Chapter 4: Methods

Introduction

My intent in this chapter is to give an overview of the methods used to investigate reflection prompts and mechanisms for knowledge integration. In each of the following four chapters I present the results of a different investigation, and the methods specific to each are described in substantial detail in that chapter. Some aspects, of course, are common to all the investigations and need only be presented here.

The self-monitoring prompts described in the pilot work evolved into the directed prompts of the dissertation study. The dissertation study focuses on the positive effects identified in the pilot work. One question the pilot work made salient is, What role does prompt specificity play in the success of self-monitoring prompts? In other words, is the benefit of the prompts derived specifically from having students plan and monitor, or is it that we simply encouraged students to take time to stop and think? One goal of the study, then, is to compare prompts of different levels of specificity.

Another goal of the study is to characterize reflection prompts in terms of the kinds of reflection they elicit, and to investigate relationships between that reflection and students' success on the project. Thus, another question addressed is, Does the specific focus of students' reflection play a role in the positive effects of prompts? As discussed in Chapter 2, we have reasons to hypothesize that both levels of specificity and various focuses for reflection might be beneficial to students.

A third goal of the study is to investigate individual student differences in reflection and learning. A question is, Do students' beliefs about science and learning science affect the ways in which they use and benefit from reflection prompts?

Research Context

Using the Knowledge Integration Environment, students look at scientific "evidence" from the World Wide Web. The goal of KIE is to engage students in thinking critically about information and to help them develop a more integrated understanding of science topics. Among other sites, KIE is being implemented in the Computer as Learning Partner (CLP) classroom discussed briefly in Chapter 2. CLP provides a one-semester curriculum introducing the physical science topics of thermodynamics and light to eighth graders. The pilot studies and the dissertation work all took place in this classroom.

The Research Paradigm

The CLP/KIE classroom provides an ideal environment for principled refinement of instruction, in that the teacher welcomes technological and curricular innovation, as well as classroom research on those innovations. Furthermore, the class is only a semester long,
making opportunities for iteration more frequent. I refined the prompts and their delivery regularly over a series of four semesters (from KIE's inception) leading up to the dissertation study research. At the same time, the scaffolded knowledge integration framework helped me interpret the effects of the prompts and to design new investigations to better understand those effects. As a result, the reflection prompts used in the dissertation study benefited from many iterations on both their practical application and theoretical foundation. I was able to refine a set of design principles to inform the wording of the prompts and their delivery. For example, an early prompt asked "Questions we still have are …." I discovered that students needed more guidance and over time I refined the prompt to say "Pieces of evidence we didn't understand very well included …." I also added "thinking types" (Scardamalia & Bereiter, 1991). In the beginning, I used several thinking types, but over time identified the three used in the dissertation study: "Thinking Ahead," "Checking Our Understanding," and "Thinking Back." The study in the dissertation work also benefited from this iterative refinement approach, as I had a good understanding of the interesting questions to ask because of the earlier investigations. For example, I learned that students respond to directed prompts for reflection in varied ways, which led to an investigation of the effects of the focus of students' reflection.

I use a mix of individual, pair, and group data in my analyses. All of these levels are important. At a gross level, we can investigate mean performance on a variety of measures and draw conclusions about the effectiveness of the two types of prompts. However, not all students use the prompts in the same way. Investigating at the level of pairs working together informs us of differences in the effectiveness of prompts for different pairs. Again, we can break the analysis down, and investigate the effects of individual characteristics on students' performance. All of these levels contribute to understanding both the effects of prompts and the mechanisms behind those effects.

The Students

The research took place in six classes of at most 32 students each. The same experienced teacher taught each class, and the basic curriculum was identical for each of the six classes. The school is located in a small city in the San Francisco Bay Area. The student population is mostly middle-class and is ethnically diverse, with a relatively large population of recent immigrants from the former Soviet Union, East Asia, Israel, and India. Students work in pairs on CLP labs and KIE projects.

The Curriculum

KIE projects come in three flavors. Critique projects foster the development of a critical eye when using evidence and evaluating arguments. Theory comparison projects help students see that multiple sides may exist to arguments and that evidence should be used effectively to improve those arguments. Design projects engage students in an application of their knowledge, guided by scientific evidence. All three types of projects engage students in sustained reasoning.

The KIE projects used in the CLP/KIE classroom have been designed to complement the CLP curriculum and to serve as capstone activities for CLP labs. The "All The News" KIE project (introduced in Chapter 3) provided the primary context for the dissertation study. All The News took place approximately in the middle of the semester, at the conclusion of a
series of labs and projects focusing on heat flow, thermal equilibrium, energy conversion, and the nature of light. The instructional goals of the All The News critique project are two-fold. First, we want students to improve their understanding of the science concepts involved in the project. At the same time, we want them to develop an understanding of critiquing evidence and claims.

In the All The News project, students critique evidence cited by a fabricated news article about energy conversion and elementary thermodynamics. The students are told that a "science tabloid" wants to become a respected science journal, and has requested the students' help in doing so. The project involves (a) reading the article to be critiqued and looking at its concomitant evidence about heat flow, energy conversion, and thermal equilibrium, (b) critiquing the evidence and the claims being made, and (c) writing a letter to the imaginary editor with a synthesized critique and giving guidelines for future use of evidence. The evidence is critiqued on the basis of its science, methods, credibility, and usefulness. The claims are critiqued on the basis of their validity, and students also write a "claim changes" note saying what changes should be made to the wording of the claim. (See Appendix E for the article used in the dissertation study, and Appendix F for the evidence referenced by the article. See also Appendix G, which presents a full example from each condition of a pair's work on the project, including their responses to the reflection prompts, their evidence and claim notes, and their letter to the editor.)

**The Software**

The KIE software represents a blend of commercial and custom software. The basic elements of KIE include a tool palette, which provides a checklist of activities involved in the current project and also facilitates navigation among the other tools. The commercial tools include a Web browser and a word-processing and graphics application. The custom tools include a guidance system, an argument editor, and a Web-based discussion tool. The guidance system ("Mildred") will be discussed here. (For a discussion of the argument editor, see Bell, 1997, 1998; for a discussion of the discussion tool, see Hoadley, Hsi, & Berman, 1995.)

KIE—and Mildred—have benefited directly from our experiences in designing and refining the Computer as Learning Partner software. For example, sentence-starter prompts have been used successfully in the CLP E-LabBook software. With the help of these prompts, students learn to make predictions, analyze results, and draw conclusions in their lab "reports." The CLP software also provides a checklist of activities. The checklist significantly reduces the amount of time the teacher spends answering procedural questions (e.g., "What do we do next?") and frees up time for conceptual questions (e.g., "Why would the temperature drop along a curve like that?"). The CLP software provides logistical help with using the software, and provides cognitive guidance to help students think about each activity. All of these aspects of the scaffolding in the E-LabBook software help students be more autonomous in their learning.

KIE also includes procedural, logistical, and conceptual guidance. The primary difference in the two approaches is that KIE has a greater emphasis on conceptual guidance in the form of both hints and prompts. This conceptual guidance is necessary to help students working on KIE projects engage in the sustained reasoning required by these projects. As a result they develop the ability to look critically at information they see on the Web rather
than just accepting it at face value—a necessary skill, since much of the information available on the Internet is of questionable validity.

At the time of the dissertation study, Mildred had evolved into a hint-giving and prompt-giving application. (At the time of the pilot work, Mildred only gave hints, and prompts were delivered through word-processing documents.) This important refinement resulted in most of the explicit cognitive scaffolding being provided by the guidance system rather than being dispersed throughout the students' workspace. As a result, students using KIE can request and receive appropriate hints as they work on the notes for which they receive prompts. Reflection prompts are among the prompts given; other prompts are more like the activity prompts the pilot work showed to help students do the project. The hints and prompts given in Mildred model appropriate modes of inquiry and provide stepping-off points for students to engage in meaningful discourse with their peers about particular activities or evidence. This conceptual scaffolding is intended to help students develop an integrated understanding of the subject matter by encouraging them to produce explanations for scientific phenomena and to be reflective in their learning.

The Assessments

Since CLP/KIE is a research-oriented classroom, the curriculum uses many different kinds of assessments to evaluate students' learning. This study links students' knowledge integration and beliefs about science (as measured by these assessments) to their reflection (as indicated by their responses to prompts).

Students take a pre-test to assess their level of understanding of heat, temperature, and light at the beginning of the semester. Their final exam is an identical test, given at the end of the semester. Both the pre- and post-tests are coded for use in assessing students' learning over the course of the semester. Only the post-test is graded by the teacher. The subject matter test uses multiple choice questions followed with short-answer questions asking students to explain their answer or give the main reason for their answer. The questions ask them to apply to real-life situations the scientific principles they have learned in class. The pre- and post- subject matter tests are paper-and-pencil tests. Typically students take a full class period (about 50 minutes) to complete them.

Similarly, students take identical pre- and post-tests to assess their beliefs about science and learning science at the beginning and end of the semester. This assessment investigates students' beliefs about and attitudes toward science and learning science. The questions are situated in the context of science; because we consider beliefs to be domain-specific, we do not ask them about their beliefs about learning in general. The beliefs pre- and post-tests are given on-line, using a series of Web forms. As with the subject matter tests, the beliefs tests are coded and the codes are used to assess changes over the course of the semester. Neither beliefs test is graded. (See Appendix H for relevant questions from the beliefs test.)

The classroom teacher encourages students to take seriously ungraded assessments like the beliefs tests and the subject matter pre-test. He appeals to their interest in contributing to educational research and, when necessary, threatens to lower the grades of students who obviously do not make an effort. Most students cooperate fully.

The teacher assesses students' CLP labs and KIE projects, as well. The current research investigates students' work on one KIE project, the All The News project. Aspects of the
project that are graded and/or coded include students' responses to reflection prompts, their evidence critique notes, their claim critique notes, and their letters to the editor.

Most KIE projects have quizzes associated with them, as well. The All The News project is accompanied by a pre- and post-project assessment intended to check students' conceptual understanding of the specific science ideas involved in the project and their ideas about critiquing before and after they engage in the All The News project. I use two questions from this quiz to assess change in students' ideas about energy conversion and thermal equilibrium. All The News also uses a post-project quiz in which students critique a piece of evidence and a scientific claim.

Study Design

How does this dissertation address the research questions? In this section I describe the design of the study.

Prompting Conditions

Students were assigned to one of two prompt conditions, to allow comparison of the two levels of specificity of reflection prompts. One group of students received generic prompts and the other group received a directed set. Each condition provided students with the same number of prompts, to equalize the time spent on prompted responses. Students were assigned to conditions on the basis of their class period assignment, which is a random process in this untracked school. All students in a single period were in the same condition. The periods were assigned to conditions by matching the periods based on students' first quarter grades, their beliefs, and the teacher's perception of the class as a whole. Approximately equal numbers of pairs were assigned to each prompt condition, with variation being due to uneven class sizes. The directed prompt condition included 44 pairs of students, and the generic prompt condition, 47 pairs. (A few "pairs" were actually individual students, due to uneven class sizes.)

All students in the generic prompt condition received identical sets of 11 generic prompts. Generic prompts asked students to complete a sentence like, "Right now, we're thinking…." Generic prompts were intended to be indistinguishable from one another. (See Appendix I for the generic and directed prompts used in the dissertation study.)

Students in the directed prompt condition received, instead, 11 directed prompts. The project included 6 "Thinking Ahead" prompts, 4 "Checking Our Understanding" prompts, and a single "Thinking Back" prompt, which was similar in nature to the "Thinking Ahead" prompts, but was reflective rather than forward-looking. The directed prompts were refined versions of self-monitoring prompts that elicited the best responses in earlier trials. For example, one directed prompt oriented toward planning was "To do a good job on this project, we need to…"; one oriented toward monitoring was "In thinking about how it all fits together, we're confused about…." 

In each condition, prompts occurred at exactly the same locations—for example, if the directed prompt condition involved one prompt at the beginning of an activity and two at the end of the activity, the generic prompt condition would have this set-up, as well. However, generic prompts were essentially indistinguishable from one another, regardless
of their placement. To students, these prompts were all called "Our Thoughts" and provided a general impetus meant to encourage reflection.

Some students were confused about how to respond to prompts—in particular, some found the generic prompts a stumbling block. When students asked, "What should we write?" they were told that anything they thought of was fine. The teacher did not give guidance about how to respond (though he did sometimes suggest that students check the hints in Mildred for ideas).

Table 4–1 summarizes salient aspects of the two conditions.

<table>
<thead>
<tr>
<th>Directed Prompt Condition</th>
<th>Generic Prompt Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>44 projects</td>
<td>47 projects</td>
</tr>
<tr>
<td>6 Thinking Ahead (TA) prompts</td>
<td>11 Generic Prompts (in same locations in the project as TAs, COUs, and TB)</td>
</tr>
<tr>
<td>4 Checking Our Understanding (COU)</td>
<td></td>
</tr>
<tr>
<td>1 Thinking Back (TB) prompt</td>
<td></td>
</tr>
<tr>
<td>484 total prompt responses</td>
<td>517 total prompt responses</td>
</tr>
<tr>
<td>(44 projects x 11 prompts/project)</td>
<td>(47 projects x 11 prompts/project)</td>
</tr>
<tr>
<td>Examples:</td>
<td>Example:</td>
</tr>
<tr>
<td>Thinking Ahead: To do a good job on this project, we need to…</td>
<td>Right now, we're thinking…</td>
</tr>
<tr>
<td>Checking Our Understanding: In thinking about how it all fits together, we're confused about…</td>
<td></td>
</tr>
<tr>
<td>Thinking Back: As we worked on this project, we wish we'd spent more time on…</td>
<td></td>
</tr>
</tbody>
</table>

Table 4–1: The Directed and Generic Prompt Conditions

As Table 4–1 shows, I had approximately 500 prompt responses in each condition available for coding. These responses provide the data for the analyses of students' reflection. Students created 91 projects total; those projects comprise the data for the investigations of the effects of prompts on students' project performance. These data sources will be reviewed more completely later in this chapter.

Pairing Students

To investigate the effect students' beliefs had on their reflection and their learning, each student was paired with another student of similar beliefs. (See Appendix H for relevant questions from the beliefs assessment.) Where possible, student pairs were arranged so that pair members exhibited different levels of prior academic performance as measured by their previous grades in science class, to reduce the possibility of an overlapping effect of beliefs and ability. Students' beliefs about the nature of science and learning science were assessed in the dimensions of autonomy, strategy, and process. These dimensions, introduced in Chapter 2, are discussed more completely in Chapter 7. Their scores in each dimension were summed to develop an overall beliefs score, based on which they were paired. Their beliefs, while viewed as falling on a continuum, were grouped into three general categories for the purposes of pairing the students with one another. The pairs' overall beliefs categories are referred to as high, medium, and low, where "higher" beliefs include a personal responsibility for one's learning, a stance that understanding represents the best strategy for learning science, and a belief that science is a dynamic field. These beliefs are highly valued in the CLP/KIE classroom. "Lower" beliefs include putting
responsibility for one's learning on someone else, having a partiality to memorization, and expressing a belief that science is a static field. Of course the terms high, medium, and low serve as caricatures representing complex sets of characteristics. The grouping followed Linn and Songer's (1993) finding that approximately 60% of students exhibit mixed beliefs, and that approximately equal numbers comprise each of the groups at the extremes of the continuum. Thus, to the extent possible given uneven class sizes, pairs were constructed to follow this 20%-60%-20% breakdown. Table 4–2 summarizes the research design.

Table 4–2: Pairing Students based on Beliefs

<table>
<thead>
<tr>
<th>Condition</th>
<th>Directed Prompt</th>
<th>Generic Prompt</th>
<th>Total N (pairs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Beliefs Pair</td>
<td>7</td>
<td>10</td>
<td>17 (19%)</td>
</tr>
<tr>
<td>Medium Beliefs Pair</td>
<td>22</td>
<td>21</td>
<td>43 (47%)</td>
</tr>
<tr>
<td>Low Beliefs Pair</td>
<td>11</td>
<td>10</td>
<td>21 (23%)</td>
</tr>
<tr>
<td>Unmatched Beliefs (High &amp; Med. or Med. &amp; Low)</td>
<td>2</td>
<td>4</td>
<td>6 (7%)</td>
</tr>
<tr>
<td>Pairs without Beliefs Data</td>
<td>2</td>
<td>2</td>
<td>4 (4%)</td>
</tr>
<tr>
<td><strong>Total N (pairs)</strong></td>
<td><strong>44</strong></td>
<td><strong>47</strong></td>
<td><strong>91</strong></td>
</tr>
</tbody>
</table>

In a few cases, pairs had to be constructed with students who had slightly dissimilar beliefs (high-medium or medium-low combinations); these pairs are eliminated from the relevant analyses. Also eliminated from some analyses are pairs including one or two students for whom pre-beliefs scores were unavailable (due to the student arriving mid-semester). Four students worked alone on the project. All of these students were low-beliefs boys. Their data are included in some of the analyses but excluded where pairwise information is required.

Though gender mix was not accounted for in pairing the students, the two conditions both included mostly male-female pairs (61% of the pairs), then female-female (22%), male-male (13%), and a small number of males working alone (4%).

Data Sources and Outcome Measures

As previewed earlier in the chapter, primary sources of data for this research include students' All The News projects, their responses to reflection prompts, quizzes requiring students to apply their knowledge of critiquing in a novel situation, and pre- and post-tests of subject matter knowledge and beliefs about science and learning. (Throughout this dissertation, when I include quotes from students' written work, it has been cleaned up to eliminate any particularly confusing typographical errors. Some of the less distracting errors have been retained.) Note the distinction between prompt responses and the projects themselves; though the reflection prompts were delivered as part of the project, they are analyzed separately from the other aspects. Thus, the All The News projects included students' evidence and claim notes and their letters to the editor. Interview data represents another valuable data source.

I provide an overview of the outcome measures in the following sections. Chapters 5, 6, and 7 will discuss in more detail the specific measures used.
Project Quality

The projects were coded to identify students' performance on measures focusing on project quality, with particular emphasis on evidence of knowledge integration. These coding schemes and those used for the prompt responses were developed formatively, growing out of the data and the theoretical framework together, and were conceptually validated with multiple groups of experts.

Project success was first scored holistically. The overall project score was based on conceptual validity (the quality of students' ideas as compared to scientifically normative ideas) and the degree of completion. Then I made a more detailed coding of project success on the basis of (a) overall critique quality, (b) coherence of ideas, and (c) guideline quality. These represent the three main project quality measures used throughout the dissertation. I assessed overall critique quality on the basis of how well students addressed the science, methods, and credibility of the evidence and the validity of the scientific claims. To assess coherence, I identified where students made appropriate links as compared to linking inappropriately or giving contradictory ideas. This measure may be considered a blend of the measures of conceptual validity and principled knowledge integration used in the pilot work. I also developed a guidelines quality score; I investigated the guidelines students wrote to the editor of the paper, describing strategies for critiquing evidence in the future. (Chapter 5 outlines how these codings were completed in greater detail. Chapter 5 also discusses other, more detailed codings of students' work on the projects.)

Reflection Prompt Responses

I refined the coding scheme used in Study 3 of the pilot work (reported in Chapter 3) to investigate students' focus of reflection. As in the pilot work, I divided students' responses to the reflection prompts into individual, independent ideas, called comments. In the dissertation study, each comment was characterized as focusing on actions, project activities, project ideas, or knowledge. Comments coded as actions were typically schoolish responses, focusing on school or social behaviors or very general project goals. Comments coded as project activities were goal-oriented, but were specific to the particular project. Comments coded as project ideas were also specific to the project at hand, but focused on concepts students were to learn (e.g., energy conversion, critiquing) rather than on logistics. Comments coded as knowledge could indicate a plan to think about knowledge or could indicate actual links to existing knowledge. These knowledge-focused responses are grouped because both indicate a propensity toward knowledge integration. Responses of "no problem" or the like were coded as not reflective. A few comments did not fit into this coding scheme; these comments were coded as other. (Chapter 6 outlines these codes in greater detail.)

I then assigned a set of overall characterizations to each response based on the proportion of comments in each response focusing on each type of reflection. Those proportions allow identification of the degree to which students focused on each aspect of reflection. I also counted the number of words and comments in the responses, to assess the degree of elaboration of the responses.
Other Written Outcome Measures

Assessments immediately before and after All The News indicated students' knowledge integration as a result of the project. Additionally, the pre-tests for beliefs were used for assignment into beliefs categories and the post-tests were investigated to identify any changes to student beliefs as a result of their prompting condition.

Interviews

Three interviews were done with a cohort of 25 students chosen at random from the six class periods (approximately four students per class). One of these students proved extremely uncooperative; that student's data is eliminated from any investigations of the interview data. Interviews were performed to assess or confirm students' general problem solving ability, critiquing ability, prompt preferences, scientific ideas, and beliefs about science and science learning. Throughout the interview sequence, students' conceptual understanding of science was assessed. The interviews illuminated trends in prompted students' reflective activity, their beliefs, and their success on projects. All interviews were audio-taped.

In the first interview, done early in the semester, students were interviewed about their beliefs about science and learning science. They also solved a complex and ambiguous problem involving energy conversion, to establish a baseline measure of their initial understanding of energy conversion.

Pilot interviews investigated students' ability to critique familiar and novel pieces of evidence, to articulate and demonstrate understanding of characteristics of good and poor critiques, and to choose prompts that would be most helpful to them in thinking about and writing a good critique. A similar approach was used in the second interview, taking place after students completed All The News. Students were given a set of real student critiques of a piece of evidence from All The News. They were asked to rank order the examples from best to worst critique, and to explain their reasoning. I also gave them a set of prompts (a mix of directed, generic, and activity-focused), and asked them to choose which would be most useful to them to think about or write about if their task was to write a great evidence critique. They again explained their reasoning.

In their last interview, students' understanding of energy conversion and their prompt usage post-instruction was assessed. First, I gave students a set of three words related to energy conversion, and asked them to make a sensible (scientifically valid) sentence using all the words. This was repeated for four sets of words. This activity allowed me to assess their understanding of energy conversion in a novel way. Then, I evaluated their use of prompts and expectations for reflection. I first gave them a directed prompt oriented toward planning, and three real student responses. One response focused on content, one on behavior, and one was metacognitive. Students had to order the responses in order of preference, and explain their reasoning. I then gave them a generic prompt and three analogous responses, and again had them rank the responses and explain their ranking. If time permitted, I also gave them a similar activity for a directed prompt oriented toward monitoring and a generic prompt with analogous responses.

Appendixes J, K, and L give the scripts for the three interviews.
Investigations and Analyses

As previewed in Chapter 1, I investigate three separate but interwoven areas in addressing the research questions outlined earlier in this chapter. The results of these three investigations are presented in Chapters 5, 6, and 7. First, in Chapter 5, I investigate the effects, at a gross level, of the two types of reflection prompts on students' work on the project. Then, in Chapter 6, I describe the focuses of students' reflection in response to the two types of prompts. In Chapter 7, I investigate students' beliefs about science and learning science, and relate those beliefs to students' performance on the project. A final investigation links the previous three. Chapter 8 presents this synthesis.

Effects of Reflection Prompts

The first investigation looks at the effects of reflection prompts on students' performance on the project. I compare the two conditions on the overall quality measures outlined earlier in this chapter, as well as on the other more specific aspects of their work on the notes and the letter in the project. Here, the emphasis is on the "meat" of the project, rather than their responses to the reflection prompts themselves.

Analyses here include t-tests, ANOVAs, chi-squares, and Fisher exact tests to compare the performance of students in the two conditions. Specific analyses will be reviewed in greater detail in Chapter 5.

Focus of Reflection

The next investigation compares the kinds of reflection students engage in in response to each kind of reflection prompt. I describe the focuses of reflection made for each type of prompt, and for the directed prompts, I break it down further by planning and monitoring prompts. Focus of reflection is coded using the coding key outlined earlier in this chapter and described in full in Chapter 6.

Analyses include ANOVAs and t-tests to compare the focuses of reflection for the two conditions and for the two prompt orientations for the directed prompts in particular. The analyses of the focus of reflection provide a complement to those that investigate the effects of reflection; here, we see what students do in response to reflection prompts that might account for the differences in performance delineated in Chapter 5.

Beliefs about Science and Learning Science

The third set of analyses round out the investigations by focusing on the role students' beliefs about science and learning science play in their reflection and their use of reflection prompts. I first describe students' beliefs before and after the course, and portray how dimensions of students' beliefs about science and learning science are related to one another and how they change over time. I then relate those beliefs to the analyses of effects of prompts and focus of reflection. Analyses in this chapter include correlations and ANOVAs.
Synthesis

The final investigation links the previous three, identifying models for student performance that take into account the type of prompts they received, the reflection they engage in, other aspects of their performance, and their beliefs. The analyses include multiple regressions to develop predictive models of project quality measures and ANOVAs to compare groups of students with similar characteristics.