Chapter 2: Research Framework

Introduction and Rationale

Research on knowledge integration has evolved over the past decade. This work and other literature have framed the design of reflection prompts, the current study, and the Knowledge Integration Environment as a whole. In this chapter, I provide a selective history to introduce the tapestry into which my research is woven.

Research on Knowledge Integration

Linn began developing ways to help students integrate their knowledge in the late 1970s (Linn, 1980). In the mid '80s, she and her colleagues began work in the eighth grade physical science classroom in which the current work takes place as well as high school and undergraduate computer science classes. I will review the work at the middle school level first.

Research in the CLP/KIE Classroom

Linn, Doug Kirkpatrick, and their colleagues developed a set of laboratory activities for Kirkpatrick's single-semester, eighth grade physical science class. The early curriculum focused on the topics of heat and temperature; later, light was added as well. At first, they described the computer as a "lab partner." Later, they added more supportive software and used the computer as a "learning partner," instead. In the curriculum, which is laboratory-based, the computer is used as a tool to collect and graph real-time data, perform simulations of experiments, and help students track their progress.

Songer and Lewis were early collaborators in the CLP classroom. Songer (1989) investigated ways to help students develop an integrated understanding of insulation and conduction, using a continuum line as a representation to help students link their often disparate models of insulation and conduction. Lewis (1991, 1996) concentrated on students' ideas of heat flow. Like Songer, she also used an innovative representation—a simulation of heat flow through different materials—to help students identify weaknesses in their knowledge and make connections, here between real-life experience and a dynamic model of a scientific phenomenon. She identified three types of students: oscillating, progressing, and converging. The three types of students showed different patterns of knowledge integration.

Clark and Hsi worked more recently on the problem of knowledge integration. Clark (1996) developed a measure of students' knowledge integration through investigating the kinds of ideas they cited. A student who cited the principle that black absorbs light and converts it to heat, for example, would show less knowledge integration than would another student who additionally linked that principle to a lab done in class or an experience outside of class. Hsi (1997) investigated the role discussion plays in knowledge integration. She found that discussion can help students make their own models and ideas visible and that they benefit from seeing and reflecting on others' ideas and models. Hsi proposed electronic discussion as a forum for the processes of distinguishing among and linking ideas.

Research in Programming Classes

At the same time as this work was happening at the eighth grade level, Linn and Clancy were also formulating ideas about knowledge integration at the high school and undergraduate levels, in the domain of computer science (Linn, 1992; Linn & Clancy, 1992). My own early work in the area of knowledge integration took place in the context of this computer science work. I investigated undergraduates' understandings of parentheses and quotes as they were learning the computer language LISP (Davis, Linn, & Clancy, 1995a; Davis, Linn, & Clancy, 1995b; Davis, Linn, Mann, & Clancy, 1993). In this work, we developed the idea of rule-refinement; like Lewis (1991), we identified groups of students who exhibited quite different patterns for knowledge integration. Additionally, we saw that students sometimes *accepted* ideas as valid that they never would *apply* on their own. An analogy to the CLP work would be that when given "some materials are naturally cold" as a multiple choice option, some students accept it, though those same students never say or write that idea of their own volition.

The Dissertation Research

My current work, reported in this dissertation, involves eighth grade students and takes place in the context of the Knowledge Integration Environment software and curriculum, which have developed directly out of CLP's decade of research on designing curricula and technology for middle school science teaching and learning.

Using the Knowledge Integration Environment, students complete projects drawing on scientific evidence from the World Wide Web (Bell, Davis, & Linn, 1995). KIE blends custom and commercially-available software. The KIE software, which will be discussed in greater detail later in this chapter, is used by students participating in curriculum units developed by the KIE research group and others. Those units, called "projects," are designed to encourage a deep understanding of science concepts rather than a collection of scientific facts, and to help students apply the science principles they have been learning in class, integrate those principles with other knowledge, and extend their understanding to new situations. The projects engage students in sustained reasoning: They help students develop an integrated understanding of science concepts while at the same time encouraging them to learn to think about and use evidence.

In my current work I investigate more deeply the mechanisms of knowledge integration. I am interested in particular in the role reflection plays in the process of knowledge integration. I hypothesize that reflection allows students to expand their repertoire of ideas. I further hypothesize that reflection helps students identify weaknesses in their current understanding, or places where links and distinctions should be made. Through these processes of expanding and identifying, they can engage in the knowledge integration processes of linking and distinguishing ideas. Like others in the long history of this research, I have developed an instructional intervention to increase the likelihood of knowledge integration. This intervention takes the form of reflection prompts. Unlike much of the other work reported in the previous sections, though, my instructional intervention plays a metacognitive role rather than focusing on specific science concepts. The reflection prompts explicitly ask students to explain their current thoughts. Furthermore, rather than looking mainly at the products students produce, I use the prompts as a vehicle to investigate how the *focus* of students' reflection influences the kinds of learning in which they engage. As a result, I can make claims about the specific role reflection plays in knowledge integration.

Background

The design and development of reflection prompts and how they are delivered through the Knowledge Integration Environment builds on others' work on reflection. The current research is also integrated into a larger corpus of work involving students' learning and their epistemological beliefs.

Reflection and Reflection Prompts

Encouraging reflection has been the focus of many research programs, and these programs define and promote reflection in a range of ways. For example, questions from teachers, peers, software, or texts can promote knowledge integration by eliciting explanations. Students who provide explanations to other students' questions or who explain examples they find in their textbooks seem to strengthen connections among their ideas. Early research in reading investigated the ways in which questions inserted in texts affected subjects' understanding of the texts (e.g., Rothkopf, 1966). More recent research indicates that prompts or questions that elicit self-explanations lead to improved understanding of texts (Chi, Bassok, Lewis, Reimann, & Glaser, 1989; Chi, deLeeuw, Chiu, & LaVancher, 1994; Webb, 1983). Bielaczyc (Bielaczyc, Pirolli, & Brown, 1995) found that students can be trained to give self-explanations when learning LISP, and that this training promotes improved understanding.

Research on Reflection Prompts

In classrooms, various delivery systems for prompts have also improved reflection. For example, in reciprocal teaching, used most often in reading classes, students prompt each other to explain using a set of general questions that can be asked about any kind of paragraph (Brown & Palincsar, 1989; Palincsar & Brown, 1984). The CSILE learning environment allows students to choose prompts based on their own goals (Scardamalia & Bereiter, 1991). Research by both of these groups indicates that students make better connections among ideas when the students engage in instruction using prompts. In their work in Minstrell's high school physics classroom, van Zee and Minstrell (1997) identify "reflective discourse" as a way teachers can promote students' articulation of their conceptions, fostering conceptual change in the process. Others have successfully used prompts, delivered in various ways, to encourage students to reflect on their problem-solving processes, inquiry methods, and lab work (Collins, Brown, & Holum, 1991; Gunstone, Gray, & Searle, 1992; Schoenfeld, 1987; White & Frederiksen, 1995, 1998).

The Computer as Learning Partner project has long used sentence-starter prompts to foster reflection. Originally, CLP prompts encouraged students to make predictions and reconcile their data with those predictions. These prompts proved successful at encouraging students to integrate their knowledge. Later, CLP implemented prompts for completing each aspect of a lab, and again, students' understanding improved (Linn & Songer, 1991).

To help students integrate their knowledge, instructors must select the right level of instruction; research points to the value of specific, contextualized prompts over abstract prompts. Linn and Clancy (1992) have found that students are most successful at learning programming when they discuss specific prototype problems rather than abstract approaches. Davis (1995) found that students benefit from contextualized prompts that help them clarify and focus their thinking. Bell and Tien (1995) and Clark (1996) found that students revise their work more often in response to prompts that make specific suggestions. And, in reciprocal teaching, students essentially internalize an appropriate program of prompts for a particular activity—for example, reading a passage (Brown & Palincsar, 1989). We might hypothesize from Baker and Dunbar's (1996) work that prompts must also target the appropriate problem space in order to be accessible and relevant to students.

White and Frederiksen (1995, 1998) have shown success using prompts for reflective assessment in their mechanics curriculum for junior high school students. Students who routinely answered such prompts developed greater understanding of the subject matter and of the inquiry process. Tien, Rickey, and Stacy (in press) explicitly encouraged students to articulate a model of their current understanding of a chemical process and to reflect upon the implications of their observations on their conceptual model. Students who engaged in these and other innovative activities appeared to develop a greater conceptual understanding than did those students in a traditional college chemistry course. Lan (1996) found that students who were scaffolded in self-monitoring did better on exams and had better representations of their knowledge. Other researchers have also discussed the benefit to students' understanding of explicit planning and monitoring (e.g., Bielaczyc et al., 1995; Brown & Palincsar, 1989; Palincsar & Brown, 1984) and the positive effects of planning on writing in particular (Flower & Hayes, 1980).

Why does engaging students in reflection like this help? This dissertation attempts to answer questions like this.

Reflection Prompts in KIE

KIE projects require sustained thinking and conceptual understanding, but they also require much more than that. Students need to be able to write well, to manage their time, to follow instructions to achieve their goals—all the kinds of skills required in the real world. While a good grasp of the science concepts will earn points in this circumstance, so will several other skills or traits. Thus, very different students are likely to succeed. In addition, students typically work in pairs on KIE projects. Thus, a pair's performance is influenced by the knowledge and skills two people bring to the task, rather than one.

The KIE software and curricula have developed directly out of CLP's decade of research on designing curricula and technology for middle school science teaching and learning. The prompts used in KIE build on the CLP experiences as well as those of other researchers. KIE projects are more open-ended than CLP labs, less activity-driven than summarizing a passage in reciprocal teaching, and more directed than the "knowledge-building" of CSILE.

Thus, KIE requires prompts that explicitly encourage students to make explanations and to reflect at selected points as they work on complex projects.

A basic question to be addressed by the research is: In working on projects like these, do students merely need to be prompted to reflect, or do they need guidance in determining what to reflect about? Students make choices about the focus of reflection—some focus mainly on science content, for example, while others focus more on instructional goals. A related question, then, is: Do all focuses of reflection lead to the same results? A comparison of *generic* and *directed prompts* helps us address these questions. The prompts contrasted in this research differ in their specificity and degree to which they are contextualized in students' activities. However, both types afford different focuses for reflection.

Defining reflection broadly as having both a metacognitive and a sense-making component and looking at what students focus their reflection on, in response to both types of prompts, gives us insight into the mechanism by which reflection can lead to learning, helping to fill the hole in the literature identified by Resnick (1987). Perhaps instructors should refrain from directing students to reflect in any particular way until more is known about the mechanism behind the effects of that reflection; this interpretation provides one rationale for using generic prompts for reflection. On the other hand, we may know enough about expert thinking to provide beneficial direction for students. This study, with its comparison of the two levels of prompt specificity, provides insight into multiple aspects of this issue: What level of specificity leads to the most knowledge integration and for whom? What kinds of reflection are best and for whom? How does reflection in response to a directed prompt compare to the reflection in response to a generic prompt?

The generic prompts encourage students to "stop and think," without providing instruction in what to think about. Students can then choose to focus on their own subject matter understanding, on their understanding of the project goals, or on their own learning and thinking. The generic prompts leave the contextualization to the students; by being open-ended, they provide a non-disruptive opportunity for students to express their thoughts and contemplate their understanding. An example of a generic prompt is, "Right now, we're thinking…."

Piaget used interviews with students as a way to investigate children's thinking (Inhelder & Piaget, 1958). Over the past decades, though, thinking aloud has undergone a shift from being a mode of inquiry to being a method of instruction; early instructional instantiations mostly involved teachers modeling their own thought processes and more recently the students themselves engage in "loud thinking" (Kucan & Beck, 1997; see Dewey, 1901, for an exception). Generic prompts act as a way to encourage thinking "aloud," but they give us and the students a written record of those thoughts. In doing so, generic prompts provide us with a baseline of the kinds of reflection students engage in when they are responsible for directing their own reflection.

It may be that not all students are able to reflect in this way. Inhelder and Piaget (1958) claimed that the ability to reflect on one's own thinking is generally found in adolescents as opposed to young children; they note, however, that age is not the only factor. Others would claim that differences in ability are not related to age but to other characteristics. Regardless, generic prompts should help all students to slow down as they work on complex science projects and as a result at least some students will become aware of areas in which their understanding is problematic.

The directed prompts, on the other hand, give students hints about what to think about; for example, "what to include in the report" or "pieces of evidence we do not understand." Specifically, directed prompts are intended to elicit planning (in the form of "Thinking Ahead" directed prompts) and monitoring ("Checking Our Understanding" directed prompts). These prompts may constrain students by explicitly encouraging a particular type of reflection, although the pilot work discussed in Chapter 3 indicates that students interpret even similar prompts quite differently. An example of a directed prompt oriented toward planning is, "To do a good job on this project, we need to…"; one oriented toward monitoring is, "In thinking about how it all fits together, we're confused about…."

Directed prompts may act as a "more able other," prodding the students to consider issues they may not have considered otherwise (cf. Vygotsky, 1978). Scardamalia and Bereiter (1991; Bereiter & Scardamalia, 1987) have found that, with proper external supports to focus their attention on the salient planning and justification issues of writing, middle school students can "transform" their knowledge rather than relying on a knowledge telling strategy for writing. Students are often not very accurate in their assessments of their own understanding, but directed prompts oriented toward monitoring may help them develop those monitoring skills. Directed prompts in KIE may give students a better understanding of the kinds of questions they should be addressing. The directed prompts in KIE are activity-specific; that is, they are developed with a particular activity, such as critiquing evidence, in mind. As discussed earlier in this section, research indicates that this specificity may be important (cf. Bell & Tien, 1995; Brown & Palincsar, 1989; Davis, 1995; Linn & Clancy, 1992).

Students' Beliefs about Science and Learning

My research identifies which types of prompts best help students engage in knowledge integration and how the prompts achieve that success. Students may differ in their use of prompts because their beliefs about science and learning science may determine in part how they interpret and respond to prompts. Students' success in science class can be shown to be related to their epistemological beliefs. Eylon and Linn (in press) report that students' beliefs are correlated with their long-term progress in addition to their short-term performance. Linn and Songer (1993; Songer & Linn, 1991) identified a relationship between students' beliefs about science and their apparent propensity to integrate their knowledge. I investigate ways in which students' beliefs influence the reflection they engage in and the learning this facilitates. By "beliefs" I refer to students' ideas about what science is like as a field, what counts as science, and how one does science.

My work builds on research that has identified student beliefs and traits in the areas of the nature of learning, motivation, and science. Most research in this area has focused on either students' view of learning or their view of science, while the intersection—students' beliefs about themselves as science learners—provides an interesting area of research. Beliefs about learning include beliefs in quick learning, certain knowledge, simple knowledge, and innate ability (Schommer, 1990, 1993). Beliefs about motivation include performance versus learning or mastery goals (Ames, 1992; Ames & Archer, 1988; Dweck, 1986; Dweck & Leggett, 1988). Though much of this work makes reference to learning in general, rather than in any particular domain, we can extend this work to consider students' particular beliefs about learning science. Others have investigated epistemological development (e.g., Belenky, Clinchy, Goldberger, & Tarule, 1986; King & Kitchener, 1994; Perry, 1970; see Hofer & Pintrich, 1997, for a review).

Possible beliefs about the nature of science include a static, relativistic, or dynamic stance toward the areas of scientific explanations, parsimony, relevance, and learning (Linn & Songer, 1993; Songer & Linn, 1991). Students also vary in their understanding of the purposes of predicting, experimenting, and questioning in science (Carey, Evans, Honda, Jay, & Unger, 1989; see also Carey & Smith, 1995) and of the purposes of scientific work, the nature and status of scientific knowledge, and science as a social enterprise (Driver, Leach, Millar, & Scott, 1996). Within physics specifically, students may vary in their beliefs about the structure and content of physics and about learning physics (Hammer, 1994). All of these dimensions are visible in teaching and interviewing students; for my research, I chose those most salient to students in the CLP/KIE classroom.

Each of these beliefs about learning or science may be further influenced by the disposition the student has regarding that belief; that is, the inclination they have toward acting on it, their sensitivity toward situations in which it is relevant, and their ability to modify their behavior based on the belief (Perkins, Jay, & Tishman, 1993). I postulate that these dispositions are malleable rather than fixed, and that a curriculum like CLP/KIE can help students develop more productive beliefs about science and learning science.

Based on Songer and Linn's (1991) taxonomy of static, dynamic, and mixed beliefs and building from their instrument for identifying students' beliefs, I have developed a method of analysis to investigate the different dimensions delineated by the assessment tool. A natural question emerges after reviewing the related literature: To what extent are students' views about *science* and about *learning science* linked to one another? Songer and Linn characterized students as static or dynamic using measures of both aspects of their epistemologies. Separate measures for these two areas allows assessment of relationships or distinctions between these dimensions; I separate the dimensions because I hypothesize that they are differentially linked to students' knowledge integration.

What are the dimensions making up a student's view of the nature of science that I investigated? What are the dimensions of a view of the nature of learning? Exploratory interviews with middle school students, case study analyses, and the review of the literature summarized above helped me develop a list of interesting dimensions.[1] (See Table 2–1.)

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[1] The taxonomy presented in Table 2–1 builds on work done by others. A partial list of acknowledgments can be made. For example, the *use* and *process* of science dimensions are investigated by Linn and Songer (1993), as "relevance" and "explanations." Other dimensions similar to *process* include Carey's "guiding ideas and questions" (Carey et al., 1989); Ryan and Aikenhead's (1992) "knowledge in science" and "scientific method," Burbules and Linn's (1991) "scientific evidence," Hammer's (1994) "content of physics," and even Schommer's (1990, 1993) "certainty of knowledge." The *strategy* dimension within the nature of learning area clearly builds on the work of Schommer, Hammer, and Linn and Songer. The *autonomy* dimension builds on Hammer's "learning of physics" and Schommer's "source of knowledge." And, as a last example, the *goal* dimension builds on work done by Ames and Archer (1988; Ames, 1992), Dweck and Leggett (1988), Schommer, and Schoenfeld (1987).

Epistemology of...	**Dimension**	**Characteristics**
Nature of Science	*Use of Science* *Process of Science*	Relevant or Irrelevant Dynamic, Mixed, or Static
Nature of Learning	*Strategy for Learning* *Autonomy of Learning* *Goal of Schoolwork*	Understand Ideas or Memorize Facts Internal or External Responsibility for Learning Learning Goal or Performance Goal

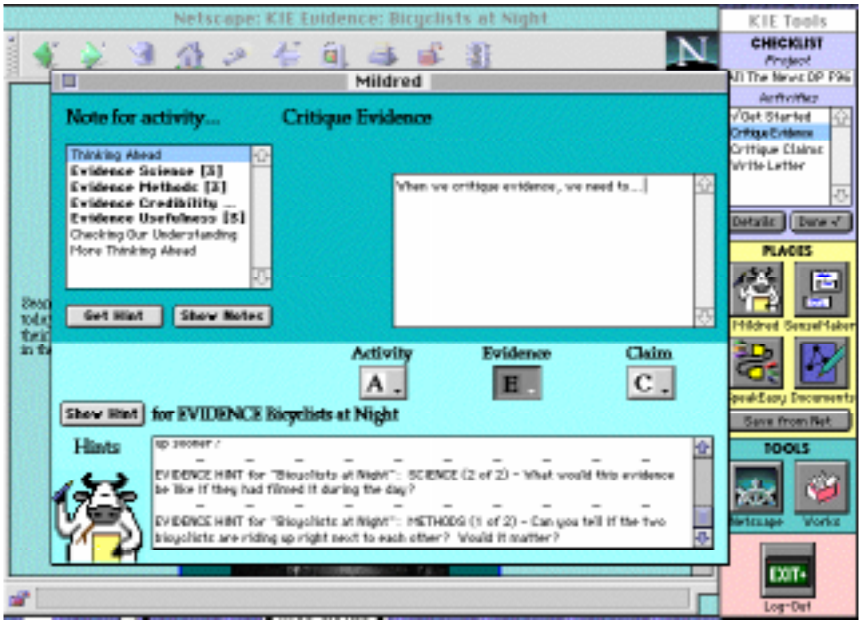
Table 2–1: Dimensions of Student Beliefs

By investigating students' particular beliefs about the process of science and their beliefs about learning science (for example, their autonomy and their preference for memorization or understanding), I can identify relationships among particular beliefs, prompt usage, and student success. I hypothesize that students' beliefs will play a role in their use of prompts and in their knowledge integration.

Design of Guidance in Technology-Based Learning Environments

The literature reviewed in the previous sections implies that we need to consider instructional goals and student characteristics when we design learning environments of any sort. How can we best design technological systems to foster productive reflection?

The scaffolded knowledge integration framework (Linn, 1995) emphasizes the need for providing students with support as they differentiate among and make links between their ideas. The Knowledge Integration Environment engages students in difficult tasks requiring sustained reasoning. One aspect of the KIE software is a guidance-on-demand system (called "Mildred") designed explicitly to help provide this support. Figure 2–1 shows the Mildred system. In this section, I describe other successful learning environments that have influenced our design of Mildred, and compare features relevant to this research.



When we critique evidence, we need to...

EVIDENCE HINT for "Bicyclists at Night": SCIENCE (2 of 2) – What would this evidence be like if they had filmed it during the day?

EVIDENCE HINT for "Bicyclists at Night": METHODS (1 of 2) – Can you tell if the two bicyclists are riding up right next to each other? Would it matter?

Figure 2–1: Guidance in the Knowledge Integration Environment

Our work with the CLP E-LabBook software has played a profound role in our designing of KIE; some of these influences are outlined in detail in Chapter 4. In particular, KIE builds on lessons learned about logistical and cognitive guidance (Davis, 1996; Stern, in progress). Our knowledge of other learning environments has also influenced the design of KIE as a whole and Mildred in particular. For example, Linn and Clancy (1992; Linn, 1992) used hypermedia tools and case studies to support students learning computer languages. By modeling expert thinking processes and allowing students to make their own thinking visible, they reduced some of the complexities students faced while learning to program. They note that helping students develop skill in monitoring their own knowledge organization warrants further investigation (Linn, 1992). Mildred was designed in part as a result of this call.

Mildred provides students with sentence-starter prompts as used in E-LabBook and CSILE. The CSILE environment for knowledge building allows students to choose their own sentence-starter prompts (which Scardamalia and Bereiter call "procedural facilitations") for writing notes about science topics (Scardamalia & Bereiter, 1992). CSILE's developers claim these prompts push students to the edge of their zone of proximal development (Vygotsky, 1978)—that is, the level at which they can work given proper supports—and can help students transform their knowledge rather than just reporting it (Bereiter & Scardamalia, 1987; Scardamalia & Bereiter, 1991). The developers of CSILE caution that designing good procedural facilitations is difficult and must be done thoughtfully to avoid derailing students' cognitive processes (Scardamalia & Bereiter, 1992). The prompts used in KIE have evolved from activity-focused prompts (similar to procedural facilitations and to the prediction and explanation prompts in CLP) to reflection-oriented prompts partly in light of this issue. (Chapter 4 discusses this evolution in more depth.) In CSILE, the students' notes are pooled into a class database representing the collective knowledge of the group. In KIE, the focus is generally at a more individual level, but a student or a pair using KIE can view all of their notes at once to aid in the integration of their ideas.

Others have also implemented ways to encourage reflection using technology. For instance, the "Progress Portfolio" provides a reflective inquiry environment designed to help students coordinate their inquiry processes (Loh, Radinsky, Reiser, Gomez, Edelson, & Russell, 1997). This content-neutral environment supports self-monitoring, goal maintenance, and the development of reflective reasoning skills. A different approach is found in BGuILE, which embodies a domain-specific model for supporting students' science investigations (Tabak, Sandoval, Smith, Steinmuller, & Reiser, 1998; Tabak, Smith, Sandoval, & Reiser, 1996). The investigation model used involves observing, comparing, relating, and explaining; tools in the environment scaffold these actions. The software includes prompts that support students in making explanations. KIE itself is domain-neutral, but the curriculum used within the KIE software includes hints and notes given via Mildred that offer similar topic-specific support.

Reif and Scott (1997) have developed a computer tutor called "PAL" that uses reciprocal teaching as a model for its interventions with students. PAL helps students make and implement decisions and assess their implementations. Students who used PAL developed a better conceptual understanding of the physics they were learning than did a control group. Mildred does not include any intelligence (though one student commented, "She's pretty smart for a cow"), but does offer questions to help students focus their attention in appropriate directions.

Some propose going further than Scardamalia and Bereiter (1992) and giving learners control of most of the scaffolding in the system itself (Jackson, Krajcik, & Soloway, 1998). In some ways adaptable interfaces like that of Jackson's "Theory Builder" are similar to Mildred's, in that Mildred provides guidance on demand in addition to giving prompts for notes. However, students using Mildred are not responsible for consciously changing their use of the software. That is, students using Mildred cannot misdiagnose their understanding and turn off scaffolding that might have helped them in their knowledge integration. All students may not benefit equally from control over the interfaces of their learning environments. Theory Builder includes "reflective scaffolding" (oriented toward planning, describing, explaining, and evaluating) that is used differently by different students. As with the reflection prompts in KIE, supports may benefit students in different ways.

The dissertation research allows us to develop a set of productive learning environment design principles, based on a blend of good pedagogy (informed by the scaffolded knowledge integration framework) and good educational software design (informed by the ideas of learner-centered design [Soloway, Guzdial, & Hay, 1994]). The Mildred software, for example, provides hints at the level of activities, evidence, and claims, and supports an iterative note-taking experience for students to reflect, work on an activity, and then reflect some more.

These features support the tenets of the scaffolded knowledge integration framework. For example, hints make expert thinking visible, and notes allow the students to make their own thinking visible. Hints also help students connect the science ideas to their own experiences; a typical hint might ask, "Have you ever experienced anything like this before?" or "What would happen if the experiment was done during the day?" Mildred also acts as a catalyst for students to talk to one another and exchange ideas. Last, by providing prompts for reflection and other, more explanation-focused prompts, Mildred helps promote autonomy by enabling them to engage more freely in knowledge integration.

These design decisions support particular pedagogical goals of KIE and in particular scaffold students as they engage in the sustained reasoning inherent in KIE projects.

Mildred thus fosters knowledge integration by helping students add ideas to their repertoires (through hints and through the exchange of ideas via conversations with others) and link, distinguish, and reorganize ideas (through prompts and hints). In particular, Mildred helps students identify weaknesses in their knowledge by providing alternative examples, thought experiments, and counter-evidence to consider, and by providing a place to make their own thinking about these ideas visible and explicit.

This chapter has reviewed the history of research on knowledge integration and outlined how my research extends that work. I also reviewed relevant literature on reflection, beliefs, and technologies to support reflection, and discussed the relevance of my work to those areas. In the next chapter, I discuss the pilot work done comparing reflection prompts with more activity-focused prompts, providing evidence to support the idea of using reflection prompts as an instructional strategy.