, are in earlier stages of their degree work, are considering teaching as a career, and enroll in a learning science course as a prerequisite to applying for admission to either elementary or secondary teacher education. An example of a required adaptation is that UW students are mostly grouped by disciplinary major and they study and design lessons for secondary students, whereas Rutgers students work in interdisciplinary groups and study in both elementary and secondary contexts.

Partly to reduce the time and resources necessary to separately develop eSTEP for the particular needs of two different populations of users, partly to address a number of practical considerations, and partly to obtain standardization and control for our research, we built a common website to support both courses. In both courses, most of the students' time is spent in extended (2–3 week) facilitated small-group PBL activities in which they acquire (through integrated text and video study) learning science concepts as they design assessments and learning activities. Although students may continue to attend some classes to hear occasional lectures and meet face-to-face with their groups, most of their individual and collaborative work takes place and is submitted online through the course Web site (eSTEPWeb.org), which guides individual students and groups through steps for completing each problem. This website illustrates much of what about our course is theory-based design, and is described next.

Components of the Course Website, eSTEPWeb.org

The main parts of the course website, eSTEPWeb.org, are:

1. The "Knowledge Web," a multimedia online resource that is used during lesson design and includes two integrated networks:
    a. The Case library, a digital library of stories of real lessons in real classrooms and representing the landscape of practice
    b. The theories net, a hypertext book containing conceptual knowledge from the learning sciences and representing the conceptual landscape.
2. PBL Online: A site including step-by-step scaffolding and tools to help groups carry out authentic lesson design tasks

I will explain these web components in greater detail, simultaneously elaborating on the theoretical issues related to their design and describing instructional activities that make use of them.

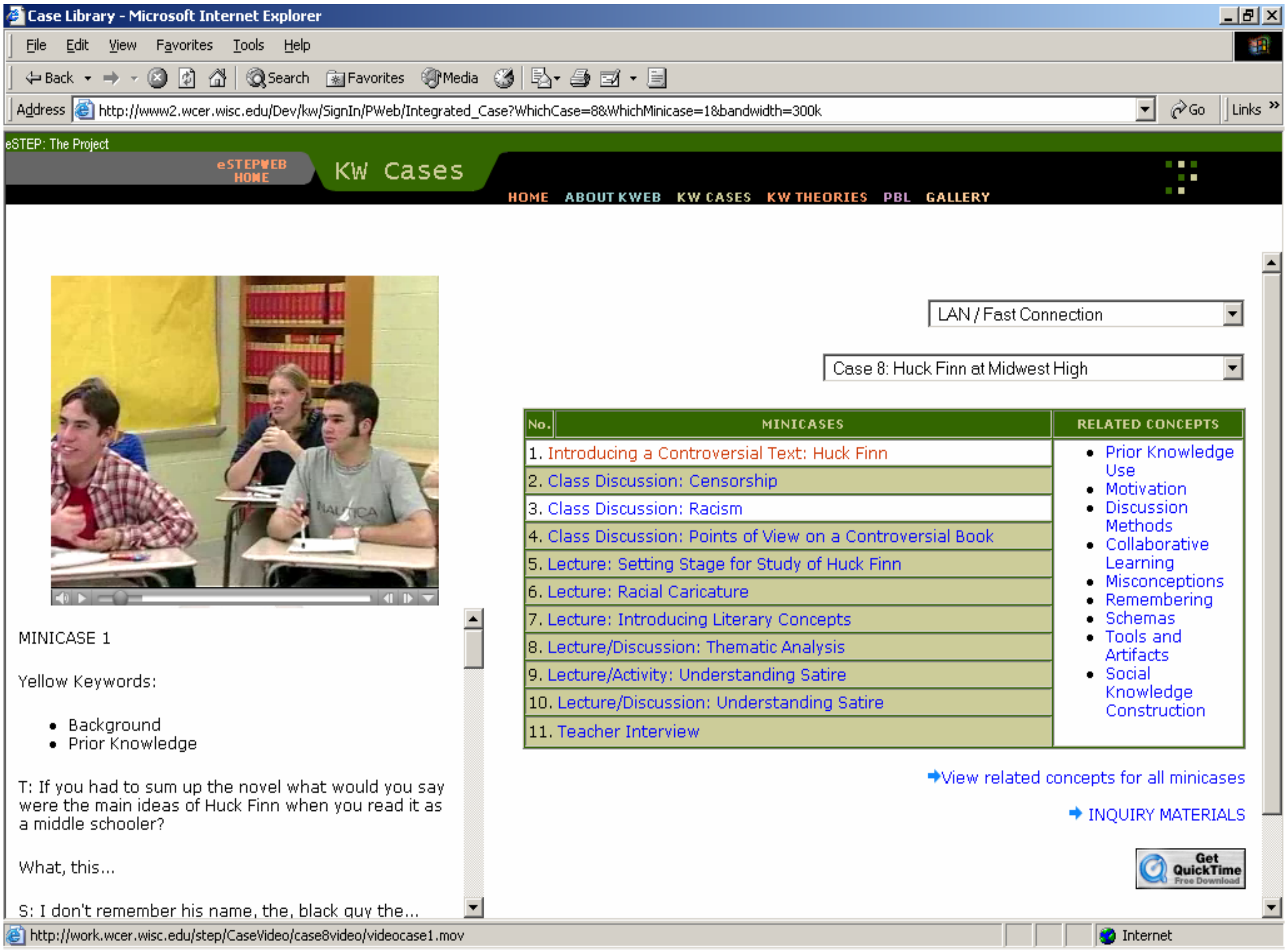

Figure 1. A Web Page from the Case Library

The eSTEP Knowledge Web

This discussion will draw a distinction between two kinds of domains: the highly perceptual domain of professional practice (such as mechanical engineering, medical practice, classroom instruction, etc.) versus the highly conceptual domain of classroom subject-matter knowledge through which practices should be understood and interpreted (such as physics and art for architecture, biological sciences for medical practice, learning psychology for teaching). The eSTEP Knowledge Web (KWeb for short) is a multimedia hypertext resource on the WWW that contains materials related to both practitioner and conceptual domains and that is explicitly designed to support instruction that has the goal of creating mesh between them.

The Case Library: A Landscape of Practice. Our case library is a flexible instructional resource that represents the perceptual landscape of practice. It currently contains 11 cases for five subject disciplines and is growing. Although cases vary in how they are designed, a typical case in our collection is a story about learning and instruction in an actual classroom setting. A typical case's components include approximately 15-20 minutes of edited video plus supplementary materials, such as teacher commentary, examples of student work, class handouts, test scores, information about school context, etc. Our cases range from examples of problematic classroom instruction that could be improved (redesign cases) to examples of exemplary instruction we would like for students to emulate (adaptation cases). Most cases lie somewhere in-between.

To enable instructional flexibility we edit video footage in a way that captures major to-be-taught themes in small segments of video called minicases. In eSTEP, cases are collections of such minicases; however, when desired, minicases can also be extracted from their larger case contexts and reassembled into different groupings for instructional purposes. For example, a lecture or other presentation for the eSTEP course might use an assembly of minicases, drawn from various case contexts, that illustrates a course topic, such as *social knowledge construction* or *teaching for transfer.*

How the technology itself shapes conceptual analysis is illustrated by our rule of thumb for minicase size: A video less than two minutes long can be downloaded quickly with a fast connection and, if downgraded in quality, with a 56K modem. Hence, the two-minute (or less) minicase was born. Yet our experience indicates that this is a good grain size for illustrating meaningful and complex instructional events that require complex interpretations using multiple concepts.

The Theories Net as a Conceptual Landscape. The theories section of KWeb currently consists of about 100 densely interlinked web pages that contain explanations and other instruction for selected learning sciences concepts. These pages are intertwined and linked with the 100+ minicase segments in the case library that illustrate varied instances of learning science concepts at work in the classroom. Hence, while viewing any case or related minicase in the KWeb cases library, the user can easily link to relevant learning science concepts in the theories net. For example, from a case on the teaching of Huckleberry Finn, shown as figure 1, one can access a range of learning science concepts in the theories net, which can be combined in various ways to help interpret the case. Also, on every learning science page within the theories net, there are links, not only to other related concept pages, but also to minicases within the library that illustrate that page's learning science concept. This is shown in figure 2, where the page on *social knowledge construction* contains a list of minicases from the case library that illustrate a range of situations in which that concept is experienced in the domain of practice.

Designing the conceptual structure for the theories network proceeded as a rational historical and conceptual analysis of the learning sciences domain. Our analysis uncovered significant theoretical intermingling: similar but subtly different ideas with similar names are claimed by different theories. A good example is the term "constructivism," which is uncomfortably shared by the sociocultural, sociocognitive, and information processing theories and is used in reference to both instructional methods and theories of learning. Also, there was considerable historical confounding of theoretical knowledge. For example, the body of knowledge that is often taught and represented as information processing theory presents concepts derived from early versions of the theory side-by-side with those derived from later versions. Hence, from the student's perspective, one idea may seem to be explaining phenomena in very different ways, a situation that frequently leads to serious misconceptions that must be challenged, such as the idea that information processing psychology is synonymous with a behavioral or passive "knowledge-transmission" perspective. Designing the theories net taught us first hand that learning sciences in instructional contexts is an ill-structured domain with numerous sources of messiness.

We needed a pragmatic structural metaphor for setting up the site and specifying relationships among concept pages and minicase nodes in the network. Such structures facilitate navigation and serve as tools for constantly updating and maintaining a website, but they impose constraints upon domain representation that we must be able to live with. We chose a loose family metaphor, such that every page, or node, in the theories net is linked with other nodes in the web that are designated as its ancestors, parents, children or "other relatives." The theories net is organized as three interlinked idea families: Cognitive Theory; Sociocultural Theory; and Cross-Theory Ideas. The Cognitive Theory family has two main branches: Information Processing and Sociocognitive (Developmental) Theory. Each idea family and its main branches also have several major family branches. As an aid in navigation, the family metaphor helps prevent disorientation in hyperspace (Diaz, Gomes, & Correia, 1999), since from any entry point within the theories net the user can identify the major theory and idea families to which that page belongs. The family metaphor also supports site maintenance very adequately: when a new node is added, only its parents and relatives need be specified, then its position in the network with respect to all other nodes is automatically generated. And, while the family relationships metaphor is an apparent hierarchy at superordinate levels, it is a loose family metaphor that affords creation of partially non-directional graph structures specifying complex interrelationships among pages (there can be three or more parents, for example, and relational links can be either directional or non-directional). Thus, the structure is valid for representing complex, conceptually messy domains.

Instruction With the eSTEP Knowledge Web

In designing our KWeb, we adopted a number of proposals and ideas from CFT, a theory of advanced knowledge acquisition for ill-structured domains. In particular, we designed the KWeb to support two forms of hypertext instruction suggested by Spiro et al. (personal communication, 2002): Domain criss-crossings and small multiples. We use these strategies to create mesh between the conceptual analogies of the learning sciences and the perceptual landscape of practice. These strategies attempt to compact experience and so are expected to accelerate development beyond what might be accomplished through traditional instruction combined with field-based professional placements.

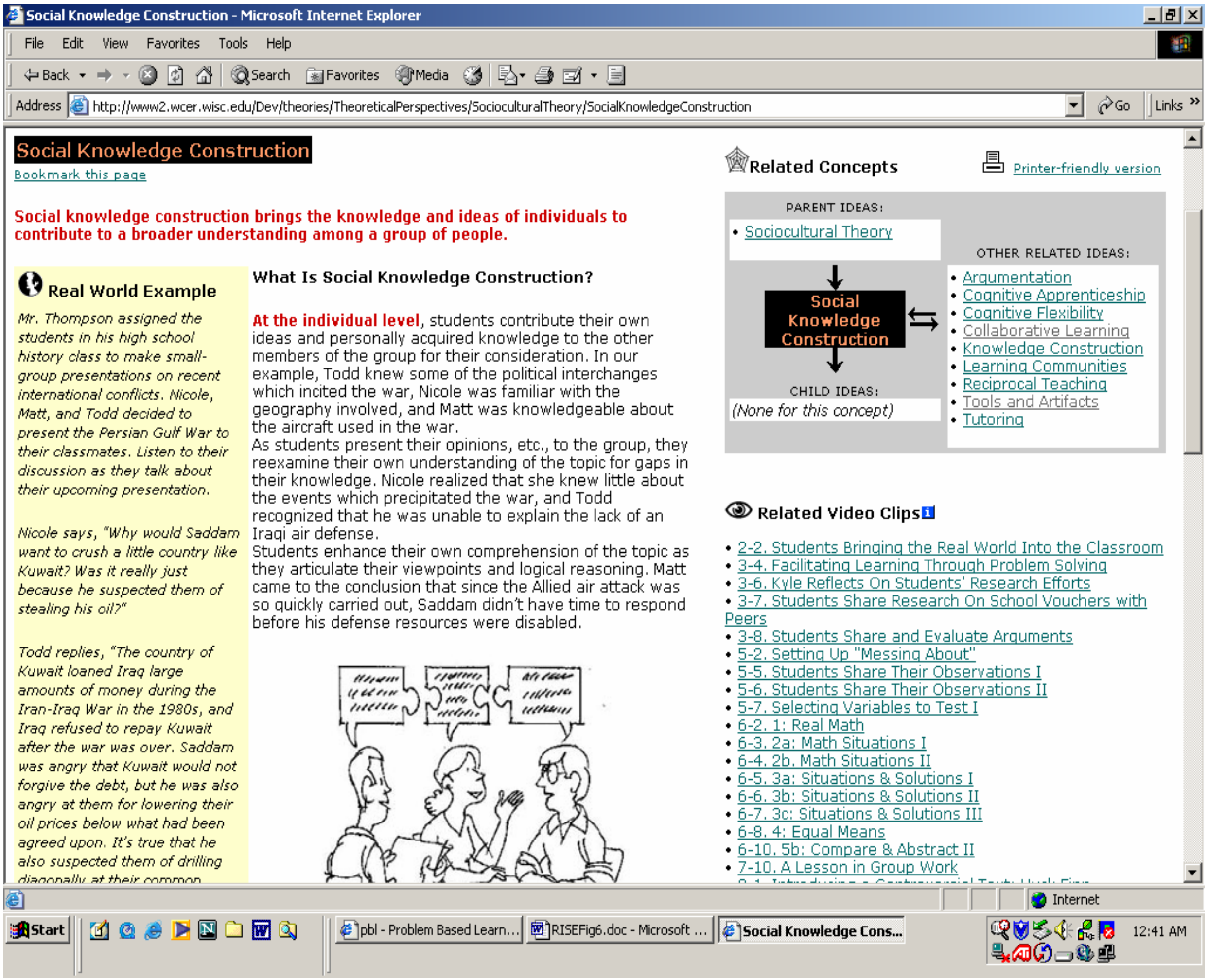

Figure 2. A Page from the Theories Net

<u>Domain Criss-Crossings and Small Multiples</u>. This instructional strategy assumes that students come to the instruction with prior knowledge of important, previously learned (perhaps at a basic level) subject-matter concepts for which more enduring and sophisticated understandings are required. Instruction guides students in studying a large number of varied real-word cases that represent the landscape of practice contexts in which those concepts are to be "perceptualized." For example, a course lecture or assignment might require students to view a large number of minicases illustrating a variety of ways the concept *transfer* is found in the domain of practice. The strategy is intended to help students develop patterns of understanding representing varied ways in which practice is meshed with key subject-matter concepts. *Video* cases are usually preferred, since perceptual processes stimulated while watching an activity on

film show significant overlap with those stimulated during physical participation in an activity (Gibson, 1979; Zacks & Tversky, 2001).

Domain criss-crossings are combined with the small multiples strategy, in which students are asked to repeatedly mesh concepts, in different blends, to a single case. The purpose is to provide students with practice in "perspectivity" (e.g, Goldman-Segall, 1998), and to encourage habits of mind associated with "cognitive flexibility" (e.g., Feltovich, Spiro, Coulson, & Feltovich, 1996). Depending on the sophistication of the students and the difficulty of the subject matter, the multiples approach may begin with activities in which students examine complex cases but consider multiple themes sequentially. For example, students in eSTEP may be asked to "see" a minicase, first as an example of *knowledge construction*, then as an example of *classroom management*, and finally as an example of *formative evaluation*. From this strategy of sequential viewing, instruction proceeds to a more advanced phase in which students are scaffolded in constructing and evaluating more complex interpretations that combine and recombine multiple concepts.

Case-Based Learning with the KWeb: Learning Theory. What type of learning does the criss-crossing and small multiples activities afford? Our way of thinking is that examining many cases as examples of learning science concepts creates overlapping idea "families" (Derry, 1996), assemblies of meshed conceptual/perceptual fields. Instruction creates, within students, memory patterns associated with various concepts and their contexts. Through criss-crossing and small multiples instruction using a video case library, the students' memory representations are gradually enriched, differentiated and expanded with exposure to varied perceptual presentations of concepts. Hence, for each student individually or the class as a whole, the conceptual/perceptual field associated with a concept such as *transfer* increases in its range of real-world application.

Students are not expected to recall specifics of cases used in instruction, because a process of pattern meshing occurs in which both constructive and reconstructive memory processes promote active memory change over time, leading to integration, abstraction, and loss of case details. We believe this process tends to strengthen memory and later perception for situational aspects that tend to occur repeatedly across contexts and cases with family resemblance.

Our view of case-based learning can be contrasted with that of Kolodner and Guzdial (2000), for example, who assume memories of cases encountered remain basically intact. From their perspective, cases represent possible templates for thought, old friends that, if learned, might later be recalled and adapted and combined to guide thinking in a new situation. The belief is that new events in the real world will trigger a "reaching backward" (Salomon & Perkins, 1989) to find relevant cases in memory, which are then used to guide current behavior. From our viewpoint, the reaching backward is triggered by pattern matching with the environment, which activates a conceptually-rich memory "schema," as that term in used in the tradition of Bartlett (1932), representing a meshed perceptual/conceptual cognitive field.

eSTEP PBL Online

Returning to the description of eSTEP components, this section describes the online problem-based learning (PBL) environment we have developed. The KWeb, as described above, is used both independently and in conjunction with PBL online. The purpose of PBL is to help students acquire domain knowledge, usually scientific knowledge, in the context of solving real-world problems based on a real-world cases. Originally developed for medical education (Barrows, 1988), PBL has made its way into many other types of classrooms, including K-12 classrooms. What we know about this method is largely gleaned from wisdom of practice, both from its developer, Howard Barrows, and from the widespread PBL community that uses this method and has begun to conduct research on it. In this community there is a standard PBL procedure, and some members feel strongly that it shouldn't be changed. This procedure takes students through a facilitated small-group, student-centered process in which students discuss and "solve" a problem case (e.g., a case of medical diagnosis) as they fill out a whiteboard that has been structured to facilitate their inquiries. In filling out the whiteboard, students proceed through stages in which they observe facts in the case, formulate hypotheses, identify learning issues for further investigation, conduct research, and revisit and discuss hypotheses until a problem solution is reached. The main purpose of this activity is to learn about a conceptual scientific domain that underlies a real-life 'problematized' case.

The purpose of PBL in eSTEP is to promote meshing of perceptualized learning science concepts to visions of future professional activity, through discussions that employ those concepts as a cause-and-effect language of goal-based instructional planning. Originally, eSTEP PBL problems were face-to-face small-group activities supported by the KWeb but carried out primarily in classrooms. The eSTEP team decided that PBL should go on line for a number of reasons (Steinkuehler, Derry, Hmelo-Silver, & DelMarcelle, 2002). First, we wanted to distribute some of the facilitation responsibility to the system and the students themselves, lightening the responsibility for teacher assistants, who often lack experience with this complex instructional method. Second, the eSTEP community is growing, and an online system facilitates larger course management. It makes the site more scalable for professional development, enabling us to offer distance education courses. Finally, the online environment facilitates data collection and analysis for our research on professional learning and transfer.

The eSTEP PBL system supports either online small-group instruction or a hybrid model in which students meet face-to-face in small groups during class and then extend their work outside of class through online interaction. In both online and hybrid models, students are guided by a human facilitator, typically a teaching assistant, and are required to complete and submit individual and group artifacts, products related to and documenting various stages of instructional design, through the online system. The online system collects and displays data on student performance and affords detailed monitoring of work by individuals and small groups, permitting detailed (and powerful) formative assessment of individuals and groups throughout the course. This is both a bane and benefit of online courses, for this monitoring capability makes them powerful learning tools that place substantial performance demands on both students and instructors (O'Donnell, December, 2002).

Although they can be set up in different ways by the course manager, eSTEP instructional design activities in PBL typically involve a phase of individual study and preparation, followed by a phase of facilitated small-group design work, followed by a final phase in which the individual analyzes, extends, and reflects upon the group's work and how much the individual gained from it. These phases are scaffolded online by the eSTEP system, which guides students through a series of steps. The number of steps and required activities for each step may vary from problem to problem, as desired by the course manager/designer.

Example eSTEP PBL Activity. Here we describe one of the activities created for the fall, 2002, course at UW Madison, which took students through a four-week, nine-step design challenge. All students in this course completed two PBL activities on line. The example to be described is the second activity that was completed by the English majors. Similar design problems were created for students in secondary science, mathematics, social studies, and foreign language.

When students entered the eSTEP PBL system to start their design challenge, they saw a "sidewalk" with nine steps, each step associated with a particular due date for completion (see figure 3). Each student began the task by mouse clicking on step 1, which opened a page of instructions and a design problem appropriate to that student's academic teacher certification area. The design problem for English majors, Huckleberry Finn at Midwest High, is shown in Figure 5. Previously, each student had been assigned to a small discipline-based work group that was maintained in this problem activity and throughout the course.

Like design problems for other disciplines, the English problem referenced and linked to a particular video case in the eSTEP video library, a classroom story that students were asked to analyze in preparation for their design work (figure 1). Students were asked to draw lessons and ideas from the case under study and then apply those lessons and ideas by working with their group to design or redesign a similar type of instruction. All design problems for all disciplines required students to warrant their instructional designs through learning science research. This research was facilitated by availability of the eSTEP KWeb (figure 2) and other online research resources integrated with the eSTEP PBL system.

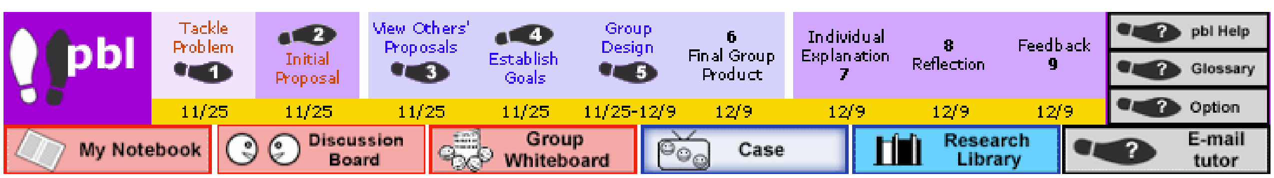

Figure 3. eSTEP Sidewalk

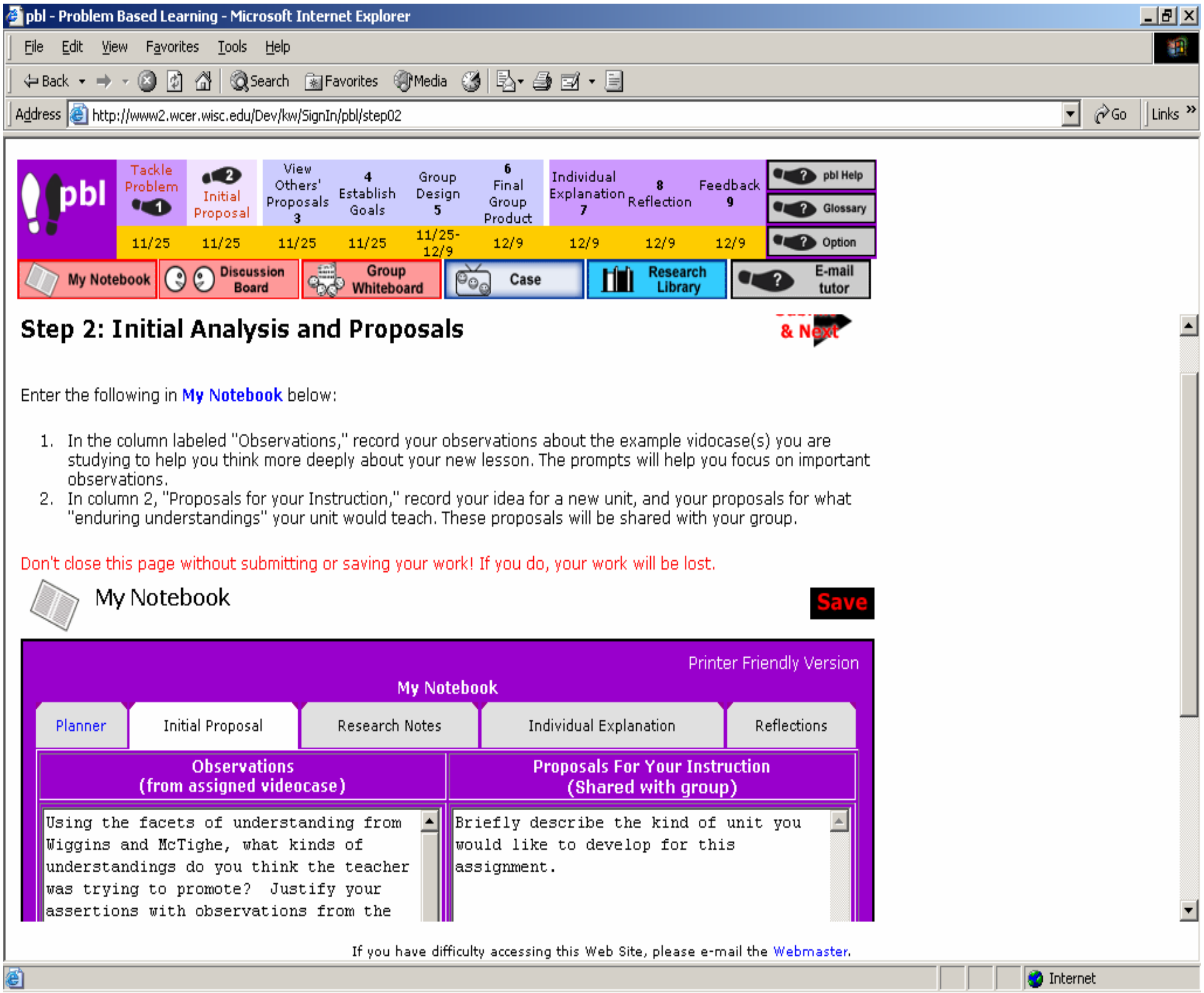

Figure 4. The PBL Site at Step 2, Showing Part of Individual Student Notebook With Prompts

Teaching "Controversial" Texts

Teachers who address controversial and sensitive topics through literature studies take a risk and sometimes meet disapproval from parents, administrators, students, even colleagues. The case you will study as part of your STEP PBL activity is based on the English classroom of a popular high school teacher, Mr. H, who is now in his fifth year of teaching. For the past several years Mr. H has gone out on a limb in teaching a controversial seven-day unit based on The Adventures of Huckleberry Finn. A "classic" in American literature, this book is taught in many high schools. However, over the years it has also appeared on several lists of banned books, due to its controversial racial content.

The video case, Huck Finn at Midwest Hi, is based on a high school honors English class that is being audited by one student who is the only African-American student in the classroom. You will see video based on the first four days of instruction, although the unit continued for about seven days. In this unit, Mr. H poses the question for the class, "Should the book be banned?" Throughout the unit, Mr. H and his students approach the issue from multiple perspectives, connecting what they are discussing to their own environment and simultaneously delving deeply into important literary concepts, such as satire, which are fundamental to intelligent reading and social criticism. Thus, the instructional goals for the unit pertained to critical thinking about a controversial social topic, as well as development of domain-specific expertise in the field of English literature.

Mr. H's discourse style, teaching and assessment methods, and choices for how to handle various topics and issues in this classroom environment should be of interest. Through reading, questioning and discussion Mr. H and his students seem to reach a higher level of understanding, although (as noted in Mr. H's interview), not all ideals are achieved. However, by the end of the book, students ironically see Mark Twain as one of history's greatest opponents of racism, and a brilliant writer who was able to deal with the issue at a time when few other writers would or could.

Notice there are yellow "keywords" placed throughout the video. These keywords are based on Mr. H's own description of how he thought about his teaching when he viewed and helped edit the video.

Your Group's Task

Carefully study the video case of Mr. H's classroom plus the inquiry materials related to the case, in order to develop ideas for how you would teach a similar unit. Your group's task is to follow the online PBL steps (based on the Wiggins and McTighe approach to instructional design) in planning a 1-2 week unit focusing on race and diversity issues present in this novel, ***or a different novel of your own choosing which also focuses on race or diversity issues***. You may also choose to plan your instruction for a very different teaching context. For example, you may develop ideas for teaching in a rural high school, in middle school, in a racially heterogeneous classroom, or in a non-honors classroom. The choice of teaching context, as well as which novel you use, is your group's decision.

Watching the video case closely is important. As you are watching, identify some learning science principles that are (or are not) at work in the video and that may be influencing the success of the instruction. Some questions you will wish to think about while watching the video case and in discussions with your group include:

-What do you think the teacher is trying to accomplish?

-How does he know his students are achieving what he intends for them?

-Why is he teaching as he does and how successful are his instructional activities?

Following examination of the video case, your group will follow the PBL steps to generate proposals for goals, assessments and instructional activities for a similar unit of instruction. You may use the case to inform your own unit plan, or you may also have different ideas that you would like to put forward. During your PBL activity, your group will articulate: 1. the enduring understandings you hope your students will achieve, 2. how you will use assessment to insure those understandings are acquired, and 3. the activities and methods of instruction and classroom/discourse management you will employ. Your approaches should be framed and justified in learning science terms when possible.

While designing your unit, think about the following in relation to the case:

-Can you build on what seemed to work for Mr. H?

-What changes would you make and why?

-What types of assessments did Mr. H use and what would you use to evaluate your own teaching and your students' progress?

-Which of Mr. H's instructional activities would you include and what would you do differently?

The information you enter into your eSTEP PBL online notebook and the Group Whiteboard should provide a synopsis of your individual and group thinking on these kinds of issues.

Figure 5. A Design Challenge for English Majors

PBL activities required students to apply a process of “backward design” leading to the creation of a “group product,” a plan for an instructional unit. The unit to be developed in the English teachers’ groups (see their problem) was to employ a controversial text of the students’ choice and address instructional objectives related to themes of equity and diversity (similar to the case the students were required to study), as well as literary topics, such as satire. Students learned about backward design through readings in the KWeb and an assigned text, Understanding by Design (Wiggins & McTighe, 1998). Adhering to the steps in their PBL “sidewalk,” students first completed their reading assignments and studied their case, entering their thoughts and reflections about the case into an online notebook (see figure 4). After completing initial assignments by the date due, students were at Step 4, where they joined their group of 4-5 other students and began group design work. Groups were allowed to choose whether to work online at all times or whether to supplement online work with face-to-face meetings during class. Most groups continued to meet face to face occasionally.

During group design, steps 4-6, the pre-service teachers were scaffolded though a process in which they first carefully considered what “enduring understandings” their unit would teach. Next, they developed ideas for how they would assess their students, to determine whether goals for understanding were being acquired. Finally, they worked together to design goal-related activities. Each step in the process involved submission and discussion of the various teacher-learners’ ideas for goals, assessments, and activities. Ideas were refined online through discussion and voting, with ideas receiving strongest group support becoming part of the final group product. Group activity was supported online by a group whiteboard (figure 6) and a supplementary discussion board. As shown in Figure 6, the whiteboard contained sections (marked by “tabs”) for each stage of the groups’ work. For example, during the design of assessments the group members were in the assessment section of the group whiteboard. During each major phase of the group activity, such as the assessment or activities design phases, students entered their “proposals” for what the group’s design should include, plus a justification for their proposals, onto the group whiteboard. Students also used the group whiteboard to view and comment on others’ proposals and justifications, read comments about their own proposals, and modify their own proposals in response to group feedback. Students controlled what the system put into their final product with a voting mechanism through which proposals receiving group support were included.

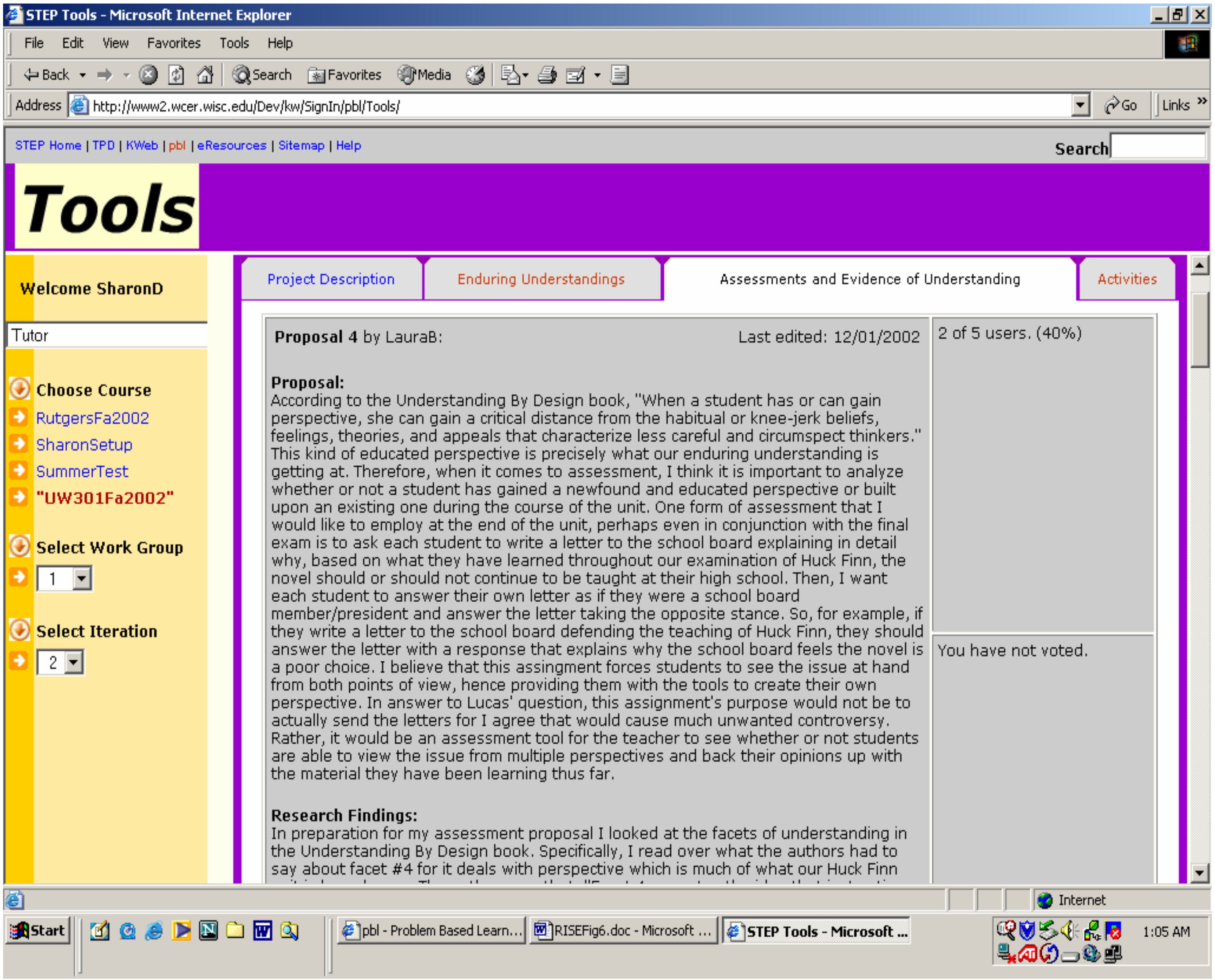

Figure 6. Part of a Group Whiteboard (Viewed from the Facilitator's System)

Thus, the group whiteboard "forces" students to design an instructional unit, thinking about assessments and activities in a certain order and in terms of how they would lead to enduring understandings. Thus the group whiteboard represented the course manager's epistemological commitments regarding what kinds of goals, knowledge and evidence the course manager wanted students to consider and discuss during learning. Parenthetically it is noted that the group whiteboard in eSTEP PBL is a general tool that allows course managers to change these commitments from problem to problem and course to course, by altering the number of tabs, tab headings, and instructions to learners within each tab.

Upon completing the group product -- a justified plan for an instructional unit specifying goals, assessments and activities -- individual students completed steps 7-9 individually. In step 7 individual students wrote their own critique and analysis of the group product. In step 8 students reflected on their learning, and in step 9 provided anonymous feedback on the activity and site. A TA facilitated all steps online. Each TA in the fall course managed four small groups of about five or six students each.

Students' Ratings of eSTEP PBL Activities and Site Tools

There were two instructional design PBL activities in the fall course at UW-Madison, similar to the one described above. Based on a class size of 60 and a response rate of about 97%, the following ratings of components of the two PBL activities (Table 1), and the system tools used during the PBL activities (Table 2), indicate that while there is room for improving the design of eSTEP PBL, the activities were valued and generally well received. Several patterns in these responses can be observed. First, from PBL-1 to PBL-2, there was a substantial increase in student satisfaction. This is likely due to a number of factors, including student and TA experience with the method and system, as well as the use of discipline-specific cases and problems in PBL-2 (rather than the generic instructional design scenario grounded in a case on design-based instruction in a science class, which was employed in PBL-1). Second, a decrease in ratings for TAs likely reflects a deliberate fading of scaffolding. Since TAs were trying to decrease their involvement in student work, it is not surprising that students perceived their input as less important. Finally, it is notable that the most rewarding activities for students were those involving collaboration rather than individualized work. Also, a highly rated tool was the hypertext information resource, the eSTEP KWeb.

Table 1. Students' Ratings of Phases of Two eSTEP PBL Activities

"How much did you learn from the following activities?" Scale: 1 (Nothing) – 5 (A lot)		
Activity	PBL 1 Rating	PBL 2 Rating
Overall PBL activity	3.8	4.35
Initial Proposal	3.35	3.70
View others' proposals	4.24	4.33
Establish goals	3.84	4.19
Group Design	3.94	4.38
Final group product	3.73	4.08
Individual explanation	3.91	3.84
Reflection	3.72	3.88
Interaction with group	4.28	4.37
Interaction with TA	3.06	2.87

Table 2. Students' Rating of eSTEP Tools

How well did the following tools work? Scale: 1 (Very poorly) – 5 (Very well)		
Cases	3.58	4.02
Case related concepts	3.75	4.22
Notebook – Initial proposals	3.64	4.05
Notebook – Research notes	3.66	4.02
Notebook – Individual evaluation	3.91	4.16
Notebook -- Reflections	3.84	4.18
Group Whiteboard	3.75	4.16
Group Discussion	3.65	4.07
Research Library	3.58	4.21
Knowledge Web (hypertextbook)	4.29	4.50
PBL Help	3.27	3.45
Worked Examples	3.07	3.46

Although a few students' comments reflected a struggle with technology (this type of comment is becoming less common with increasing availability of high-speed Internet connections), characteristic quotes from students, taken from their reflections about the experience, are positive.

- *. . . this lesson that we have designed as a group is definitely something I could see myself using down the road when I have my own classroom. I feel it is a well thought out lesson that can be easily modified to meet the needs of whatever type of class "make-up" that I may have.*
- *I will attempt to use this method when creating lessons plans for next semester. I think it is a valid model that helps the teacher keep objectives clear and plan meaningful activities which cater to the objectives.*
- *I would use the unit itself. It was a good final product. I would also use this method of creating lesson plans.*
- *The plan that we made up as a group will be something that will be extremely useful for me as a teacher. I also learned the value of input from others' viewpoints on the same unit because you are able to see different perspectives that can give you some new and different ideas.*

With future refinement, we are confident that online design activities in the STEP PBL site will prove to be an important and successful addition to current approaches to teacher preparation.

Concluding Comments

The research reported in this chapter is about making the conceptual systems taught in college classrooms useful to students' future professional lives. Toward this end, my colleagues and I are designing and evaluating new kinds of learning environments that combine video with online learning technologies, evaluating these designs in theory-based studies within laboratory settings and in the context of online courses in the science of learning, offered for future teachers. Our experimental instruction engages pre-service teachers in video study to help them acquire perceptual familiarity with events they will encounter in classrooms. Through integrated text study, learners *mesh* this perceptual knowledge with a system of concepts associated with the science of learning. Through planning and design problems, learners connect this meshed perceptual/conceptual knowledge with systems of thought about actions that help manage classrooms. Our future research will continue to seek better designs for learning and will test ideas about the relative value of these instructional components and how they should be integrated, sequenced and facilitated.

Future work will also test the Activity Field Hypothesis (AFH), a theory of learning and learning environment design that is introduced in this chapter and evolving with this work. This theory posits existence of a continuously organizing virtual "activity field," a complex system of cognitive activation representing human experience during learning. The research questions we will address using our web-based course are: 1. Do learning environments that integrate text and video study with collaborative design produce evidence of productive activity fields? 2. Can evidence of more or less productive activity fields be causally linked to important learning objectives, such as sophisticated, spontaneous *use* of learning-science concepts in authentic teaching tasks? 3. Can manipulation of learning environment characteristics, such as facilitation, online tools, and activity design, predictably vary learners' activity fields?

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[2] The term *learning science* refers to current scientific theory and findings concerning student learning and development in informal and formal educational settings.