RETHINKING LEARNER-CENTERED INSTRUCTIONAL DESIGN IN THE CONTEXT OF “NO CHILD LEFT BEHIND”

DISSERTATION

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ABSTRACT

The accountability inherent in “No Child Left Behind” has resulted in a tendency for classroom teachers to default to transmission models of teaching and learning in which information is drilled in preparation for state proficiency tests. Transmission models of teaching and learning often lead to problems of disassociation of knowledge, meaning that students are not able to transfer or apply their knowledge outside of the classroom. Classroom resources such as computer software exacerbate this problem, as many of the currently available software programs are geared specifically towards aiding students in meeting proficiency standards, and the easiest way to implement such software is through the use of drill and practice, sequenced activities.

Constructivist learning theory offers a learner-centered philosophy that has the potential to alleviate these issues of disassociated knowledge. I posit that by placing constructivism as the philosophy behind the design of computer software, it is possible to create classroom resources that aid students in meeting proficiency standards while avoiding problems of disassociated knowledge. I have devised and tested an instructional design model that foregrounds the tenets of constructivism towards the design of viable classroom software, within the boundaries of proficiency standards. Key to this model
was the placement of teachers as Subject Matter Experts and the placement of students as experts of content delivery and interface design (which I call Design Expertise).

This thesis explores one approach to applying this instructional design model in a public school setting. While ultimately successful in producing a program for a 6th grade science classroom, this study highlighted many potential barriers to the success of the model. These barriers include access to the students, time and other constraints that prevent teachers from participating as pedagogues in the design process, and the difficulties in guiding students through the process of generating software ideas that are contextualized (i.e., not disassociated) in real-life situations.

I posit that, with some modification, this model can be successful on both classroom and district levels towards the design of constructivist software. Future work includes testing this hypothesis and examining the possibility of training students and teachers on constructivist design.
Dedicated to my nagymama.
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CHAPTER 1

INTRODUCTION

THE EDUCATIONAL CLIMATE

The U.S. education system has a history of reform that is geared towards molding students into knowledgeable and efficient workers who are competitive on an international level (Besser, 1993; Beyer & Liston, 1996). This history began as a shift in society’s conception of the teacher from the disseminator of local knowledge and customs to the disseminator of standardized curriculum materials (Beyer & Liston, 1996). Standardized materials made possible standardized measuring of achievement as well, and eventually led to the development of strict disciplines and areas of specialization (Besser, 1993). In this context, knowledge can be seen as a linear progression towards one accepted Truth within each discipline.

This conception of linear knowledge is still prevalent today in the form of state proficiency standards, which act as a map of what students should know at the culmination of each grade level in order to “master” a subject. Subject mapping tends to lead to a banking model of education in which students are receptacles waiting to be filled, with the teacher transferring his/her knowledge to the students (Freire, 2002,
pp.72-74). Teaching becomes manifest in “[p]rogrammed instruction, drill and practice, and tutorials” (Willis, 2000, p.10).

In environments such as this, learners often come to understand the curriculum as representing “little more than an arrangement of subjects, a structure of socially prescribed knowledge, or a complex system of meanings which may or may not fall within his grasp” (Greene, 1971, p.137). The students who are successful in this environment are not necessarily students who reach a deep understanding of the curricular content, but those who learn how to “jump through the hoops” set forth by the education system (Keddie, 1971). Moreover, when learning becomes this abstract and isolated from real-life situations, most students are left with an arbitrary collection of symbols and formal strategies that are disconnected, nontransferable, and nonapplicable (Bohn & Sleeter, 2000; Petraglia, 1998; Fasheh, 1990).

So, to whom do we turn for explanation when students do not achieve according to our standards? In other words, “Who is responsible for a person’s education” (Taylor & Johnsen, 1990, p.115)? A historical perspective indicates that over time this responsibility has shifted away from the student taking responsibility for his or her studies to teachers and instructional designers being responsible for instruction; the idea of learning as studying has shifted to learning as receiving instruction (Taylor & Johnsen, 1990). “Many of today’s students believe that (a) problems are something that are presented by teachers rather than discovered by good learners, (b) that good learners almost instantly know the answer to all problems … and (c) that if they can’t solve a
problem in five minutes then they can never solve it” (CTGV, 2000, p.17). While this is problematic, we must be careful not to pass all blame for this situation onto the students.

The teacher is often the first curriculum, meaning that a teacher’s energy and treatment of the material can strongly affect a student’s attitude towards the material. “[P]ositive ideas and attitudes about learning and about what remains to be learned are not an automatic consequence…They depend on effective teaching” (CTGV, 2000, p.17). If we understand that these types of attitudes regarding teaching and learning are part of the culture of the classroom, then combating student ennui, apathy, and defeatism must be part of a larger struggle to transform the culture of the classroom (Windschitl, 2002).

Yet, in spite of the teacher’s best intentions, there is a climate of accountability in today’s school, the pressure of which can sway teachers to ignore their intuitions regarding effective teaching in favor of tried-and-true methods and “teaching to the test”. For example, as Biggler (1996) noted in her study of classroom environments,

Mrs. L. felt that her literature teaching over the years had suffered as a result of students’ declining skills and motivation, and the imposition of standardized tests that required she “teach to the test.” Her Regents-level students spent considerably more time on writing and literature than the non-Regents class, but even in her Regents classes she had recently stopped teaching her “prized heroes” unit to students because she felt they needed more time to master basic skills. (Biggler, 1996, p.10)

While many states had proficiency and accountability systems in place by the year 2000, the type of classroom focus on required skills evidenced by Mrs. L.’s teaching became a nationwide preoccupation as a result of the “No Child Left Behind” Act (NCLB) ¹, signed in 2002 by President George W. Bush. NCLB was designed as a means of ensuring the

¹ See http://www.nclb.gov/.
academic success of public school students, primarily through mandating annual testing\(^2\) on a core set of subjects and setting forth consequences for the schools in which students are not testing well. Prior to this Act, the repercussions of failing to meet the standards fell, for the most part, on the students. As Swope (2000) notes, “on the basis of standardized test scores, students are being flunked, denied access to a desired course or school, or even denied a high school diploma” (p.11-12). Teachers and principals (and their schools) have also been accountable to student achievement in that they run the risk of being labeled as “failing” (Swope, 2000). Under NCLB, states are also required to track their schools in terms of their Adequate Yearly Progress (AYP) towards becoming “Proficient” (as determined by each state). If there exists a school in which students continue to perform poorly (without improvement) on the state’s proficiency tests, that school will be required to compile an improvement plan and offer more school choices (after 2 years of non-improvement), or offer school choices and supplemental services (after 3 years). In extreme cases (after 4+ years), the administrative and teaching staff can be fired\(^3\) or the school can be reconstituted\(^4\).

As a result of such sanctions, teachers, even when they recognize the value of more active and learner-centered pedagogies like constructivism\(^5\), often default to transmission models of teaching and drill and practice, because they are easier to implement and a more predictable way to ensure that students acquire the required

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\(^2\) This includes testing 4th and 8th grade students in math and science every two years as a condition for receiving federal funding (http://www.ed.gov/nclb/accountability/ayp/testing-faq.html#12).

\(^3\) This case, though possible, is unlikely. See (Goldhaber & Anthony, 2003; Nichols, Glass & Berliner, 2005).

\(^4\) Please refer to http://www.ed.gov/nclb/accountability/schools/accountability.html#5 (NCLB website) and http://www.ode.state.oh.us/reportcard/PDF/0405Guide.pdf (the Ohio Department of Education) for more information on these consequences.

\(^5\) I discuss constructivism in more detail in Chapter 2.
information (Brooks & Brooks, 1993). Thus, teacher accountability to standard assessment results further promotes educator allegiance to “skill and drill” methods of education. This approach might aid students in obtaining high scores on the tests, but what happens to their ability to transfer knowledge to other contexts or their ability to retain knowledge past the exam? Gee (2003), among others, claims that transference can occur only when a student recognizes that two problems have the same underlying principles. Further, unless teachers take the time to explicitly show students how to transfer knowledge to different domains or which familiar problems share common underlying properties, students may not learn to become active, critical learners capable of transfer. Additionally, strict adherence to skill and drill methods of teaching further divides students who were already classified as “at-risk” from those who are in environments where all students excel at these standardized assessments because their educations exceed the expectations set forth by the standards (Ladson-Billings, 1994).

In addition to the learning theory employed (e.g., behaviorism or constructivism), classroom culture is also shaped by the learning resources available. For example, while the popular presentation software package Microsoft PowerPoint allows for dynamic linking between slides (i.e., through the use of a button, one can move from Slide 7 to Slide 16), it is most often used as a means to linearly convey information (i.e., Slide 7 to Slide 8 to Slide 9), as this is the usage that most naturally follows from the design of the PowerPoint interface. At its worst, this linear transmission model of information and the bulleted oversimplification of information can have serious ramifications for learners, such as reinforcing the problem of passive learning (noted above) and fostering
superficial reasoning (Tufte, 2003). While these drawbacks can be avoided, there is a distinct relationship between what gets designed and how it gets implemented. Certain software designs, such as the one explored above, lend themselves to certain implementations.

In the context of the state proficiency standards and how they are used to shape the classroom culture of accountability, many educational technology designers feel pressured to design explicitly for these standards (Kleibacker, 1999). Further, marketing experts in the field of education suggest accommodating accountability by making explicit the correlation between software products and the proficiency standards they address (e.g., Frost, 2002; Jay & Longdon, 2003), going so far as to explicitly encourage instructional designers to organize and advertise their product catalogues according to the curriculum standards addressed (Winter, 2002). Sadly, the type of software that most easily fits these requirements is drill and practice software, because the drill style most easily accommodates the tracking, timing, and recording of student progress towards standardized knowledge; this type of software is also the easiest to program, as all components are easily sequenced and quantifiable in terms of measurements of student performance (Mergel, 1998; Weisburgh, 2003).

One example of such software can be found on the website Study Island⁶. This site claims to appeal to various learning styles through the option of game style or standard quiz style for all of their online activities. One example of a gaming alternative is “Splat”, a Frogger-type game in which the student must move the ladybug avatar through lanes of cross-traffic and avoid being hit. The student is still required to answer

⁶ http://www.studyisland.com/
questions in the form of a quiz, but now, instead of just clicking on the answer and
getting a star for right answers and a spoken “wrong” for incorrect answers, the student
must move the ladybug to the letter of the correct quiz answer. Errors in the game,
whether in the form of being hit by a vehicle or selecting the wrong letter, are rewarded
with a Homer Simpson-like “D’oh!”. So, while “Splat” might be fun to play, the
application still remains drill and practice, coupled with visual processing and
psychomotor skill practice.

Educational technology designers cannot ignore the political weight of
proficiency standards and initiatives such as “No Child Left Behind”; this would be
irresponsible, as it ignores the daily classroom expectations placed on teachers to aid their
students in meeting proficiency standards. Rather, educational technologists need to
develop an understanding of how student identity and student-directed exploration and
meaning making can be prioritized within the demands set forth by proficiency standards.

**STUDY MOTIVATIONS**

As an educational technologist, I see myself addressing these concerns through
my design approach to educational technologies. Historically, existing/traditional
instructional design (ID) models have relied on behaviorist and cognitivist discourses
with respect to the nature of teaching and learning. As DeVaney (1998) states, “no
discourse ever can position a neutral subject” (p.571). As such, the way one talks about
educational technologies will affect how one defines the place of technology in society,
how one understands its function in that place, and how one envisions the future of society’s relationship to technologies.

Behaviorism was the dominant learning theory when the practice of instructional design began (Ertmer & Newby, 1993). Proponents of this theory conceptualize the learner as a “black box”, because the inner processes of learning cannot be scientifically analyzed or proven (Hung, 2001), and conceptualize learning as acquiring the correct responses to stimuli encountered in the world (Ertmer & Newby, 1993; Hung, 2001). Content is considered to be “learned” when the student exhibits the correct response with sufficient frequency. Cognitivism, on the other hand, was a reaction to the limitations of behaviorism, that is, the inability of behaviorism to explain such things as “language development, problem solving, inference generation, critical thinking” (Ertmer & Newby, 1993, p.56). Cognitivists “focus on the conceptualization of students’ learning processes and address the issues of how information is received, organized, stored, and retrieved by the mind” (Ertmer & Newby, 1993, p.58). This means that instead of measuring the frequency with which the learner can provide the correct responses, cognitivists are interested in “encouraging him/her to use appropriate learning strategies” (Ertmer & Newby, 1993, p.59) to ensure the proper encoding of the information in the mind.

Both behaviorists and cognitivists tend to view the technology as a standalone unit, encapsulating the environment and content needed to foster expertise in the student. These technologies are often geared to be “teacher-proof” or “student-proof”, meaning that the applications are designed to be robust in the face of technological illiteracy and can recover from poorly chosen paths in the software (e.g., clicking on a component
unrelated to the current activity). These features are meant to ensure that the “proper”
cues and feedback are given, but also restrict flexibility for student-directed inquiry.
They are also intended for individual use.

Neither of these discourses, or the software they produce, fit with my desire to
prioritize student-centeredness and student directed exploration. Thus, in order to begin
the exploration of my own educational technology discourse, I turned to the learning
theories proposed by Vygotsky and Piaget (see Fostnot, 1996; Wadsworth, 1996), which
have evolved over time into the learning theory known as constructivism. Damarin
(1998), among others, has noted that there is not one single view of constructivism in
play today, but rather many constructivisms that emphasize the various nuances of
constructivist learning theory (e.g., the importance of social interaction to the individual
construction of knowledge). My own interpretation of constructivism is delineated in
Chapter 2. Briefly, this interpretation conceptualizes learners as the sum of their life
experiences, of which cognitive and cultural aspects are a part. Learning is a self-
directed process, which is best fostered by an environment that allows for, among other
things, contextualization of new knowledge in ways that relate to students’ experiences
and backgrounds. This understanding of constructivism, when combined with theories of
identity and cultural models as posited by Holland et al. (1998) and Gee (2003) and the
theories of pedagogy as posited by Biggler (1996) and Delpit (1988), can be used to help
alleviate the issues of irrelevance and disassociated knowledge as described above.

The points outlined above worked towards forming an understanding of student
identity and student-directed exploration and meaning making. Still, my goal was to find
a way to prioritize these understandings within the public school context. This context includes not only the boundaries of administrative and governmental policies (e.g., school policies for technology integration and state proficiency standards), but also constraints in terms of time, access to computers, and other learning resources. To this end, I first devised four Software Criteria, which are listed in order of importance in Table 1.1. These Criteria are derived and supported in Chapter 2, and are meant to serve as a guide for navigating the tensions created by the combination of a constructivist approach to instructional design and the public school context.

1. The software aids students in meeting state/district proficiency standards.

2. The software is compatible with the teaching and learning philosophies of classroom teachers. Such software should also be compatible with their philosophies of how technology should be integrated into the classroom, as well as school policies on technology integration.

3. The software presents the content in such a way that aids students in the individual construction of knowledge, in keeping with the students’ cultural models.

4. The software should integrate curriculum from at least two subject areas.

Table 1.1: Software Criteria.

Next, I developed an instructional design model by which to design and develop new educational technologies. This involved first placing constructivism as the philosophy behind the instructional design (ID) process. Second, based on my understanding of constructivism and identity and their implications with respect to issues of power and privilege within the ID process, I incorporated classroom teachers and
students as co-designers. In this way, I allowed for multiple perspectives in the ID process rather than placing all decision making power with the educational technologist alone. I suggest that these modifications to the traditional ID model provide an avenue to explore a new way of embedding authentic content, employ student input to explore relevant ways of presenting educational content, and design and develop educational technologies that lend themselves to learner-centered applications and environments. A more detailed description and justification of these amendments is given in Chapter 2. This description also specifies the relationship between the Software Criteria and the ID model.

In order to apply this Revised ID Model, I created a plan for implementing the model in a public school setting. The primary features of this model’s application are as follows:

1. Teachers are placed as Subject Matter Experts (SMEs) for the purpose of software content selection. This placement works towards meeting teacher needs, including the demands set forth by accountability to proficiency standards, and the shaping of classroom culture.
2. Students are placed as Design Experts (DEs) for the purpose of designing the interface for the content selected. This placement works towards enabling the individual construction of knowledge by allowing students’ cultural models to shape the software design.
3. I am placed as the educational technologist (i.e., instructional designer), co-designing with the SMEs and DEs. Rapid prototyping is employed as a means of designing a viable software product within the time and resource boundaries of the public school system.
4. Both SMEs and DEs are placed again as software reviewers, in an effort to ensure the design(s) meet their needs and specifications.

The full plan, in the form of a timeline, is located in Chapter 3. This study examines the feasibility of this plan as an application of the Revised ID Model as well as the Revised ID Model itself.
PROBLEM STATEMENT

Earlier I stated that “educational technologists need to develop an understanding of how student identity and student-directed exploration and meaning making can be prioritized within the demands set forth by proficiency standards,” and this understanding must be incorporated into the instructional design process. In an effort to address this tension, I explored the existing approaches to instructional design and the dominant discourses that shape those approaches, rejecting both. I arrived at the conclusion that constructivism is a better discourse for informing instructional design. With this study, I set myself the task of developing and testing an instructional design model that is compatible with the student-centered nature of constructivism, while still navigating within the constraints set forth by NCLB and state proficiency standards in the public school context.

RESEARCH QUESTIONS

In order to assess the feasibility of the Chapter 3 implementation of my Revised ID Model, my research was guided by the questions located in Table 1.2, which are again listed in order of importance. This ordering was determined by prioritizing the process of instructional design over the product that it produces.
1. How effective was this design approach in producing a viable software product? Which factors facilitated its success? These questions address the practical implications of applying this approach, using the Timeline detailed in Chapter 3, in the public school setting.

2. Similarly, what were the barriers to success? For example, is there knowledge that would have been useful to have that I either did not have or collected too late? Were the methods and frequencies of data collection inadequate for the types of data I was trying to collect?

3. In what ways and to what degree were students engaged with this project? For example, did students show interest in participating in the project? Were they active participants, or did they show signs of apathy or active resistance? What factors influenced these reactions?

4. How did teachers and administrators respond to this process? To what extent did these individuals aid in the completion of the project or resist/embrace their roles in the project?

5. What type of product was designed and developed using this approach? Specifically, to what extent were the Software Criteria fulfilled?

Table 1.2: Research Questions.

These questions aid in assessing the model’s usability as an instructional design model in three ways:

1. as a means of creating a viable software product (Questions 1 & 2)
2. as a means of exploring the extent to which administrators, teachers, and students can and will participate as co-designers (Questions 3 & 4)
3. as a means of creating software that fulfills the Software Criteria (Question 5)

In order to answer these questions, my role in this research was as a participant observer within the process of participatory design. Participant observation is a research methodology in which the researcher acts as both a participant and an observer. As noted above, my role in the software design process was as the educational technologist, co-designing and developing software prototypes and products. By placing myself also as an observer within the process, I was better able to reflect on the dynamics of the process
as the design unfolded. I was also in a better position to prompt the teacher and student co-designers for their own reflections on the design process rather than relying on formative and summative evaluations of the software product to provide insight into the triumphs and difficulties of the design process.

**ASSUMPTIONS**

There are 6 assumptions I have made in order to construct this study.

1. That it is appropriate to incorporate computing technology as a component in formal education, and this technology can have a positive impact on student learning.

   This assumption has its roots in the many technology initiatives the U.S. school system has seen in recent years (Bork, 1993; Jones, 2003), which is a reflection of our society’s growing dependence on computer technologies and a history of educational reform meant to aid students in becoming knowledgeable and efficient workers. In addition, computer technology has the potential to provide students with explorations of knowledge and simulations that they might otherwise not have access to. When used in context with other materials, I believe technology can enhance the educational environment. More detail on my understanding of technology’s place in education can be found in Chapter 2.

2. That the principles of constructivism enhance student learning.

   This assumption is based on the literature noted above and in Chapter 2 regarding the ramifications of cognitive disconnect between classroom knowledge and everyday life. By working to incorporate relevance and authenticity from the students’ points
of view, teachers enable students to correctly process and assimilate new knowledge into their existing understandings of the world. Without a means of tying new knowledge to existing knowledge, students may not be able to retain or utilize that information later.

3. That student input at the design stage will aid students in the individual construction of knowledge, providing a greater chance of meaning making.

As with Assumption (2), this assumption ties into my understanding of student construction of knowledge as understood from a constructivist standpoint. Just as I expect constructivist teachers to learn about their students’ contexts and then work to relate new information to them in ways the students find relevant and authentic, so, too, should the technology they encounter work towards this end. As such, the educational technologist should work with students to explore design interfaces that other students of that population will find relevant and authentic, and thus engaging.

4. That constructivist learning theory is a fruitful place to begin when researching and designing for formal education settings.

This assumption is borne of the belief that the ideology one brings to the instructional design model will be embedded, in part, in the final software product. Given my understanding of the potential conflicts elicited by NCLB and proficiency standards, and my belief that constructivism offers a method of alleviating some of these conflicts, it seems natural to me that constructivist learning theory is the place to begin this research project. This assumption is further supported by my understanding of how constructivism can be combined with instructional design, which is explored in Chapter 2.
That software can be a more effective learning resource when designed at a more local level (i.e., on a school-by-school basis).

This assumption is based on the belief that classroom resources shape classroom culture, as discussed above, and that designing at a local level best ensures that the teachers’ and school’s (and possibly district’s) ideal classroom culture is accommodated by the software’s embedded ideology. This is in opposition to software that is typically designed at a broader level, whereby the presentation of information, pacing, and other features have been designed for a conception of the classroom and its culture that can be applied nationwide. Having local access to student culture also provides a greater chance that the software will present information in ways that students find relevant and authentic.

That participant observation is a valuable methodology for exploring the educational technology design process.

Participant observation allows me to act as both researcher and participant in this software design process, while at the same time accounting for the limited time that both students and teacher are able to commit to this project. For more information on the intricacies of my choice of participant observation, please refer to the Limitations listed below, as well as my exploration of this point in Chapter 3.

**LIMITATIONS**

While I attempted to design this ID model to be as accommodating as possible, there were still several practical limitations inherent in it. A primary limitation of this study was the extent to which participants were able to act as co-designers in the design
process. Ideally, both teachers and students would be working with me at each step of the development process, choosing which interface components to employ and how best to incorporate student suggestions into a coherent whole. Expectedly, due to the time constraints of the standard public school day, teachers and students were not able to act as full co-designers on the design team. Rather, they served as experts to be brainstormed and consulted with. I was still the primary technology designer.

This diminished role of the teachers and students and my role as the primary technology designer lead to a second limitation. This affected the range of ways that the brainstorming and evaluation data could be incorporated into the design(s) in that I made the bulk of the design decisions. Each person brings to the design table their own conceptions of what the end product should look like and how it should function. These conceptions are based to a large extent on what that designer has seen previously, become accustomed to, and prefers to use him/herself. In short, these depend upon each person’s cultural context. By limiting the bulk of design decisions to one person, the design is biased towards that individual’s cultural model.

My role as the sole technology developer lead to a third limitation in terms of how extensively the learning module could be developed, as well as the aesthetics (i.e., look) of the end product. As the sole programmer, I was limited in the number of ideas and changes I could implement before each evaluation. This also limited the amount of time I was able to dedicate to the graphic treatment of the software prototypes and end products.

There were also issues of power, privilege and culture inherent in this study that must be acknowledged. I list these as limitations, because they limit the extent to which
the participants were able to be present as full co-designers, that is, on equal footing and without restrictions or duress. The first of these is my education level, a Ph.D. candidate. This gave me authority in defining the research approach, which my co-designers might not have felt comfortable questioning. Relatedly, the teacher’s educational degrees placed them in an authority position with respect to educational content and learning theory. My area of expertise, computer science, granted me additional authority given that we were developing an educational technology. Yet even this could be a point of contention for teachers and students with a certain degree of technological literacy. My gender also becomes a factor in this. Personal experience has taught me that when a male contradicts my statements regarding technology, regardless of how young and inexperienced he is, his voice tends to be valued over my own.

Terminology is another area in which I had to be careful to tread lightly, being careful to avoid unnecessary jargon. Jargon is not just restricted to terminology that relates to the technology, but also more everyday issues. One example is the use of “gender” instead of “boys and girls,” which can actually illicit different responses when used in conversation, even with the same person during the same conversation.

A third area in which issues of power manifested themselves is within the school itself. The administrators of the school building are under political pressure to meet certain district goals for that school, and these pressures are in turn placed on the teachers. I had to be aware of the ways in which teachers and administrators enforced and resisted these pressures, and the ways in which these pressures, in turn, affected my ability to apply this ideal ID model in real life.
SIGNIFICANCE OF THE STUDY

The significance of this study is fourfold. First, this study adds to the literature on instructional design and constructivism by proposing a method of instructional design that is aligned with the principles of the constructivist learning theory as described in Chapter 2. Of primary interest in my model is the use of teachers as Subject Matter Experts (SMEs) and students as Delivery Experts (DEs).

This understanding of the role of teachers and students in design leads to the second point of significance: a shift in the interpretation of what it means to employ a humanistic (i.e., learner-centered) approach to instructional design. Traditional instructional design models promote their approaches as humanistic (i.e., learner-centered) because of their accommodation of the learner’s intellectual abilities, prior knowledge base, and learning style. My approach reinterprets “humanistic” as also including the learner’s cultural background.

Third, this study provides an opportunity for students, teachers, and administrators to give voice to the ways in which they want to participate in the design and development of technologies for their classrooms and schools. This voice also enables them to shape the future landscape of classroom technologies.

Fourth, this study builds on the work of the Cognition and Technology Group at Vanderbilt (CTGV) by providing an alternative view of what it means to embed “authentic” content in instructional technologies. Rather than merely understanding authentic content as scenarios that draw on multiple subject areas, I extend authentic
content to include authentic contexts for content delivery as determined by the student users.

**OUTLINE OF THE CHAPTERS**

Most dissertations follow a five-chapter format with Introduction, Literature Review, Methodology, Analysis, and Conclusion chapters. I have broken from this format by splitting my data analysis between three chapters. The detail required to describe and analyze the phenomenon I encountered in the field to address each of my research questions seemed to necessitate answering the questions in logical groupings rather than in the standard single chapter format. These logical groupings are (1) the process, (2) the participants’ responses, and (3) the software product. While interrelated, they each affected the conclusion in different ways, as noted in each chapter’s summary. The full details of the seven-chapter division are provided below.

**Chapter 1: Introduction**

In this chapter, I highlight the historical and political constraints currently influencing the classroom, and the means by which educational technologists can work within these constraints towards student-centered technologies. I also discuss my research questions, and the limitations of, assumptions behind, and significance of my approach.
Chapter 2: Literature Review

In this chapter, I review the literature on constructivism, identity, and instructional design, the three primary components of this study. I use the information gleaned from this literature base to derive an approach to combining these areas through the process of designing educational technologies, and construct a Revised ID Model.

Chapter 3: Methodology

I begin this chapter with a short explanation of my research design. This includes a description of my site and sample, as well as a detailed phase-based overview of my projected design timeline, including the specific data I planned to collect and the objectives of each phase of the design. I then explore the nuances of participant observation and its place in this study. I end with an overview of the data collected and a discussion of the data analysis methods employed in answering the research questions.

Chapter 4: Analysis of the Research Plan

In this chapter, I begin my analysis with a discussion of the design process itself. I examine each proposed phase of the software design plan from Chapter 3, exploring the ways in which the actual research timeline diverged from the initial plan. Each phase exploration ends with an explicit listing of the facilitators of and barriers to process success for that phase. These lists are used to inform preliminary revisions to the research plan and instructional design model themselves. The findings of this chapter aid in answering Research Questions #1 and #2.
Chapter 5: Analysis of Participant Responses to the Project

In this chapter, I explore how participants responded to their participation in this study. I begin with a discussion of the ways in which the administrators accommodated this project, as well as the ways in which their agendas supported the agendas of this study. I follow this with a similar discussion of the ways in which teachers impacted my agendas for this project. Finally, I discuss the ways in which students responded to my initial presence in the school, and their reactions to various components of the software design process. These response analyses inform not only the instructional design plan, but also provide useful information for working with participants on an endeavor such as this one. The findings of this chapter aid in answering Research Questions #1 through #4.

Chapter 6: Analysis of the Software Products

In this chapter, I explore the software created during this study. This includes a basic description of each final software product, a critical analysis of the ideology embedded in the software product, student responses to the software product, and an analysis of the ways in which the software did and did not meet the Software Criteria listed in Table 1.1. This works primarily towards answering Research Question #5, but is also a measure of the success of my instructional design model (Research Questions #1 and #2). I conclude that only one of the software products produced during this study was a success, and provide a listing of those factors that directly influenced this outcome.
Chapter 7: Conclusion

In this chapter, I draw from the political context detailed in Chapter 1 and the analyses in Chapters 4 through 6 to inform a discussion of the difficulties of designing constructivist software. I extend this discussion to speculate on the viability of the Revised ID Model of Chapter 2 to future applications. I end with suggestions for directions for work in the area of constructivism and instructional design.
CHAPTER 2

LITERATURE REVIEW

INTRODUCTION

This study is informed by literature in the areas of constructivist learning theory, identity and cultural models, and instructional design. In this chapter, I first explore constructivist learning theory and its implications for the educational environment. I then turn my attention to the topics of identity and cultural models, tying these concepts to concerns raised in the discussion of constructivism and elucidating a theoretical base for the ways in which the educational environment and educational technologies allow and block students from academic engagement – the “who” of instructional design. This discussion, in turn, informs an exploration of the place of technology in a constructivist learning environment – the “when and where” of instructional design. Finally, I turn my attention to the “how” of instructional design, touching briefly on traditional design methods and philosophies, and exploring how theories of constructivism and identity can be used to inform the process of instructional design. Together, this literature aids in defining and justifying both the Software Criteria that I delineated in Chapter 1, my
approach to instructional design (ID), and the modifications I suggest to the traditional ID model in the form of a Revised ID Model.

**CONSTRUCTIVISM: AN OVERVIEW**

Jean Piaget and Lev Vygotsky, two foundational theorists of constructivism, posit that learning is a construction of the learner (see Fosnot, 1996; Wadsworth, 1996), and that learning is driven by the learner’s responsibility to process and assimilate new information. In turn, responsibility is placed on the instructor(s) to provide environments that foster learning. For Piaget, this meant providing developmentally appropriate activities and information. For Vygotsky, this meant recognizing that learning is a social act and occurs when the learner has reached the “zone of proximal development” and is ready for guidance to the next stage of comprehension and learning. Together, these points regarding the nature of learning and the roles of students and instructors in the learning environment are the foundations of constructivism. In the next two sections, I consider each of these points in turn.

**CONSTRUCTIVIST LEARNING THEORY**

Constructivism is a theory about learning. This means that it does not contain a guide for teaching, but instead an understanding of how people learn, both inside and outside of a formal educational setting. Unlike the banking model touched on in Chapter 1, constructivists view learning as an active and idiosyncratic process. While there might
exist an objective, “real” world out there\textsuperscript{7}, every individual creates his or her own conceptions of it. These individual conceptions, also known as truths or mental models, are based upon individual experience, and shape what the individual comes to accept as real. So, rather than a single Truth towards which all individuals should work, a constructivist perspective emphasizes that there exist many truths.

These internal truths are referred to by Piaget as “schema,” and are conceived of as clusters of concepts and related factoids. As new information or experiences are encountered, the individual works to fit this information or experience into a coherent place in his/her existing knowledge constructions. This coherency creates what is called “equilibration” between the individual and the external world, a state we each strive to maintain. If the new information fits naturally within an existing schema, the individual simply “assimilates” this knowledge into the proper cluster. However, when the new information does not make sense to that individual (i.e., disequilibration is experienced), existing schema either need to be reworked or a new schema created. This latter process is known as “accommodation.” As the number of schema grow, so, too, can the complexity of the interrelation of knowledge within and between those schema.

Stressing the individual nature of knowledge is in no way an attempt to claim that there can be no consensus among the mental models. The existence of communities and societies with shared perceptions of the world shows that this is not the case. Rather, constructivism tells us that individuals can come to collectively share and accept some conceptions of the world (i.e., schemas) through social negotiations (i.e., assimilations

\textsuperscript{7} Damarin’s (1998) categorizations of constructivisms indicate that only “weak” and “cognitive” constructivism support the concept of an external, “real” world. My view of constructivism tends more towards these categorizations, although it cannot be wholly categorized as one of these.
and accommodations); these collective conceptions become recognized as community knowledge.

The process of creating coherent (and collective) mental models is aided when the learning activities engaged in are

1. scaffolded (built upon previous knowledge and developmentally appropriate to help students do things they could not do on their own, where guidance is gradually rescinded as learners become able to achieve on their own),
2. collaborative,
3. coached/apprenticed (guided), and
4. authentic (approximating real-life situations), contextualized (as opposed to isolated facts and symbols outside of authentic contexts), and learner-controlled (tied to learner interests with student-directed explorations rather than teacher-directed).

Problem-solving or anchored instruction environments are often viewed as the most conducive to providing for these factors (Willis, 2000). Yet, given the idiosyncratic nature of knowledge construction, there is no one way to teach all students, no predetermined path that can be taken to ensure learning. Each student will arrive in the classroom with different prior knowledge constructions (i.e., different schemata). The responsibility for accommodation and assimilation of new information is on the student, as their knowledge constructions are internal mechanisms that cannot be directly controlled by another source. At the same time, students are not empty vessels who will perfectly absorb whatever is transmitted to them (Merrill, 1991). “Too often teaching strategies and procedures seem to spring from the naïve assumption that what we ourselves perceive and infer from our perceptions is there, ready-made, for the students to pick up, if only they had the will to do so” (von Glasersfeld, 1996, p.5). As such, there are no guarantees. There are also no hard and fast rules, although general guidelines can
be constructed. “[T]he focus from an instructional point of view is on…consciously creating environments that capitalize on the way people learn” (Boethel & Dimock, 1999, p.11).

**CONSTRUCTIVIST ENVIRONMENTS**

Those interested in providing a learning environment that supports constructivism need to be mindful of the following points regarding planning, context, interaction, educational goals, community knowledge, and depth/breadth of the environment.

**Planning**

Constructivism does not imply lack of structure. In fact, more planning and preparation must go into creating a learning-centered environment over the predetermined unit normally transmitted to students, or the unit that is “explored” according to specific guidelines and a predetermined path such as is found in most science kits.

Preselecting activities does not have to take the control away from the student. Understanding learning through a constructivist lens does not translate into letting students learn whatever they want and hoping they will turn into educated, functioning individuals; this follows more along the tenets of discovery learning. Obviously, an educator cannot practically customize the learning experience for every single child in the classroom. However, activities can be designed for the class that allow for individual
customization of the activity according to student interests and allow for breathing room for student-led discovery.

Also, recall that mental models are constructed on the basis of previous experiences. As Merrill (1991) points out, “[t]he student needs a variety of experiences to construct an adequate mental model. A mental model is modified as a result of every new experience” (p.47). As such, selection of activities should reflect a range of ways for students to explore the material and engage with it.

**Context**

Learning means more when situated within a real-life context, or at least when the problems being posed are authentic and relevant. Information assimilated and accommodated outside of such contexts can lead to gross misunderstandings of even the simplest information, as well as a lack of ability to transfer knowledge to various other contexts (Boethel & Dimock, 1999). Having a larger context helps students make the appropriate connections between old and new information rather than struggling to place misinformation into their mental model frameworks (Driscoll, 2002). Providing this context requires that teachers become “knowledgeable about students’ perspectives, interests, and experiences” (Boethel & Dimock, 1999, p.12) so as to be able to relate new material in a way that optimizes potential for student meaning-making. This does not mean creating a new lesson for each student; that would be too time consuming and impractical. But this does require a certain amount of cultural competency and a

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8 This can be extremely difficult for teachers working in schools with high turnover rates in the student body. In these cases, students do not necessarily have the same backgrounds or educations.
willingness to assess the current level of student knowledge and understanding through nontraditional means (i.e., exploring through methods other than multiple-choice tests and other “objective” testing methods). Rather, group discussions and activities can be used to explore current conceptions of a topic before beginning the lesson. Students are more than the sum of their cognitive abilities, and the life experiences they reference to support their mental models can prove to be a great insight into their thinking processes.

Conceiving of context in this way also lends itself towards a cross-disciplinary approach (Davis & Shade, 1994; Adams & Burns, 1999). By stepping outside the traditional knowledge boundaries set up by separation of the disciplines and showing students how these disciplinary knowledges are interrelated, teachers provide students with a better chance of understanding the rich context in which these knowledges reside and a better chance of connecting them to the students’ prior mental models. One example is studying fractions as part of a music class. Students not only become better able to read music, but come to recognize a practical application of the mathematical lesson of fractions as well. While some students may be able to make these connections on their own, teachers must be aware that other students may require that these cross-disciplinary patterns be made explicit, and that the ability to recognize the transferability of knowledge across disciplines often requires explicit practice of transference before students are able to do so on their own (Gee, 2003).

In spite of the need for authentic and relevant contexts, educators cannot simply end at the concrete examples offered by the real world. The world we live in is highly symbolic, abstract, and theoretical, and students must also be prepared to consciously
function on this level. This means tying the contextualized experience to the symbols they will need to function at this abstract level, and giving them the terminology they will need to tie their knowledge constructions into the accepted discourse of their society. This can be as simple as showing students that the symbols ‘4 > 3’ will convey that a group of four apples is larger than a group of three apples, or as complex as explaining the notions encapsulated by the central limit theorem and sampling/standard error using graphs (see Gravetter & Wallnau, 2000). By moving into the region of the symbolic and abstract, the door is also opened for a full range of hypothetical situations that require a move beyond concrete operations.

**Interaction**

It is important to point out that while the constructivist’s goal is to aid each student in the individual construction of knowledge, this in no way should be interpreted as guiding students only through individual learning activities. Interaction with others can often be the catalyst that makes students question their existing knowledge or their environments and take that first step towards deep understanding. Without this type of engagement, students can easily make the mistake of accepting a dissonant experience or fact without reflection. In a discussion of erroneous beliefs as they relate to scientific concepts, Bruning et al. (1999) note that

The ordinary experiences of everyday life (even prior schooling) are a source of data that seem to support naïve theories. Consequently, the presence of well-developed but incorrect theories, coupled with everyday experiences that seem consistent with these theories, leads to a set of beliefs about how the world operates that is very difficult to change. In fact, many students find their naïve
concepts superior to the abstract and, in many cases, seemingly counterintuitive principles of Newtonian physics. (p.349)

Coaching and apprenticeship can provide the atmosphere for redirection that is needed at these points. As noted previously, interaction with others is also the means by which individuals come to understand their society’s conceptions of the world.

Still, not every learning activity can or should be wholly collaborative. Individual accomplishments should also be incorporated into the constructivist classroom for two reasons. First, being able to work alone is as important as being able to work in a team. Second, the point of constructivism is, as stated previously, to foster individual knowledge constructions, not team knowledge or abilities. Within the classroom environment, it is possible that a few aggressive and outspoken students will “rule” the classroom at the expense of the quieter students. Selection of significantly difficult content can work to prevent this (CTGV, 2000). Additionally, allowing for enough “wait time” after questions before calling on students also provides an opportunity for inclusion of those students who are slower or less willing to respond (Brooks & Brooks, 1993). Finally, a clear conception of how the teacher envisions an ideal classroom culture informs classroom interactions: is the ideal a community which favors unity but suppresses difference, or a city which celebrates difference as a starting-point for negotiation (Himley, 1997)?

Educational Goals

So, in this attempt to guide students through meaningful learning experience, what do we mean by “learning”? For a constructivist, learning is not just having the
answer. In fact, there are often many “answers” to the same problem, a multiplicity of truths (Brooks & Brooks, 1993). As such, teachers must remember that the process is part of the answer. This includes not only solving the problem on one’s own, but also learning how to find problems. Mistakes encountered along the way provide the kind of teachable moments that enable deeper understanding (Boethel & Dimock, 1999; St. John, 1998). Cutting off that teachable moment can inhibit the budding curiosity that leads to self-directed learning (St. John, 1998).

This is not to sidestep the issue of intended outcomes, but rather shift the focus from behaviorist outcomes to cognitive processes and deep understanding of the content. One method of measuring deep understanding is a think-aloud process. This is often used in evaluations of computer software interfaces to gauge the mental steps a user is going through to complete a task (see Ericsson & Simon (1993); Nielsen (1997)). By collecting this data, software evaluators come to understand where users have gone off track and how best to set them right. Educators can use a similar process to understand how students have arrived at their current conceptions and how to redirect them if

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9 This wording implies that there is one right answer and one right way (one right set of tasks to complete) to find it. While neither I nor others who subscribe to a constructivist philosophy believe this, this practice is rooted in cognitivism. Cognitivists “focus on the conceptualization of students’ learning processes and address the issues of how information is received, organized, stored, and retrieved by the mind (Ertmer & Newby, 1993, p.58). The mental structures that organize and store information are known as schemata (see Wadsworth (1996)). This means that instead of measuring the frequency with which the learner can provide the correct responses, cognitivists are interested in “encouraging him/her to use appropriate learning strategies” (Ertmer & Newby, 1993, p.59) to ensure the proper encoding of the information. Given the focus on the internal mechanisms of the user, the educator is very focused on being able to tap into these prior knowledge constructions so that students can build the appropriate new schemata for the new information. “Designers use techniques such as advance organizers, analogies, hierarchical relationships, and matrices to help learners relate new information to prior knowledge” (Ertmer & Newby, 1993, p.59). Retention of information is still an issue. “Forgetting is the inability to retrieve information from memory because of interference, memory loss, or missing or inadequate cues needed to access information” (Ertmer & Newby, 1993, p.59). There is also still a transmission model of knowledge employed here, and the end goal of cognitivism is still the production of the most accurate mental modeling of the natural world, an objective all students can achieve with the right education.
necessary. In this way, testing, which is often considered the indicator for whether educational goals have been achieved, is integrated into the learning process. This type of integrated testing also morphs the test into a source for further learning rather than a tool for ranking students.

To return to the idea of no one right answer, educators need to realize that “fostering appreciation for a multiplicity of truths and options is the ‘real’ mission of education because ‘real’ problems are rarely unidimensional” (Brooks & Brooks, 1993, p.111). “If we expect students to be able to deal with complex problems in the real world, we must provide them with opportunities to learn how to solve them” (CTGV, 2000, p.17). In the classroom, the multidimensional nature of reality is often interpreted as a density of information, a mixture of trivial and relevant information that the student must decipher in order to use the information in completion of a goal (Petraglia, 1998). One caveat of which the educator must remain aware is whose density of information is embedded in the instruction (Petraglia, 1998). “[T]he information available to a learner in such environments is not that provided by the real world, it is generated by the developers’ idea of what informational denseness and conceptual association in the real world would look like” (Petraglia, 1998, p.60).

**Community Knowledge**

“Perhaps the most difficult task in organizing constructivist learning environments…is reaching a useful accommodation between supporting students in reaching their own understandings and steering them toward an accepted body of
knowledge, i.e., the required curriculum” (Boethel & Dimock, 1999). Why is this important? Aside from issues of accountability to standard assessments, “[t]here are in fact agreed-upon concepts, principles, facts, processes, procedures, and activities that learners must learn. A significant amount of what every child must learn to earn a living and function in society…must be shared” (Merrill, 1991, p.51). The current conception of this shared knowledge in the United States is outlined for elementary and secondary school children as state/district proficiency standards. Each teacher must learn how to reach this accommodation on his/her own within the bounds of their own set of proficiency standards and classroom resources.

**Depth/Breadth of Environment**

One question that arises here is whether constructivism must be a whole school approach or can be approached on a classroom-by-classroom basis. Obviously it would be best if the entire school was managed and organized in a way that allowed for collaboration among teachers, and the traditional disciplinary boundaries were collapsed in such a way that allowed for a richer learning-centered atmosphere. Unfortunately, “the organizational and management structures of most schools militate against these goals. So…it must be done in individual classrooms” (Brooks & Brooks, 1993, p.103). The message here is that teachers interested in constructivism can employ these methods in their own classrooms regardless of what other teachers in other classrooms are doing. Unfortunately, the level of interconnectedness of disciplines available to the students will be limited. It may be harder to encourage students to take control of their own learning
REACHING STUDENTS: IDENTITY, CULTURE, AND THE CLASSROOM

In my discussion of Context in Constructivist Environments (see p.29 of this document), I stated that in order for teachers to provide a knowledge framework that best fits with their students’ needs in terms of accommodation and assimilation of new information, teachers must achieve a certain level of cultural competence in terms of their students’ perspectives, interests, and experiences. This cultural competence is at the heart of learner-centeredness, which is the main tenet of constructivism. While I made some suggestions above on how to achieve this competence, a more detailed understanding is needed of the nature of identity and culture if educators are to customize their approaches to cultural competence to their own teaching styles and classrooms. In this section, I provide a brief overview of identity and the role of culture in identity and identity performances.

A person’s identity is often spoken of in terms of components such as gender, race, ethnicity, sexuality, and class. These components act as labels for others and come with societal expectations. Individuals learn what is expected of their identity components from feedback gained through personal interaction (e.g., with parents and peers) as well as information gleaned from the markers of society’s cultural models (e.g.,
magazine images and TV shows). “Cultural models are images, story lines, principles, or metaphors that capture what a particular group finds ‘normal’ or ‘typical’ in regard to a given phenomenon” (Gee, 2003, p.143). These cultural models\textsuperscript{10} are often incorporated into identity at an unconscious level, and group members will verbalize these models differently in various situations.

“The dialect we speak, the degree of formality we adopt in our speech, the deeds we do, the places we go, the emotions we express, and the clothes we wear are treated as indicators of claims to and identification with social categories and positions of privilege relative to those with whom we are interacting” (Holland et al., 1998, p.127). Take for instance the scenario of ordering a meal in a restaurant and being asked if you would like garlic bread with your meal. You are somewhat tight on money. Do you ask “Is it free” or “Is that included with the meal”? The choices an individual makes in even simple situations such as this one convey to others what social class that individual comes from and triggers a corresponding response as to how you should be treated.

In spite of the increasing diversity of the student population, the teaching population continues to consist of “primarily white, middle-class females” (Tauber, 1998). Thus, white, middle-class cultural codes permeate the classroom in conceptions of the ideal student. Black students tend to expect a teacher to be tough with the students and tell them what to do, but white teachers give more implicit orders and become frustrated or angry when Black students do not respond correctly (Delpit, 1988). This failure to understand the implicit codes of a cultural world that is not their own has led to

\textsuperscript{10}I see cultural models as a special case of mental models in that the cultural models are specific to cultural components.
many failure theories in the United States, such as the mental health model, the early education model, and the specialization model\textsuperscript{11}. Teachers often have no problems reprimanding students for not knowing the codes, but rarely if ever are these codes addressed specifically. In fact, many proponents of a liberal education, under the impression that being explicit can “limit freedom and autonomy” (Delpit, 1988, p.284), openly oppose directly addressing these implicit codes.

To prevent the perpetuation of failure theories and the miscommunications rooted in disparate cultural models that give rise to them, constructivist teachers should position themselves as researchers of their students’ cultural models. Because of the largely unconscious nature of these cultural models, researchers of cultural models – in this case, teachers – must thus rely on a combination of verbalizations and observations to understand cultural models (Gee, 2003). Through conversations with and observations of the students in the classroom, teachers form an understanding of who the students are and can work to tailor educational experiences to these cultural models and interests, linking educational content to the lived realities of the students. By employing such a pedagogy, teachers work to create a classroom “space” for the students’ cultural models instead of a classroom “place.” The distinction between places and spaces is discussed below. While that distinction focuses around collaborative environments, the discussion can easily be translated back to the classroom environment.

\textsuperscript{11} See Gordon (1982) for a description of these failure models.
COLLABORATION: PLACES AND SPACES

Given that this study is concerned with the process of instructional design, how individual cultural models influence collaboration within a group (in this case, an instructional design team) is the focus of my discussion of place versus space. According to Merriam-Webster Online\(^{12}\), to collaborate is “to work jointly with others or together especially in an intellectual endeavor.” This seems innocuous enough, but the choice of team members, the type of questions asked and evaluations used, all work to create a certain space. Talburt (2000) helps us to understand a space as “a place in use” (p.19), where a place “represents an order of distributed relationships, location, and fixity, such as a given culture to be transmitted, an interpretation to be learned, or defined skills and methods of reasoning to be acquired” (p.19); the performance of identity components (as per a person’s cultural model) acts as the catalyst.

While each member exists as a collection of many shifting identities or identity component performances\(^{13}\), the dynamics of a collaborative environment tend to fix each member into a single identity performance within that environment. This performance may or may not be true to the individual’s inclinations, and can be structured and fixed in a number of ways. The labels that tend to define an identity, such as race and sexuality, define a person in ways that are not always obvious and in ways of which the person may not even be aware (Talburt, 2000). Labels come with expectations. These expectations

\(^{12}\) http://www.m-w.com/

\(^{13}\) In my own life, I take the concept of shifting performances to describe the idea that I perform one set of characteristics with my family, another for my friends, another in my academic and professional life, and so on. While there are common threads that run through all of these performances, there are certain aspects of my personality that I have learned to repress or accentuate in each of these contexts. See Hall (2001) for more on shifting identities.
can blind/deafen team members to the actual identity being performed by an individual, even the possibility that the labeled identity can be performed in another way. “Space can be squelched by assumptions that everyone shares a particular perspective or by impositions of such a perspective. If space does not allow for contestation, then it is no longer a space” (Blackburn, 2003, p.2). On the other hand, threats of oppression and perceived vulnerability can result in a person squelching aspects of his/her identity of their own volition (Blackburn, 2003). Expectations for labels can be ascertained by studying how team members receive various performances, but a collaborative space cannot be structured in advance in such a way that allows for all team members to be in their comfort zones. Comfort zones vary from person to person and from context to context, and as these shift so too can an individual’s perception of being boxed in or supported by the expectations of the label (Blackburn, 2003).

This space has implications for ideology\(^{14}\) both during and after the collaboration. As stated by Belsey (1996):

> [I]deology is both a real and an imaginary relation to the world—real in that it is the way in which people really live their relationship to the social relations which govern their conditions of existence, but imaginary in that it discourages a full understanding of these conditions of existence and the ways in which people are socially constituted within them…It is a set of omissions, gaps rather than lies, smoothing over contradictions, appearing to provide answers to questions which in reality it evades, and masquerading as coherence in the interests of the social relations generated by and necessary to the reproduction of the existing mode of production. (p.594)

The collaboration tends to perpetuate the existing societal ideology, the existing cultural models, as each member of the collaboration has little choice but to start with the ideology s/he has been socialized to accept. The collaborative space thus reflects the

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\(^{14}\) An ideology is that which a group takes as “common sense” explanations or expectations.
norms of a culture (dominant or not), privileges certain voices and ways of knowing and understanding, and implicitly and explicitly creates power dynamics. This is not to say that ideology is a constant. Team members bring their own idiosyncrasies to the collaborative space, which resist and reinforce the societal norms, gloss over and expose the gaps, in various ways.

In the classroom, ideology primarily takes the form of the learning theory employed and the behavioral norms expected of the group of students. The students best able to succeed in the classroom, then, are those who are able to assume the subject position\textsuperscript{15} set forth by the ideology, as these are the students for whom the classroom functions as an educational “space”. As an example, I defer to Biggler’s (1996) study on the ways in which teacher-constructed classroom environments block and affirm the voices of non-mainstream students, and how student academic engagement can be influenced as a result. The school participating in the study was experiencing a rapid increase in the number of Puerto Rican students in a traditionally Italian- and Polish-American community. The participating teachers, Mrs. L and Mrs. T, each approached the concept of inclusive education differently in their English classrooms. Particularly, Mrs. L focused on grammar drills and other mechanics in an effort to bring the Puerto Rican into the mainstream, intentionally bypassing or squelching opportunities to bring student culture into discussions, while Mrs. T worked to foreground student backgrounds and personal stories as a means of discussing literature and literary mechanics. The ways in which they addressed multiculturalism in the classroom further conveyed their

\textsuperscript{15}A subject position can be understood as the cultural model for which the ideology seems obvious or intuitive.
conceptions of the ideal subject position for students. Below I contrast examples from the teachers’ discussions of the Nicholas Mohr book *The Window Display*. The first is from Mrs. L’s classroom.

When she did encounter a Spanish term in reading aloud a biographical sketch of Nicholas Mohr’s childhood to her class, she stopped at the word *barrio* and pointed to her two Hispanic students to ask them to guess at what the missing word was:

Mrs. L.: [reading aloud] *Nicholas Mohr was born in Manhattan, where she grew up in El —?—*. [Teacher pauses] The word begins with “B.” [pointing to the two Hispanic students in the classroom] You Hispanic students have some insights here? [No response from two students. Long pause] *Barrio. She grew up in El Barrio.*

(Biggler, 1996, p.26)

This next example is an excerpt from Mrs. T’s classroom discussion regarding a character in the book.

Mrs. T: He’s learned Spanish, he’s picked it up rather—or, English—and he’s picked it up rather quickly, but of course he has the accent, and sometimes that—
David (Puerto Rican): What accent?
Mrs. T: A little Spanish accent. Wherever you come from, you bring with you, the one—
Mario (Puerto Rican): [addressing David] You know how you—
Carmen (Puerto Rican): ()
Mario: Sometimes your grand—my grandmother, my grandmother says, instead of “yellow” she says “jellow.”
(Biggler, 1996, pp.21-22)

Through interactions such as these, it can be seen that Mrs. L created a classroom “place,” while Mrs. T created a classroom “space” for her Puerto Rican students. The engagement levels of the students in these classrooms was affected accordingly, with Mrs. L’s students showing fewer signs of academic engagement.
Like the teaching style of Mrs. T, a collaborative space that allows for critical reflection of the ideology and ideal subject positions offers the possibility to break free from the “givens” of the dominant ideology and creates the possibility of an alternative space\textsuperscript{16}, a new local ideology.

**COMPUTER SOFTWARE AS A PLACE/SPACE**

The virtual environment of a computer software program should also be thought of as a place that has the potential to be a space, as any byproduct of a collaboration in turn reflects the ideology of the collaborative space. These byproducts encapsulate the ideology of the collaborative space and set forth an ideal subject position from which these byproducts are best understood and used.

Educational discourses and practices are filled with conscious and unconscious assumptions and desires about the who that a curriculum or pedagogy is addressed to. The field of education is driven by research aimed at determining ever more exactly who the student is so that s/he can be more efficiently and effectively addressed. And such assumptions, desire, and research shape education’s structures of address to its imagined audiences. (Ellsworth, 1997, p.58)

Computer software is no different. The language used to convey the content embedded in the software, the interface images and navigation controls, and the feedback mechanisms employed all work to implicitly label the “who” the technology was designed for. As with other identity labels, this “who” also comes with expectations in terms of life experiences of the student, what motivates that student to learn, and what

\textsuperscript{16} It may seem at this point as if I feel that critical awareness will solve all problems. This is not the case. It is quite possible that the hubris of individuals claiming to be critically aware will blind them to their own assumptions. This is a danger that anyone working in a self-proclaimed critically aware collaborative space needs to remain mindful of.
type of guidance and affirmation that student requires for learning. In this way, the computer software is a place that has the potential for space. Those students who fit the “who” constructed by the designers of the computer software will be most successful in both the virtual environment and in transferring the knowledge gained within the virtual environment back to real life situations.

However, success within the virtual environment does not necessarily indicate that the “who” of the software has corresponded to the student’s identity. Rather, the student may merely be a competent reader. Competent readers have learned how to decode the signs and representations of a genre and can be successful navigating through such genred space without ever becoming the ideal spectator17 (Gledhill, 1997). For example, in a genre such as games for girls, the signs and representations include the avatars available to players and game play features. Understanding these cues and how they affect the game experience are key to game success. To be the ideal spectator, the girl would have to be the embodiment of the user characteristics, the “who,” embedded in the software by the designer(s). So while students may be able to succeed in the virtual world as competent readers, the learning experience provided by the computer software will be more meaningful and successful as a learning experience if the “who” of the software better corresponds to the actual students using the software than the identity students can assume for the purpose of software use. In terms of cultural models and context, this means that students will be better able to assimilate and accommodate new information when it is presented to them within their existing cultural model frameworks,

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17 The ideal spectator is the person whose cultural model best aligns with the intended reading of the genre, that is, “the spectator for whom the text is made, which the text needs in order for its constructed meanings and pleasures to be fully realized” (Gledhill, 1997, p.373).
thereby increasing the probability that students will recognize the connection between new information and old.

With this understanding of the “who” of computer software, I turn next to the “when and where” of computer software in the constructivist environment.

**CONSTRUCTIVIST LEARNING THEORY AND COMPUTER TECHNOLOGY**

So what is technology’s place in the constructivist environment? To answer this question, it is important to first qualify that technology does not have the power to do anything (DeVaney, 1998). Rather it is “how teachers and students use available technologies” (Driscoll, 2002). An educational environment based on constructivist notions places technology as a resource for learning rather than something to learn from or as an opportunity to gain technological literacy alone (Boethel & Dimock, 1999).

While no technology can be constructivist on its own, its design can lend itself to constructivist applications. This is not to say that the technology could not be used in standard, non-constructivist, non-learner-centered ways. For example, when using the software program Inspiration™, a program that allows for drag-and-drop iconic flowchart creation, constructivist teachers could have students explore their understanding of certain concepts in a graphical manner, but non-constructivist teachers could use the program to map a prescribed set of ideas, events, etc. Unfortunately, due to time constraints and a mountain of demands, it is easy for teachers to slip back to this non-constructivist approach. This is especially true when using computer technologies, which
traditionally lend themselves to drill and practice and linear transmission models of teaching and learning.

Given the reliance on learner-centeredness, it might be easy to believe that the only “good” constructivist technologies are those generic enough for students to manipulate on their own, such as an authoring environment, or communication technologies that foster collaboration, such as email or online chats. This is not the case.

Computer technologies have a wide variety of communication and multimedia capabilities that can be used to (1) probe and organize student knowledge, (2) explore concepts in simulated environments, and (3) prompt reflection (Boethel & Dimock, 1999). In the first case, using technology as the probe for current student knowledge and understanding gives teachers a basis for guided exploration and reflection. Students can use programs such as Inspiration™ to map their current conceptions of topics, which can then be used to aid group discussion before the topic is explored. In the second case, the teacher can set herself up as the initial probe to frame an exploration of student-held conceptions on the computer, and then enter the scene again to guide reflection. Applications such as SimTown™ allow students to not only engage in simulated activities, but customize those simulations to the student’s own lived experiences in their own cities and towns (see Adams and Burns (1999) for a full accounting of this example). Reflection must be engaged in to help students “consolidate the concepts and procedures they learned” (Maddux et al., in Boethel & Dimock, 1999, p.21). In the third case, reflection can be folded into the technology itself when that technology is used as a communication tool among students or between students and community members,
locally or globally. One such example is Electronic Learning Circles, which allows students to receive feedback not only from their own teachers but also from teachers around the world (Boethel & Dimock, 1999). The key to making these processes constructivist is tying the technology-based experience to other classroom activities and to larger community (real-life) contexts in a way that fosters engagement and enables student-directed meaning-making.

In Chapter 1, I noted some of the practical demands of the classroom, particularly those set forth by state/district proficiency standards. In this context, how can software designers, according to constructivist principles of learning and technology integration, aid teachers in aiding students in the individual construction of knowledge while still meeting (or surpassing) the requirements of the state/district proficiency standards and other curricular constraints? Below I detail four criteria that I believe enable software designers to work within these tensions.

**SETTING SOFTWARE CRITERIA: THE PRACTICAL CONSTRAINTS OF CONSTRUCTIVISM**

In this section, I derive the four Software Criteria (see Table 1.1) based on the previous discussions of constructivism, cultural models, and instructional design, on the Chapter 1 discussions of the political demands set forth for the schools, and the practical constraints of the school environment.

The first criterion pertains to state/district proficiency standards. Regardless of the learning theory employed, standardized testing has ramifications for nearly every
classroom in the United States. The requirements of the proficiency standards can be at odds with the nature of learning, and even inhibit the directions in which teachers would naturally develop a lesson. Rather than work as if these tensions are not significant or can be ignored, the first criterion I list is that the software aid students in meeting state/district proficiency standards. By acknowledging the importance of standards in this way, I posit that the software can be assured of aiding students in meeting the standards, as well as designed to surpass these standards and meet the learning requirements of the teachers and students. Thus, the first criterion requires that, “The software aids students in meeting state/district proficiency standards.”

Second, recall that the first component of creating a constructivist learning environment is planning that environment (refer to p.28 of this document). These environments are shaped first and foremost by the teaching philosophies of teachers, within the constraints set forth by the teaching philosophies of the school as enforced by the school’s administrators. Technology integration is under similar constraints, that is, determined by both the teachers’ and administrators’ philosophies for integration. This constraint is in response to the recognition of the ways in which classroom resources can shape the curriculum. By working within the teachers’ and school’s philosophies of teaching, learning, and technology integration, the software can be used to promote the classroom culture desired by teachers and administrators. Therefore, the software should be compatible with the teaching and technology integration philosophies of both the teachers and school policy/administration. Thus, the second criterion states that, “The software is compatible with the teaching and learning philosophies of classroom teachers.”
Such software should also be compatible with their philosophies of how technology should be integrated into the classroom, as well as school policies on technology integration.”

The third criterion works to incorporate the implications of cultural models on the individual construction of knowledge. Rubin et al. (1997) tell us that engagement with the material is a “necessary (but not sufficient) prerequisite for … learning”. Finding ways to tie the software to the students’ cultural models is one means of creating a “space” for students with the software, thereby fostering academic engagement. The implications for a classroom space versus place, as they relate to academic engagement, were highlighted in the anecdotal evidence provided by Biggler (1996). Similarly, designing and placing computer software as an extension of the classroom’s space extends that classroom’s space to encompass the technology. As such, the third criterion stipulates that, “The software present the content in such a way that it aids students in the individual construction of knowledge, in keeping with the students’ cultural models.”

The final criterion addresses the depth/breadth to which constructivism should permeate the learning environment. As stated in the discussion of constructivist learning environments, constructivism is most effective when it is applied across all classrooms in the school (refer to p.35 of this document) and the contexts within which information is presented reflects the multidisciplinary nature of real-life situations. This can contribute to an understanding of the context of school knowledge, which fosters deep understanding and transferability. Once compatible lessons or information have been identified, teachers should be relied on to assess the amount of information to be included
in this software in order to avoid overloading students with the complexities of the overlapping of disciplines as encountered in day-to-day life. This, too, works within the second criterion pertaining to planning the educational environment. Thus, in the interest of presenting information in as realistic a manner as possible, without overloading the students with too much information, the fourth criterion states that “The software should integrate information from at least two subject areas.”

With these Criteria now in place, the question now becomes: how could such software be constructed?

INSTRUCTIONAL DESIGN: THE CREATION OF COMPUTER SOFTWARE

Instructional design (ID) is the process by which computer software is designed and developed. As noted in Chapter 1, it is generally conceived of as a linear process, and is believed to implicitly incorporate the behaviorist and cognitivist philosophies from which it originated. In short, proponents of these philosophies believe that learning activities can be preselected towards predetermined outcomes, and that these activities and outcomes are universal for all students.

The ID model is traditionally based on a very quantitative worldview, meaning that only those aspects of end-users and learning activities that can be clearly measured are taken into consideration. Morrison et al. (2001) provide us with a very succinct model of a typical ID process, which they call “The Complete Instructional Design Plan”:

1. Identify instructional problems and specify goals for designing an instructional program.
2. Examine learner characteristics that will influence your instructional decisions.
3. Identify subject content, and analyze task components related to stated goals and purposes.
4. Specify the instructional objectives.
5. Sequence content within each instructional unit for logical learning.
6. Design instructional strategies so that each learner can master the objectives.
7. Plan the instructional message and develop the instruction.
8. Develop evaluation instruments to assess objectives.
9. Select resources to support instruction and learning activities.
(p.6)

Though they say that this plan need not be linear, they claim that novice designers should follow these steps in order. Note the emphasis on organizing and sequencing content for the accuracy, efficiency, and success of the software product. While not explicitly addressed, designers using models such as this one tend to share the belief that the software produced is meant to be a stand-alone instructional unit rather than a supplement or resource to a larger educational unit. The design plan above implies this in the fact that content, instruction, and assessment (i.e., the entire instructional unit) are combined into the instructional program itself (steps 1-8), with supporting (external) resources selected only at the end of the development of the instructional program (step 9). These external resources are also termed “Support Services”. In other portrayals of this model (see Figure 1), these other resources are developed/selected in the same stage of development as the Summative Software Evaluation (i.e., the final evaluation of the software that marks the end of development).

“Instructional designers’ under-elaborated acknowledgement of the ill-structuredness of everyday situations has erected and reinforced a model of the learner that moves with great efficiency through problem-spaces toward clearly identifiable solutions or at least a finite set of possible alternatives” (Petraglia, 1998, p.60). These
tenets are contrary to the philosophy of constructivism as described above (e.g., the real-life density of information that needs to be interpreted and culled to find the problem space, without reliance on only one “right” way to solve the problem; the social and cultural aspects of knowledge construction). Additionally, while some instructional designers contest the mechanistic nature of the ID model, claiming instead that this approach is in fact humanistic (i.e., learner-centered), a closer examination of how they define humanistic belies this claim. Morrison et al. (2001) explain the philosophy behind their ID model as follows: “[a] humanistic approach to instruction recognizes the individual learner (student or trainee) in terms of his or her own capabilities, individual differences, present ability levels, and personal development” (p. 17). At first, this philosophy seems compatible with constructivism, in that designers are meant to focus on accommodating individual nuances in the users (e.g., students) of the instructional product. Yet, further exploration of this philosophy shows that the conception of the individual learning is not quite what constructivists have in mind.

Elements of the process include examination of learner characteristics and identification of readiness levels for learning. Furthermore, the application of systematic planning for designing various forms of individualized or self-paced learning also can allow for various individualized styles of learning. (Morrison et al., 2001, p.17)

By conceptualizing the learner as merely the sum of that learner’s abilities, prior knowledge, and learning style, cultural aspects are ignored. As noted above in the discussion of Context in Constructivist Environments (refer to p.29 of this document) and the discussion of Reaching Students (refer to p.36 of this document), these cultural aspects are essential to providing the proper framework for knowledge assimilation and
accommodation. Additionally, by focusing on individualized (solitary) learning, the social aspects of learning are also ignored.

Some designers, categorizing their work as constructivist-ID, have tried to incorporate constructivism by selecting “preauthenticated” content. “Preauthentication presumes that one can separate those tasks that are inherently authentic from those that are not” (Petraglia, 1998, p.59). Is this not what teachers are doing when they plan a constructivist environment? Not quite. Recall that students’ perceptions of reality (i.e., their mental models) are based on their experiences and informed by their cultural backgrounds (i.e., their cultural models). As Petraglia (1998) notes,

A problem with the goal of authenticating learning arises with we remember that constructivism argues that the world is not understood independently of our experiences, and that, therefore, any sense of authenticity can be neither predetermined nor preordained…that is, a thing is real insofar as it is prerequisite (i.e., implicates) other things which we believe are real. Thus, much of what we know to be real is not known in any objective sense, but is believed (in the fully tentative sense of that word) to be real. (Petraglia, 1998, p.58)

In a constructivist learning environment, teachers first probe student knowledge to understand how students currently conceive of their realities. The exploration of the concept(s) in question is then tailored according to this probe. Preauthentication builds in assumptions (noted primarily in #2, #5, and #6 of the complete instructional design plan listed above) about the lived realities of students, potentially excluding groups of students according to race, ethnicity, class, gender, age, etc.

The tensions surrounding ID originate from both the constructivists and the traditional designers. Traditional designers contrast their well-documented methodology for design with the lack of documentation and rules for constructivist design (Merrill,
Constructivists, on the other hand, trouble the intentions of the traditional designers with respect to conceptions of the learner, the learning process, content, and educational goals, among other concerns. I believe that many of the constructivist concerns can be alleviated by viewing “constructivism as a philosophy and not a method, while treating ISD\textsuperscript{18} as a method and not a philosophy” (Dunn, 1994, p.85). Using this approach, the flexibility constructivism offers can shift the focus of, and possibly even strengthen, the process of ID. I explore my own conception of how constructivism can be applied to the ID process below.

**REVISING INSTRUCTIONAL DESIGN: WHO DESIGNS?**

Regardless of the designer’s understanding of learning, technologists have tended to be non-educators\textsuperscript{19} with a propensity towards viewing the technology as a finite lesson or activity\textsuperscript{20}. There is no explicit understanding of the technology as working within a larger lesson plan context. This is not to demonize the educational technologists. On the whole, technologists involved in instructional design (ID) are just trying to do a job, to make a good product. Wilson (1997) claims that “ID theories are much closer to

\textsuperscript{18} ISD stands for Instructional Systems Design. I take ISD as synonymous with ID here.

\textsuperscript{19} Muffoletto (1993) has noted that throughout the history of instructional (software) design, the designers have tended to be engineers or other field experts outside of the classroom, while teachers were viewed as managers of the curriculum, there to deploy the software. This tendency is a byproduct of the idea of “teacher proof” curriculum materials. Apple and Jungck (1990) and Apple (1994) have also noted this phenomenon in their work on the deskilling of the teaching workforce. Of course, this point regarding the occupation of designers is not to discount those teachers who have designed and implemented their own technologies into their own classrooms (Bork, 1993), but rather to note that they comprise only a small percentage of the group of educational technologists.

\textsuperscript{20} This view of the software product as containing the entire lesson is inherent in the ID model’s encapsulation of content and assessment into the final software product, and the selection of what Morrison et al. (2001) term “Support Services” (see #9 of their ID model above). Through this phraseology, it is apparent that information outside of the software is considered supplementary to the software, rather than the software being supplementary to other curricular items.
engineering than to science. They are about how to get something done, how to design a solution, not about how the world is. In that sense, they are really less theories and more models for action, for problem solving.” While Wilson makes a valid point regarding the problem-solving bent of ID, what he overlooks is that the theories technologists use, such as the learning theories discussed above, contain assumptions about how the world is, and these assumptions are encapsulated in the technologies that the theories inspired. For example, are students forced to explore the embedded content in a linear fashion, according to someone else’s conception of how the content makes sense (as with behaviorist and cognitivist approaches), or are students free to explore the content in a variety of ways or from a variety of perspectives, allowing for individualized understanding of the embedded content (as with a constructivist approach)? Further, through their role in interpreting and employing learning theories at their own discretion, the technologists are placed as the experts on educational technology.

In addition to defining how the user learns, the educational technologist also implicitly defines the identity of the user. Designers design for those like themselves (Landauer, 1995; Cooper, 1999) and are influenced by the myriad of designs they have already encountered. Thus, the way designers of a certain race, class, and gender present the content may not relate to how students of other races, classes, or genders experience that content in everyday life. When certain identities (e.g., Latinos) are not present during design discussions, the technology is less likely to reach those students who have been overlooked in that design.
Jonassen et al. (1999), Druin (1999), and Kafai (1995) give examples of constructivist instructional design in which the students themselves are the designers of the interface: the way the content is delivered to the learner, how the learner navigates through the content, and what counts as learning success and failure within the instructional unit. As a learning experience, Kafai (1995) notes that this approach is probably the ideal mergence of instruction and technology integration as students arrive at a better understanding of the material when they are required to teach it to someone else. It also ties to student interest in that students are able to create the virtual environment according to their own identities, and often implicitly involves transfer of content to other contexts and ties to real life as students work to design instruction for another group of students. However, this type of student involvement is not practical within every classroom, as it requires time outside of regular instruction and significant levels of computer access for design and implementation of the design. Druin (1999) provides an alternative in which a team of instructional designers co-designs computer technologies with students. While this is closer to the ideals of constructivism as outlined above, it still falls short of the vision of technology within a larger teacher-planned environment to ensure both learning of the material and relevance to the multiple student identities in the classroom. Druin’s model comes closer to mimicking the role of the Subject Matter Expert (SME) in the traditional ID process in that researchers are still in control of the bulk of the design process.

According to my interpretation of constructivism, the teacher guides the students through the learning experience. Borrowing from Boethel & Dimock (1999), technology
should only be used in one of the three parts of the learning experience—probing and organizing student knowledge, exploring concepts in simulated environments, or prompting reflection—rather than encompassing the entire learning experience.

Regardless of which part it appears in, the teacher-guided and learner-centered focus of constructivism demands that the content to be embedded be selected by teachers. Outside of authoring systems or generic communication tools (i.e., chat rooms), which one could argue still streamline a mode of being and thinking through their interfaces, all technology-based content is embedded. Given these constraints, I propose that content first be selected by both the teacher(s) and the educational technologist(s) in order to assess the fit of the educational technology to the subject matter. This joint effort places teachers as SMEs in the instructional design process. I also propose that students, who are relied on for issues of student identity and authenticity and relevance of content and delivery, then take the role of Delivery Experts (DEs). As DEs, students can give teachers and educational technologists insights into how best to convey information in terms of their own life experiences and their own senses of authenticity.

In order for teachers and students to assume their roles as SMEs and DEs, respectively, it is essential that, for those aspects where the researcher/designer is working with teachers and students towards the development of a software product, the researcher/designer is but one of many co-designers of a product. Everyone’s expertise must be recognized and respected. Any conclusions reached should be a negotiation between co-designers. This works towards creating a design “space” instead of just a design “place”.
Input from disciplinary experts can keep us from ‘reinventing the wheel’ or misunderstanding how concepts tie together in the grander narrative of that field, but relying on one type of expert voice also streamlines the discourse to the currently accepted way of thinking and being within that expert discourse. The notion of the expert arose as a result of “the emergence…of secularization and the decentralization of authority, the rise of vernacular technical languages…and the autonomous, detached educated individual who owed allegiance to no one or no object, person or government, except for the pursuit of knowledge and truth” (Muffoletto, 1993, p.94). The expert thus “acquired a social mandate to assign the realm of meaning and ideas in which particular definitions of reality and judgment prevail as valid and true. The expert was also charged with the shaping of the significance and meaning of the experience…the discourse” (Muffoletto, 1993, p.95). Through deference to these experts, each society develops a “‘general politics’ of truth; that is, the types of discourse which it accepts and makes function as true, the mechanisms and instances which enable one to distinguish true and false statements, the means by which each is sanctioned” (Foucault, 1980, p.131). The nature of inquiry is also limited by the discourse (Blackburn, 2003). For example, in a vision of education that sets the students as empty vessels awaiting knowledge, there is no way to conceive of the teacher as anything but a transmitter of that knowledge. If all members of a collaborative team share this view of students, then no other conception of the teacher in the classroom will be allowed for. In a similar fashion, the collaborative space created by the team of scholars who created the national standards is skewed towards scholarly concerns through its omission of teachers’ voices (Ladson-Billings,
1994), teachers who in their own right are experts in the field. The problem is compounded by those who develop the course materials for the K-12 setting, as these developers feel compelled to design according to national and state standards and to show how their products meet these standards to the exclusion of all other concerns (Kleibacker, 1999). Changing the design process to allow for more perspectives, in this case the perspectives of students and classroom teachers, begins to allow for the design of resources not currently available (Pippin, 1995). New resources, in turn, provide new opportunities for different spaces.

**REVISING INSTRUCTIONAL DESIGN: A CONSTRUCTIVIST ALTERNATIVE**

In the previous two sections I have critiqued the traditional approach to ID, as well as some of the constructivist-ID responses to the traditional approach. Based on these critiques, I have posited that constructivism can be seen as shifting the focus of and strengthening the process of ID, instead of as contrary to it. This potential lies in using the principles of designing constructivist learning environments to inform the process of ID. I have also posited that teachers should be placed as Subject Matter Experts in the role of content selection, and students as Design Experts in the role of interface design. In this section, I delineate my revisions to the ID model in the context of constructivism and the place of technology in constructivist environments, student identity, and the role of experts in educational technology design. Note that these revisions at times adjust the ordering of the steps of the traditional ID model.
The full application details of this model are listed in Chapter 3. Below I list the revised steps of the ID process, followed by a justification of each revision. Unlike the traditional ID model above, the steps of this revised model should be executed in order.

**The Revised Model**

1. Identify the places in the current curriculum in which a computer-based tool could aid in the individual construction of knowledge.
2. Identify the relevant subject content and current delivery methods for the information. Also identify the relevant proficiency standards the current unit or future unit is meant to address.
3. Conceptualize a new lesson (or modify an existing one), supplemented by the computer technology.
   a. Brainstorm with students to design and develop approaches to this lesson, in keeping with the cultural models of the students.
   b. Work with teachers to structure/sequence the students’ ideas or the student-generated software elements to fit the teachers’ needs for the lesson.
   c. Work with teachers to develop any additional materials needed by the lesson.
   d. Create or revise the prototype(s).
4. Conduct formative evaluations with teachers to evaluate the fit of the software to the teacher’s needs and with students to evaluate the delivery/environment/space of the software. This feedback can result in the return to #3 of this model, provided revision is required/requested by any of the co-designers (i.e., teachers or students).
5. Perform a summative evaluation of the final software product and the lesson components pertaining to the software.

Figure 2 illustrates the cyclical nature of steps 3 and 4.

**Justifying the Revisions: #1**

Revised ID: Identify the places in the current curriculum in which a computer-based tool could aid in the individual construction of knowledge.
This step is similar to that of the traditional ID model – “Identify instructional problems and specify goals for designing an instructional program” – but is slightly reworded to emphasize the role of technology as a supplement to a lesson instead of the lesson itself. Recall that in a constructivist environment, technology can be used in one of three phases of each lesson: (1) to probe and organize student knowledge, (2) to explore concepts in simulated environments, or (3) to prompt reflection. Further, these three phases are essential steps in the individual construction of knowledge. As new technologies are envisioned and developed, it could be the case that the existing lesson is reworked to accommodate the ways in which that technology now aids students in knowledge construction, or that a new lesson is developed because of the learning potential now offered by the technology. This revised step also rethinks the goals of the instructional program by placing the emphasis on the areas in which teachers note students are having difficulty with concepts rather than simply on those areas in which students are testing poorly. This is the first portion of the teacher’s role as Subject Matter Expert.

**Justifying the Revisions: #2**

*Revised ID:* Identify the relevant subject content and current delivery methods for the information. Also identify the relevant proficiency standards the current unit or future unit is meant to address.
Recall the traditional ID step #3: “Identify subject content, and analyze task components related to stated goals and purposes.” The revised step is similar to this step, but adds proficiency standards as a goal, as per Software Criterion #1 (aiding students in meeting state/district proficiency standards). The revised step also removes the analysis of the current tasks towards lesson objectives, as this was already fulfilled by Revised ID #1. Further, the revised model’s approach to the lesson is now defined by student input and structured according to teacher review of that input (see Revised ID #3).

**Justifying the Revisions: #3**

*Revised ID:* Conceptualize a new lesson (or modify an existing one), supplemented by the computer technology.

Rather than relying on the “expert” educational technologist to review tasks, lesson objects, and learner characteristics to devise a new instructional program, this revised step now acknowledges the value of the expertise of the teachers and students as co-designers. This revision works towards creating a collaborative “space” for instructional design. Further, it is important to address the implications of cultural models for “spaces” (#3a) and learning theory (#3b and #3c) during the design of educational technologies, because it is during this stage of software development that the biases and assumptions of the designer(s) become embedded in the technology, including the boundaries of how the technology can be used.
Justifying the Revisions: #3a

Revised ID: Brainstorm with students to design and develop approaches to this lesson, in keeping with the cultural models of the students.

This step somewhat replaces #2 of the traditional ID model – “Examine learner characteristics that will influence your instructional decisions” – while working to achieve #6 of the traditional ID model – “Design instructional strategies so that each learner can master the objectives.” At the heart of this revised step is determining what elements or features would best suit the needs of the students when approaching the lesson content. These elements and features are not only cognitive, but also dependent on the cultural models of the students. According to my discussion of expertise above, students are the best source for the ties between their cultural models and the software content. In other words, student expertise (in the form of Design Experts on a collaborative team) should be included in any discussion of the design of the instructional program.

Key to the success of this step is working with students to determine (1) how they would approach the content, and (2) ways in which they would design the instructional program to foster engagement. This also works towards satisfying Software Criterion #3: “The software presents the content in such a way that aids students in the individual construction of knowledge, in keeping with the students’ cultural models.”
Justifying the Revisions: #3b

Revised ID: Work with teachers to structure/sequence the students’ ideas or the student-generated software elements to fit the teachers’ needs for the lesson.

This step is a melding of #5 and #6 of the traditional ID model. These were to “Sequence content within each instructional unit for logical learning” and “Design instructional strategies so that each learner can master the objectives”, respectively.

Recall that one of the components of creating a constructivist environment is to steer students towards the accepted/tested body of knowledge, as recognized by the society in which they live. However, this steering is not just the achievement of testable, behaviorist outcomes, but focused on cognitive processes and deep understanding of the content. This revised step asks, Given the teachers’ discernment of where students need more help to achieve this deep understanding, as per step #1 of the revised model, how best can the approaches explored in Revised ID #3a be utilized towards aiding students over this cognitive hump? This question works towards not only tying classroom content to the students’ cultural models, but also towards acknowledging the expertise of the teachers with respect to their knowledge of their students and how students learn. This is the second portion of the teacher’s role as Subject Matter Expert.
**Justifying the Revisions: #3c**

*Revised ID:* Work with teachers to develop any additional materials needed by the lesson.

This step was step #9 of the traditional ID model: “Select resources to support instruction and learning activities.” The rank of this step in the list (and according to Figure 1) placed the selection of support materials as an afterthought. That ranking also implicitly implies that the supporting materials are there to support the technology, as opposed to the technology supporting a lesson that aids students in knowledge construction. So, the traditional model’s prioritization is contrary to both the importance of planning a constructivist environment as well as the place of technology in a constructivist classroom.

The revision works towards developing all surrounding content and lessons at the same time as the software product rather than considering them to be external to the product and to be dealt with at the latest stage of the ID process. The design team is better able to design classroom resources that fit classroom needs if they are customized and designed in conjunction with the surrounding lesson, as opposed to designing a lesson around which the teacher must create a lesson. Further, in this way, the design team is better able to design a classroom resource (i.e., the software) that fits the teacher’s needs in planning a constructivist environment. This also resists the traditional means of incorporating technology into the classroom, which, according to Muffoletto (1993), requires that teachers design their lesson plans to accommodate the “teacher-safe”
technology rather than designers designing technology to meet the needs of specific classroom teachers.

**Justifying the Revisions: #3d**

*Revised ID*: Create or revise the prototype(s).

This step is similar to that of traditional model’s #7 – “Plan the instructional message and develop the instruction.” In the revised step, the final instructional message is developed during this step by the educational technologist as a combination of student (#3a) and teacher (#3b) input, tempered by the technologist’s understanding of user needs (e.g., fonts, mouse dragging versus clicking) in computer-based instructional environments. This message is then implemented in the form of at least one prototype for review in Revised ID #4.

**Justifying the Revisions: #4**

*Revised ID*: Conduct formative evaluations with teachers to evaluate the fit to the teacher’s needs and with students to evaluate the delivery/environment/space of the software. This feedback can result in the return to #3 of this model, provided revision is required/requested by any of the co-designers (i.e., teachers or students).

This step works towards fulfilling both Software Criterion #2 (within the teaching/learning and technology integration philosophies of the teacher/school) and
Software Criterion #3 (aiding students in knowledge construction, within their cultural models). It is similar to that of the traditional model’s #8 – “Develop evaluation instruments to assess objectives” – taking the form of a Formative Evaluation conducted with teachers and student designers. Following Revised ID #3, the educational technologist has created at least one prototype for review. All prototypes created must also be evaluated for the extent to which they meet the needs of the classroom teachers, and the extent to which they engage the students. According to Chapman (2003),

Children who are engaged show sustained behavioral involvement in learning activities accompanied by a positive emotional tone. They select tasks at the border of their competencies, initiate action when given the opportunity, and exert intense effort and concentration in the implementation of learning tasks; they show generally positive emotions during ongoing action, including enthusiasm, optimism, curiosity, and interest.

Engagement in this context should be gauged not only by the self-reporting of the students towards these ends, but also by visible signs of engagement as observed by teachers and/or the educational technologist conducting the evaluation. And, as noted above, engagement is a necessary condition for learning. Engagement with the software is also used here as a means for assessing whether the students’ cultural models have been accommodated by the software “space”.

If multiple prototypes were created for this step, then a single prototype should be selected for further development for the next round of revisions. Revisions are based on the feedback from the evaluation, the inclinations of the educational technologist, and any revisiting of #3a, #3b, or #3c, as needed. This cycle should continue until the design team is satisfied with the instructional program.
**Justifying the Revisions: #5**

*Revised ID:* Perform a summative evaluation of the final software product and the lesson components pertaining to the software.

Like Revised ID #4, this step is again similar to #8 of the traditional ID model. Unlike the evaluations of that step, this step also includes the feedback of other students of the same population. The point of this process is to design software that aids at least students of the same school district in the individual construction of knowledge. To this end, this step asks, How does the feedback of the larger student population compare to that of the student designers? Ideally, the instructional program being evaluated will also include the lesson developed in the previous Revised ID steps, as the technology functions as a component in a lesson and not as a standalone tool.

**CHAPTER SUMMARY**

In this chapter, I briefly explored the theories of constructivism, identity and culture, and the notion of places versus spaces. These explorations were utilized to explore the perceived tensions between constructivism and traditional instructional design (ID) methods. Rather than choose constructivist-ID or traditional ID as they are currently applied, I posited that the theories of constructivism, identity and cultural models, and places/spaces could be used to inform and revise the ID model. To this end, I formulated an instructional design model that incorporated the following elements:
1. Teachers would be placed as the selectors of software content. This works to support their roles and responsibilities in planning the constructivist environment.
2. Students would be placed as interface designers as an attempt at incorporating the students’ cultures and senses of authenticity into the software, as opposed to relying on the instructional designer’s conception of (pre)authentication.

These elements shift the idea of a humanistic (i.e., learner-centered) approach to ID away from the conception of the students as the sum of their cognitive parts (i.e., an evaluation of their prior knowledge/abilities and their learning styles as fodder for instructional design), refocusing instead on (a) including the students’ cultural models and senses of authenticity into the ID model and (b) recognizing the value and expertise of all design participants (i.e., students, teachers, and technologists) rather than just that of the technologist. By respecting the voices of teachers and students in this manner, there is also the possibility of new classroom resources, which aid in the planning of constructivist environments. Additionally, I posited that the simultaneous development/planning of the curricular components that the software is meant to supplement would further aid in planning the constructivist environment for future students.

Chapter 3 delineates the details and timeline of this revised ID process as well as the methods I planned to employ to study the practicalities and implications of this model.
CHAPTER 3

METHODOLOGY

INTRODUCTION

As stated in Chapters 1 and 2, I constructed and assessed an approach to the design and development of software for the classroom that incorporates theories of constructivism and students’ cultural models into the traditional instructional design model. This was a qualitative study. As Erickson (2003) points out, the difference between qualitative and quantitative studies is that qualitative studies are concerned with “those KINDS of things (and KINDS of KINDS) that are relevant to social actors for the conduct of their everyday lives” while quantitative studies are concerned with counting instances of those kinds of things. Since the primary goal of this study was to examine the successes and limitations of this process for future educational technology designers, my focus was on kinds of things rather than instances (numbers) of things.

In this chapter, I will explore my research design, the research approach that I theorized was best suited to the design, a review of the data collected and how these are used in future chapters to answer my research questions, and how I analyzed and synthesized the data.
RESEARCH DESIGN

Bray, Lee, Smith, and Yorks (2000) note that any person(s) initiating research should be able to introduce an initial plan, but that once in the field the researcher(s) must be open to altering the plan in light of reflections and findings during the research process. I take this initial plan to be a deterrent to what I call “researcher’s block.” I envision researcher’s block as a stuck place, somewhat similar to writer’s block in nature. In this stuck place researchers are at a loss for ideas as to how to proceed or even how to begin. Given limitations in terms of resources (i.e., the time constraints of the school year and day, and lack of money for hiring additional prototype programmers), I worked to create an initial research design that was as detailed as possible. This plan included a timeline and an overview of the phases of the project, including the specific time required for each phase, the participants involved, and what data I planned to collect.

It was my intention that any revisions made to this process once product development (Phase 2) began would be negotiated with the participants, my fellow designers. This decision worked towards minimizing the one-sidedness of conventional research “which gives the researcher exclusive control of the research design, the final account, and subsequent use of the material” (Eisenhart, 2000). These last two points are addressed again in the data analysis section of this chapter. An analysis of the revisions to this research plan is the focus of Chapter 4.
Site and Sample

I chose Lochley Intermediate\textsuperscript{21} as my research site primarily because I knew one of the teachers there, Ethel\textsuperscript{22}, and she had expressed an interest in working with me. I met Ethel while she was working on her Master’s degree at OSU, first as a student in a class for which I was a TA, and then as a fellow student in a class on evaluating (constructivist) educational technologies. It was during this second class that I had a chance to visit Ethel’s school as part of an assignment. Ethel’s constructivist teaching philosophy, methods, and use of technology made her an excellent candidate for participation in this study. Given her willingness, as well as the technology resources at her school, I felt comfortable that she and her school site would meet my requirements. Ideally, these requirements included a school with relatively up-to-date technology, access to technology on a whole class basis (meaning every student could sit at his/her own computer during evaluations), and teachers interested in technology integration and an integrated curriculum. These teachers also needed to be from different subject areas in the same grade level. Having teachers from the same grade level meant that their students would be entering the study with similar knowledge bases and could contribute equally to the designing and testing of the software program(s) produced during this study.

After confirming with Ethel over email that she was indeed still interested in working with me, I sent a formal letter of inquiry to the school (see Appendix A). I also attached a research proposal with a tentative timeline and list of required resources (see

\textsuperscript{21} The name of the school has been changed in order to protect the identities of the student participants.

\textsuperscript{22} All participant names are pseudonyms.
Appendix B). The principal contacted me over the phone to discuss the research proposal I had sent him, and to ask a few questions of his own. Soon after this conversation I received a letter in the mail indicating that I was permitted to conduct my study at his school. For reference, the list of key participants at this school is located in Table 3.1. I have also noted the genders of the student designers.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Position or Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eric</td>
<td>Principal</td>
</tr>
<tr>
<td>Agnes</td>
<td>Assistant Principal</td>
</tr>
<tr>
<td>Nancy</td>
<td>Math Teacher</td>
</tr>
<tr>
<td>Ethel</td>
<td>Science Teacher</td>
</tr>
<tr>
<td>Bailey (f), Bill (m), Candy (f), Dexter (m)</td>
<td>Student Designers – Math</td>
</tr>
<tr>
<td>Freddy (m), Jaeger (m), Klutz (f), Snoopy (f)</td>
<td>Student Designers – Science</td>
</tr>
</tbody>
</table>

Table 3.1: List of Key Participants.

I realize that this choice of school and participants constitutes a convenience sample. Convenience samples are those that arise from the ease with which the researcher is able to draw together the participants (Herek, 1997). Questionnaires conducted in malls are one example. Findings based on convenience sample studies cannot be generalized to the entire population (the group the sample is meant to represent) as the researcher has not taken the steps necessary to ensure that the sample used is actually representative of the population as a whole (Herek, 1997). Only a truly randomized sample can achieve this level of generalization. Nonetheless, given the time constraints of the study, the cooperation of a teacher that I knew shared my philosophies
of constructivism and technology, and my belief that the school’s facilities met the needs of this study, I felt comfortable that this convenience sample would not compromise this study.

Although my findings cannot be generalized to the entire population, providing a rich context still allows others to assess the transferability of my findings to their own situations (see Guba & Lincoln, 1989). In Chapter 7, I will discuss potential strategies for such transference. Below I describe the site and sample in terms of community, district, school, teachers, and classes. In this way I hope to contextualize not only my direct interactions with participants, but also the larger context within which we were working. This information provides a basis for my explorations of the facilitators and barriers to the success of my software design approach, as well as the primary basis for the discussion in Chapter 7 of the transferability of the study findings. Much of this specific information was not known prior to the commencement of this study, and so did not impact the development of the instructional design model employed. Nor did this information impact the development of the larger Research Design plan. Rather, the design plan was meant to be generally applicable to schools that exhibit the same general characteristics as the school described below.

Community

Lochley Intermediate is located in Alma Village\textsuperscript{23} in Central Ohio. Alma Village is a community that is rapidly evolving from a traditional, rural environment to a growing metropolis. The current population of Alma Village is about 16,000. The population is

\textsuperscript{23}“Alma Village” is the pseudonym I chose for the city in which the school is located.
roughly 90% White Non-Hispanic, 6% Black, 1% multiracial, 1% Hispanic, and 0.6% American Indian. 1.3% of the population is not U.S. born. Median household income as of 2000 was $46,765 and the median house value was $132,400.

There are 7 colleges or universities within a 40-mile radius of Alma Village. Even so, most of the Alma Village residents (83.5%) claim only an education level of high school or higher, with only 16.3% reporting a Bachelor’s degree and 3.1% reporting a graduate or professional degree. Only 2.7% of the population is unemployed, which is below the national average. A large car manufacturer, Autoval24, employs the greatest percentage of the employed population.

District

Lochley Intermediate is located in the Orchard School District25. While the district currently consists of approximately 5,000 students, population estimates suggest a 30% increase over the next 10 years26. There are five elementary schools (K-4), one intermediate school (5-6), one middle school (7-8), and one high school (9-12). Teacher salaries in this district range from $32,000 to $77,696, based on years of experience and education levels. Across the district, 98.6% of all teachers have at least a Bachelor’s degree, and 50.3% have at least a Master’s degree.

Community support from local businesses seems to be expected in terms of “major contributions of land, goods, funds, as well as the appreciated time and energy of

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24 In the interest of preserving the anonymity of my participants, this name is a pseudonym.
25 As with the school name and the name of the participants, the name of the school district has also been changed.
26 These figures are from the Orchard School District website.
their employees. Community support is further reflected in successfully passed levies. In order to support levies and bond issues, the district website provides not only their own summary of the levies and bond issues, but also newspaper reports on these. A tax calculator is also provided through the Office of the Treasurer web page so users can assess the effects a levy would have on them. Parental involvement is expected for activities ranging from tutoring to craft shows and pumpkin carving nights.

In terms of curriculum, not only is Autoval the largest employer in the area, but it also has a great influence over the schools through the quality tools they offer through their Autoval Education Service Program. These tools will be detailed in more depth in the School section below.

The district maintains a web space dedicated for staff use, which links to curriculum guidelines and resources, health insurance claim forms, and salary information. The majority of the curriculum links and resources are for information on “No Child Left Behind”, Grade Level Indicators, and Content Standards. Also highlighted here is the district’s emphasis on continuing professional development, as evidenced by links to the Central Ohio Regional Professional Development Center and the Association for Supervision & Curriculum Development.

While their web pages are well designed and informative, the technology policy for the district has not been updated in two years. While this could be a reflection of a robust policy, it could also be a reflection of the fact that the district’s technology

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27 Again, this information is from the Orchard School District website.
28 http://www.cositpd.org/
29 http://www.ascd.org/portal/site/ascd/index.jsp

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committee, responsible for the review and selection of software for the district, has only met once in the last four years.

The district’s mission statement reads, “The Mission of the Orchard School District is to provide educational opportunities for students of all ages and abilities to reach their fullest potential so they will make a meaningful contribution as life-long learners to our community, and society as a whole.” With this in mind, the grade levels have been organized in a way that is meant to scaffold the students’ individual growth and independence. In terms of classroom environment, this means that elementary students stay in the same classroom all day with the same teacher, while in 5th grade they transition to two teachers, four teachers in 6th grade, and a different teacher/room for every subject in middle and high school. The curriculum and extra-curricular activities offered also expand to accommodate the perceived needs of the students at every level as they become functioning members of society. For example, by the time students reach high school, they are offered the choice between three foreign languages and 11 advanced placement courses. Sports and various club and organization memberships are also available to students at all grade levels.

In terms of standardized testing, this district is doing quite well. According to the 2004-2005 Report Card, this district is rated ‘Excellent’. They met 23/23 of the state indicators, have a performance index of 95.8/120, and have met the requirements for Adequate Yearly Progress.

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30 Access to and explanations of these report cards can be found at http://www.ode.state.oh.us/reportcard.
School

Lochley Intermediate was in its fourth year of operation at the time of this study, and houses 5th and 6th grades only. This is the only public school in the district that covers these grade levels. The building is quite new, and is situated in the middle of a rapidly expanding housing development. A drive through this housing development gives a feeling of moderate affluence, as the homes are mostly two stories with garages, and have small lawns and standardized exteriors. The school facilities include a large lunchroom, complete with vending machines and a hot lunch line available to both staff and students, a gymnasium with bleachers and a basketball court, both band and music class resources, a kiln, an outdoor recess area, two staff lounges, two computer labs, a library space in which students can access research materials both in book format and on the computer during lunch or other free times and where A/V equipment such as the Elmo machine is stored, a school store in which students can buy pencils and other odds and ends, and two full wings of classrooms.

Within the school, 100% of the teachers have at least a Bachelor’s degree, and 68% have a least a Master’s degree. In addition to meeting the ongoing licensure requirements for professional development, the teachers also attend various in-services and workshops selected and arranged by the school administrators, and whatever other sessions the teachers feel are necessary. The district also reimburses teachers for their expenditures at conferences.

31 In spite of the newness of the building and the two wings of classrooms, Lochley Intermediate is still feeling the impacts of the rapidly growing local population. During the 2005-2006 school year, they added an additional 7.5 classrooms to the building.
Teachers in this school are split into teams. In the 5th grade, this means that each student belongs to a teacher team of two (Math/Science and Language Arts & Social Studies), and, in the 6th grade, a teacher team of at most four (Math, Science, Language Arts, and Social Studies). These teacher teams work together to plan lessons, share technology and other resources, and organize group projects and events between students. With an average daily enrollment of 788 students, not every student can be on the same teacher team. Rather, 5th and 6th grade are each split into four teacher teams: Blue, Green, Red, and White\textsuperscript{32}. Teacher teams are created in-house, and are constructed to take advantage of the various strengths and weaknesses of the teachers on the team.

The school also employs Intervention Specialists, who work with students with learning disabilities. There are also two in-house specialists available to work with gifted students. Students in need of these services, whether gifted or learning disabled, are pulled out of the regular classroom for weekly supplemental instruction. Observation data and interviews indicate that classroom helpers/volunteers/tutors are also available.

Together, the teams and other personnel are focused on following the school mission statement, which is

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By creating a safe and nurturing environment, the Lochley Intermediate Community will work together to move students forward academically, socially, and emotionally. We will meet students at their individual levels using quality educational opportunities to promote life-long achievement.
[Lochley Intermediate Teacher Handbook]
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As part of this mission, at the beginning of the school year, the teachers of each color team guide their students through the construction of a team mission statement, ground rules, and a poster detailing the responsibilities of teachers, students and parents in

\textsuperscript{32} In response to the growing population, a Purple team is being added for the 2005-2006 school year.
student education. All of these are placed on the classroom hallways, doors, or walls. While the sentiments are similar across the teams, the individual mission statements, rules, and responsibilities do vary. The teams work to organize the points listed in order of priority. Each student is required to sign the posters to show their support of these sentiments. Table 3.2 shows the Green team’s mission statement, Table 3.3 the team’s responsibility lists, and Table 3.4 the team’s ground rules.

**6th Grade Green Team Mission Statement**

Green Team Leprechaun will make friends and pass the proficiency test in March, so we can play sports, pass to the 7th grade, and have a successful future. We will accomplish this by following the ground rules, getting involved, and studying hard.

Table 3.2: Green Team Mission Statement.
Table 3.3: Green Team Responsibility Posters.

<table>
<thead>
<tr>
<th>Teacher Responsibilities</th>
<th>Student Responsibilities</th>
<th>Parent Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Create a safe learning environment.</td>
<td>2. Be on time.</td>
<td>2. Make sure child is cleaned and fed.</td>
</tr>
<tr>
<td>3. Teach lessons.</td>
<td>3. Be prepared to learn.</td>
<td>3. Ensure child gets enough sleep.</td>
</tr>
<tr>
<td>4. Evaluate work.</td>
<td>4. Do your best.</td>
<td>4. Be involved.</td>
</tr>
<tr>
<td>5. Communicate with parents.</td>
<td>5. Ask questions.</td>
<td>5. Pay school fees.</td>
</tr>
<tr>
<td></td>
<td>6. Complete assignments.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Give attention to teacher during lessons.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Be organized.</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.4: Green Team Ground Rules.

6th Grade Green Team Ground Rules

1. Follow school rules.
2. Come to class prepared.
3. Have fun.
4. Be honest.
5. Treat others how you want to be treated.
6. Respect yourself and others.

The school mission is also realized on a more individualized manner throughout the school year. The school incorporates the Baldridge model for success as a means of meeting its objective for fostering “life-long achievement”. Students keep portfolios on

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The Baldridge model for success is a corporate model aimed at realistic goal setting and achievement within the workplace. Recently, this model is also being applied to schools. For more information on the Baldridge model, visit the official Baldridge website at http://www.baldridge.com/. For a report on the Baldridge model as applied to educational reform, please see Walpole and Noeth (2002).
themselves in which they list (academic) goals, and learn to review and revise these goals realistically. See Appendix C for examples of the goal-related forms used by the students.

In addition to dividing the students between these teaching teams, there is an overall division in the school between academic departments; the assistant principal oversees math and science, while the principal oversees language arts and social studies. According to my interview data, there is no curriculum-based collaboration between academic departments. In fact, when discussing the cross-curricular nature of the social studies programs, the principal highlighted them as all including “a heavy component of reading, reading comprehension, and um…cooperative learning, and mastering concepts in chunks” [Interview, 8 October 2004]. There was no mention of overlap between social studies (or language arts) and either math or science. Interviews with the teachers also suggested that there is no overlap between academic departments.

**Ethel:** I do integrate with math, obviously, since I also teach a class of math. And Nancy and I also plan together. So…we’re pretty close. But as far as branching into language arts or social studies…I haven’t…done that. I haven’t done it here, I should say. … It is very much…science and math department. [Interview with Ethel, 16 November 2004]

**Nancy:** I would say I probably incorporate more everyday life into math, versus other subject areas. … I think I’m more than the subject area. I probably definitely, um, …show how everyday life…works with math. [Interview with Nancy, 18 November 2004]

Within this departmentalization, the curriculum of the school seems to be based almost entirely on content standards. In the words of the principal, “Now, we’re standards based, so anything that comes from the state becomes part of our local course of study or curriculum” [Interview, 8 October 2004]. This manifests itself in various
ways. Starting with the daily requirement of lesson plans, each lesson plan must include a list of the content standards that the lesson addresses. See Appendix D for an example layout. In order to enforce this correlation between content standards and the lesson plans, the administrators perform walkthroughs of the building.

**Eric:** Oftentimes we do our walkthrough, we’ll come back to our offices, open up the state content standards, to determine whether or not that particular lesson, uh, is congruent with, or compatible with, the grade level expectations and grade level indicators.

... And, and we ask our teachers...to develop their lesson plans using state content standards, and we’ve given our teachers some expectations on what a lesson plan looks like including grade level indicator, benchmarks and standards.

... We spend a lot of time doing that. And in the last 3 or 4 years, as the standards-based initiative has grown momentum, thanks to No Child Left Behind and accountability. Uh, I think our teachers have gotten on board. They know that we want to have opportunities to build success in our kids. We want our kids to be successful, and success is predicated on what happens in the classroom every day, but it’s also predicated on high stakes tests. So we want our kids to be prepared for those in addition to being well-rounded, prepared for the next grade level as well. So...we focus on the content standards, and the expectation is that every lesson, in some form or fashion, relates to grade level content standards. Grade level indicators.

[Interview, 8 October 2004]

Students also take an active role in fostering the correlation between their studies and the content standards. As stated earlier, the students at Lochley Intermediate are involved in Autoval’s Education Service Program. This involves the inclusion of short cycle test results in the Baldridge-based goal setting portfolios mentioned above. One such test can be found in Appendix E. These tests are supplied by Autoval and are aimed at measuring student improvement towards proficiency exams. Since each test contains five questions, one from each strand, the tests can also aid teachers in pinpointing areas in
which the students need more instruction. The teachers participating in this study had mixed responses to these.

**Ethel:** You know, we’re starting with, uh, this is where you should be in sixth grade at the beginning of the year, and of course they’re not there yet, because they haven’t been all the way through sixth grade. So I think for them, for the students, it’s a little frustrating, because they want to show that they know. Whereas right now it’s showing that they don’t know. Although, the farther we get along in it, it’s showing growth, for sure. Um, but…some of them are getting discouraged with it.

**Barb:** Do you think, um…there would be other ways that you’d be able to glean the same information without using the …?

**Ethel:** I don’t think it needs to be graphed. But I think the whole thing with Baldridge is graphing it makes it a visual tool, so the students, if there’s—they need to set their own goals and graph their own, because then it becomes more intrinsic for them.

[Interview, 16 November 2004]

Nancy noticed no such frustration, and in fact finds these tests empowering.

**Nancy:** I would say probably, what I see more than anything is, since I want them to be in charge of their future, that works that. Because they set goals, and they’re always looking at their goals and determining if they need to raise their goals or lower their goals. And I always talk about the importance of not starting too low or starting too high. Either way. So I really think it empowers them more to be in charge of what happens to them.

...  

**Barb:** Do you ever get the sense that, you know, you have some kids that are getting disgruntled or frustrated, you know, with…?

**Nancy:** Not at this age. I think if they were older, maybe, but not at this age. And, the nice thing about this age is they know that, um…that they can change. This isn’t forever.

[Interview, 18 November 2004]

In terms of standardized testing, Lochley Intermediate ranks just below the overall district rating. The school is still rated ‘Excellent’, has met 7/7 of the state indicators, and has a performance index score of 94.9/120. However, the school has not met the requirements for Adequate Yearly Progress.
In terms of technology, the school does not have a formal policy. Rather, the principal encourages teachers to try using technology with minimal repercussions for failure.

**Eric:** I would say that *philosophy* is use technology…to support your instruction, to *augment* your instruction, and give kids opportunities to *extend*, to enrich their learning, using computers and media. Also use technology to remediate and individualize instruction.

... So we have a *philosophy*, we have an outdated *plan*, and we have some veteran teachers that are reluctant to experiment. It’s up to *us*, Agnes and *I*, to say “it’s okay to experiment”.

**Agnes:** Mm-hmm.

**Eric:** *Try* new things. We encourage it. The worst that could happen is you have a failed lesson. We’re flexible, you can pick up the pieces and start all over again. [Interview, 8 October 2004]

Along this vein of trying new things to support instruction, while the administrators do take some initiative to select software (e.g., participation in the Jason Project), it is largely up to teachers to search out and review software on their own.

**Agnes:** And I would say, often what happens is a teacher, a classroom teacher will see a piece of technology or maybe heard about some thing from someone else. So then we will then purchase it for that teacher or, or let them, you know, try, try it out, run it through, see what happens, and then *they* make a recommendation, this is something we need to do *inaudible*, find out if there are other teachers that are interested. Um, but it’s *often*, I think a *lot of times*, they, one, one of the classroom teachers has found something. Um, and for *me*, I think, *they*, them going through that, and um, um, working through it with their students is probably better than I could sit down in front of the computer and I could look at it and go [affecting another voice] okay this looks really good [end voice]. I’d rather have the students run through it or the teacher actually utilize it in the classroom and see if it really matches up or see if it really, cuz they would have a better feel for. You know, ultimately we make the decision yes or no, but… [Interview, 8 October 2004]

It is the “matching up” of technology to the curriculum and the content standards that must be the focus of any technology integration in the classrooms at Lochley
Intermediate. As the principal put it, “technology to us is a lot more than going to find a website” [Interview, 8 October 2004]. This part of their philosophy is reflected in guidelines for such things as their video policy, located in the teacher’s handbook. This particular policy also reflects the school’s philosophy of student learning as needing to be active and reflective. A copy of this policy is provided in Appendix F. I have taken the liberty to emphasize (with boldface) those parts of this policy that reflect on the school’s teaching with technology philosophy, expectations for the teacher’s role in the classroom, and understanding of student learning.

In terms of technology resources, and in addition to the media services in the library and the two computer labs listed above, every classroom is equipped with a TV and four or five computers. Unfortunately, the principal reported that it is not uncommon to walk into a classroom and see none of the computers turned on. He cites lack of comfort with technology as a primary factor in the lack of use in the classroom. However, each teacher is required to use the computer each school day for administrative tasks. All school memos are sent exclusively over email, and teachers are supposed to check their email three times a day. In addition, the administrators urge teachers to post their lesson plans on the server so teachers can better synchronize their lesson plans and tweak them over time.

In addition to these tasks, the school has recently invoked a new technology initiative aimed at replacing the traditional means of mailing communications to parents with email correspondence. A database system, designed in-house by Lochley Intermediate’s technology facilitators, is being used to track parents’ email addresses.
Roughly 70% of all parents currently have email access. Those who do will now receive all communications, including weekly reports and scheduling for parent/teacher conferences, over email. Parents of students who are considered “at-risk” will still have reports and conference scheduling information sent via “snail” mail to ensure that these parents are kept informed. For those parents who do not have email, and who do not have an “at-risk” child, it is assumed that they will contact the school on their own if they desire a meeting during parent/teacher conferences. The logic behind this is that parents of children who are doing well often do not come anyway.

Through the teacher requirements for technology usage, the new initiative to communicate with parents over email, and a lack of formal initiatives to find and try classroom software for the students, it seems as though the primary technology philosophy of the school is that of technology as a communication tool.

Teachers

The teachers involved in this study, Ethel and Nancy, were both on the 6th Grade Green team. Nancy teaches math, while Ethel teaches both math and science, so Ethel acted as my science teacher. Nancy was asked to be my second participant teacher, because she was the other teacher in Green team’s Math/Science department. As I noted in the School section above, integrating curriculum between academic departments in this school was not an option34.

34 Unfortunately, if I had conducted this study during the 2005-2006 school year, this might have been different, as Ethel now teaches Science and Social Studies. Her cross-departmental status might have provided more opportunities to work across Lochley Intermediate’s academic departments.
Nancy

Nancy has been teaching for 16 years, and is in her fourth year at Lochley Intermediate. In addition to her teaching responsibilities, she is also a member of the Continuous Improvement Team (CIPT) at the school, an administrative group that looks at the “goals of the district and how we can make the goals of the district match the goals of our school” [Interview, 18 November 2004]. To this end, the CIPT devises plans to ensure that they are indeed continuously improving (from year to year) in various areas measured by their school Report Cards. Outside of the school, Nancy is a swimming coach at the YMCA.

In Nancy’s words, “I see myself as more of a realist than an educator” [Interview, 18 October 2004]. What does this mean? It means that in her daily teaching she uses “big words”, gives speeches on the importance of enunciation, not only for class time but also for future business-related phone conversations, and tries to show the students how what they’re learning in class can be applied to daily life through activities such as calculating discounts in the grocery store.

Just like she reports to work everyday, she believes it is the job of the students to recognize school as their job. As such, she doesn’t “hound” them for homework, but recognizes their individual right to choose how well they will each do in school. Assignments are graded on a pass/fail basis, for a total of 15 points every week. Based on her understanding of how students construct knowledge and demonstrate their abilities, Nancy does not require that each assignment be fully completed, as she can tell from the work shown on homework/board work and performance on tests where each
student is at in his/her understanding of the topic(s) and whether, with continued effort and time, each student could complete the tasks successfully. In an interview, she stated

Nancy: So depending on where they’re at in their learning, they may only have to complete a fourth of it. Because I can see in that fourth that they can be successful or not, so why make ‘em do the whole thing?

... When I look at what they produce for me, that’s where I really determine. And I can also see when they’re working their frustration level. So why frustrate ‘em? It’s not worth it. Cuz then I get mad. And then nobody’s happy.

[Interview, 18 November 2005]

This attitude was supported by my observation data, which showed that Nancy consistently walked through the room to check off student names in relation to their assignments. For a deduction of points, late assignments were also counted towards student grades.

Whether as a result of the Everyday Math series being used or as a result of her teaching style, my observation data suggests that Nancy’s classroom is run in a very drill and practice manner. Each class follows a format of Nancy standing at the podium, reading through problems for the students to answer from their homework or to do during class. The following excerpt from my research journal is pretty typical of classroom interaction.

Nancy is standing at the podium, all students (except one, who has left hers at home) have their journals out. Nancy reads off the problem, students raise their hands, and she calls on one student, then another, then prompts the rest of the class to see if these answers are correct: “Will that work?”


Board work is also incorporated, with student names being pulled randomly from a tin. In these ways, Nancy feels that she is able to accommodate everyone’s learning needs.
In the area of technology, Nancy is probably one of the teachers mentioned by the principal who does not turn her student computers on during the day. The math classroom has three student computers along the wall. The fourth computer in Nancy’s room is on her desk. When not teaching, Nancy can be found at her desk, usually working on the computer. She feels comfortable with email and web searches, and has taken a class on web design, but is not comfortable with spreadsheets or presentation software. In addition, she feels the math curriculum supplied by Everyday Math does such a good job in terms of addressing the content standards as well as the learning needs of the students, that she can’t imagine where technology could be incorporated into that curriculum. In fact, further conversation with Nancy indicates that she sees the place of computers in the classroom as more of an enrichment tool than a supplement to everyday activities.

**Nancy:** I mean, this series is so cut and dry that, I mean I guess I – I can see it easier for science cuz they do research projects, I can see it easier for language arts. All of those things that you can take concepts and do a project. I don’t know, unless for enrichment that we were studying how Roman numerals came about.
[Interview, 18 November 2004, regarding Everyday Math and technology integration]

**Nancy:** But I think – I know I *have*, in the past, had kids that needed enrichment, um, there was, they did alternative activities, which they were on their own, which they did use the computer and they had to find out the area of the classroom. So they had to research the computer to find out how to measure the area of the classroom, how to cut out things. So I *have* in the *past*. It’s just that this year everything’s driven by the state. We’ve *lost* that.
[Interview, 18 November 2004, regarding her teaching experience at Columbus Public]

**Nancy:** You know I used to do, with the other math series, I used to do where I could pretest and posttest the kids. The kids that passed the pretest, that’s who I gave the enrichment to.
[Interview, 18 November 2004, regarding her teaching experience at Columbus Public]

Nancy: Yeah. I would like to. Like an enrichment type activity with it.

[Interview, 1 June 2005, regarding the future potential of the program developed during this study for use in her math classes]

Nancy’s attitude towards technology, and her perception of the math curriculum’s ability to address student needs, could be one reason why, as she stated in an email, she has not utilized computers as a part of her curriculum in 11 years.

Ethel

Ethel has been teaching for 10 years, and is in her third year at Lochley Intermediate. Ethel began as a Kindergarten teacher, moving on to self-contained fourth and fifth grade classrooms, and finally 5th grade math at Lochley Intermediate. As stated previously, Ethel now teaches 6th grade science and math. Like Nancy, Ethel is a member of the CIPT.

Ethel considers herself a constructivist, and therefore works to create a learning environment in which she functions as guide, helping students to construct knowledge on their own via hands-on activities rather than giving them a lot of instruction or telling them the answers. She sees her main responsibility in the classroom as meeting student needs, and follows her list of other priorities along the lines of the responsibility poster created for Green Team. Each time that I observed Ethel’s classroom, the students were engaged in a lab or other group activity to explore concepts such as classification and mixtures. Follow-up lessons are always given the day afterwards to tie the lab experience back to the lesson objectives, aiding students in grounding their experiences in textbook
terminology and knowledge. These hands-on activities come not only from the textbook, but also from videos and Internet activities that Ethel searches out to supplement the lessons and fill in gaps where the material may be abstract or have no clear connection to the real world. Unfortunately, with the deadlines put in place by content standards and the drive for high achievement on proficiency exams, Ethel does not always have the time to adequately supplement her lessons, or take lessons in a tangential direction that the students find interesting.

While Ethel also follows the same grading policy as Nancy for math, in science she compiles student grades primarily from lab worksheets and tests. Since her class is so hands-on, Ethel makes herself available during the completion of the worksheets to make sure students are going in the right direction without giving them the answers. For example, during one of my observations, students were investigating various objects in order to classify them according to malleability and metal/non-metal. The objects under investigation were a thin, long coil of copper wire, a chunk of sulfur in a Ziploc bag, a nail, and a rubber chip. The following excerpts from my research journal from this day highlight not only the hands-on, exploratory nature of student labs, but also Ethel’s teaching philosophy.

It was now time for a lab on classifying elements. Ethel turned the lights on full and gave them extensive instructions on the handling of sulfur and how it’s not to get wet because it gets stinky. The students were noisy during these instructions, so they received another tally on the board. The students worked together as a table. Ethel read over the worksheet and answered questions, telling those sneaky students who asked questions off the worksheet that she didn’t know and they’d have to figure it out or “I don’t have your notes. I don’t know. You have to decide that.” She finished with a speech about how they’d investigated the Smartees in a previous lab through taste, and to “only taste when I tell you. And I’m telling you now no tasting today.”
As Ethel walked around the room with her travel mug I heard her say various things to the students.
“This table is doing a great job.”
“Did you do #4? Do that first.”
“The directions are right there.”
“Tell me what you don’t understand.”

There was also an interesting exchange at a nearby desk.
Girl (to Boy on left): I think you should smell this again.” (to boy on her left)
Boy: It smells like rubber.

Boy: “Copper is kinda like metal.”
Girl: But it’s not magnetic.
Boy: I said kinda like metal.

Boy (to Ethel): Is every piece of metal magnetized?
Ethel: Look at this question right here. [points to worksheet] What do you think?
Boy (to Girl): Told ya!

Ethel stopped at the table directly in front of me, where she challenged the students’ assessment of the malleability of the nail.
Ethel: If I gave you a hammer, could we make it bend?
*inaudible response from the students*
Ethel: Is it hard?

In addition to these investigative guided lab experiences, tests are generally in the form of extended response, which aids not only in assessing the students’ understanding of science concepts but also cultivates their writing abilities in preparation for the proficiency exams. Extended response may also involve the use of formulas from posters around the room to answer questions with scientific content. Memorization of formulas is not considered a requirement.

As may already be apparent, Ethel, unlike Nancy, considers herself technologically proficient and able to troubleshoot most problems on her own. She has a Master’s in Education with a focus on technology in the classroom, and she has
participated in courses aimed at boosting her technological proficiency. Her comfort with technology and her view that the use of technology is essential for student success in life are reflected in her classroom setup. The science classroom has four student computers along the wall, each of which seems to be on all day long. When Ethel needs to use the computer for administrative tasks, she sits at one of these. In addition, Ethel’s technology philosophy is reflected in her use of the computer lab, which she tries to reserve about once a month.

**Ethel:** We get to the lab about once a month, if we’re lucky. The barriers are...there’s only one extra lab, and you have to sign up for it, and...if you miss the slot to sign up then you’ve missed the opportunity to go. And you can only sign up a week in advance.
[Interview, 16 November 2004]

When asked if she wishes she had more computer or video time to supplement her other curricular activities, Ethel responded

I would be a little afraid that I wasn’t getting everything in that I needed to. That’s probably why I don’t do it more. Because I know my schedule. But I think it would...probably keep motivation up, cuz I don’t do it probably enough right now.
[Interview, 16 November 2004]

At the same time, Ethel would like to see computers available for each student every time it could complement the lesson.

**Class**

The particular math and science periods used in this study were chosen by Ethel and Nancy, because they ran back to back and optimized my time in the school. In this section, I will describe the classroom make-up and layout, and then turn to a more
extensive discussion of behavior management (i.e., the tally system) within the classroom.

**Math Class**

The math class consisted of 23 students, 2 of whom were non-White. Only 14 students were granted parental permission to participate in this study, and only 8 of these were granted parental permission to participate as software designers.

Students in this classroom sat in groups of 4. Rather than tables, these groups were formed by pushing 4 standard student desks together.

From my time in the math classroom, it does not seem as if there are any classroom aides associated with this class. There are also no pets.

**Science Class**

The science class consisted of 22 students\(^{35}\), all of whom were White\(^{36}\). All of the students were granted parental permission to participate in this study during classroom observations and as software reviewers, but only 15 were granted parental permission to participate as software designers.

Students in this classroom sat in groups of four at long tables. These tables were not only used during lecture and note-taking sessions, but also served as lab tables.

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\(^{35}\) At the time of class observations, there were actually 23 students. According to Ethel, this student did not participate in the study, because his family was moving soon and his mother felt it unfair to have him start the study without being able to end it.

\(^{36}\) As a note, 97.3% of the study population is White.
Various adults were in attendance on observation days. According to my interview with Ethel, these included a man from OSU who was completing his student teaching requirement with her, and a classroom tutor for those students who did not qualify for LD services but still qualified for extra help.

There is a class pet in the back of the room.

**Behavior Management**

While most of the students I observed were well behaved, they did need some supervision in order to stay on task. In order to achieve this in a consistent manner, Green Team devised a tally system. I happened to be present at the inception of this tally system.

Ethel then explained that starting today she was trying something new: every time she had to tell the class to quiet down they would get a tally on the board. They could then reflect on the tallies to see how they were doing day to day. One student asked if the class would get a reward for having the fewest tallies, and Ethel responded, with a thoughtful expression on her face, that this was something they could talk about and that it might be something that they need. [Research Journal, 25 October 2004]

So, behavior management, just like many other aspects of the students’ environment in the school, was an open negotiation between students and teachers, a means of guiding students through the process of goal setting and achieving, in accordance with the Baldrige model for success. In the end, there was a full list of transgressions for which students were accountable under the tally system. These were all listed on a poster above the whiteboard: materials, locker, talking out, not following directions, out of seat,
inappropriate behavior, uncooperative behavior, gum/candy, and poor hallway behavior.

As Ethel explains,

**Ethel:** If they don’t have their materials for the day they get a tally. If they have to go to their locker because they forgot something in their locker, that’s a tally. So it’s just a way to keep them on track. And then, at the end of the week, we compile tallies for everybody, and if they have two or less they get a little treat. A little piece of candy. At the end of the nine weeks, if they have seven or less, they get to participate in a movie and popcorn. So for some of them it’s very rewarding to, you know, just get a pat on the back. For doing a good job. For some students, we have to modify and say, “You know what? You didn’t get as many tallies this week as you did…last week, so thank you for [chuckle] improving.” You know? So, it’s just our behavior system.

[Interview, 16 November 2004]

Nancy tended to give out more tallies than Ethel, as Nancy’s class sessions were geared more towards quiet work to be done at the student’s seat, while Ethel’s classes were naturally louder and more mobile due to the hands-on, group nature of her lessons.

While I did not observe any of Ethel’s students being or having been punished for anything other than noise level during line-up at the end of class, I was able to observe Nancy having students swap seats, having students “lose their desks” (i.e., having to sit in the corner in one of the chairs by the computers), and students in Lunchtime Academy (i.e., detention).

**Informed Consent**

Prior to the study I submitted my research proposal to The Ohio State University's Human Subject Review Committee, which required measures were taken to ensure that the study would have no ill effects on the participants. In keeping with this requirement, participation in this study was wholly voluntary and there was no penalty for not
volunteering. If at any time a participant had become frustrated, stressed, or uncomfortable for any reason, that participant could have been excused from the study without penalty. However, no students ended their participation during the study.

All adult participants and parents of the participant students received a consent form indicating the conditions of their participation, while all student participants received an assent form, which I read aloud to the class. These forms were signed and returned to me before I collected any data from that participant. My contact information was provided on the consent form, which each participant and parent retained a copy of so as to ensure that each participant and parent was able to reach me at any time to discuss any issues or concerns that arose as a result of participation. Throughout this entire study I was not contacted by any of the parents.

**Confidentiality**

Confidentiality of the participants was ensured first by the use of pseudonyms\(^{37}\) in my data write-ups. Additionally, any audiotape recordings were used for my own research purposes only, listened to and transcribed by me alone, and will be destroyed one year after the study has been completed.

Any materials collected from the students, such as the questionnaires, the low-tech brainstorming prototypes, and the evaluation forms, were either collected without identifying information on them or re-labeled with a pseudonym as part of the de-

\(^{37}\) One student was not able to come to the last design session or the final review session, and so did not have the opportunity to choose his own research name. All other student designers chose their own pseudonyms. I chose the pseudonyms for all of the other participants.
identifying process. These materials will also be destroyed one year after the study has been completed.

Until the time at which these items are destroyed, all hardcopies of the data will be locked in my home office desk.

**Timeline**

This research lasted from 8 October 2004 to 13 June 2005. My presence during this time period was not persistent, but these dates correspond to the first and last dates of data collection in the school. A detailed projected timeline is provided in the project Overview below, which facilitates my later discussion of the data analysis.

**Overview**

The project was broken into five phases. These phases represent a conceptual breakdown of the instructional design process in terms of the data that needed to be collected at each stage and the participants that would be involved in that portion of data collection. In an effort to define my initial research plan as clearly as possible, I detailed, for each phase, the duration of the phase, the participants involved, where this participant interaction was to take place, and the description of the participant involvement. I also strived to incorporate into my research design safeguards against the pitfalls of qualitative research.

One of the temptations of fieldwork is that it presents the unsuspecting researcher with so much potential data that might possibly be of use, data often so easy to attend to and record, that newcomers risk losing sight of what they are getting
data for. In practice, it isn’t a bad idea to maintain a running dialogue with yourself to ask, “Why am I recording this? What use am I likely to make of it? (Wolcott, 1995, p.204)

In an attempt to initiate this dialogue with myself, I included with each phase a listing of the specific data to be collected, a discussion of my objectives regarding the purpose of this phase, and the data collected towards my overarching research objectives as defined by my Research Questions (located at the beginning of this chapter). This phase summary is written in future tense to indicate that this was my initial research plan and not what actually occurred. Again, the analysis of the facilitators of and barriers to the success of this Overview can be found in Chapter 4, along with an accounting of how the phases actually proceeded.

Phase 1: Establishing School Context  
Duration: 2 weeks  
Participants: Principal (Eric) and Assistant Principal (Agnes)  
Location Desired: Principal’s and Assistant Principal's office

Description of Participant Involvement:

An interview will be conducted to describe the school context for technology integration, state/district proficiency standards, and the possibilities and limitations of collaboration between teachers towards an integrated curriculum.

Objectives:

This phase will aid in establishing the administrators’ views of the context as well as the structure of the context. Guba & Lincoln (1989) tell us that documents are useful for understanding the context of a study. Policy documents are useful for understanding how things are “supposed to be.” Supplemented by interview and observation data, these can also be used to uncover differences between administrative mandates and the lived realities of the people in this context (Angrosino & Pérez, 2000; Dereshiwsky, 1999a).
Specific Data Collected:
I will collect interview data from the principal and assistant principal. These interviews will be audiotaped and supplemented with handwritten notes. See Appendix G for the list of interview questions.

I will also collect various documents such as the state and district proficiency standards relevant to the 6th grade classes I will be researching in and the school’s policies on technology selection and integration. Additionally, the grade levels in this school are broken into teacher “teams.” I will be working with green team – the team Ethel is on. If there exists documentation on the structure of and guidelines for these teams, I will also collect these documents at this time.

Phase 2: Establishing Teacher and Classroom Context, Pinpointing Content for Software
Duration: 2 months
Participants: 2 teachers (including Ethel); students of these classrooms
Location: Classrooms

Description of Participant Involvement:
[Teacher Context]
Interviews will be conducted to establish 1) how teachers view technology requirements, how they currently use technology in the classroom, and their ideal views of technology in the classroom, 2) how standards are currently accommodated in the curriculum, and 3) philosophies of teaching and learning.

[Classroom Context]
Classroom observations will also be conducted at this time, preferably one per week in teacher’s classroom. Informal interviews will be employed to explore questions that arose from these observations. These questions may be sparked by discrepancies – instances in which I want to confirm my hunches regarding an observed incident, or occurrences that I did not think to ask about during formal interview sessions – between interview data, policy documents and observation notes. These informal interviews will be conducted with both students and teachers, as the need arises.

I will also ask the teachers to provide me with the topic areas covered during the year so we can, as a group, pinpoint the specific lessons that would be most compatible for an integrated lesson as well as suited to technology integration. One or two group meetings may be necessary to select the lessons that are best suited to integration and discuss which portion of the lesson we believe could best benefit from a new software program. It is my intention at this time to select lessons that the students have already completed by the beginning of Phase 3.

[Preliminary Student Context]
I will first introduce myself to the students through a recruitment speech. See Appendix H for this speech. During this phase I will also ask the students to complete a short questionnaire. This questionnaire is geared towards investigating their perceptions regarding educational software, what features they like and do not like in software, what their favorite software titles are both at school and at home, their favorite non-computer-based activities, and how much time they spend on the computer. See Appendix I for a copy of this questionnaire.

Objectives:

The formal interviews in this stage provide the teacher’s view of the context. Interview and focus group data can provide valuable insights into the perceptions of the participants (Dereshiwsky, 1999b) as well as a reference for local terminology. The discrepancies and convergences of teacher responses will also aid in later analyses regarding the influences and barriers to the effectiveness of this design approach. However, interview transcripts cannot be used to construct the thick descriptions necessary for discussions of context and deep analysis of the nuances of the dynamics of interpersonal interactions. Additionally, “every telling is a partial prevarication” (Grumet in Casey, 1995-96, p.219).

Classroom observations will thus be used to supplement formal interviews and document data, providing an avenue for crosschecking these other data sources (Dereshiwsky, 1999a). Observations also provide the types of key vignettes necessary for thick descriptions. One potential limitation of observation in this context is my own participation in this research and the resulting lure of putting down my pencil (Gewertz & Errington, 1994; Dereshiwsky, 1999b).

The questionnaire will be useful as preparation for a more formal interaction with the students in Phase 3. It will provide a basis for exploring instructional avenues with the students, interface elements, and the like. These answers will also aid me in selecting the low-tech materials I will bring to the brainstorming session.

Specific Data Collected:

Formal interview data will be collected from the teacher participants. These interviews will be audiotaped and supplemented with handwritten notes. See Appendix J for a list of these interview questions.

Focus group data from the content selection sessions will also be recorded to audiotape and supplemented by handwritten notes.

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38 See the section “Issues of Representation” below for more information on thick descriptions and their influence on analysis.
I will also collect observation data and informal interview notes in a notebook (my Research Journal).

The questionnaire will be given in survey format in both Likert-scale and open-ended questions. See Appendix I.

**Phase 3: Establishing Student Context, Exploring Methods of Presentation and Learning of Content**

**Duration:** 3.5 months  
**Participants:** Eight students (the volunteers selected above); two teachers  
**Location:** Classroom, computer lab

**Description of Participant Involvement:**

[Brainstorming in the Classroom]  
In this phase I will explore how students have experienced the lessons as they are currently taught (most likely without technology). I will cover each lesson separately, establishing what students remember from the lesson and, through the use of role play, how these students would teach the lesson to someone else (again, without the use of technology). Using low-tech methods of paper and pencil, glue, etc., students can express how they feel the material should be covered through technology. These low-tech methods enable exploration of interface design outside the bounds of existing technologies and without concern for accommodating varying levels of technological expertise on the part of the students. We will discuss their designs one at a time before we end this session to make sure I understand their visuals.

[Testering in the Computer Lab]  
Student input will be used to design up to three software prototypes\(^\text{39}\). These prototypes will be tested in the computer lab, and student/teacher feedback will be used to select a single prototype as well as to guide revisions of the software. The first computer lab meeting will test the three software prototypes created, with the subsequent two computer lab meetings used to evaluate revisions made to the prototype selected for development and to make suggestions for future development.

To allow for time to develop these prototypes, the first low-tech meeting will be held at the beginning of the 3-month period. The initial three prototypes will be presented at the end of this month. The subsequent prototype tests will be three to

\(^{39}\) Utilizing multiple prototypes during evaluation enables me to test various elements suggested by the students in different combinations. As noted by Delman (2004), students of this age group are only able to analyze concrete examples of combinations. Unfortunately, given the time constraints of this study, there will not be sufficient time to develop all possible models for review. Three prototypes is probably the most I will be able to handle.
four weeks apart, dependent upon the scheduling needs of the teachers and students. While the evaluations will be largely survey based, a focus group discussion with the students will also be used to discuss possible ways to address issues that arise during the evaluations and inform future modifications of the prototypes. I currently intend for the verbal feedback portion of each evaluation session to last for only about 15 minutes of the total hour of evaluation, but it is possible that more time for discussion might need to be allotted. Survey and verbal feedback will be used to confirm/disconfirm my understanding of how student culture is acknowledged and accommodated by the software produced by this process. Any disconfirming data will be used as a starting point for further data collection, primarily in terms of subsequent prototype modifications and survey evaluations, according to the principles of grounded theory and rapid prototyping.

As the technology evolves, so too should the accompanying lesson into which the technology is to be integrated. Short focus groups after the prototype meetings can be used to explore this evolution.

This phase is an ideal time to work in initial member checks with the designing student and teacher participants. For example, now that they can see concrete examples of how the data from the low-tech brainstorming sessions was utilized, were there better ways to brainstorm together? Would they have offered different suggestions? Do they see their initial suggestions in a different light?

Objectives:

By the end of this phase the final software product, version 2.1, will be developed. In addition, the entire lesson of which the software is a component will also be developed. This includes any activities, worksheets, or lectures related to the use of this software.

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40 Grounded theory is a process by which data is coded as it is collected, avoiding as many preconceived codes as possible, and using the theories that emerge from these codes as a means of directing subsequent data gathering. See Charmaz (2000) for more on the grounded theory approach.

41 Wilson, Jonassen, and Cole (1993) define rapid prototyping as the process by which “a small-scale prototype is built that exhibits key features of the intended system. This prototype is explored and tested in an effort to get a better handle on the requirements of the larger system….Its advantage is that it allows for tryout of key concepts at early stages when costs are small and changes more easily made.” They go on to differentiate between shallow or narrow prototypes. Shallow prototypes are those in which “the entire look of the product is replicated minus some functionality” (Wilson et al., 1993), while narrow prototypes are those in which “a small segment is completed with all functionality, leaving other whole portions of the final product undeveloped” (Wilson et al., 1993). Given Delman’s (2004) note that intermediate school-aged students are only able to analyze concrete examples, I chose the path of narrow prototypes.
Preliminary analyses will be performed at this point regarding the effectiveness of and barriers to this design approach. I will also have sufficient data to analyze the extent to which students were engaged in the actual design process.

Specific Data Collected:

Low-tech brainstorming materials (e.g., construction paper drawings of potential software screenshots) will be collected from each participant student. This brainstorming session will be audiotaped and supplemented by handwritten notes.

The prototype evaluations will be given in survey format in both Likert-scale and open-ended questions. I chose this format, as I have found it most useful in other software evaluation sessions I have conducted. There will be three of these evaluation sessions during this phase. I believe three sessions will be sufficient for collecting and implementing student input without losing student interest. Since the software has not been developed yet, the full evaluation cannot be developed, but a preliminary version is located in Appendix K.

Focus groups held after the survey portion of the evaluation will be audiotaped and supplemented by handwritten notes.

A copy of the lesson plan developed will be collected for analysis.

Phase 4: Final Evaluation

*Duration:* 1 visit, approximately 2-3 weeks after Phase 3

*Participants:* Students and teachers

*Location:* Computer lab

Description of Participant Involvement:

In this phase I will conduct the final evaluation of the software. Changes will not be made after this point, but data on suggestions for change will still be collected in order to help inform future designs of this nature. In addition to the eight students and two teachers involved in Phases 2 and 3, I will be employing the aid of all of the students who volunteered but were not chosen as designers. This additional student feedback will aid in assessing the effectiveness of the design approach outside of the design team’s (biased) assessment. A small discussion (no more than 20 minutes) might be held afterwards if clarification of the student responses is necessary.

Objectives:

This phase will aid in evaluating the overall effectiveness of this design approach. For instance, does collaboration with students, such as occurred in Phase 3, aid in
the creation of software for a culturally relevant curriculum? Or more succinctly, do the design decisions made by a small subset of students (eight in this case) represent their classroom culture sufficiently that the resulting software product equally engages all students?

Specific Data Collected:

The final prototype evaluations will be given in survey format in both Likert-scale and open-ended questions. If a discussion session is held, it will be audiotaped and supplemented by handwritten notes. Again, not having a full version of the software ready for analysis makes it impossible to draw up the full evaluation form, but the preliminary version is in Appendix K.

Phase 5: Exit Interviews
Duration: 1 week, 2 weeks after Phase IV to allow time for data review before interviews
Participants: Principal and Assistant Principal; two teachers; eight students (co-designers)
Location: Classroom; Offices

Description of Participant Involvement:

As my research goal is an evaluation of the process employed here, I am interested in analyzing this process not only from my perspective, but also from the perspectives of the research participants. A focus group with the principal and assistant principal, a focus group with the teachers, and a focus group with the students will be conducted to discuss this design process. At this point, I will also review with the participants my own analysis of the process in order to collect feedback and prompt further reflection on and analysis of the data (member checks).

Objectives:

This phase will aid in understanding how teacher perceptions of this technology match with the claims they made regarding technology in their interviews from Phase 2. This phase will also aid in understanding how teachers and administrators understood and felt about their participation in this process. Exit interviews with the students will permit not only a glimpse into their perceptions of their role in this design process, but also assess my analyses regarding their engagement with the process and my findings regarding the accommodation of their cultural identities through the software and the design process.

Prototype evaluations and exit interview questions will be informed in part by Rothe’s model of formative evaluation. This model is based on the idea that “[s]oftware is shaped within a social context. Therefore, there is little neutrality
in the selection of knowledge, content, learning outcomes, language, ethics, or cultural perspectives. These features comprise assumptions underlying software which serve as the guide for student thinking and acting with the software” (Rothe, 1991, p.368). So unlike other evaluation models that focus on usability and learning outcomes, this model provides a means of examining language usage, selection of knowledge, underlying ideology, culture-specific assumptions, and ethics (value assumptions) in educational software. A summative (final) evaluation completed by myself according to this model will also be used to explore what type of software product was designed through this process.

Specific Data Collected:

Exit interviews will be conducted with the principal and assistant principal (Appendix L), teachers (Appendix M), and the student designers (Appendix N). This data will be audiotaped and supplemented by handwritten notes.

Summative evaluation completed by myself.

Reciprocity

The researcher is obviously benefited by the opportunity to conduct the study and collect data. The notion of reciprocity, then, refers simply to the potential benefits of study participation on the part of the participants. This process was meant to leave the participant teachers with a new technology and integrated curriculum plan for a single lesson. Unfortunately, time constraints, which will be detailed in Chapter 4, prevented the development of the lesson plan meant to accompany the software developed. There were also barriers to creating an integrated curriculum plan, which have been addressed briefly above and will be covered again in later chapters. As it stands, this study resulted in the completion of a successful science program, which is precisely what Ethel was hoping to gain from this study (see Chapter 5).
In return for participation in the study, the student designers received a copy of the final math and science programs, as well as the preliminary prototypes. This was in keeping with their sense of ownership over the software, as detailed in Chapter 5.

This study should also inform the approaches of other educational technology designers interested in working with the schools to design and develop technologies for the classroom that meet the criteria listed in Chapters 1 and 2. As such, this was a chance for the principal, assistant principal, and teachers to voice the extent to which they would like to participate in technology design and development for their school in the future.

**RESEARCH APPROACH**

This study is one in which I was involved as a participant, working with co-designers in the school (teachers and students) towards the creation of a software product. My role in this study was thus twofold: to develop the technology and to report on the process. Given the descriptive nature of this study and my dual role in it, the research strategy that seemed to best fit the needs of this study was participant observation.\(^{42}\)

Participant observation is an attempt to merge the subjective nature of group membership with the “objective” methods of observation and analysis typical of early ethnography (Tedlock, 2000, p.465). Patton (in Dereshiwsky, 1999a) provides five dimensions of participant observations: role of the observer (full, partial, or onlooker),

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\(^{42}\) I would have preferred that all individuals involved in the design process—teachers, students, and myself—be full co-designers of this design process. As a team we would have then been deciding what data needed to be collected and when, and would have also been developing and reflecting on the designs together. In this way, the design process would have followed the guidelines of participatory design. However, orchestrating this type of involvement was not practical at this time given my limited time with the teachers, and limited access to students.
portrayal of role to others (overt to covert), portrayal of study purpose to others (full, partial, covert, or false explanation), duration of observations (single, several limited duration, or multiple long-term), and focus of the observations (single variable, a set of variables, or holistic). In Phases 1 and 2 of the research design I was acting as partial observer, not yet immersed in the environment and the process of design. In subsequent phases I was acting as a full observer, a full member of the design team while reporting on the successes and failures of the team. Students and teachers knew that I was observing them and what I was observing and why, and thus I was employing overt observations. Teachers and administrators were fully aware of the purpose of my research, as they were involved for the entire process. Students only entered the study during Phase 3, and thus I felt that in addition to being made aware of their role in the design process, they only needed a very brief introduction to the research objectives. According to Patton’s dimensions, this translates into the use of full explanations for teachers and administrators and partial explanations for students. Given the timeline of this project and schedule of observations and design meetings, I was able to conduct several limited duration observations. Finally, I did not have a set list of variables to research, and so placed this study into Patton’s category of holistic focus of the observations. In this way, I allowed for variables to emerge and was able to analyze them according to the principles of grounded theory, leaving me open to the dynamics of the design process.

As I noted above, there is a danger in being both a participant and an observer, a danger that the researcher(s) will be “swept up” in the moment, “inclined to put down our
pencils” (Gewertz & Errington, 1994). Also, as the participant observer becomes more a part of the lives of the participants, the researcher needs “to ask what of local concern are we currently ignoring or downplaying in importance” (Gewertz & Errington, 1994).

Even so, as a participant observer, I was better able to analyze the inner-workings of the proposed design process than I would have been as an external analyst. I was able to not only reflect on my own role in this process, but also work with the other participants to “(a) [discuss] the quality of the process being used, (b) [reflect] on its effectiveness in achieving the group’s goals and maintaining effective working relationships among members, and (c) [set] goals for improving the process” (Krug, 2002). This type of reflection aided in not only assessing the facilitators and barriers to the success of the proposed design process (Research Questions #2 & #3), but also address participant responses to the project (Research Questions #4 & #5).

**DATA COLLECTED**

As noted in the discussion of the research design, there were five types of data that I planned to collect in the field: documents, interviews, observations, surveys, and focus group data. These are listed in Table 3.5. These were supplemented by my reflective research journal, which was used to track the design process from beginning to end by exploring various design decisions and recording preliminary hunches and findings.

One danger of qualitative research, especially for the participant observer, is the melding of interpretations of the data and the data itself into an undifferentiated whole
(Dereshiwsky, 1999b). This research journal provided a location for me to house reflections in such a way that I was able to keep evidence from the field separate from my interpretations of that evidence.

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Specific Data Collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Document</td>
<td>Proficiency standards, Technology policies, Teacher team guidelines (if possible), Lesson plans (if possible), Low-tech brainstorming materials, Summative evaluation according to Rothe’s model (conducted by myself)</td>
</tr>
<tr>
<td>Interview</td>
<td>Interviews with the Principal, Assistant Principal, and Teachers</td>
</tr>
<tr>
<td>Observation</td>
<td>Classroom and computer lab observations</td>
</tr>
<tr>
<td>Focus Group Data</td>
<td>Discussions from the brainstorming sessions; Exit interviews</td>
</tr>
<tr>
<td>Survey</td>
<td>Prototype evaluations in both Likert-scale and open-ended style</td>
</tr>
<tr>
<td>Reflective Journal</td>
<td>Notebook in which I will store personal reflections on the data collected and the process, memos, and preliminary attempts at data write-ups</td>
</tr>
</tbody>
</table>

Table 3.5: Data Collected During This Study.

**Towards Answering the Research Questions**

As stated in the research design, these data were collected for the purpose of answering the research questions. I reiterate here to what end I collected each piece of data. While I only list it explicitly for some questions, it should be understood that my reflective journal was used in answering every question.

In order to understand what type of product was designed and developed using this approach, the product itself was analyzed via the summative evaluation, as well as through the use of the prototype evaluations.
Understanding which factors facilitated the success and effectiveness of this project and which factors acted as barriers to the success and effectiveness of this approach was possible by first understanding the context in which this software endeavor took place, which was covered in detail above. The interviews and observations were key in understanding this context. My research journal was also useful in examining project decisions during the course of this study and analyzing how these decisions affected the outcome of this study.

Student engagement was studied through the use of observations and focus groups with the students during evaluation sessions. Exit interviews with the students were also useful in answering this question.

Finally, exit interviews with teachers and administrators were helpful in understanding how teachers and administrators responded to being a part of this software design process. Observations and informal interviews also played a role in answering this question, especially in terms of the teachers.

**DATA ANALYSIS: METHODS AND ISSUES OF INTERPRETATION AND REPRESENTATION**

*Methods*

In order to analyze the data mentioned above, I planned to code the data even while I was collecting more data. Following the suggestion of Erickson (1986), I began coding by first thoroughly reading through the data to be coded and then coding on paper copies of my data. In this way, I began to uncover patterns (Wolcott, 1995; Corbin, 1986) and conditions for emerging assertions (Corbin, 1986) without being limited by
data analysis software. I termed this step “free coding”. As the study advanced, I also performed a secondary coding of the data with the specific research questions in mind. In this way, I allowed unforeseen variables to emerge while also exploring the extent to which I was collecting sufficient data to answer the research questions. I termed this step “question-based coding”. These paper codings were then entered into data analysis software to aid in the management of coded information and the vast amount of data being collected. I incorporated memoing to track codes as they emerged and evolved, folding into and linking to each other, and kept a running codebook. This continual analysis and reflection helped to guide subsequent efforts to collect data.

**Issues of Interpretation**

Traditional approaches to qualitative analysis often fracture [respondents’] texts in the service of interpretation and generalization by taking bits and pieces, snippets of a response edited out of context. They eliminate the sequential and structural features that characterize narrative accounts. (Riessman in Casey, 1995-96)

It was my intention to write according to the traditional approaches warned against in this quote. By taking evidence from the field out of context and placing it in the context of my own interpretation, my own biases and (outsider) perceptions, I ran the risk of misrepresenting the local meanings inherent (but not obvious to me) in this evidence, of establishing unfounded assertions (assertions without sufficient evidence of the

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43 One example of this is the format in which the software assumes data is meant to be coded, collected together by codes, and analyzed.

44 Memoing is “a process for recording the thoughts and ideas of the researcher as they evolve throughout the story” (Trochim, 2002). Charmaz (2000) note three types of memoing: code notes (concepts discovered in the data), theory notes (preliminary summaries of findings), and operational (practical) notes. My Research Journal provided a forum for all three types of memoing.
phenomenon as a pattern). As Erickson (1986) notes, thick descriptions such as those found in analytic vignettes “can be used to mislead as well as inform” (p. 150). As counter-measures I planned to employ the methods of triangulation, negative case analysis, peer debriefing, and member checks.

**Triangulation**

Triangulation is the use of multiple data resources, multiple data collection methods, and/or multiple theoretical frames from which to draw. In terms of resources I was drawing on data collected primarily from and with teachers and students, and including documents such as the low-tech brainstorming materials and prototype evaluations. I also used multiple methods to collect my data: interviews, focus groups, observations, surveys, and document analysis.

**Negative Case Analysis**

Negative case analysis is used to uncover conditions separating outlying cases from the emergent norms on which current assertions are based. This enabled me, as the researcher, to develop a deeper understanding of the nuances and dynamics of which I was only a temporary participant (an outsider). This was most beneficial in uncovering some of the political dynamics within the school, but these do not appear as part of this dissertation as I felt they were outside the scope of this study. Negative case analysis was also useful in analyzing participant responses (see Chapter 5), by ensuring that I was
understanding these responses according the cultural models of the participants and not my own.

**Peer Debriefing**

Peer debriefing was used to ensure that at no time during the data collection or analysis did I allow myself to lose track of the goals of this study in terms of what data I was collecting and what questions I was hoping the data would answer. I selected a reader who was not invested in my project, and who was willing to read my analyses once or twice a month and offer honest and constructive critiques of my emergent assertions. This reader also aided in reviewing the low-tech brainstorming materials to decrease the likelihood that significant juxtapositionings of student-drawn icons or color schemes were not overlooked when investigating student meanings in these materials. In addition to this, I also hoped to gain an outsider perspective on the influences on and barriers to the success of this process of designing a software product. Based on past experience on product development teams, I have realized it is easy to become consumed with the production of the technology, to become gradually more inattentive to the initial goals of the research as the product becomes more developed.

**Member Checks**

As an outsider to this school site it was especially important that I work to establish “an accurate snapshot” (Sewid-Smith, 1997, p.597) of the situation according to local meanings. As an outsider in terms of both the public school system and this
particular school, I was entering a foreign environment. Given this placement, I could easily have misinterpreted the everyday goings-on in the school, such as behavior management and teaching philosophies, if I had relied solely on my own perceptions and understandings.

As such, I tried to conduct a member check with the teachers once a month using small analytic write-ups of the data thus far. While the principal was interested in reviewing my preliminary analyses, neither of the teachers nor the assistant principal expressed an interest in reviewing the data with me. As a result, the only member checking I was able to conduct with the teachers was through short verbal exchanges over data recently collected and its immediate implications. The focus groups were the only forum in which I sought member checks with the students, and these were conducted as conversations with the students to confirm/disconfirm my interpretations of their low-tech brainstorming materials and analyses of their prototype evaluations. Entries in my reflective journal tracked all of these instances of member checking, as well as the corrections and qualifications made to my own analyses as a result.

**Issues of Representation**

I was but one member of this design team. As such, I wanted to foreground the active presence and contributions of the participants, my co-designers, as much as possible in the write-ups. I see thick descriptions as key to this effort.

Using the action of “winking,” Geertz examines how—in order to distinguish the winking from a social gesture, a twitch, etc.)—we must move beyond the action to both the particular social understanding of the “winking” as a gesture, the *mens rea* (or state of mind) of the winker, his/her audience, and how they construe the
meaning of the winking action itself. “Thin description” is the winking. “Thick” is the meaning behind it and its symbolic import in society or between communicators. (Makela, 2003)

To this end, in addition to the summative work that I believe is necessary for a coherent write-up, I worked to include vignettes and key quotes to pass on to readers the flavor of the moments from which I was forming my assertions and to show that the assertions are based on patterns rather than one-time incidents. In addition, I wanted to leave a sufficient enough data trail that, as suggested by Erickson (1986), readers of my analysis will have enough information to assess the credibility of my assertions. This will also enable readers to infer whether the design approach employed in this study has elements that are transferable to their own situations.

**CHAPTER SUMMARY**

In this chapter, I explored my initial research design, providing both an extensive school context and a detailed initial research timeline in terms of data collection and research objectives. I also touched on how this data would be used to meet these research objectives and answer my overarching research questions. I then explained the appropriateness of participant observation for this initial research plan. Finally, I discussed the ways in which I incorporated some of the tenets of qualitative research into this study.

In the following chapters, I will discuss the relative successes and failures of this initial research plan in the field (Chapter 4), the ways in which the participants engaged in and/or resisted their roles in this study (Chapter 5), and the software that was produced
in the course of this study (Chapter 6). In Chapter 7, I will use these discussions to inform a revision of the initial research plan for future constructivist software design endeavors.
CHAPTER 4

RESEARCH PLAN ANALYSIS

INTRODUCTION

As I stated in Chapter 3, the research design I was working from was only designed as an initial (ideal) guide to how this process would go. This initial guide was meant to function as a checklist of what data to collect when, who to collect it from, and what was to be accomplished at each phase of the design process. In reality, there were many factors that facilitated the success of this initial plan, and many factors that proved to be barriers to the success of this initial plan, where success is gauged by the capacity of the plan to foster the plan user’s ability to achieve the research and software objectives. In this chapter, I will provide a detailed analysis of which factors facilitated and hindered my progress towards the objectives of the original research proposal, and which factors facilitated and hindered my progress towards my objectives for the software.

For each of the five Phases of the initial research plan, I begin by recapping the initial plans for the Phase\textsuperscript{45}, and then compare these to the actual ends of the Phase. I end

\textsuperscript{45} These Phases were first detailed in Chapter 3.
with a summary analysis of the barriers and facilitators for that Phase. The Phases are analyzed chronologically.

This chapter does not provide a comprehensive reporting of every barrier and facilitator encountered during this study, but rather highlights those directly pertaining to the process itself. Other barriers and facilitators will be highlighted in the subsequent chapters on teacher and administrator responses to the study (Chapter 5), student engagement (Chapter 5), and the analysis of the software itself (Chapter 6).

**PHASE 1**

Phase 1 was meant to acquaint me with the school administrators, from whom I would learn about the official policies on technology integration and content standards, and the potential for an integrated curriculum/software program, while also giving me the opportunity to collect policy and other relevant school documents.

The duration of this Phase was meant to be two weeks. It would begin with an interview with the principal, Eric, and an interview with the assistant principal, Agnes. It was at this time that I planned to collect the school policies and other documents. The remainder of the two week timeline would then give me the opportunity to analyze the documents before meeting with the teachers for their interviews.

**Differences Between the Initial and the Actual**

Phase 1 began on 8 October 2004. While this Phase included an introduction to and impromptu observation of the science period, and an introduction to and impromptu
observation of the math period, the focus of Phase 1 was to interview the principal and then the assistant principal.

Unexpectedly, the interview involved both the principal and assistant principal. I had hoped to interview them separately in order to ascertain a richer administrative context. Yet I do not believe this unexpected change was a barrier or facilitator to either the research plan or the software design. Administrative context and official policy statements were not central to the success of this project, but rather worked to explain, to a limited extent, how things functioned within the school and to set a richer context for the transferability of the project.

It was during this interview that I first discovered that the school was split between the math/science and social studies/language arts departments.

**Eric:** Not only do our teachers work in departments...

...The way this building is designed, Agnes runs science and the math departments, I run the social studies and language arts departments.

[Interview, 8 October 2004]

More details on the departmentalization of the school have already been covered in the School section of the Research Design in Chapter 3, and so I will not revisit that discussion here. However, at this time, the implications of this were that an integrated unit would only be possible across the domains of math and science.

In terms of the documents I wished to collect, the principal felt that all of the information I was looking for could be found in the Teacher Handbook, if that information was written at all. There existed neither a technology policy nor
documentation on the teacher teams. While a Teacher Handbook was not available at the time, I was told that a copy would be made before my next visit to the school.

Though I was not able to collect or analyze documents other than those publicly available (i.e., school web pages) during this time, I was able to begin the consent process for all of my participants. I also spoke to the students in the participating classrooms in order to initiate contact and hand out the packets for parental consent\textsuperscript{46}. Given that I had already received teacher consent, I also conducted some preliminary, impromptu classroom observations of the two classes from which I was hoping to receive consent/assent. Since I did not have student consent/assent as of yet, I focused these observations on the teachers. Luckily, this was also the one day during my observation period that Ethel had access to the computer lab. This observation enabled me to observe how Ethel uses computers for classroom activities and what type of worksheets she writes to accompany these activities. The lesson from this lab session is included in Appendix O.

\textit{Barriers and Facilitators, Phase 1}

Research Barriers: The only research barrier of Phase 1 was the unavailability of the in-house documentation. This prevented a more in-depth analysis of the school context than

\textsuperscript{46} These packets included an introductory letter and a research proposal geared towards aiding parents in understanding what their child’s role would be during this study, if they allowed their child to participate. The included proposal also included a clause indicating that participation was voluntary, and students could withdraw at any time. Contact information and an official consent form on OSU letterhead were also included, giving parents the opportunity to select whether they wanted their child to participate in observations and surveys only, as a designer, as a software reviewer, or not at all.
was available from just an interview and my cursory observations around the building. It also prevented me from understanding the way things are “supposed to be” in terms of school policies.

**Software Barriers:** Recall that the 4th criterion for the software was that it integrate curriculum from at least two subject areas. The administrator interview implied that an integrated software program might not be possible outside of math/science.

**Research Facilitators:** The first and foremost facilitator of this Phase was the receipt of consent from all of my adult participants (i.e., the administrators and the teachers). I was also able to get an early start on parental consent forms for students, as I had planned on this being a component of Phase 2. Given the timing of my school visit during the school day, I was also able to observe Ethel’s use of the computer lab and Nancy’s classroom teaching style. These provided an introduction to their teaching and technology philosophies.

**Software Facilitators:** The impromptu observation of Ethel’s use of the computer lab and the collection of the accompanying lab worksheet (written by Ethel) served to provide insight into the type of software that Ethel would like to have designed for her classroom, and how she viewed its place in her lessons.
PHASE 2

Phase 2 was meant to be focused around teacher observations. These observations would aid me in understanding the teacher’s teaching and technology philosophies, as well as the constraints they worked under in everyday classroom situations. These understandings would be supplemented by a formal interview with each of the participant teachers. In this way, I could better assess how to design a technology for their classrooms. During this time I would also become more familiar with the curriculum being used and the content standards the curriculum was meant to meet, not only through observations but also through the collection of lesson plans used through December. The lesson plans were collected for this time period only because I wanted students to be familiar with the potential software topics by the time we began our brainstorming sessions together in January (Phase 3). It would have been impossible for them to have a fair say without knowing in advance the content under discussion. Finally, this Phase would also provide me with the chance to become familiar with the students I would be working with. This familiarity would be aided first by my classroom observations, and second through a student questionnaire (see Appendix I).

In terms of the students, this period would also provide them with the time needed to not only become accustomed to me, but also with the potential curriculum topics used during Phase 3’s software design sessions.
Differences Between the Initial and the Actual

While successful in terms of accomplishing the classroom observations and teacher interviews, this Phase uncovered roadblocks in terms of the need for more stringent selection criteria for participating teachers and students, and the practical constraints on creating an integrated, software-supported classroom lesson.

On 26 October 2004 I returned to the school to pick up the students’ parental consent forms and began formal observations of the classrooms. It was also on this date that I began working towards scheduling interviews with the teachers. Classroom observations were very informative in terms of understanding how the participant teachers actualized their teaching philosophies. In addition to the impromptu observation on 8 October 2004, I observed each class once a week starting on 26 October 2004 and ending on 16 November 2004. By this point I had reached the point of data saturation as far as the observations were concerned.

The timing of the teacher interviews presented pros and cons in terms of this project. By being placed after observations had already begun, I was able to double-check some of the conjectures I had already begun to make, as well as discover answers for questions that had arisen during observations and other preliminary data analysis efforts. These interviews were timed after the point of (observation) data saturation, so there was little point in returning to the classroom to corroborate interview responses. In fact, no new information arose as a result of reviewing the observation data through the lens of the interview data findings. Yet, while interview data could now be used to
triangulate observation and school document data, the interviews created roadblocks in terms of my software objectives.

Recall #4 from the Software Criteria (see Table 1.1). In order to satisfy this criterion with math and science, I collected lesson plans from the previous school year. In situations in which the topic has not been pre-selected by the client (the teachers, in this case), Clark and Mayer (2003) suggest conducting “a content analysis to define the major topics and related subtopics to be included” (p.15). The lesson plans were the most accessible means of conducting this analysis, as every day’s lesson from the previous school year had been archived. See Appendix P for an example of the lesson plans collected, and Appendix Q for the entire list of topics compiled. Again, this software was meant to meet the teachers’ needs as well, meaning that the topics chosen would need to be topics for which they also saw the need for further visualization or other capabilities that were not available to them through their other class resources. This was more difficult for science, as many of the lessons were already accompanied by a hands-on lab that led students through an exploration of the concepts they were studying.

As is seen through the interview selections below, the teachers had divergent needs in terms of visualization tools.

**Ethel:** Wh—what I’m teaching right now, with the *matter*…um, elements and…compounds and…chemical and physical change, *that* would probably be good. If there was some kind of way to show…*how* it…you know, like um…something that they could virtually manipulate to see how it kinda all works.
**Barb:** Like how?
**Ethel:** It’s kind of—I don’t *know*. It’s kinda of—it’s *complex*, because we’ve talked about elements, we’ve talked about compounds, and you know elements making up the compounds. But *still* it’s so *abstract* to them. That they don’t
seem to get it. So if there was something that kind—kind of worked them through that.

[Interview, 16 November 2004]

Nancy: Actually I think you could do something with geometry and tessellations …

Knowing how to create tessellations. So if you could have something that actually they could physically manipulate by moving, and, and flipping and turning to create tessellations.

…

Three dimensional objects with learning, with the three dimensional objects, how to, how to figure out what the area is or the volume is. Because they could actually manipulate that object to see how many sides it is. Because when they’re not 3D it’s very difficult for them to be able to visually see that object. So that they can count the faces and the edges and the vertices. To be able to see patterns and things like that. I think that would be great!

[Interview, 18 November 2004]

From these interviews, it seemed that the potential topics for software, as chosen by the teachers, were tessellations, area and volume, elements and compounds, and physical and chemical changes. These topics were not complementary, and would not allow for an integrated math/science lesson without quite a bit of manufacturing. There was thus a tension between my research agenda and leanings towards an integrated curriculum and the needs of the group (6th grade math and science teachers and students) I was to be aiding through my research. The teachers had each selected their topics for software design by deciding which topics the students would most benefit from having computer visualization tools available for. Of main concern was that the software meet these needs, as per Software Criterion #2 (i.e., the need for software to meet the teacher’s needs). Yet the uncomplementary nature of the topics chosen by the teachers conflicted with the original sentiment behind the creation of Software Criterion #4 (i.e., integrating the curriculum) and Software Criterion #3 (i.e., aiding the individual construction of
knowledge). Further, observation data suggested a lack of regular computer time, and other (non-computer based) means by which potentially complimentary software topics were already being sufficiently covered. While I could have prioritized the creation of an integrated software package, the needs of the teachers and students took precedence as per my prioritization of the software criteria. Consequently, I decided that an integrated math/science lesson would not be ethical.

In addition to the unexpected curriculum consequences of the teacher interviews, other information was also revealed to me on 2 December 2004 that might have disqualified students from participating as designers if I had known of it beforehand and understood exactly how precious time would be during subsequent design sessions. While it had been my intent to randomly select four students from each class to be software designers, Ethel had taken it upon herself to modify my research plan and had told the students that the first four to return their parental consent forms would get to be software designers\(^{47}\). During a conversation in which I was working with Ethel to set up a time for January’s design sessions, she informed me that one of the student designers from her class would have to leave sessions early because of band conflicts, but that she didn’t think it would be a problem.

In order to prepare for the upcoming brainstorming sessions of Phase 3, I began conducting various web searches by 22 November 2004 in order to find applets\(^{48}\) and other applications that already covered the teacher-chosen topics. I was also interested in analyzing the students’ questionnaires at this time, as I would use these responses to help

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\(^{47}\) Incidentally, this tactic resulted in a 100% return rate for parental consent forms.

\(^{48}\) An applet is a small Java program that can be run inside a web browser. This is one way of embedding interactive content (e.g., games or other dynamic applications) on a web page.
focus my own brainstorming for ideas (i.e., characters, settings, activities) I could supply if the students had a hard time coming up with ideas of their own at the outset. I thought it might be easier for the students to begin by critiquing my ideas than it would be for them to pull ideas out of the air. See Appendix R for the summary of answers to the questionnaires.

**Barriers and Facilitators, Phase 2**

**Research Barriers**: The most notable barrier of this Phase was the loss of the potential for an integrated lesson. Second, more stringent selection criteria were required for teachers in that they not only needed to be interested in and able to develop an integrated unit, but also have complimentary needs.

**Software Barriers**: None.

**Research Facilitators**: One key facilitator was the ability to reach the point of data saturation in terms of classroom observations, including the teaching and technology philosophies/practices of both teachers. The timing of this point of data saturation also allowed me to double-check my preliminary assumptions and analyses during the teacher interviews and short email exchanges before winter break.

**Software Facilitators**: A key facilitator in terms of the software was the ample time I had between the end of the official Phase 2 activities and the beginning of Phase 3. This not
only enabled me to analyze the student questionnaires at my leisure, but also to become familiar with the ways in which the topics under consideration for software development were currently being visualized through computer software.

**PHASE 3**

Phase 3 was the longest and most demanding of all the Phases in terms of both the software and research objectives. Phase 3 was meant to last three and a half months, January through mid-April. I would begin this Phase with low-tech brainstorming sessions aimed at letting the students guide me through presenting the curriculum topics in ways that are interesting to students. In this way, I worked to place the students as Delivery Experts\(^\text{49}\) in the design process. From the ideas generated in these sessions, the teachers and I would work to select three prototypes for rapid prototyping. These prototypes would be implemented at a very basic level for the first formative evaluation in order to give students and teachers just enough of an idea of each software program to be able to select a single prototype for full development for subsequent formative evaluations. There were to be two or three formative evaluations with student designers and teachers before the whole class summative evaluation. During this Phase, the accompanying worksheets and/or other lesson-related materials were also to be developed with and by the teachers towards the goal of creating the entire unit of which the end software product would be a part.

\(^{49}\) This term was defined in Chapter 1.
Differences Between the Initial and the Actual

Phase 3 began differently than intended because of the Phase 2 decision against subject/lesson plan integration and the resulting need for separate math and science programs. This required the need for two sets of brainstorming sessions, two sets of formative and summative evaluations, and the development of two lessons of which the developed software would be a component. From a research perspective, deciding against an integrated curriculum and thus creating two separate design teams (i.e., math and science) provided the opportunity to compare techniques and processes between the two groups. In addition, the smaller student groups – four students per group instead of the entire eight at once – made design sessions more manageable, as I was the only adult in the group50.

This Phase was compromised by limited access to the participants. On 14 January 2004, I found out that not only would I have one student designer whose extracurricular activities would conflict with design sessions, but that there were conflicts with choir, band, and speech. These affected all of my students, math and science, depending on the day of the week during which we were to meet. Further, the timing of the 6th grade proficiency exams lengthened the desired amount of time between brainstorming and the first formative software evaluation. Finally, pre-existing time constraints on the teachers made creation of the accompanying lesson plan impossible.

50 When I designed the initial research plan, I had decided to have a maximum of four student designers from each class in keeping with Druin’s (1999) suggested ratio of a maximum of three students for every one adult involved. I had assumed that the teachers would be in attendance for all brainstorming and software evaluation sessions. However, even once it became clear that the teachers would not be present, I decided to remain true to my Research Proposal (Appendix B) and Student Recruitment Speech (Appendix H) as four students wasn’t too far over the prescribed maximum per adult. It also allowed me to work with a larger sample of the student population (22% rather than 16.7%), which in turn allowed for greater student input and an increased potential for accommodating student culture in the software.
Low-Tech Brainstorming

I conducted two brainstorming sessions for science and two for math. I chose to interweave these – science followed by math followed by science followed by math – rather than conduct one before the other, as I thought it may prove useful to employ student management/interaction techniques or student software ideas (e.g., basic game ideas, characters, interaction components) across the sessions. These brainstorming sessions all took place during the study hall period (11:30 -11:55 a.m.), but any student who had a conflict (e.g., band) had to be dismissed 10 minutes early.

The first brainstorming session with the science students occurred on 20 January 2005. I arrived for this session with a box of “goodies”: gel pens, markers, colored pencils, crayons, pencils, rulers, stencils, stickers, and various colors of construction paper. These were all the tools I thought would be needed to conduct a low-tech presentation of ideas, and would provide another venue for assessing the color preferences of the students. As per my arrangement with Ethel, I collected the students from the classroom and then took them back to one of the conference rooms.

I told them we’d be doing some brainstorming about designing software on the topics of physical/chemical change and elements/compounds. According to my original plan, I tried to first establish what they know about these things. I got stilted responses on the academic side and some very eager suggestions from the boys about a space alien invasion (Freddy\(^{51}\)) and a mystery game (Jaeger). I switched tactics, and tried to feel out what kinds of scenarios they wanted given their questionnaires had said they like adventure/puzzle games. Jaeger offered up a battle scenario after which you collect elements. But he couldn’t tell me the point of collecting elements. Time to switch tactics again. I asked if maybe we could do something where we have to solve a lot of puzzles after which we get rewards that would help us do something, like defeat space aliens. No go with the kids. They tried a few more scenarios, and then I switched over to asking about

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\(^{51}\) This name, as well as the names of all student names, have been changed to protect the identities of the students. All of the students, except Jaeger, chose their own pseudonyms.
specific game tasks rather than the whole game. I went to the whiteboard and
drew up a game where I’m hydrogen and I know I want to make H2O, but I’m
swimming through other elements that I could accidentally bond with instead. I
have 3 guys, and I need to make it to oxygen. This set the kids off, and suddenly
we had ideas, such as Ele-Man, a Pac-Man rip-off. Excellent! I brought out the
paper, gel pens, crayons, pencils and rulers and told them to draw a screenshot.
They did not know what a screenshot is. Maybe an opening screen? No. I want
to see what the screen of the game should look like. I transferred my idea to a
piece of construction paper to show them, and they were off with their own ideas.
[Research Journal, 20 January 2005]

I gave the students a set amount of time to draw, based on an educated guess of how
much time would be needed afterward to discuss their drawings with them before the
girls had to leave for other activities. Outside of a nutrition prototype offered by Snoopy,
all of the screenshots were on-topic with elements and compounds. I had the students
take extra construction paper in case they wanted to draw other ideas that came to them
before we met again the following week.

Ethel came in as I was cleaning up my “goodies” and asked how things had gone.
I stated that I would like to run our collective ideas by her, but she said that whatever we
came up with would be fine. I was uncomfortable with this, as the academic worth of the
ideas was unclear, but I had sufficient data from the students to create at least one
prototype for the evaluation sessions.

I returned again on 25 January 2005 in order to conduct the first brainstorming
session with the math students. Based on my experience with the science students, I
began this session by introducing the students to the process – the purpose of my
observations, what we’d be doing today and next week, and how these brainstorming
sessions would inform prototype development towards the creation of software for next
year’s math class – and then focused the day on tessellations. The initial exchange is listed below.

Barb: So, today we’re here to brainstorm about software ideas. And Nancy suggests that we do something on the topics of tessellations and volume and area. So, just to start out with, can somebody tell me what a tessellation is?

Dexter: Where you, like, draw some shape over and over again or something like that?

Barb: Okay. So, can the shape be a circle?

Dexter: No. [drawing on the whiteboard]

Barb: Okay. So they interlock perfectly.

…

Barb: Okay. Have any of you seen, or can you give me instances of places where you use tessellations.

Students: [complete silence]

Barb: Like, where do they come up in your life right now? Anywhere?

Dexter: Um

Students: [complete silence]

Barb: Like your kitchen floor? On the tile?

Dexter: Oh yes! Um, the design in my, um, kitchen floor.

Barb: Alright.

Dexter: So like in designing tile decorations or something like that.

Barb: Yeah. Now would that be fun to do?

Students: [various “no” responses]

Dexter: Let’s so.

Barb: So what are some things we could that would have you make some kind of pattern?

[Brainstorming Session #1: Math, 25 January 2005]

Building from the above understanding of tessellations, I led the students through an exchange of ideas related to activities that could involve the use of tessellations. After ensuring that each student had some idea in mind, I gave them time to draw.

I drew a screen of an avatar needing to build a tessellation bridge over a chasm.

Bill, who was sitting to my right, copied from my drawing, but was not able to process

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52 This format is modified from the previous science session in which I had tried to cover all of the potential topics at once rather than covering one topic a day.

53 This name has been changed to a pseudonym. During the actual brainstorming session, I referred to Nancy according to her title (i.e., Mrs.).

54 As a note, most of these activities did not have any tie to real life applications of tessellations.
the concept of a tessellation, and so his bridge was a compilation of various shapes. Dexter wished to create a house out of a tessellated shape, but his drawing reflected the same conceptual problems as Bill’s. Candy created a game in which the avatar had seven minutes to build a shelter out of grass, trees, and sand before drowning in the rain. Finally, Bailey wished to build a boat out of triangles that would be used to carry the avatar to a volcanic island on which a clue was housed; the clue could be destroyed if the boat is not completed in time. Further discussion of the drawings seemed to indicate that Bill, Dexter, and Candy still did not know what a tessellation is, but we had some program elements to work with.

My second brainstorming session with the science students occurred on 27 January 2005. I focused the day on physical and chemical changes by first having them tell me what the difference is and by giving me examples. I knew from the previous session that they were capable of doing this, but wanted to refresh this information in their minds. We then began discussing different ways this information could be placed into a fun game. My focus had been on games, because of the results of the questionnaire analysis. Amazingly, though, while discussing the “fun” aspect of various ideas, Freddy piped up with “It doesn’t have to be a game.” Wow! This opened up a whole new avenue for us, and ways we could integrate software into the lessons for next year’s students. The tone of the discussion became more focused on drill and practice, but the ideas were still interesting and engaging. Primary among the ideas generated was a Simon Says type game in which students were asked to create either a physical or chemical change, and then had to combine the only two elements on the screen that
would fulfill this request. Any combination showed the student the result of the combination with written feedback. The second workable idea was a memory type game in which students had to not only recall the placement of elements on the screen, but also match those items that result in chemical changes. A match provided the student with an animation of the change. These ideas, together with the ideas from the previous science session, provided for some very exciting programming avenues.

I returned the next week on 1 February 2005 for the final brainstorming session with the math students. The demands of the school day had resulted in a late start for this session, so rather than probing the students for information, I showed them the worksheets they’d been using in class for volume and prompted them for ideas of interesting things we could do with volume. The students were unable to comply. I offered up an idea about having to get a clue by transferring a certain volume of water to open a door, which I borrowed from a puzzle game I once played. While not favored by the students, this prompted them to offer their own ideas, most of which had to do with obstacles on an adventure of unknown purpose. Bailey suggested that perhaps we needed to rescue a princess. We spent a lot of time drawing, with some students creating multiple drawings. Even so, there were only three prominent ideas developed by the students. The first idea was to find the volume of five 3D figures, which would open a gap in the wall large enough for the avatar to go through. A variation on this was to match each of the shapes to their volume equation for the same result. The second idea was to solve for volume equations in order to (somehow) eliminate space between the avatar and a prize or clue. The third idea involved an optimization problem in which the
student would try to pack as many candy bars as possible into a box based on the volume of each bar and the total box size. After reviewing these, most of which seemed to fit into an adventure/journey game based on the fact that students presented them as a continuation of their ideas from the previous brainstorming session, we broke for lunch.

Teacher Selection of Prototype Ideas

After my own review of the sketches and ideas from the brainstorming sessions, I emailed the teachers the above listings for potential software ideas on 14 February 2005. I incorporated this step into the initial design plan to ensure that the software designed would meet teacher needs. I had been depending on the teachers’ feedback as a key contributor to successful software design, and had envisioned presenting the software ideas to the teachers and working with them to tweak the ideas to make them better suited to the teachers’ teaching and curriculum needs.

From the list of math topics generated, Nancy chose to have me implement the journey-based sequence of tessellation and volume puzzles, figuring that it “sounds like a good adventure” [Email, 14 February 2005]. While the selection of only one prototype idea was contrary to the initial research plan of beginning with about 3 prototypes and whittling down to one final prototype, I felt compelled to defer to these teachers in prototype selection. Ethel, however, found favor with two prototype ideas, Simon Says and Ele-Man, and inquired as to how many I would develop. Given how close the graphical content of Simon Says was to the quiz proposed by the students, I offered to develop these three in preparation for the first formative evaluation.
In the end, I created the three intended prototypes for science: Ele-Man, Simon Says, and the Basic Quiz. Each of these was created using Macromedia Flash. Ele-Man was a Pac-Man style prototype in which students had to avoid amoebas while searching out elements to form a compound. I developed the first level for this evaluation, in which students had to collect two hydrogen and one oxygen towards the creation of water. At the end of the level, a movie was provided to show how the elements combined to form the compound. Figure 3 shows a screenshot of the level, and Figure 4 shows a screenshot of the compound movie. Simon Says was based on physical and chemical changes. I created three screens of this, in which students were given one object (e.g., fire) and were asked to create either a physical or chemical change with one of the other four objects. Only one of the four would create the desired change. For example, given fire and the choice of charcoal, gasoline, wood, and a nail, create a physical change. Answers were scored based on the first attempt, although students could combine the fire and the four objects indefinitely to view a movie of the result. In the end, feedback was tailored to the student’s score and whether that student needed more guidance with physical or chemical changes, both, or neither. Figures 5-7 show screenshots of the first question of the prototype. Finally, in the basic quiz, Test Yourself, students were shown the movie of the combination of objects (e.g., fire and wood) and then asked to pick whether what they saw was a physical or chemical change. Their selection triggered an explanation of why what they saw was a physical or chemical change. Students could watch the movie as many times as they wanted before and after picking the type of change. Again, only the
first attempt at answering was scored, and final feedback was tailored to their responses.

Figures 8-10 show screenshots of a sample quiz question.

As noted above, I created only one prototype for math, Pickle Rescue, which involved a series of tessellation and volume based puzzles (rooms). A lot of time was spent trying to figure out how to tie the puzzles together. Since the students had not developed a storyline of their own, I developed one myself. The software takes place in the following context:

Ninnian Pickle and Maisy Pickle were walking through the forest one day. Suddenly, a large human hand appeared from the sky and kidnapped Maisy! Ninnian must now quest to the Land of Picnic to save her.

This storyline is obviously not an “authentic” or “real world” constructivist storyline. Its genesis lies in the creation of the first avatar, which I thought looked like a pickle. See Figure 11. Since the students had suggested rescuing a princess, and since the main avatar looked like a pickle, I decided to focus the storyline around a pickle/food theme and a rescue mission at a picnic. For this rescue mission, I compiled the students’ ideas with some of my own to create a series of six rooms. In the first room, students were required to tessellate objects in order to create a bridge over a chasm. In the second room, a clue for a subsequent puzzle was acquired. In the third room, students were asked to pick a raft (a tessellation) in order to float to an island and pick up another clue. In the fourth room, students were asked to match volume equations with the appropriate shape. When matched correctly, a gate opened that allowed the avatar to continue on his quest. The clue for this was acquired on the island of room three. In the fifth room, students had to redirect a certain amount of water in a fountain to free a ladder from the
fountain. The application of volume equations was needed for this puzzle, and the clue for this had been acquired in the second room. Finally, in the last room, the ladder was needed to climb up to the finish point. Figures 12-25 show screenshots of the rooms of this first prototype. If hints were needed along the way, students could click on a hint bubble and a thought bubble appeared above the main avatar’s head to show what was needed. These were, in order, the completed bridge, the location of the clue in the second room, standing on the island with the second clue, matching equations and shapes, freeing the ladder, and where the ladder needed to be placed in the last room. Figures 26-31 show images of the hints used in the hint bubbles.

In addition to the storyline, I also focused on trying to make the prototypes as visually appealing as possible. Graphics are an important factor in overall appeal of software. As I noted in my analysis of the Student Questionnaires in Appendix R,

The desire for a 3D environment or 3D characters also came up (2), tempered by one student’s remark that “I don’t like software that looks like the makers didn’t try very hard.”

The impression of the importance of graphics these responses gave me was reiterated during Formative Evaluation #2: Science. Between the first and second evaluation sessions, I had created shadows and highlights for the objects in the (2D) science prototype in order to simulate a 3D environment. Upon opening the game, one student remarked,

**Snoopy:** You made it better!
[Formative Evaluation #2: Science, 29 April 2005]

Later reactions in the math software evaluations also reiterated this phenomenon.
Formative Evaluation #1: Science

Knowing that I had a lot to accomplish with this first round of formative evaluations, especially with science, I requested double the amount of time I usually was able to spend with the student designers. Also, since the teachers would not be present at these evaluations, I began a tradition on this day of leaving a CD of the software and the evaluation forms with the teachers so they could complete them as time permitted. While it had been my hope to collect these forms in person and review their evaluations in a live discussion format, the teachers instead mailed the evaluation forms back to me each time and clarification of evaluation responses was conducted solely over email.

The first formative evaluation was conducted for the science prototypes on 21 March 2005. Knowing that I had three prototypes to work through and that some of the students would have to leave early due, I set the following schedule:

11:10 – Simon Says (5 minutes for play, 5 for evaluation and discussion)
11:20 – Test Yourself!
11:30 – Ele-Man

This schedule was also meant to leave sufficient time at the end of play and discussion for students to be able to fill out the evaluation forms.

I handed each student a CD with the prototypes on them, and instructed them on how to get to our files and what exactly we’d be doing during this time. While they played, I kept up a constant dialogue with the students, answering questions and prompting them to use various features. I also worked to keep them on task with preliminary evaluations of the software, discussing colors, usability, and highlighting aspects of the prototypes that were and were not favored. This open dialogue continued
on through the actual evaluation sheets. See Appendix S for a copy of the evaluation sheet. Unfortunately, everyone except for Snoopy needed to leave early, and so she was the only one I could ask my follow-up question: Did any new ideas come to you after seeing the ones today? Unfortunately, Snoopy continued her trend of unrelated ideas (e.g., the nutrition based Pac-Man idea from the first brainstorming session) with a suggestion for a program that would let students view the life cycle through watching animals die and decay.

Before leaving the lab, I tested the math prototype in order to ensure that there were no problems. If there had been, I still had enough time to install the prototype on laptops I could bring in on my own. The program worked, but it was VERY slow, and the images did not display correctly (i.e., the colors were off and the tree tops were rendering about 1 inch above the tree trunks). While not ideal, I felt these were manageable problems for the next day. I also felt that testing the prototype on the school computers would give more realistic feedback, as the final program would be running on these computers and not my laptops.

Formative Evaluation #1: Math

The second formative evaluation was conducted for the math prototype on 22 March 2005. Before leaving with the students, Nancy requested that I briefly help her with the game at her own computer, as she was having some usability difficulties. Once in the lab, I told the students that we were there to test the program we’d come up with during brainstorming. Since they hadn’t given me a story, I relayed the one I had created.
Students responded well to the main avatar, Ninnian Pickle, and enjoyed the fact that I had programmed his eyes to track the mouse as the user aided him in solving puzzles.

**Bailey** [upon viewing the opening screen of Pickle Rescue]: I like the pickles. I think they’re adorable.
[Formative Evaluation #1: Math, 22 March 2005]

**Bailey** [during play in the first room of the game]: Oh, his eyes move!
**Barb**: Yeah. They’ll track the mouse wherever it goes.
[Formative Evaluation #1: Math, 22 March 2005]

These were roughly the last positive things the students had to say about the program. Just as in the science evaluation, I kept up a running dialogue with the students as they moved through the game, prompting them to tell me what they were supposed to be doing at each step and asking them about various features, such as the scenery. They noted the slow speed of the program (Bailey recommended putting Ninnian on a skateboard or roller skates to speed him up), the “weird” tree trunks and unrecognizable burger (due to color display problems) from which they needed to rescue Maisy Pickle, and the overall dull palette I had chosen (“It looks like he’s in the desert”). The students were also confused by some of the puzzles, and had some problems with usability (i.e., clicking on or moving objects in the game).

**Barb**: So overall I would say we did not like the game?
**Candy**: Yeah.
**Barb**: Yeah? Well, what do you think went wrong?
**Dexter, Candy, & Bailey** [talking over each other to answer]: *inaudible* dull *inaudible*
**Candy**: It kinda moves too slow.
**Bailey**: And some of the things were too hard, to do.
[Formative Evaluation #1: Math, 22 March 2005]
After about 20 minutes of struggling through the program with the students, and given the slew of negative feedback, I suggested abandoning this prototype idea in favor of a fresh start.

**Barb:** Alright, well, do we wanna completely throw this one out? And start again?

**Bailey:** No.

**Barb:** Why?

**Dexter:** *inaudible*

**Bailey:** I think there’s a really good storyline to it. I like the storyline.

**Candy:** I like the pickles.

**Barb:** Okay.

… [some more critique of colors, unrecognizability of burger]

**Bailey:** And I like the signs. I like how that says “Welcome to Picnic”.

**Barb:** Okay. So we just need to tweak this idea and it could get better?

**Dexter:** Yes.

**Barb:** So we don’t need to completely throw it out cuz it sucks that much?

**Dexter:** No.

**Barb:** You’re positive. Cuz we can start again. That’s the power of designing.

**Dexter:** No.

**Barb:** Okay. [time to dismiss Bill]

[Formative Evaluation #1: Math, 22 March 2005]

Given the students’ desire to salvage the existing program, I focused on guiding students through a discussion of what they liked and what they wanted to change in every room.\(^{55}\)

Once finished with actual game play, I gave the students the evaluation feedback forms immediately (see Appendix T for the form), because Bill had to leave early and the extra troubleshooting during game play had been very time consuming. Once all of the forms were completed, I pulled out screenshots of the program so we could step through them one at a time in order to review the feedback they had already made and to discuss what

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\(^{55}\) If I had had more regular access to the students, and thus more design sessions, I would have pushed harder to start over. I wasn’t all that happy with the playability or academic worth of the game, was not sure it was meeting Nancy’s expectations for software for her classroom, and wanted to branch out and try again. However, I really wanted the students to be a part of the design process, and their input and participation was a major factor of this research design, and so I followed their lead and tried to make the best of the remainder of this design session in the hopes of vastly improving the software for next time.
else could be changed. In addition to some of their other changes, the students added the
idea of scoring or timing the game at this point in the review, but did not have clear ideas
on how to implement either of these. From a programming standpoint, the screenshots
were probably the best idea I had had for this review session, as they allowed for a more
hands-on assessment of the screens – allowed for drawing right on the screens so
potential changes became apparent immediately – and created a better way to discuss
student feedback with Nancy.

Once the students were dismissed for lunch, I met with Nancy and Ethel in the
lunchroom to discuss the students’ suggestions for prototype changes. In my discussion
with Ethel, I first related the students’ preference for Ele-Man⁵⁶, which I had ascertained
via direct questioning before dismissing them, and then told her about some of the other
changes students wanted, such as hotkey commands instead of just mouse control for the
quiz. I then reviewed the screenshots with Nancy. She approved of all of the students’
changes. Like the students, she wanted a score to be utilized to gauge game success.
Yet, in addition to just reporting on this score, she wanted high score lists to be stored for
student comparison. Given the nature of CD games, such high score recording is not
possible without installation on a computer, but I did not dismiss the possibility of this
feature outright.

⁵⁶ While we would only be choosing one program for final development, I was interested in developing all
of the science programs at some point. In addition, Ethel had not yet chosen which single program she
wanted to have developed.
Modifying the Prototypes

Using a combination of my own notes from the evaluations, the formative evaluation sheets provided by the teachers and student designers, and my leftover “to do” lists from before the first evaluations, I began implementing changes to the programs.

My goal for Ele-Man\(^\text{57}\) was four levels, all of which were to end with a movie that showed the elements of that level forming that level’s target compound. Using compounds that the students would encounter in their everyday lives was important to me, as I didn’t want to show them the creation of things they wouldn’t recognize. In the end, I chose water, hydrogen peroxide, ammonia, and baking soda. These choices also reflect an increase in level difficulty through the number of elements to collect, in keeping with general expectations for game level difficulties, while still only including the first 18 elements\(^\text{58}\). Knowing that the students would not be familiar with the elements as I was portraying them\(^\text{59}\), I also took it upon myself to implement a clickable Periodic Table. This Periodic Table would be a supplement for Ele-Man, but could also be used as a standalone program.

While I exercised a lot of freedom in deciding how Ele-Man would function, such as the selection of compounds and the design and layout of the graphics, my modifications to Pickle Rescue followed almost exclusively the screenshots we modified

\(^{57}\) On 5 April 2005, Ethel communicated to me that she had chosen Ele-Man as her favorite prototype, both in terms of its fit to the curriculum and her perception of how “fun” the students would find it.

\(^{58}\) I decided to draw from only the first 18 elements of the Periodic Table, as I felt that in a game situation such as this one, where the elements are already small images, more than three electron rings would be outrageously hard to decipher.

\(^{59}\) This assumption was based on worksheets and the science textbook sections covering the topics of elements and compounds. The book, in particular, discussed elements using the theory of electron clouds. Since these are difficult to visualize, I used the deprecated theory of electron rings. My goal with this prototype was to aid in student understanding of why elements bond together to form compounds, not to explore the intricacies of the likelihood of finding electrons in a certain electron cloud.
during the formative evaluations with the students and the lunchtime review of these with Nancy. Some other modifications were implemented as well due to the feedback on the evaluation forms. In addition, I deleted one of the puzzles and replaced it with one entirely of my own creation. While greatly improved, I was still dubious about the potential success, in terms of both academic worth and student appeal, of Pickle Rescue.

**Formative Evaluation #2: Math**

I began the second set of formative evaluations with the math students on 27 April 2005. Unlike the first round of evaluations, for which I had the students for an hour, this round of evaluations took place during the study hall period (11:30 -11:55 a.m.), halving the amount of time I had with the students during the earlier round of evaluations.

We encountered login problems, which shaved an additional seven minutes from our evaluation period. Luckily, I had incorporated keyboard shortcuts to flip between puzzle rooms during development, and prompted the students to use these during their own evaluations. Rather than waiting for each student to finish each room, I instead instructed the students to watch each other once one of them had finished, or came close to finishing, that puzzle.

The students recognized their changes and claimed to like the game much better (outside of some lingering usability issues), but I could not put much stock in their responses given the lack of sufficient time for each of them to truly explore the puzzles. Additionally, the students had to fill out the evaluation forms on their own time and
return them to me at the end of the week, as there was not sufficient time for these forms during the study hall period.

This date also marked the point at which I began to realize that the amount of time the teachers would be able to dedicate to the study was dwindling rapidly. A discussion with both Ethel and Nancy made clear that the turnaround-time for their evaluations would be at least two weeks, and that the day-to-day demands of the school day were continuing to increase for both of them.

Formative Evaluation #2: Science

Two days after the 2nd formative evaluation for math, I returned to the school to conduct a formative evaluation for science. While waiting for the students to log on, I explained how, based on their favorite from last time and Ethel’s preference, we only had one prototype to work with now.

Curious how much the students actually read through the information by themselves, I did not direct them to the supplementary Periodic Table I had designed. None of them looked at it, instead skipping directly to Ele-Man. Freddy began play in expert mode – trick elements that cause death when the avatar collides with them, no visual of the target compound for the level, faster killer amoebas – while Snoopy picked beginner – no trick elements, a clear visual of the level’s target compound in the middle of the maze, and slow amoebas.
While I exploited Snoopy’s success to show Freddy60 all four levels, the compound movies, and the final screen of the game (including the total time taken for game play), I took the opportunity provided by Freddy’s continual deaths to redirect him to the Periodic Table and explored it with him.

This evaluation session also highlighted the need for an accompanying worksheet, which would have aided in structuring the overall evaluation of the prototypes. In addition to not exploring the Periodic Table on their own, the students also did not choose to play the compound movies once they realized that these were not essential to game success.

**Barriers and Facilitators, Phase 3**

**Research Barriers:** In terms of the brainstorming sessions, my research barriers included the lack of constructivist-based guidance during brainstorming sessions with the students. In terms of actual software design, I temporarily lost my focus on teacher needs and authenticity during software design. Pickle Rescue, while cute, does not necessarily meet Nancy’s requests for classroom software (e.g., 3D object manipulation for volume and tessellations), nor accurately convey information to the students. This worked against my Software Criterion #2 (i.e., the need for software to meet the teacher’s needs), as well as Software Criterion #3 (i.e., aiding the individual construction of knowledge). I categorize this design point as a research barrier, because I view the software criteria themselves as part of my research plan and not part of the practicalities of developing software. Finally,

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60 Klutz had been pulled out of this session by another teacher, and Chase was absent that day.
the lack of sufficient time to develop an accompanying lesson plan defeated one of the objectives promised by the Research Proposal given to the school administrators and teachers.

**Software Barriers:** First, more stringent guidelines for student participation were required, particularly in terms of potential scheduling conflicts with design sessions. A second pitfall was the lack of constructivist-based guidance during brainstorming sessions with the students, leading to a very drill-and-practice feel for many of the prototypes. Third, while I had searched for applets and other applications that covered the teacher’s selected topics as well as reviewed the class materials given to me by the teachers, I did not have enough information about what the students had already seen on these topics. As such, my initial brainstorming session with the science students was a bit too advanced for 6th grade science. A review of my Phase 2 interview with Nancy also shows that the brainstorming sessions and the resulting software design got a little away from me in terms of fulfilling Nancy’s wishes/needs. She had asked for very basic manipulation of shapes to aid students in counting vertices and edges, for which I had found some great applets, but the bridge puzzle was the only component of the prototype that required student-driven manipulation of shapes. The matching puzzle between the shapes and their volume equations comes closest to showing edges and vertices, as these shapes are somewhat translucent and rotate to show all their sides. Nancy also did not redirect the academic value of software design back towards her requests. Finally, the development
of a single prototype for math, combined with my decision to follow the lead of the students in design decisions, led to a lack of safety net for failed prototypes.

Research Facilitators: The most prevalent research facilitator of this Phase was my realization that it was okay if I implemented software changes that the students had not directly requested, because I was the educational technologist and had the authority to make such decisions given that the changes would still be reviewed by the students during the following evaluation period. A second facilitator was the length of time taken between the second formative evaluation and the receipt of the teacher’s evaluation forms (three weeks), which enabled me to compile preliminary lists of the facilitators and barriers to the process thus far. Third, the realization that prototypes do not have to follow a game format in order to appeal to students allowed for a greater range of approaches to software design for the classroom.

Software Facilitators: First, the low-tech nature of the brainstorming sessions allowed students to pursue any angle they wished in terms of screenshot drawings, freeing us to discuss any ideas that the students offered. Second, the running dialogue format of evaluations, along with the use of printed screenshots, was probably the biggest facilitator in terms of accommodating student identity within the software. Third, the use of developer shortcuts that allow the user to navigate easily through the program without necessarily having to play through in a linear fashion allowed the design team to compensate for other technical issues and time barriers during evaluations.
**PHASE 4**

The summative evaluation was meant to take place two to three weeks after the final formative evaluation. This Phase was designed to aid me in assessing how well the design efforts of a small subset of students would match with the needs of the larger student body.

*Differences Between the Initial and the Actual*

The summative evaluations for both math and science occurred on 25 May 2005. While the summative evaluation was meant to take place in May, the actual spacing between this and the final formative evaluation was longer than expected; these Phases were a full four weeks apart due to scheduling conflicts with the math classes. Through email exchanges regarding the problems – primarily time-based – with obtaining parental consent for other students to test the software, we were eventually able to resolve these scheduling conflicts such that the math software would be tested by the original math reviewers and the science software tested by the original software reviewers, provided that I also conduct the final exit interview with the student designers during their study hall period on that same day.

*Summative Evaluation: Science*

The entire science class participated in this summative evaluation. I entered the session intending to run the sessions as I normally do: introductory statement regarding why we’re here, a discussion of the prototype and time to go through it, and then
evaluation forms. Ethel had other ideas. Rather than letting the students read the introductory web page on their own, Ethel had one boy volunteer to read it out loud to the class. After reading the section on the Periodic Table, Ethel had each student click into the Periodic Table and go through it.

**Ethel:** Everyone click on the Periodic Table real quick. I want us to look at that. Just click in. Do you remember all that way, like towards the middle of the year, when we were talking about elements and how they make compounds, and we looked at the Periodic Table? The game is based on that idea. So you have to kind of have that in your mind before you can play. You don’t have to *know* the Periodic Table, as far all the elements, right?

**Barb:** Right.

**Ethel:** They just have to have familiarity with that.

**Barb:** So, what this does is give you a short introduction to what the actual elements look like. What their atomic structure looks like. So you can click on any of the symbols, and you’ll see pulls up that element. With the nucleus, and all of its electron rings.

**Boy:** Whoa [quietly]

[Ethel and I help the kids click around a bit]

**Ethel:** Now when you’re playing this game there’s something we never talked about that I want to make sure you understand. The *outermost* ring of each of those elements has a specific number of electrons that would be there to fill it. And if that ring is not *full*, it can join with another element to fill that ring and that’s how compounds are made. So, for example, when you look at the nucleus, the ring that’s just outside of it, it’s full when it has 2. But it’s not always 2. As you go out, I think they increase.

**Barb:** Yeah. They go to 8 and then 8 and then 18.

**Ethel:** So that should now help you out with this a little bit.

**Barb:** Okay, so now if you wanna. Take your time on this, and when you’re done, scroll back up to the *top*, click on the Summative Evaluation link, and then you can go and play Ele-Man.

[Summative Evaluation: Science, 25 May 2005]

While Ethel’s intervention wasn’t planned, it really helped fill the gap left by the missing worksheet – the accompanying lesson that was not developed during this study. Students now had a context in which to process the information they were seeing, not only
academically, but also how it fit into the game play to come. It also ensured active
student participation.

Ethel’s proactive involvement continued throughout the evaluation, aiding in
focusing the game play. This was especially important during the compound movies
(e.g., water formation), which students were prone to skip over.

Ethel [to one student]: See how they join and fill that out?
... Ethel [to another student]: Watch it again and watch how they come together.
... Ethel [to yet another student]: Watch the rings.
... Ethel [and another student]: Now what are they trying to make?
[Summative Evaluation: Science, 25 May 2005]

I welcomed these interventions. Ethel’s proactive involvement also aided the objectives
of this study. Given the length of game play, and the length of the evaluation forms,
students were not able to complete the written evaluations before the class period ended.
Again Ethel stepped in to help.

Ethel: Class, we are out of time.
Girl: No!
Ethel: What I want you to do. Listen carefully. I will let you have time
tomorrow in class to finish these. If you’re not done, I will take them. If you are
done, you can give them to Barb. Okay?
[Summative Evaluation: Science, 25 May 2005]

As the summative evaluation of the math prototype shows, this kind of proactive
involvement on the part of the teacher, or at least the educational and classroom
management techniques employed by Ethel during this scenario, was essential to a
successful evaluation session.
Summative Evaluation: Math

While only 10 of Nancy’s 23 students were able to participate as reviewers, the entire class came to the computer lab and played Pickle Rescue. Those students involved as reviewers sat in a cluster together for ease of staying on task and filling out forms. The students not involved as reviewers were relatively on their own in terms of going through the software, though I did float through their section occasionally to guide them and answer questions. Nancy sat at a table near the non-reviewers and graded papers. While Nancy was relatively uninvolved in the review process, she did occasionally redirect students who had “mastered” the prototype (i.e., finished it with a full score of 100) to other math websites.

On an academic level, the students were not using the volume equations to solve the volume-based puzzles, but were instead employing mindless trial and error methods to get through the game. I tried at one point to get the students’ attention on the volume equations I had written on the board so that these would be employed in solving the puzzles, but they were too able to work through the puzzles without the equations to take notice.

In addition to these problems, Bailey, one of the software design students, took this evaluation sessions as an opportunity to campaign for her aesthetic leanings in terms of the avatars. She spent nearly the entire evaluation trying to convince other students that Ninnian Pickle should be on a skateboard and wearing a cap, while Maisy Pickle should be wearing pearls and a pink dress. This campaigning was more evident in
student reviewer answers on the evaluation forms, which sometimes took the form of “Bailey told me to say X.” followed by their own answers.

Students were especially interested in their scores. A small group of students played repeatedly to see who could get the max score. As such, the session recording is punctuated by conversations of the format:

**Student A:** I got ##.
**Student B:** Darn it! I got ##!

This reinforced the design decision made by Nancy and the student designers to incorporate a scoring feature into game play. While I had not wanted to do this, as it drastically changed the tone of game play in a way that I thought discouraged understanding in favor of competition, it seems that scoring was a significant factor in student engagement with the prototype.

Unlike the science prototype, which required the full class period for testing, the students working with the math prototype were all able to complete it well before the end of the class period. As such, Nancy returned to the classroom with the software reviewers and non-participants, and the software designers remained with me in the lab for their exit interview.

My overall feeling at the end of the session was that the evaluation was very disappointing. Without a worksheet or other guidance, the students, while engaged in terms of score comparison, did not stay on (academic) task, and it was hard to tell what, if any, academic worth the program might have. Additionally, without all the personal guidance given by the student designers and myself, I am unsure how intuitive/playable the student reviewers would have found the activities.
Barriers and Facilitators, Phase 4

Research Barriers: There were no significant research barriers during this time.

Software Barriers: In terms of the math class, Bailey spent a lot of time soliciting support for putting Ninnian Pickle in clothing rather than allowing students to focus on the game itself. Given this, the evaluation data from the math session is not necessarily reliable.

Research Facilitators: Ethel’s proactive involvement with the science evaluation made for a very rich data collection session during the science class’ summative evaluation session. It also provided a perfect opportunity to compare the difference between the science and the math group in terms of the effects of the teacher’s involvement and direction on the students’ attitudes towards the software and software-related activities.

Software Facilitators: Again, Ethel’s proactive involvement was a great facilitator in that she kept the students focused on the task of exploring and evaluating the software.

Phase 5

Phase 5 was meant to be conducted two weeks after the summative software evaluations. In addition to discussing the participants’ responses to study participation and the software product, these interviews were also meant to serve as member checks for preliminary data analysis. As such, focus groups, in the form of exit interviews, were
to be conducted with (1) the teachers, (2) the administrators, and (3) the student
designers.

**Differences Between the Initial and the Actual**

Given that this Phase was designed according to participant groups, I break this analysis
into sections for Students, Teachers, and Administrators to reflect these groupings.

**Students**

As explained above, student exit interviews were conducted during the study hall
period on the same day as the summative software evaluations, 25 May 2005. While this
timing did not allow for analysis of evaluation data before the interviews, it did provide
more enlightening responses from the students. Because the responses of their fellow
students were fresh in their minds, they were more aware of the viability of the software
produced. During evaluation sessions, the students were also very aware of how their
ideas were incorporated (or not) into the prototypes. Even these assessments, though,
were tempered by the reactions of their fellow students. Thus, interview responses were
more reflective than they would have been even the next day, once the experience had
worn off.

In the case of the math students, in which the exit interview immediately followed
the summative evaluation and in which the students were not happy with the final
product, this meant that the students had a hard time focusing on the process over the
product. Regardless of what question I was asking, the students found a way to either
bypass my question altogether or formulate their answers in such a way as to lead directly back to software feedback. For example,

**Barb:** Alright. So, back to…this process. Were there things that you did not like about how we designed the software? So, like, we did the construction paper session, and then we did the software evaluation. Other than not being able to be more hands-on, and not having more time, like, seeing the software as I was doing it, were there other things you didn’t like?

**Candy:** I didn’t like that there were few, um, levels that you had to go through. I thought there should be, like, ten of ‘em?

**Dexter:** Yeah, be more levels.

**Bailey:** I think you should be able to choose in the beginning if you wanted to play advanced, easy, or like, medium.

**Dexter:** Yeah, that’s what we said before. And also there should be like, um, when you actually do get to Picnic? I think there should be, like, an obstacle to get to the little picnic table thingie.

**Candy:** Yeah!

[Exit Interview: Math, 25 May 2005]

The science students, who were admittedly happy and content with their final product, were able to hear my questions and stay on task with their answers. Combined with the one process-based reflective response from the exit interview with the math students, it seems that the students would have liked to see the following two changes to the process:

1. *An additional brainstorming session*

   While the students found these to be both fun and useful, they seemed to want more input on exactly how their ideas were going to be implemented. Regarding the low-tech brainstorming sessions,

   **Barb:** Was there anything you would have changed about those sessions? Like, have more of them? Or
   **Freddy:** Maybe, maybe like one more.
   **Barb:** One more?
   **Freddy:** Just so we could do more ideas or like, um, improve our ideas from before.
   **Barb:** Okay. And you don’t think the software evaluations did that as well? You think it would have been better to just sort of rehash before we actually started developing?
Freddy: Yeah.
[Exit Interview, Science, 25 May 2005]

While not as explicit, Bailey’s response to the process also indicated a need for more brainstorming, or more hands-on planning as far as screenshots and interactivity goes.

Barb: Did you have anything that you didn’t like about it [the process]?
Bailey: I kinda wish we could helped design it, like, on the computer.
Barb: Okay. So like if I hadn’t gone away for a month and?
Bailey: Yeah. So like looking at what’s going and deciding what, if we need something there, while we’re actually there.
Barb: Yeah, the problem with doing that is that it takes too long.
Bailey: It takes a lot of time out of class.
Barb: Right.
[Exit Interview, Math, 25 May 2005]

The end of the above exchange also highlights the practical constraints of the second student suggestion for the process: more frequent meetings.

2. More frequent meetings
I had noted in my research journal that I had to spend some time jogging the memories of the students at the beginning of each session. At the beginning of the brainstorming session, this meant reminding them of why we were all there together. At the first formative evaluation, this meant reminding them of the brainstorming sessions. And at the second formative evaluation, this meant reminding them of decisions we’d made during the first formative evaluation. It seems that the students also recognized the lack of cohesion between meetings.

Barb: Alright. Uh, do you wish we had been able to meet more often about this, or do you think we had enough time?
Freddy: I think there was too much time in between the meetings.
Klutz: Yeah.
Freddy: There was like, two weeks? I’m not sure.
Barb: We had like about a month between each one.
Freddy: Yeah.
Barb: So we should’ve met, like, every couple weeks instead?
Freddy/Klutz: Yeah.
Barb: How would that’ve made it better?
Freddy: So we woulda, we, we still woulda had like an idea that we
could still do, and not had to like try to like, um, tried to remember it for
that period of time, so you can just like of like
Barb: So you forgot too much in between.
Freddy: Yeah.
[Exit Interview, Science, 25 May 2005]

**Teachers**

While teacher interviews were conducted the following week, on 1 June 2005, I
did not have sufficient time to review the data before these interviews, as the bulk of my
time was spent finalizing the CDs to be distributed to the students before the end of the
school year.

Teacher interviews were conducted during the study hall session of locker-
cleanup day, one at a time. This was contrary to the initial intent of the research plan to
conduct this exit interview in a focus group format, but was in keeping with my Phase 2
decision to wholly separate the math and science groups. Given the timing, the
distracting environment, and my own lack of proper questioning (lack of “why” follow-
up questions during the interview), these were not as informative as I had hoped.
However, I did leave these with a good sense of whether/how the software produced
during this study would be used in the future.

In keeping with Nancy’s technology philosophy, detailed in Chapter 3, it would
seem that, if used, she would employ the software as an enrichment activity. Given her
busy schedule, though, I am uncertain as to how much time she will devote to creating enrichment activities to accompany the software.

**Barb:** And do you believe that the end product of this design endeavor will be useful to you in terms of teaching future classes?

**Nancy:** Oh, I think so. It’s just another, um, way to do things. A different mode.*inaudible*.

**Barb:** So do you see yourself as, like, while you cover these things you’ll incorporate this into your lesson?

**Nancy:** Oh sure. Oh easily. Easily.

**Barb:** Would you ever just like set up the software in the back?

**Nancy:** Oh, here in back? Oh definitely.

…

**Barb:** Looking at it, um, are you planning on creating a worksheet or something

**Nancy:** Yeah. I would like to. Like an enrichment type activity with it.

[Interview, 1 June 2005]

Since this exchange, I have learned that the math program, Pickle Rescue, will not be used as part of the math curriculum. Ethel plans to employ her software as part of her introduction to the lesson on elements and compounds. She has chosen not to create accompanying worksheets, but relies on verbal guidance during game play.

As for points the teachers want other educational technologists to keep in mind, the teachers highlighted areas that complemented their teaching philosophies. In Ethel’s case, she focused on being student-centered, in keeping with her constructivist leanings.

**Ethel:** I just think keeping in touch with the students is really important as far as what’s gonna keep them interested. I think the end product they liked so much because they, you know, the students had a say in what was gonna happen. With the programs.

[Interview, 1 June 2005]

Nancy focused first and foremost on the content standards, in keeping with the priorities of the school and school district. However, she also highlighted student-centered
teaching in her recognition of the age-appropriateness of the activities and characters in her math program.

Nancy: I would say definitely they need to be involved in the standards that education has gone towards, and to find things that match up with the standards, because that’s what we need to be doing.

Barb: Okay. *inaudible* So, other than standards, anything else?

Nancy: I mean, I think the standards should drive everything. And then, keep it as realistic as possible but yet still having a lot of fun with the kids. I think the kids like the characters.

…

I really do. I think the kids liked that. And it was still really good age-appropriate stuff, which is good. It wasn’t too sophisticated, it wasn’t too…baby. So.

[Interview, 1 June 2005]

Nancy’s response works towards validating the priority ordering of the Software Criteria listed in Chapter 1 – schools (and teachers) place emphasis first and foremost on whether classroom resources (like software) help to meet content standards. This response also reinforces my assessment that the software satisfied at least part of Software Criterion #3 (software that the students find engaging), which will be addressed in more detail in Chapter 6.

Administrators

Eric began our meeting by referring to my original research proposal and asking me how I would be answering these questions. I briefly covered issues of negotiations with teachers, lack of access to and time with the students, and difficulty with the brainstorming sessions. When asked during the interview what he would tell other educational technologists interested in a process such as the one employed during this study, Eric reiterated some of these issues.
Eric: I would ask them to spend some time thinking about how best to get specific information from the kids. Um, through their questioning. And through the environment they’re questioning the kids in. Also, um, teachers are very focused on…the day. And when you have that, you don’t always have their full attention. Oftentimes they’re thinking about their next lesson, or their next parent concern, or what have you. Um, so I think maybe some time away from the building with the adults might enhance the process a bit.61 [Interview, 13 June 2005]

In addition to his suggestions for fostering more active teacher participation, Eric expressed disappointment over his own lack of involvement with the project, both in terms of his time constraints and my lack of communication with him.

Barb: Um, would you have wanted to be more involved in the design process yourselves?
Eric: Yeah, I would have. You know, I felt like I didn’t always know exactly where you were in the process. Um, you know we gave you a tremendous amount of freedom, and I think, I thought that’s what you needed.
Barb: Mm-hmm.
Eric: To make this program work. But I would’ve liked to have been more involved. Um, but it was my choice that I wasn’t more involved. I just had to work out where I would spend my time.
Barb: Ideally, how would you have been involved if you could have been?
Eric: Um, probably do the interviews with you, along the way some mid-checkpoint that we could talk and you could show me your project or maybe answer questions about the curriculum.
Barb: Okay.
Agnes: Or have the kids talk about where they’re at at some point.
Barb: Okay.
Eric: Yeah. Yeah, I just think, um, checkpoints along the way would have been helpful for me to realize where you were, where our kids were, and what that final product is. And how much time went into it, actually.
…
Barb: Was there, um, any reason that you didn’t communicate to me during this process that you wanted to be more involved?
Eric: I wanted to be. However, I did not have the time to be more involved. [Interview, 13 June 2005]

61 In fact, I had tried to schedule time away from the school, including offering to take Ethel and Nancy out for lunch or coffee, but neither of them ever expressed any interest in meeting like that. Nor did they ever accept offers to help with grading or other activities in an effort to compensate them for time spent on this project.
In future endeavors, although they participate only at the fringes, administrators should be included in more member checking throughout the process, or at least be kept up-to-date with progress reports. Yet I would still resist an administrator presence at interviews and other meetings, as the monitoring of responses implicit in that presence would prevent the kind of open atmosphere of the design, evaluation, and interview sessions.

**Barriers and Facilitators, Phase 5**

**Research Barriers:** The only research barrier of this Phase was the lack of access to the students, which disallowed sufficient time to analyze data between the summative evaluations and the exit interviews. Aside from the obviously missed opportunity for further member checking, this also inhibited my ability to pursue with the students any discrepancies between their written summative evaluation forms and their verbal responses during the exit interview.

**Software Barriers:** Given that the summative evaluations and exit interviews were listed in the initial research plan as the end marker for software modifications, there were no software barriers during this Phase.

**Research Facilitators:** During this Phase I received valuable feedback on the design process from the students. In the case of the math students, I even received better student feedback on the software from the exit interview than I had during formative evaluations.
This resulted in reflections on the process by presenting the potential of reorganizing the process in such a way that a whole class Formative Evaluation would be placed before the final Summative Evaluation is conducted with just the student designers.

Software Facilitators: Again, as the Summative Evaluation marked the end of software modifications, there were no software facilitators during this Phase.

SUMMARY OF PHASES

While I was able to meet an overarching objective of creating custom software, there were many places where the initial research plan could have been more accommodating of and realistic about the dynamics and uncertainty of real-life situations. Below I list some of the ways I would alter the plan based on the analysis above.

1. A better screening process for the school, teachers, and students is needed to ensure a willingness/desire to use technology, a willingness to participate in the study, the ability/desire to work towards an integrated lesson, and the ability to meet for the full time period selected for design (i.e., no student conflicts).
2. Explicit software objectives should be included as part of the overall research plan.
3. The educational technologist should be prepared for brainstorming in terms of guiding the students towards more authentic uses for the technology, or activities that are more constructivist in nature. This process as-is is very games based, very drill and practice.
4. One additional brainstorming session for review and refinement before programming begins should be included.
5. The design should include longer evaluation periods (roughly one hour each) and be spaced closer together (e.g., no more than three weeks apart).
6. Phase 3 should be revamped in the following way: FE #1 (designers), FE #2 (whole class), SE (designers). If more evaluations are possible, a second FE with only the designers before whole class (e.g., FE #1B) or a final evaluation with the whole class again (e.g., SE #2) would both be useful.
7. More assertive member checking and overall checking-in throughout entire process should be added to this process. This amendment affects all participants.

CHAPTER SUMMARY

In this chapter, I explored the ways in which I applied the initial research plan in the field while still maintaining the integrity of the study in terms of my initial software objectives and my beliefs regarding the place of technology in education. As I noted in Chapter 3, changes to the initial research plan were expected. In this chapter, I have elucidated the reasons that guided my modifications to the plan. The resulting actual research timeline resulted in facilitators and barriers to both my research agenda and the software product, which I used to create a preliminary list of research design modifications.

In the next chapter, I delve deeper into the research Phases to analyze the various responses of my participants to the design process. I follow this with an analysis of the software itself in Chapter 6.
CHAPTER 5

PARTICIPANT RESPONSES

INTRODUCTION

In this chapter, I discuss how my participants responded to the process of software design as detailed in Chapter 4. These responses work towards informing other educational technologists’ collaborations with participants in software design endeavors such as this one. I begin by first discussing how the administrators responded to the process. Given my limited interaction with them, this analysis is based almost entirely on interview data. I then turn my attention to the teachers’ responses to the process. This analysis is based on interview data, observations, evaluation sessions, email exchanges, and other informal communications. Finally, I discuss student engagement as it relates to both the software design process and the software designed by this process. This analysis is based on observations, interviews, and brainstorming and evaluation sessions. I end each section with a quick categorization of these responses in terms of facilitators of and barriers to the research process (Research Questions #1 & #2), and a brief discussion of how these responses can be used to inform future endeavors. This latter discussion is
explored more fully in my final analysis in Chapter 7. A summary of participant responses is located in Table 5.1.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Responses</th>
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<tr>
<td>Administrators:</td>
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<td>Eric and Agnes</td>
<td><em>Motivation for Participation:</em> Technology Agenda</td>
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<td>Meeting the Standards</td>
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<td><em>Responses to the Study:</em> Accommodating</td>
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<td>Monitoring</td>
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<td>Teachers:</td>
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<td>Nancy</td>
<td><em>Motivation for Participation:</em> “Because I was asked.”</td>
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<td></td>
<td><em>Responses to the Study:</em> Reliant on Relevant Tangibles</td>
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<td></td>
<td><em>Responses to Her Role:</em> Imposed Upon</td>
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<td>Teachers:</td>
<td></td>
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<td>Ethel</td>
<td><em>Motivation for Participation:</em> “Something developed just for what I’m doing.”</td>
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<td></td>
<td><em>Responses to the Study:</em> Proactive</td>
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<td><em>Responses to Her Role:</em> Proactive</td>
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<td>Imposed Upon</td>
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<td>Student Engagement:</td>
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<tr>
<td>Reviewers</td>
<td><em>Signs of &amp; Influences on Engagement:</em> Lack of Stage Setting [math only]</td>
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<tr>
<td></td>
<td>Lacking Continuity</td>
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<tr>
<td>Student Engagement:</td>
<td></td>
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<tr>
<td>Designers</td>
<td><em>Signs of Engagement:</em> Lacking Continuity / Requiring Prompts</td>
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<td>Desire to Contribute [Brainstorming]</td>
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<td><em>Influencing Factors:</em> Recognition of Their Influence</td>
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<td>Ownership</td>
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<td></td>
<td>Spending Time with Friends</td>
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<td></td>
<td>Getting Out of Class</td>
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</tbody>
</table>

Table 5.1: Summary of Participant Responses.
ADMINISTRATOR RESPONSE

When I discuss the administrator response, I am discussing primarily how the principal responded, as he is the one I had the most direct contact with and the one who dominated the interview sessions.

The principal participated in this project out of a desire to (1) further his technology agenda for the school and (2) fulfill the school’s mandate that each lesson work towards aiding students in meeting proficiency standards. As a result of these agendas, the principal was accommodating of the needs of this study with overtones of monitoring.

Technology Agenda

The technology agenda consisted of the administrators’ plans for technology integration in the school. As I noted in Chapter 3’s coverage of the principal’s technology initiatives and informal technology philosophy, this agenda included all administrator-based attempts to get teachers to experiment with and be comfortable with (computer) technology. While not stated explicitly, the place of this study for the administrators was as a part of this agenda.

Eric: I think the process that you used, it got our teachers to think more about technology in the classroom. It also got them to understand what goes into developing software. The kids you worked with, um, probably have a greater appreciation, or deeper understanding, of content specific software. To them. So I think all parties that were involved in the process here, I think walk away with a greater understanding of educational software. I would think.

Agnes: And its use, and how we can use in the classroom and how the teachers can use it to supplement their lessons. As opposed to games and things like that.

Eric: And any time our teachers have exposure to technology, it’s a benefit. Uh, not always an immediate benefit, but sometimes further down the road they’ll feel
more comfortable with their conversations with their colleagues. It might spark interest, um, *inaudible* appreciated *inaudible*.

[Exit Interview, 13 June 2005]

Recall from Chapter 3 that the administrators see their role in technology integration as setting an example to try new technologies. While the administrators have the final say in what is used and what is not, they give the teachers free reign (within the expectations of meeting the content standards) to seek out and try new things on their own before reporting back to the other teachers and administrators on their findings.

**Meeting the Standards**

As noted in Chapter 3, the administrators of this school took extra measures to ensure that their school was doing its best to meet the content standards. These efforts included requiring at least one content standard or benchmark to be listed with every day’s lesson plan, random walkthroughs of the building to check lesson objectives against the content standards, and participation in Autoval’s Education Service Program through the short cycle tests.

The assistant principal had played the math game, Pickle Rescue, before the exit interview. Her evaluation of Pickle Rescue consisted of her recognition of how the software met the standards. This is in line not only with the general technology agenda summarized above, but also the understood technology policy that every software package in use has a clear connection back to the content standards.
**Accommodating**

I define Accommodating as flexible and responsive to the needs of my study. In the case of the administrators, this was evidenced first during my initial phone contact with the principal. In response to my letter, the principal left the following voice message on my cell phone:

> This message is for Barbara. Barbara, Eric, principal of Lochley Intermediate. Um, looking over your research proposal and would like to talk about that with you. If you would give me a call ###-####. That’s area code ###. Or Barbara you can call me on my cell phone, ###-###-####. Um, I have two teachers that would be interested in working with you. One of them would be Ethel, the other her teammate who teaches math…Nancy. So, anxious to speak with you, hammer out some of the details. Call me when you get the chance. Thanks so much. [Voicemail, Monday, June 14, 2004, 9:03am]

During the phone conversation that followed, we first reviewed the research proposal I had sent to him. We then discussed issues of parental consent and his desire to view all forms going out to parents before I sent them out, as I would not be using the school’s standard forms for parental notification and consent. The principal stated that he felt they (i.e., the school staff) would be able to help me, and inquired as to what I needed to begin the study. This led to a discussion of the letter of acceptance required by IRB. In addition to being more than supportive in terms of my IRB requirements, the principal also ended each official interview session by asking if “that was okay”. In this way, he expressed his desire to meet the needs of my study.

Further, in response to my need for a Teacher Handbook, the principal had one compiled for me to meet the document needs of Phase 1 of the study. In all of these ways, the administration was very accommodating of the basic requirements of this study.
Monitoring

Any school administrator must keep him/herself abreast of what is happening in the school. In this school, the administration style employed seemed to that of monitoring. I view monitoring as a means of keeping a watchful eye over the activities of (and, potentially, statements by) your subordinates. Occasionally, this monitoring also hinted at overtones of intending to influence the activities or statements of others.

There were several signs of the administrators’ desire to monitor the school on all levels, such as the walkthroughs of the building to check the lesson being taught against the content standards. In addition to such surface signs of monitoring, both informal conversations and interviews with the principal seemed to support my inclination to view these as monitoring. Below is an excerpt from my Research Journal entry from 8 October 2004, the first face-to-face encounter with the school administrators.

Before I left he [the principal] told me to stop by every time I’m in the building to let him know I’m there, and then come back before I leave to let him know what I observed.
[Research Journal, 8 October 2004]

This overtone of monitoring was compounded by the interest he had shown earlier in what I had already observed in Ethel’s class that morning. I had off-handedly mentioned the observation in the computer lab as a basis for a discussion on technology selection and integration. Eric was very interested in how Ethel had learned of the software, where it was on the Internet, and so forth, and asked that I supply him with the URL of the site.

In addition to this early sense of monitoring, other indications of his desire to be present at (and manage/control) other participant interactions emerged during the exit interview on 13 June 2005.
Barb: Ideally, how would you have been involved [in this study] if you could have been?
Eric: Um, probably do the interviews with you, along the way some mid-checkpoint that we could talk and you could show me your project or maybe answer questions about the curriculum.
[Exit Interview, 13 June 2005]

Barriers and Facilitators

Facilitators: The accommodating nature of the administrators, along with their own technology and standards agendas proved to be facilitators to the execution of my research plan in that they were eager for their school to participate and greatly aided the process of entry into the school.

Barriers: None.

Informing Future Endeavors

Administrators have a responsibility to the school and the students’ educations. Working in the school “under the radar”, as I did in this study, can lead to feelings of discomfort on the part of the administrators. By integrating progress reports to the administrators into the research plan, the monitoring tone I experienced at the fringes of this study might have been avoided altogether.

TEACHER RESPONSE

Teacher response is an important factor in the successes and failures of the design process employed in this study. Once in the school, the researcher/software developer
can’t help but rely on teachers for supplying relevant materials (i.e., lesson plans), for the scheduling of interviews and other data collection sessions, and for whatever other miscellaneous needs that arise during the course of the study. As will be covered in the section on Student Engagement below, teachers also influence how the students will view and respond to the design process.

In this section, I first explore the teachers’ responses individually, each of which is framed by their spoken reasons for participating in this study, thereby setting the tone of each teacher’s participation in the study. I then show how these responses can be combined to inform future design endeavors.

**Nancy -- “because I was asked.”**

Nancy had no investment in the technology promised by this design process. While she stated in an interview that, prior to using Everyday Math, she had used software for her students, she stated in a follow-up email regarding the software titles she had used that she had not, in fact, used software in her classrooms for the past 11 years. She also could not see how the current Everyday Math curriculum would allow for the inclusion of software. Additionally, each time she talked about technology, whether in past tense or as a possibility for future lessons, she referred to it only as a (study hall) enrichment activity for her students.

Given her lack of interest in the technology product (qua curriculum material) developed during this design process, Nancy had no investment in the design process itself. Her lack of investment was supported in her reason for participating in this study:
“Because I was asked” [Interview, 18 November 2004]. This lack resulted in feelings of being Imposed Upon by the demands of the study. Nancy also did not seem to have a clear conception of her place in the process and what was expected of her. These factors together led to what I understood to be a reliance on relevant tangibles.

Reliance on Relevant Tangibles

Reliance on relevant tangibles presents itself as a lack of participation except when tangibles that are perceived as relevant to the study are presented. These tangibles can be either an explicit definition of one’s role at a given moment (i.e., a clearly defined task such as “please check on parental consent status”) or as something that can be physically manipulated. While Nancy was somewhat removed from the bulk of the process, when presented with tangibles that seemed relevant to her, she usually became an active participant.

During the first observation of her class I recorded a preliminary seating chart for the Math class based on observation. At the end of that session, Nancy asked me if I needed anything else from her, and I showed her the chart to fill in the students whose names had not been called during class. She offered to run a copy of her own seating chart for the class, and made corrections as necessary with explanations of why those students had been moved. She also made attempts during these classroom observations to stop by my chair and explain to me her grading policy and teaching philosophy as she completed tasks such as homework checks. The following examples are taken from my Research Journal.
Nancy stopped by my chair as she worked her way around the room to inform me that all she does is mark off that it’s done on a chart. She doesn’t give grades, because she doesn’t want it to be a big deal.

... “It’s their education.”

... “It doesn’t stress them out to do homework. They’re stressed out enough as it is.”

... However, if the assignment is 3 days late the student must go to “Lunchtime Academy,” which is like a detention period during which students must sit around and complete their late assignment(s). There will be 3 students going today. [Research Journal, 8 October 2004]

I interpreted these moments as Nancy’s attempts at helping me to answer the questions of Phase 2 regarding teaching philosophies and practices. These had been alluded to in the Research Proposal she had received as part of her introduction letter/packet, so she was privy to the intended purpose of the classroom observations before I arrived. Through comments such as the ones above, Nancy was informing me that her philosophy involved the notion that students should take responsibility for their learning and be motivated by something other than their grades, but that their irresponsibility does not come without consequences.

Further, Nancy responded promptly to a follow-up email regarding the status of parental consent forms, given that very few had been returned at this point.

----- Original Message ----- 
From: "Nancy" 
Sent: Wednesday, October 27, 2004 2:05 PM 
Subject: Re: missing consent forms 

> I don't know if it is because they do not have a form. Ethel came over
> when I was out and made an announcement to the students about needing a
> new form. I will try to remember to ask these students tomorrow.
Nancy’s hands-off attitude towards this study changed once she was able to see the software that was being produced and how her feedback was being incorporated. She was particularly engaged in our discussion over the student suggestions for the screenshots from Formative Evaluation #1: Math.

**Imposed Upon**

At times, the responses of the participants indicated that the demands of the study were conflicting with their other obligations. The first notable instance of this with Nancy occurred in relation to the scheduling of her first formal interview. Nancy chose to have me interview her poolside at the local YMCA, where she coaches swimming for the local high school. This sort of “doubling-up” on duties was the only way in which Nancy was able to fit an hour-long interview into her November schedule.

The second notable instance of this occurred during the Summative Evaluation for Math. Scheduling conflicts with math had nearly precluded this Summative Evaluation. As a result, Nancy spent her time in the computer lab completing necessary math-related activities: grading papers. Together with the scheduling of the interview at the YMCA, it seems that Nancy was too limited in time to be a willing and active participant in this study, but perhaps was unable or unwilling to say ‘no’ when asked by the school administrators.
Ethel -- “something developed just for what I’m doing”

From our first email exchange regarding this research project, Ethel was enthusiastic.

----- Original Message -----  
From: "Ethel"  
Sent: Monday, March 01, 2004 9:17 AM  
Subject: Re: interested in a research proposition? 

> I am definitely interested. I would love to have something appropriate > for my students in science since that is mainly what I teach right now. > We were able to participate in the Jason Project this year and the > students seem to really enjoy the tech component.

Additionally, when I asked during her first interview why she was participating, Ethel responded,

Because it sounded interesting! You know, having something developed just for what I’m doing?  
[Interview, 16 November 2004]

The nature of the students’ roles as defined by the Research Proposal was also very much in keeping with Ethel’s student-centered and hands-on teaching philosophy, which I think heightened her interest in the project. Recall first from the Research Proposal (see Appendix B) that this design process situated the students as Delivery Experts for software content by letting them design, in a guided way, the activities and interface for the software. The Research Proposal also worked to ensure that students were able to take an active role through low-tech, hands-on brainstorming sessions and small group, interactive evaluation sessions. This interest in the project, and her investment in the final product, led to Ethel taking a very proactive attitude towards her own role in the study.
Proactive

I understand proactive as not only doing what is asked, but as going beyond this to seek out other areas in which you can be helpful. I categorize the bulk of Ethel’s participation in this study as proactive.

First, not only was Ethel my primary contact for scheduling throughout this study, but she was also my primary resource provider for rosters, lesson plans, and other requested information. Yet these alone merely categorize Ethel as an active and willing participant in the study. Her participation is Proactive through the way she offered resources that were not requested. These included the worksheet that accompanied her web-based lesson on 8 October 2004 and a copy of a short cycle test. She also regularly asked whether there was anything else I needed.

The second aspect of Ethel’s proactive participation was the way in which she worked to be considerate of my time and presence in the school. This included making sure I knew where to eat lunch on my first visit to the school, and issues that had the potential to affect my drive out to the school (e.g., fog delays and other weather-related closings). Ethel also tried to be considerate of my time by returning evaluation CDs and forms to me via snail mail rather than having me drive out just for these items.

The third aspect of Ethel’s proactive participation was the effort she took to ensure that the Summative Evaluation for science was as fruitful as possible by employing her knowledge of the students to guide them through the evaluation process. While Ethel worried that she had overstepped her bounds, I appreciated her assistance, as these points were not foremost on my mind when I planned the evaluation itinerary.

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62 This interaction was covered in detail in Phase 4 of Chapter 4.
Subversive

I categorize actions as subversive when the participant was unwilling to disclose information relevant to the study due to scheduling convenience for that participant or a fear of conflicts with that participant’s personal investments in the study. There were two cases in which I felt Ethel was being subversive in this sense.

The first instance was on 2 December 2004, the date on which I returned to obtain verbal assent from the student participants. It was at this point that Ethel began to disclose the possibility of conflicts between software brainstorming/design sessions and other demands on the students’ time during study hall periods. Specifically, one of the four students designers was in band, which overlapped with study hall. Just in case this did become a problem, Ethel also noted for me the fifth student to return his parental consent form for software design. In January, when I returned to pick up other requested materials, Ethel explained that all of my design students would have conflicts with the study hall period. According to the Teacher Handbook, these conflicts occurred on specific days of the week, but, depending on when the design sessions could be scheduled in, it was likely that I would have to dismiss all of the student designers 10 minutes early. I interpret her reason for gradual disclosure as an investment in having the four chosen students as my student designers. When discussing with her my ideas for the brainstorming session, Ethel felt that these four student designers would be particularly suited to the planned format.

63 These conflicts were alleviated through the use of 2 brainstorming sessions per subject, which allowed for sufficient time with the students.
**Ethel**: And I’m thinking of the ones…that that would be, and I think that would be very appropriate for those people.

[Interview, 16 November 2004]

Additionally, one of the four students – the boy with the band conflict – was the son of the superintendent, and Ethel had already noted to me in a previous informal discussion that this boy’s brother was a programmer and the boy was very interested in programming himself.

Ethel showed other signs of being subversive in terms of feedback on the brainstorming sessions. Recall that after the first brainstorming session with the science students (20 January 2005), Ethel came into the conference room to see how things had progressed. Unsure of the fit of these ideas to her curriculum plans, I showed them to her. In response, she said that whatever we did would be fine. Yet the look on her face left me dubious. When I returned on 25 January to brainstorm with the math students and obtain a science textbook from Ethel, I probed again for her response to the ideas from the first brainstorming session. After reviewing the textbook with her, I stated that I felt the ideas from the first brainstorming session were too advanced for the students’ level of knowledge. This time, Ethel agreed. I can only assume that Ethel’s initial reluctance to be verbally honest about her response to the ideas was due to uncertainty regarding how that information would affect the design process.

Neither of these subversive acts had negative effects on the outcomes of this study. Yet they do highlight a need for explicit research into potential time conflicts and the flexibility to account for them, as well as a need for the aggressive pursuit of data items (i.e., honest feedback from teachers).
Imposed Upon

At times, participants responded to the demands of the study with an air of exhaustion and impatience. The first case of Ethel seeming imposed upon in this manner was with respect to scheduling the initial interview for 16 November 2004. Ethel had scheduled me between the regular school day and Parent/Teacher conferences, certain that she would have sufficient time to prepare for the parents during the school day. Yet when I arrived for the interview, Ethel commented that she still had a lot to do before the conferences began. I offered to reschedule, to which she responded, “Let’s just get it over with” [Research Journal, 16 November 2004].

The second case in which I noticed this attitude was with respect to selecting content for the software prototypes. Creating a list of physical and chemical changes for the Test Yourself prototype was easy, and the worksheets that Ethel had provided had several examples, but the Simon Says type prototype (later dubbed “Susie Says”) required groupings of physical and chemical changes. When I asked Ethel to aid me with developing more examples or to point me in the direction of other examples, she responded that I should refer back to the class worksheets she had already given me on the topic.

Barriers and Facilitators

Barriers: Nancy’s lack of investment in the technology being developed was a barrier in terms of both the research and the software product. This disinterest was enhanced by a lack of clearly defined roles & expectations for participants, a lack of relevant tangibles.
Additionally, Ethel’s subversiveness and symptoms of being imposed upon led to a lack of information at key times in terms of both student selection and software development.

**Facilitators:** Ethel’s proactive attitude aided my ability to both design and implement the software. They also played a key role in compensating for the Barriers listed above.

**Combining these Experiences to Inform Future Endeavors**

In applying the above categorizations to future endeavors, I would first incorporate more stringent participation guidelines into the research design – verbally expressed interest in the project is not enough. If the potential teacher participant does not already use technology, or, at the very least, think about or try to incorporate technology into lessons, then that teacher will not be committed enough to the project to aid in the design of viable classroom software.

Second, it is important to be as explicit as possible at each step of each Phase in terms of the tasks required and the data collected and how these fit into the larger scheme of the flow of the project. If the full listing of specific tasks and data to be collected are unclear at the beginning of the Phase, then at least the objectives of the Phase should be conveyed. It is possible that the participants will have insights on how best to achieve the objectives, which enables them to become active participants.

Third, it is important to keep in mind that the best friend an educational technologist can have in the school is a proactive teacher – one who expresses personal interest in participating in the project. Yet, even if a teacher seems proactive and helpful,
that teacher’s attitude cannot be used as an excuse to not follow-up on seeming inconsistencies. The teacher, too, has an agenda, which might conflict with that of the educational technologist.

Fourth, it is important to be as familiar as possible with the curriculum as early as possible, as teachers cannot always be relied on as active participants in content selection and design.

Finally, actively defer to teacher help in terms of student management and building (or building off) a rapport with the students. Even for those comfortable with children, the teacher will be more familiar with the idiosyncrasies of the individual students than someone new to the situation. This also aids in drawing the teacher into a more active role in the study (e.g., software evaluation sessions).

**STUDENT ENGAGEMENT**

In this section I explore the ways and the degree to which students were engaged with this project. This exploration is based on data from my own perceptions (as recorded in my Research Journal), the perceptions of the participant teachers, and the students’ own reports during brainstorming, software evaluation, and interview sessions.

During Phases 2-5 of this study, the Phases that involved student participants, I strove to build into the Phase design aspects that would foster student engagement. I understand “student engagement” with respect to the design process as the interest the students showed in actively participating in the design process. For each of the Phase components discussed below – Classroom Observations, Brainstorming, and Software
Evaluations – I first note how I worked to foster student engagement, and then explore the ways in which these efforts were rewarded. While the brainstorming and evaluation sessions dealt with the software product as well, I reserve the discussion of student responses to the software products themselves for Chapter 6.

In terms of participants, I begin with an analysis of both student designers and reviewers in Phase 2, as students had not yet been separated out into groups. While the brainstorming sessions naturally involves only student designers, I keep my focus on them in the analysis of the software evaluation sessions as well, as the responses of student reviewers can only really be taken in the context of a response to the software and not the design process itself.

Classroom Observations

My first interaction with the students during this portion of the study was during student recruitment. All subsequent interactions took place as a byproduct of the classroom observations themselves. I strove to foster student engagement first by wording my student recruitment script in such a way that the importance of student input was highlighted. See Appendix H for a copy of the student recruitment script. In all subsequent interactions, I worked to build a rapport with potential student designers in those periods before and after class time/observations by talking to them about generic topics and answering all of their questions. Student engagement during this Phase was evidenced by signs that students were eager to participate in design sessions.
Lack of Stage Setting

As I noted above, the student recruitment speech was geared to not only recruit students, but also foster interest in the project and highlight the students’ importance in the project. I encountered very different reactions in the two classrooms. My first attempt at recruitment occurred in the science classroom. Students in this classroom were actively interested in the project, asking questions about the specifics of my recruitment speech (including a specific inquiry regarding the definition of a prototype) and volunteering to hand out the packets for their parents. Students were so eager to participate, in fact, that most of the hands that went up in response to “Are there any other questions?” were attempts to volunteer immediately for software design.

The response from Nancy’s classroom was much more reserved. Rather than asking me for clarification, the students waited for me to finish and then approached Nancy. I attribute differences between the two sessions as a difference in the ways the teachers prepared their students for my visit. While Ethel’s students had discussed my visit beforehand, Nancy’s students had not, and thus did not know how to interpret the impact of my visit. I attribute this difference to the stage setting that occurred in Ethel’s class.

Lacking Continuity

The level of student engagement during classroom observations was, at best, lacking continuity. While there were signs that the students were excited to see me and were eager to begin software design, there were also signs that the length of time between
student sessions (e.g., student recruitment speech to brainstorming, brainstorming to Formative Evaluation #1, and Formative Evaluation #1 to Formative Evaluation #2) was too long to maintain student engagement over time\( ^{64} \). One factor in this could be the large number of volunteers and other individuals visiting the classrooms on a regular basis. I became one in a sea of many faces. For the bulk of the students, recognition quickly turned into confusion about who I was. Entries from my Research Journal highlight this transition. I begin with excerpts from my first visit after Student Recruitment.

As the class filed in … A boy who was walking to his seat (right next to me) said, “You’re the person from Ohio State,” to which I responded, “Yep.” He then turned around and took his seat.

…

Neville\(^{65}\) was at the front of the line. He turned to Ethel and said, “That’s the Ohio State person, isn’t it? I knew it! I’m the smartest person in the world!” He then turned to me and said, “Are we starting the software today?” No. “Are we drawing today?” No, I have to wait for consent forms to come back in.


By the time of my last classroom observation, exchanges such as the ones above had morphed into exchanges like those below.

**Boy #1**: Are you teaching us today?

…

**Boy #2**: Are we doing the proficiency things today?

**Barb**: I have no idea.

**Boy #2**: [stood staring at me]

**Girl**: She’s the computer lady, not the proficiency lady.

[Research Journal, 16 November 2004]

Those students who were not able to recognize me were student reviewers, and thus had only peripheral interaction with me between Student Recruitment and the Summative

\(^{64}\) I cover this theme in more detail in my discussion of Lacking Continuity: Requiring Prompts below.

\(^{65}\) Again, as with all names, this student’s name has been changed to protect his identity.
Software Evaluation. As the discussions below show, the responses from the student designers were quite different.

**Overview of the Design Process**

Overall, it seems that the students enjoyed participating as designers, and were engaged as designers. In the words of Ethel,

**Ethel:** From what I could tell, it seemed like they were involved in it and they were motivated to keep doing it.

**Barb:** Why do you think that was?

**Ethel:** Just because when they came back you could tell they were excited about it, they would tell me bits and pieces of what they had done. And they weren’t like, “I don’t wanna go again” [affected a complaining/whining tone]. And they were excited to go.

[Exit Interview, 1 June 2005]

In addition to the analysis I provide below regarding the signs of student engagement, students seemed to have been motivated throughout the process as a means of getting out of class. Yet, as the data shows, designing was not so engaging that it ever became a contender for another getting out of class activity: lunch.

**Getting out of Class**

For those students who had been interested in designing software, whether they were chosen or not, my arrival incited eagerness at the possibility of a software design activity. This type of reception continued through the last day of the study, as noted during the exit interview with Ethel.

**Ethel:** I don’t know if you heard him [referring to a student in the classroom]. [affecting a student tone] “Is she here for us?” *laugh*

[Exit Interview, 1 June 2005]
When asked during their exit interviews if they enjoyed participating, all of the students stated that they had, and that, if asked, they would participate in a study such as this one again. One student provided a possible reason for this eagerness regarding my arrival.

**Dexter:** I liked it cuz we got to skip a little bit of *class.*
[Exit Interview: Math, 25 May 2005]

While there were other motivators for active engagement on the part of the students, the opportunity to get out of class cannot be ignored as a significant contributor to their enjoyment.

“Can you tell me when to go to, um, lunch?”

While the students had many positive responses to participation as software designers, such as those noted below, there were also definite signs that they had no interest in staying in design sessions indefinitely.

**Barb:** We have time that you guys could draw another one if you *want.*
**Jaeger:** I don’t know another one.
**Barb:** You’re done?
**Freddy:** Yeah.
**Barb:** Alright.
**Freddy:** My brain turned off.
[Brainstorming Session #2: Science, 27 January 2005]

This sense of wanting to keep the sessions finite manifested itself most often with inquiries regarding lunchtime – the next period for these students. In the following example, we were only 18 minutes into a 30-minute study hall period, yet students were already showing signs of restlessness.

[16:20..18:03 of silent drawing]
**Bailey:** Don’t we have to go to lunch soon?
**Barb:** Yes, I will dismiss you on time.
Bailey: Okay.
Dexter: Hopefully. I think study hall’s only like 30 minutes.
[Brainstorming Session #1: Math, 25 January 2005]

In this next example, this is the first question I was asked once we all got to the conference room for brainstorming.

Snoopy: Can you tell me when to go to, um, lunch?
[Brainstorming Session #2: Science, 27 January 2005]

Band and choir are also study hall / lunchtime activities. This third example shows that student questions evolved to more devious ways of asking about lunch dismissal as time went on.

Snoopy: Hey, do we have band today? We also have choir.
[Formative Evaluation #2: Science, 29 April 2005]

I understood these as signs that, while they were interested in designing, they were just as happy to go off to other things they enjoyed. Thus, while the elements I incorporated to foster student engagement were sufficient to keep the students engaged and active in the design process, they were not sufficient for flow, that degree of engagement in which the activity becomes (nearly) all-consuming66.

**Brainstorming**

In both the brainstorming and software evaluation sessions, I worked to create situations in which students could spearhead design plans and participate regularly (at least once per group discussion) in an open forum for feedback and (re)design. For the brainstorming session in particular, creating a student-centered environment involved the

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66 For more on the concept of flow, see Csikszentmihalyi (1990).
inclusion of hands-on design activities and group discussions requiring that each student at least present his/her idea to the group.

At this point in the design process, students were still unclear as to what to expect of the brainstorming sessions. The lack of continuity in the process (see above) cascaded into the brainstorming sessions, requiring the use of prompts to remind the students what we were there to achieve. Even so, they evidenced an enjoyment of the low-tech brainstorming materials and approach, and a desire to contribute.

**Lacking Continuity: Requiring Prompts**

In both the math and science sections, the students arrived unsure of what to do, and unable to generate topics. However, a quick example from me in each instance was enough to provide them with an example to critique and generate alternatives of their own. For example, on the first day of math brainstorming, the students needed an example of a prototype to get them thinking.

**Barb:** Okay. So like, you have to get across a river, and you need to build a boat out of some shape. And you can make it out of all triangles, and if they all interlock you don’t sink into the swamp of alligators and get eaten. But otherwise you make it across. Something like that?

**Dexter:** A little bit violent, but…

**Bailey:** True!

**Barb:** Alright. What are some things we could do? So you can build a structure. Like what kind of structure?

**Dexter:** Bridge. Um, building…

**Bailey:** Could you do like a tessellation puzzle and put like pictures on tessellation pieces and you have to put them together to see the picture that they create?

[Brainstorming Session #1: Math, 25 January 2005]
The science students also experienced a problem brainstorming for content-based prototypes during the first brainstorming session. However, unlike the math students, the science students’ problem sprung from the fact that they were too focused on entertainment games to think about educational software ideas.

On the second day of brainstorming, the math students again required a prompt to get them started on a content-based prototype. In this way, I felt that the students required prompts to get them started, even though the prompts weren’t very detailed or referenced again in any of the subsequent prototype ideas.

“Gel pens!”

I had previously discussed with the teachers my plans to use low-tech design methods for brainstorming sessions, and both agreed that these methods would be appropriate for their students and well-suited to aid in the generation and communication of ideas. As the data shows, the students enjoyed the medium quite a bit.

**Bailey**: I’m going to try this with crayons. *inaudible* crayons

[Brainstorming Session #1: Math, 25 January 2005]

**Barb**: Okay. What I want you to do. Grab a piece of paper? Any color you want. You can use any of these stencils or whatever?

**Snoopy**: Yellow! [referring to the construction paper colors]

**Barb**: I’ve got

**Snoopy**: Flamingo! [one of the stencils]

**Freddy**: Monkey! [another stencil]

**Snoopy**: Where’s the monkey?!

**Jaeger**: Gel pens! Gel pens! [slightly singy]

[Brainstorming Session #1: Science, 20 January 2005]

Students also enjoyed the freedom these design tools gave them to “mess-up”.
Snoopy: Because of just like putting your ideas down on paper instead of going right to it. And, like, you could mess up on the construction paper, and if you just went to the computer then you wouldn’t know what to do.
[Exit Interview: Science, 25 May 2005]

While these methods were appealing during the drawing phase of brainstorming, and sufficient for inciting engagement, there were other features of the design process that sustained their engagement.

Desire to Contribute

There were multiple ways in which students showed they were eager to make their voices heard in ways that contributed to software design. The first way in which students evidenced a desire to contribute was through calling out software ideas or regurgitating the software ideas of others. In each session, I had one student who came up with multiple ideas that had potential, and one student who fed off those ideas by either building on them or repeating them during the session. For example, Bailey led nearly every conversation regarding tessellation-related ideas in the math sessions. These conversations took the following format:

Bailey: Could you do like a tessellation puzzle and put like pictures on tessellation pieces and you have to put them together to see the picture that they create?
Barb: We could do that.
Candy: That’s a good idea!
Dexter: Yeah.
Barb: So sort of like a tessellation mosaic kind of thing.
Bailey: Yeah.
Barb: That would be cool. Okay. Any other ideas?
Candy: Thinking.
Dexter: Yeah.
[Brainstorming Session #1: Math, 25 January 2005]
The next idea following this exchange was again Bailey’s. I acknowledge that generating ideas in such a short amount of time can be difficult, and so not every student was able to offer original ideas during brainstorming sessions, but supporting and critiquing the ideas of others, even through regurgitation, still evidenced engagement with the design process and a desire to contribute.

The second way in which the students showed a desire to contribute was in the self-directed creation of software ideas between brainstorming sessions. At the end of the first brainstorming session, I had encouraged students to think about the topics for the next time, and gave them the opportunity to continue working on the ideas from the first session or come up with new ideas for the day’s topic on their own time. As a result of these exchanges, one math student and one science student, Candy and Snoopy respectively, came to the second brainstorming session with another idea for a software program. Unfortunately, both of these ideas were completely off topic. However, these instances still showed a propensity towards a desire to contribute in both students. They also highlight a potential need for the quieter students to work longer or away from their peers.

**Formative & Summative Software Evaluations**

During software evaluation sessions, I wanted to create an atmosphere in which students were able to explore the software without being hindered by the structure of my questions, and were able to communicate with me freely during the sessions. To this end, I first gave students a “refresher” on why we were there and which factors from previous
sessions had influenced what we were about to do. I then gave them time to work through the software prototypes. This was not designed to be a quiet time. Rather, students were encouraged to give constant verbal feedback on their experience and to talk amongst themselves. Finally, students were given time to fill out their evaluation forms. As long as students were engaged in conversation pertaining to the software and stayed relatively focused on the evaluation, I did not redirect them. Where necessary, we also reviewed student feedback as a group before breaking for lunch.

As with the brainstorming sessions, students still required prompts to focus their energies during the session, but were very inclined to provide feedback once the evaluations began. Their engagement was sustained through a recognition of their influences on the prototypes, the sense of ownership that follows from that recognition, and the opportunity to spend time with their friends.

**Lacking Continuity: Requiring Prompts**

Students again began our sessions listlessly or unfocused, but became focused and active participants as a result of short refreshers of what we were there to look at and why. The need for a refresher between the brainstorming sessions and Formative Evaluation #1 was to be expected, as the format of the two sessions was so different and the tie between them would not necessarily be obvious to someone without design experience. Yet the students also required refreshers between Formative Evaluation #1 (FE #1) and Formative Evaluation #2 (FE #2). For example, in the math prototype Pickle Rescue, I initially had a placeholder screen for the title. See Figure 12 for the FE #1 title
screen. For the second evaluation, I designed a slightly more elaborate title screen. See Figure 32. Not all of the students could track the changes between evaluation sessions, even if they could recognize that something had changed.

**Bailey:** Did you change the title?
**Barb:** Yes! Well, I mean, it was always Pickle Rescue, but I made the screen flashier.
**Bailey:** That’s so cool.
**Barb:** Do you like it? Do we all like the new screen?
**Dexter:** Yes. What’s the difference?
[Formative Evaluation #2: Math, 27 April 2005]

One way I could have alleviated this problem was by bringing “Before” screenshots to FE #2 sessions. Even without these visual aids, the lack of continuity inherent in this project was easily overcome by a recognition of their influence on the prototypes and a sense of ownership of the prototypes.

**Recognition of Their Influence on the Prototypes**

Students often verbally expressed excitement over the manifestation of their ideas in the prototypes. During the first formative evaluation session for each class, this recognition took the form of eagerness to play. For example, during FE #1 for science, I had three prototypes available for testing, which we covered in the order of Simon Says, Test Yourself, and Ele-Man. Upon opening the homepage for the prototypes, Freddy immediately recognized his Ele-Man program – “That’s my idea!” – and became anxious to play. He asked to play before testing began, immediately following the testing of Simon Says, and again following the testing of Test Yourself. By the end of Test Yourself, even Jaeger was overly anxious to play.
Freddy: Can we play Ele-Man?
Barb: In a second! *laugh* Alright. What do you think you were supposed to learn from this activity?

... 
Freddy: Can I play Ele-Man?
Barb: Not yet.

... 
Barb: Remember to put your name at the top of your first sheet.
Freddy: I think I forgot on the last one.
Barb: I took care of it.
Freddy: Okay.
Jaeger: Can I go to Ele-Man?
Barb: No! You have to wait.
[Formative Evaluation #1: 21 March 2005]

Once recognized, Freddy wanted to stamp his ideas as his own, either by making his face the background image or by renaming the game after himself.

Between the first and second formative evaluations, recognition of game elements took a slightly different tone. Rather than eagerness to play, students now let out excited verbage regarding their input. In the case of Pickle Rescue, students had suggested adding a hint character to the game in the form of a tomato. Even though he was on the title screen, it took Bailey until the second screen to recognize her influence.

Bailey: Tom the Tomato! Go Tom!
[Formative Evaluation #2: Math, 27 April 2005]

This type of excited verbal response was evident each time a student recognized his/her influence between evaluation sessions.

Ownership

A sense of ownership was apparent in the way in which students expressed an interest in the proprietary nature of the prototypes. There were two primary ways in
which this occurred, the first of which involved only the science students. As the science
prototypes were web-based, I had placed them on the web for testing purposes, providing
CD copies only in the case of network failure during our testing time. Since they were
now posted in the public domain, I placed a copyright notice on all web pages and
prototypes. The notice on the main prototype page read,

    Copyright (c) 2005. All rights reserved
    This page and all items linked to from it are the intellectual property of myself
    and my design team. You may not replicate or use any of the items posted above,
    in part or in their entirety, without written permission.

Similarly, the notice on the actual prototypes themselves read,

    This page and the SWF embedded within it are Copyright (c) 2005. All rights
    reserved.

Jaeger is the student that noticed and questioned me on these copyright notices.

    Jaeger: Did you really reserve all rights?
    [Formative Evaluation #1: Science, 21 March 2005]

I briefly explained what this meant and moved on, but this issue resurfaced during casual
conversations throughout the remainder of the study.

    The second case in which students showed an interest in ownership was in their
interest over who would receive a CD copy of the software to keep. This theme was
more prevalent with the math students, and continued throughout the entire design
process. The first instance of this occurred during brainstorming.

    Barb: Alright. Thanks a lot to all of you. It’s been a big help. Next time I see
you we’ll actually be able to test out some of these ideas on the computer.
    Bailey: Does like everybody in the class get a copy of this game?
    [Brainstorming Session #2: Math, 1 February 2005]
Following the Summative Evaluation near the end of the study, not only were student reviewers interested in how they could play these games at home, but the student designers again expressed interest in who would get their own copy of the software.

    Barb: *laugh* Whatever gets ya here. Um, on either Tuesday or Wednesday of next week, so right before you guys finish, I will come back with a CD for each of you, so that you can have a copy of this software, and the software that the science students developed as well. So
    Bailey: Science students did this, too?
    Barb: Yeah.
    Bailey: On our team, or?
    Barb: Uh-huh!
    Candy: Is it just for us 4, or for everybody?
    Barb: Just for you 4.
    Candy: Cue-l.
    [Exit Interview: Math, 25 May 2005]

In this case, ownership was a prolonged interest, as it spanned from the first brainstorming session through to the exit interview.

**Inclination to Provide Feedback**

As I have already noted above and in previous chapters, students were given time to work through the software while I watched them, occasionally prompting them to click in certain places or tell me what they thought of color combinations and other miscellaneous software features. However, not all of the feedback I received was as a result of my prompting, as the excerpts below show.

    Bailey [upon viewing the opening screen of Pickle Rescue]: I like the pickles. I think they’re adorable.
    [Formative Evaluation #1: Math, 22 March 2005]

    Snoopy: Oooh, I like the little blobs. They’re neat. [referring to the amoebas]

    Freddy: There’s no “E” in “unpause”.

200
Barb: No?
Freddy: Push Pause.
Barb: Looks like it ran out of space. Okay.
[Formative Evaluation #2: Science, 29 April 2005]

Dexter: Oh, sweet. [in response to “opening” a raft kit]
Barb: You think it’s good?
Dexter: Yeah.
Bailey: How do I get my guy to go to the raft?
Dexter: All you have to do is click on the raft.
...
Bailey: The flowers are making me dizzy! *laugh*
[Formative Evaluation #2: Math, 27 April 2005]

To me, these instances show the students were not only engaged as designers who wanted to influence the next stage of the project, but that they were interested in providing their own feedback rather than just giving me the answers I was looking for. This inclination to provide feedback is also symptomatic of their Recognition of Their Influence on the software prototypes.

Spending Time with Friends

There was occasionally a sense of “Play Time” during design sessions that indicated that one motivator for student engagement had to do with their friends. In addition to this, students also expressed disappointment on those occasions when one of their fellow designers could not join us during Formative Evaluations due to illness or a time conflict. For example, on the day of the second Formative Evaluation for science, Jaeger was unable to join us. When I noted this to the students on the way to the computer lab, Freddy had an immediate negative reaction, becoming listless and stating that “it’s not going to be fun now” [Research Journal, 29 April 2005]. Similarly, during
the second Formative Evaluation for math, Candy was out sick. Although no one expressed disappointment at her absence, she was still obviously missed, as the transcript of the evaluation shows.

 Bailey: Candy would love the tomato if she was here.  
[Formative Evaluation #2: Math, 27 April 2005]

**Barriers and Facilitators**

**Barriers:** The length of this design model and the infrequent design visits with students led to a lack of continuity for the students, thus requiring prompts at the beginning of each session to get students back in design mode.

**Facilitators:** The initial facilitator of student engagement was the stage setting Ethel employed in her classroom before Student Recruitment. There were also many factors that made this design process itself both enjoyable and engaging for the students. The selection of gel pens and other low-tech materials aided in spurring engagement after a long and seemingly unrelated period of classroom observations. This engagement, evidenced by their desire to contribute to software that other students would have to use, was sustained through their recognition of their influences on the prototypes and the sense of ownership that results from that recognition. Other facilitators, such as the opportunity to get out of class and the opportunity to spend time with their friends, were outside the control of this design process.
Informing Future Endeavors

It is important to note that student engagement with the process does not just come from the process, but rather is shaped primarily by the teachers and other external motivators (e.g., getting out of class). The teacher’s attitude not only affects the students’ initial reception of the educational technologist, but also how the students approach the subject matter and how engaged they remain throughout the design process.

In terms of the design itself, the low-tech brainstorming sessions provide a good forum for idea generation, provided the educational technologist comes prepared to prompt active participation, with software ideas for the students to critique and work from, and with highly customizable, low-tech brainstorming tools (e.g., colored construction paper, stickers, stencils, and gel pens).

CHAPTER SUMMARY

In this chapter, I discussed the ways in which each group of participants – administrators, teachers, and students – responded to their participation in this study. I further analyzed these responses in terms of the ways in which they facilitated or presented barriers to my research or software objectives. I also began an application of these findings towards the revision of the research plan (i.e., the Revised ID Model’s application) for future endeavors. These preliminary revisions are accompanied by preliminary notes on information the educational technologist should keep in mind during software design projects such as this one.
In the next chapter, I analyze the software itself, highlighting some of the ways in which the software objectives were achieved while also touching on some of the inherent difficulties of designing constructivist software. While these difficulties are implicit in my discussions of the software products, I make these points more explicit in my final discussion of the software in Chapter 7.
CHAPTER 6

SOFTWARE DESCRIPTION AND ANALYSIS

INTRODUCTION

In this chapter, I describe and discuss the products that were designed and developed during this design project. For each software product created, I first describe the software that was developed during this study\(^\text{67}\). As part of this description, I apply Rothe’s (1991) Critical Evaluation of Educational Software in order to explore the ideology embedded in the software product. I then discuss the responses of the student designers and reviewers to the software. I include a comparison of the responses of the student reviewers to those of the software designers, which aids in assessing the potential for employing a small subset of students as Design Experts for software to be used by an entire class. Finally, I discuss the degree to which the software product met the Software Criteria outlined in Table 1.1. This software analysis reveals that the Revised ID Model resulted in only one successful software product. Based on this finding, I reflect on the process to highlight the factors that led to this success. I end the chapter with a brief re-

\(^{67}\) I do not discuss the science prototypes that were not developed to completion, but instead focus only on the final products, as these are the ones that have the potential to be used in future classes.
assessment of the design process as seen through the lens of the software product analysis.

**SCIENCE: ELE-MAN AND THE CLICKABLE PERIODIC TABLE**

The science programs were developed using Macromedia Flash, and were accessible via an HTML page. The description for Ele-Man given on that HTML page is as follows:

“Ele-Man” is a PacMan style game in which you need to collect various elements in order to create a compound. To be successful, you have to collect all of the elements in your compound while at the same time avoiding the killer amoebas that guard them. Depending on your level of difficulty, you may also need to avoid elements that are not used in the compound you're trying to make. Your game will be timed.

There are four levels of game play in Ele-Man. These are Level 1: H₂O (Water), Level 2: H₂O₂ (Hydrogen Peroxide), Level 3: NH₃ (Ammonia), and Level 4: NaHCO₃ (Baking Soda). In order to collect the elements for each level, the student must move the avatar around a maze using the keyboard arrow keys. After each level, students are shown a short video that explains how the elements collected in the Level (e.g., Oxygen and Hydrogen) combine to form the target compound for that Level (e.g., H₂O₂). The video can be played as many times as needed, and can be played with narration or without. See Figures 33-35 for screenshots from the formation of water at the end of Level 1. How challenging game play is depends on the level of difficulty chosen: Beginner,

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68 The amoebas evolved separately from the educational content of the game. They were originally implemented to look exactly like the ghosts in PacMan. In order to avoid this type of overt similarity to a commercial game, I altered them slightly to be more organic looking. They reminded me of amoebas, and so I named them thusly, thinking they would probably be redesigned once the student designers saw them. Instead, the students liked them a lot and we kept them.
Intermediate, or Expert. The difficulty is chosen at the beginning of game play, and cannot be changed during the game without restarting. Figure 36 shows the initial screen of Ele-Man, which prompts students to select a difficulty level. Beginner level players are shown the atomic image and formula of each compound, and the only elements that appear are those used in the compound. Colliding with a killer amoeba results in losing a life. When all five of the lives have been lost, the player loses the game. Figure 37 shows the “game over” screen. Intermediate level players are shown the atomic image and formula of each compound, but there are also some “trick” elements that the students need to avoid. The consequence of trying to collect a trick element is losing a life. In addition, the killer amoebas move faster than the ones in the Beginner level. Expert level players are shown the atomic formula only, and there are more trick elements than in the Intermediate level. The amoebas also move faster in this level than in the previous two levels. Screenshots of the various difficulties are shown for Level 1 of the game in Figures 38-40. When the game is completed successfully, students are taken to a final screen showing all of the compounds formed as well as the amount of time it took them to complete the game (see Figure 41). The final time only reflects time in the mazes, not the time taken to play the compound formation videos.

For those students not familiar with what the elements look like, a Clickable Periodic Table is available both before and during game play. Only the first 18 elements are included, as this portion of the program is meant to familiarize students with elements they encounter during game play. Given that the students in this study had no prior knowledge of the “look” of an element, elements 19 and beyond were excluded, as the
electron structures of those elements are larger and potentially confusing. For the 18 elements listed, Hydrogen through Argon, students can click freely between the elements for a quick visual and textual overview of the electron structure of that element. Figures 42-43 show the initial Clickable Periodic Table page and a sample of a “clicked” element, respectively.

Critical Analysis of the Software

In this section, I loosely apply Rothe’s critical framework for a critical evaluation of software to Ele-Man. This framework examines language usage, knowledge selection, ideology, profit, culture, and ethics in order to uncover the assumptions and biases in software. See Appendix U for an exact list of the evaluations questions that guided this critical analysis. What follows is a short synopsis of my analysis in terms of knowledge selection and the nature of knowledge and learning in the software.

(IR) Relevant Knowledge Selection

The graphics in and of themselves do not follow the principles of authentic knowledge in that the graphics are not authentic in the scientific sense. While the videos reflect the creation of compounds the students will encounter in their everyday lives, the graphics of the elements only allow students to acquire a basic understanding on a somewhat debunked visualization theory of electron rings.

Electrons are currently theorized to orbit around the nucleus in clouds. This replaces the previous conception of electrons as orbiting in rings around the nucleus. The debunked theory was chosen for visualization, as it is easier to interpret visually than the new theory, and does not detract from the intended message of the software.
Further, the beatnik-looking avatar, which was meant to look more like Einstein, together with the amoebas, have only dubious relevance to a program on elements and compounds. However, the students liked these graphics, which aided their engagement.

Knowledge as Mastery

The difficulty designations, while they follow typical entertainment designations (i.e., less aid is provided and a quicker response time is required as difficulty increases), suggest there is content to be mastered. Mastery is measured by the ability to recall, potentially with the aid of reference materials (e.g., the Clickable Periodic Table), the first 18 elements of the Periodic Table by sight alone, and within a certain amount of time. This notion of mastery aligns more with traditional, drill and practice educational philosophies than constructivist philosophies, as does the individual nature of game play.

While the game is single-player only, watching the game in use in a classroom shows that game play is a social activity, as students not only play and discuss their own game with classmates, but also watch the games of their classmates and offer assistance. This results in an almost apprentice-like atmosphere in group play situations.

Knowledge as Recognition/Recall

Non-trick elements are in the same place between difficulty levels, thus students need only memorize where the non-trick elements are placed in each level in order to avoid the trick elements. However, since the software is intended to be used in a single
class period, the likelihood of students memorizing element placement in time to affect game play is minimal.

Learning as a Competition

While the time does not affect scoring in the game, competition is implicit in the game in that students in a classroom, especially one in which they are already tracked for achievement on tests and in their personal portfolios, will compare final game times on the side.

Students may also compare how many lives they lost during game play. This again reinforces the competitive feel of the game.

The “killer” amoebas and the threat of the loss of avatars provide a context in which mistakes do not come without consequences. Students cannot start from where they left off (i.e., there is no way to save the game and return to that point), thus the game rewards only students who can play through successfully in one shot. Some students may balk at the potential for failure (e.g., Snoopy’s desire to have the “correct” elements colored differently [Exit Interview, 25 May 2005]), because it extends the competitive nature of the game to competition with oneself. There is no “safe”, non-competitive space.
**Student Responses to Ele-Man and the Clickable Periodic Table**

In this section I describe the signs of student engagement with the software first in terms of my own observations during the Summative Evaluation, and then in terms of their written responses.

**Observed Student Engagement**

The students seemed to enjoy playing Ele-Man. I make this assessment from a combination of 3 markers I observed during the Summative Evaluation. The first of these is verbal expressions during game play. These positive verbal expressions began as early as my walkthrough of the Clickable Periodic Table.

**Barb:** So, what this does is give you a short introduction to what the actual elements look like. What their atomic structure looks like. So you can click on any of the symbols, and you’ll see pulls up that element. With the nucleus, and all of its electron rings.

**Boy:** Whoa [quietly]

[Summative Evaluation: Science, 25 May 2005]

Another notable instance of this occurred at the end of the evaluation session.

**Ethel:** Class, we are out of time.

**Girl:** No!

[Summative Evaluation: Science, 25 May 2005]

The second marker is physical actions. I noted multiple times during this evaluation that students left their own seats to discuss game play with their classmates, not only in terms of avoiding the amoebas but also to instruct others on why some elements had to be picked up and others avoided. The third marker occurred at the end of the evaluation, during the collection of software CDs. Many students inquired during this period as to who got to keep a copy of the software and if they could play at home somehow. In
addition to my own observations, Ethel also noted in her exit interview that she felt “the kids are gonna like using it again”.

**Written Responses to the Game**

The written evaluations reflected this enjoyment/engagement with the software. Overall, students liked the colors and the characters, and understood what needed to be done in order to play successfully through the game. The students also claimed to like the challenge set forth by the difficulty levels and the “trick” elements. The only notable division in student opinions was in their response to having the game timed – 10 were in favor and 6 against.

It seems that most of the students also recognized the educational content of the game. In response to the question, “What do you think you were supposed to learn from this activity?”, the primary responses were of the form “what makes what”, “what elements turn into”, “about the periodic table”, and “different elements and compounds”. I attribute much of this recognition to the fact that Ethel took great care to forefront the connection between previous class materials and the game.

As a note, for each of the questions on the written evaluations, the responses of the student designers aligned rather closely with the responses of the student reviewers. I take this as a sign that the random selection of such a small subset of students (e.g., four per class) is sufficient for embedding elements in the software that the classroom as a whole will find engaging. Of course, in making this claim, I also acknowledge that the participating classroom was rather homogeneous in terms of student backgrounds.
Meeting the Initial Software Criteria

In this section, I discuss the first three criteria set forth for the software. I do not include the 4th criteria in this discussion, following the design decision discussed in Chapter 4 to discard it. As the discussion below notes, all of the remaining criteria have been satisfied. I attribute this result to the active roles of the teacher and students in the design and evaluation processes.

Software Criterion #1: The software aids students in meeting state/district proficiency standards.

Students in 6th grade are required to “Relate uses, properties, and chemical processes to the behavior and/or arrangement of small particles which compose matter”. While Ele-Man does not directly address this benchmark, it provides the tools necessary to discuss elements at a fundamental level, which is necessary for a fruitful conversation regarding physical versus chemical changes. As Ethel explained,

I used the concept of elements building compounds and matter for the Nature of Matter Benchmark. The indicators are
1. Explain that equal volumes of different substances usually have different masses.
2. Describe that in a chemical change new substances are formed with different properties than the original substance (e.g. rusting, burning).
3. Describe that in a physical change (e.g. state, shape and size) the chemical properties of a substance remain unchanged.
4. Describe that chemical and physical changes occur all around us (e.g. in the human body, cooking and industry).

Given that every lesson at Lochley Intermediate is specifically geared towards meeting the standards, Ethel requested software elements that would aid her to meet these specific goals. Ele-Man is a direct response to her request. Thus, criterion #1 is satisfied.
Software Criterion #2: The software is compatible with the teaching and learning philosophies of classroom teachers. Such software should also be compatible with their philosophies of how technology should be integrated into the classroom, as well as school policies on technology integration.

As I noted in Chapter 3, Ethel views herself as a constructivist, and works to guide students through the process of knowledge construction via as many hands-on and real-world activities as possible. She believes in integrating technology in such a way that it supplements these hands-on classroom lessons. By “supplements” I mean that the technology addresses gaps that are not attended to by other class materials, or that the technology provides virtual hands-on activities when real-life activities are not feasible. This technology philosophy nicely complements the official school technology policy (see Appendix F for an example), which mandates that technology only be used to enhance student learning, be used in conjunction with other activities that foster active learning and reflection of the material, and never be used as “filler”.

Ele-Man and the Clickable Periodic Table are compatible with these philosophies first as a supplement to existing lessons. Ethel noted that students often have difficulty understanding the concepts of element and compound and the nature of the difference between physical and chemical changes. This software aids in alleviating that gap in understanding by showing students, at the simplest level, what elements look like and how and why they can be combined to form compounds. Although still somewhat abstract in nature, the information embedded in these software products is still an important building block for understanding subsequent topics, such as the difference between physical and chemical changes, and what it means to be changed chemically.
Second, this software meets Ethel’s technology needs in terms of length. Ethel expressed a concern over how much time could be spent in the computer lab, positing the time demands of other class lessons with the computer time the students find so intrinsically motivating. The shortness of Ele-Man and the reference nature of the Periodic Table both lend themselves to a single visit to the computer lab, without requiring any additional computer time.

When asked about using these software programs in the future, Ethel responded favorably. She felt that Ele-Man was not only engaging for students, but also addressed her concerns regarding the difficulty students had in understanding elements and compounds. Ele-Man provided a lesson component that would both interest the students and give Ethel a memorable point to refer back to in other lesson components. Additionally, Ethel was sure that other teachers in the school would also be interested in using this software once they had seen it. Given this positive review by Ethel, I conclude that criterion #2 is met.

I believe that the primary reason for the success of the software in meeting this criterion is that Ethel was involved as a software reviewer throughout all formative and summative evaluations. Her feedback reflected her teaching and technology philosophies in a way that continually guided the software towards these ends.
Software Criterion #3: The software presents the content in such a way that aids students in the individual construction of knowledge, in keeping with the students’ cultural models.

In order to address this criterion, I rely on the data from the Summative Evaluation, as I feel, given the data collected\(^\text{70}\), that it is the best indicator I have. Further, there is no definitive way to assess or diagram a student’s cultural model. Thus, in keeping with the relationship between engagement and cultural models as explored in Chapter 2, I use engagement with the software as a means for assessing to what degree the software provides a “space” for the students’ cultural models.

As I noted above, the students seemed to find the software engaging and enjoyable, thus capturing their interest. As one boy, Freddy, noted to me during the second formative evaluation, “It’s fun even though I keep dying.” This is certainly one indicator of showing “generally positive emotions during ongoing action, including enthusiasm, optimism, curiosity, and interest” (Chapman, 2003), which is a component of student engagement as discussed in Chapter 2. I believe that responses such as this one were only possible because students were incorporated as designers in this project, thus opening the way for ties to their own cultural models. The Student Questionnaire (see Appendix I) given during Phase 2, as well as the brainstorming sessions, were aimed at permitting a glimpse of some of these features, which were then revised and honed during software evaluations.

\(^{70}\text{The only way in which I feel I could have collected “better” data on this topic is by conducting an analysis of the reception and effect of this software on the 2005-2006 classroom.}\)
One example of how student guidance shaped the evolution of Ele-Man is in the selection of the underlying game idea. While I had proposed game ideas during the brainstorming sessions, students felt free to redirect me.

**Barb:** Or you could go through situations where like, you know, you need to cross a big thing of water and you have a super power of freezing. So, you know, you can freeze water but you know it still needs to be water at the end. You don’t want to like evaporate it or something.

**Freddy:** That’s over our heads. That’s too much.

[Brainstorming Session #2: Science, 27 January 2005]

Student guidance aided in steering the prototypes towards a more accessible format. A second example was the use of sound over the compound formation movies. According to Clark and Mayer (2003), “people learn more deeply from multimedia lessons when words explaining concurrent animation or graphics are presented as speech rather than as onscreen text” (p.93). Following this tenet, I decided that a voice-over option for the compound movies would be the best means of promoting learning during the compound formation movies. Knowing that sound would not always be available, I chose to always display the text being narrated and implemented a “Replay” button for each of the videos so students could re-read and re-watch the video as many times as necessary. With these design features in place, the tone of the narrative now had to be decided. During Formative Evaluation #2, I asked the students about having a voice-over like the ones on PBS – a British man narrating the video. I had been dubious about this (potentially dull) documentary format, and was considering something more “cute” for the students. However, the suggestion of a British voice-over was greeted by a “That would be cool!” [Klutz]. I thus recorded a British voice-over for each of the compound formation movies.
In terms of aiding students in the individual construction of knowledge, I assert that the software is both in keeping with the students’ cultural models and fosters the level of engagement necessary for learning. In terms of the students’ cultural models, the gaming format and other software features suggested by and developed for the students fit with the students’ conceptions of what educational software should look like. The consequences of collecting the “wrong” elements were also a direct response to student input from the software evaluations, which aided in placing the game and the nature of game play within the context of the students’ cultural models. Further, while engagement does not have to take the form of “fun” as it did throughout the bulk of observed software use, the “fun factor” can be considered an indication that the software has successfully created a “space” for the students’ cultural models, which might lead to academic engagement and learning.

Were I to categorize this software according to the constructivist criteria for technology that I presented in Chapter 2, I feel that this software is best used as a means of exploring concepts in a simulated environment. While the environment itself is not a simulation in the true sense (i.e., the “educational content” is only peripheral to main game play and understanding the underlying concepts is not required for successful completion of the game), the interactive Periodic Table and the compound formation movies of Ele-Man still aid students in visualizing and exploring abstract class concepts. That is to say, while students might mindlessly collect elements during game levels, the instructional videos of compound formation between levels, accompanied by worksheet
activities and classroom discussion, provide a foundation for further exploration of the
topics of physical and chemical changes.

Given the positive student responses, as well as the software’s potential as a
visualization tool, I am secure in asserting that criterion #3 is met.

**MATH: PICKLE RESCUE**

As noted in Chapter 4, Pickle Rescue will not be used as a part of the math
curriculum, nor as an enrichment activity. Even so, I discuss the end software product,
Pickle Rescue, here. Pickle Rescue was developed in a combination of Visual C++ and
OpenGL\(^{71}\).

**Software Description**

The story behind Pickle Rescue is as follows:

Ninnian Pickle and Maisy Pickle were walking through the forest one day. Suddenly, a large hand appeared from the sky and kidnapped Maisy! Ninnian
must now quest to the Land of Picnic to save her.

In order to rescue Maisy, the player must complete puzzles/rooms that require the
application of knowledge of tessellations and volume. There are no difficulty levels for
this game, but a score is kept. The score begins at 0, and is increased a set amount when
puzzles are completed. The score is also decreased by a set amount when students need
to reset the puzzle, either as a result of failure or as a result of confusion. In most cases,

\(^{71}\) Recall that I selected OpenGL as a means of programming 3D environments, because it is a standard
component of Windows XP. I was also using the OpenGL utility toolkit (GLUT) for window creation and
mouse callbacks. GLUT had to be included on the CD with the prototype executable, as it is not distributed
with Windows.
however, reset is not necessary in order to successfully complete a puzzle, regardless of the number of attempts. The score always ranges from 0 to 100, regardless of how many resets were required (i.e., negative scores are never assigned).

**Room #0: Splash Screen**

Figure 44 shows the Splash (Title) Screen. In addition to refreshing the storyline for student users, this screen also introduces all of the characters. Students are required only to click on the “Begin” button to begin the game.

**Room #1: Bridge Room**

The Bridge Room is the first official puzzle of the game (see Figure 45). On this screen, students are first introduced to their score (set to 0), Tom the Tomato as a means of receiving hints during game play (there is no score penalty for receiving hints), and their walking speed, which is controlled by the keyboard keys 1 through 9, adjusts the speed of avatar movement only, and can be changed at any time during the game.

In this room, students need to build a bridge using the principles of tessellations. For simplicity, cubes – namely, their square sides – are used for the initial tessellation. Students must select a cube from a pile and rotate it, using the right mouse button, until it is oriented with the existing path. Once properly oriented, students must also place the cube along the edge of the path in order to create a bridge. Eight cubes are needed to complete the bridge over the water. A score of 40 is awarded for successful completion of the bridge. See Figure 46 for the completed bridge.
**Room #2: Raft Room**

In this room, students are required to select a raft made of a tessellation in order to continue the journey. The rafts are initially presented as raft “kits” that show the shape(s) from which a raft will be created (Figure 47). Students can click on a raft kit to see the raft it makes without a score penalty. However, if a student then clicks on a non-tessellated raft as a means of transportation, a short animation shows the raft sinking and the student is penalized 10 points (Figure 48) before Ninnian rafts quickly back to shore. Selection of the tessellated raft results in the accumulation of 10 points and an animation taking the student to the next room.

**Room #3: Lock Room**

In the Lock Room (Figure 49), students are introduced to the concept of moving volumes of water around through a lock. The quantities of water that can be moved are defined by shapes at the bottom of the lock, which they have seen before on class worksheets, and the volume of water that needs to be moved is defined by the initial values on the lock (36 for the upper level and 12 for the lower level when beginning at the start position). Dimensions are given for the shapes so students can calculate the volume that each shape represents. It is intended that students will use these values to calculate the combination of shapes they need to click through in order to move Ninnian through the lock, but sufficient trial and error will also lead to successful navigation through the lock. 10 points are awarded for moving Ninnian from the upper level to the middle (Figure 50), and 10 points are awarded for then moving Ninnian from the middle
to the lower level (Figure 51). Before leaving the Lock Room, the student can move
Ninnian among the lock levels an indefinite number of times, but points are only awarded
the first time. However, each time the lock is reset, five points are deducted until a score
of 0 is reached.

Room #4: Gate Room

The puzzle in the Gate Room (Figure 58) is one in which students are required to
match shapes with their volume equations in order to open the gate to the Land of Picnic.
The placement of equations on the wall is randomly selected each time Pickle Rescue
reopens, so students cannot memorize the location of the matching equations. Matching
requires that students click on a shape, then click on its volume equation. See Figure 53.
If the student mismatches, the student can either correct this mistake by clicking on the
shapes and then their equations again until these are all correctly matched, or they can
“RESET ALL” for a five point score penalty. Short of referring to their workbooks,
students can deduce the matching equations by using the pattern matching hints provided
by Tom each time they click on a shape, or they can rely on their understanding of π’s
place in (circle-based) volume equations to eliminate wrong answers for trial-and-error
matching. In addition to the gates to Picnic opening (Figure 54), students are rewarded
with 25 points for correctly matching shapes to their volume equations.
Room #5: Land of Picnic

There is no puzzle in the Land of Picnic (Figure 55). Rather, students need only click on Maisy as a directive to Ninnian to go up and escort her down. At this point, students receive five bonus points, there are fireworks, and the flowers twinkle different colors (Figure 56).

Critical Analysis of the Software

In this section, I apply Rothe’s criteria for a critical evaluation of software to Pickle Rescue. Again, see Appendix U for an exact list of the evaluation questions that guided this critical analysis. While I do not address each criterion point by point, I provide a synopsis of my analysis below. These findings address the gender stereotypes inherent in Pickle Rescue as well as the nature of knowledge and learning as portrayed by the game.

Gender Stereotypes

The stereotypical storyline of a girl needing to be rescued by a boy reinforces gender stereotypes. This storyline was proposed by Bailey during the first brainstorming session.

Barb: Alright. So let’s say we have to do things, to build things, do puzzles, to get through some sort of game. What would be that game? Like, what’s the idea in there? What’s our quest?
Bailey: I don’t know. You’re character’s trying to save the tessegram princess. *laugh*
Barb: *laugh* Okay. That’s one way we could go.
**Bailey**: Or the person has to figure out how the princess uses tessegrams in her daily life by making things to get himself to where she is to try to rescue her? [Brainstorming Session #1: Math, 25 January 2005]

While I had been hoping to avoid such stereotypes in the software prototypes, I also felt compelled to follow the lead of the students. Given that the student designers did not propose any other storyline for the quest, we selected the rescue storyline as our wrapper for the math puzzles. In the end, Ninnian and Maisy even “live Happily Ever After!”

Gender markers were used in the design of the characters in that a pink bow and smaller nose were used to differentiate the female pickle from her male counterpart. I chose these markers based on my understanding of how they have been traditionally employed to indicate gender in cartoon characters. Bailey proposed that we go further, placing Maisy in a pink dress and pearls, but the other students were not committed to these changes and so I did not implement them.

**Knowledge as One Right Path**

There is only one right way through the game: one right bridge, one right raft, one right way to get through the lock, and one right way to match shapes and their volume equations. While small deviations are possible – the bricks used for the bridge, the means of transferring water in the lock, the placement of volume equations on the gate walls and thus their subsequent matching – there is still only one path of reasoning through the game. Combined with the worksheet format of the Gate Room, these result in a drill and practice feel for the game. This could be alleviated to some degree by having a more extensive environment to navigate through, which would allow for
multiple paths to the same end. However, the extensive time required by a more elaborate environment is at odds with the availability of computer resources in the classroom setting. Students would also benefit from more authentic puzzles.

Learning as a Guided Experience

The availability of hints from Tom the Tomato (see Appendix V for the entire list of hints) implies that learning and applying knowledge are guided processes. While the game is single-player, the continual use of “we” in Tom’s hints creates a façade of community. Yet Tom is not a peer. Rather, he is available only to point the student in the “right” direction. He provides not only usability hints (e.g., “Click on the red knobs to activate the levers”), but also educational ones (e.g., “This raft seems to have some holes…Not a tessellation…”, “This equation takes the form 1/3 * (B * h”). While students are scored on their performances, Tom views errors more as a mistake than a time for evaluating performance (e.g., “Ooops! That would put more water in the lock than the lock can handle.”). When students successfully complete a puzzle, Tom also praises the student (e.g., “Super! We can now move into the next section of the lock!!!”). This sense of community only comes to an end on the final screen, when Maisy is finally rescued, and Ninnian receives all of the credit: “Ninnian has rescued Maisy, and they can now return to Pickle and live Happily Ever After!”
Learning as a Competition

The scoring adds a competitive edge to the software that would not be there otherwise, as errors are penalized, but it was also a great factor in student engagement, as students were very eager to play the game multiple times during the Summative Evaluation in order to beat each other’s scores. This competition is expressed not only between students, but is also with one’s self in an effort to “beat” one’s top score.

Student Responses to Pickle Rescue

In this section I describe the signs of student engagement with the software first according to my observations during the Summative Evaluation, and then in terms of the students’ written responses.

Observed Student Engagement

While some students needed guidance in playing through the game, the students did remain relatively focused on the game during the entire Summative Evaluation. As Nancy noted approximately 10 minutes into the evaluation, “This is the quietest they’ve ever been.” Even when the students became noisier near the end of the evaluation, the noise level was a result of students comparing scores and playing through again to beat each other’s scores. As I visited each of my student reviewers during game play, they also remarked on their abilities to solve puzzles without having to apply any school knowledge or thought, especially in the case of the Lock Room (Room #3). At no time
did any of the student reviewers stop playing or try to switch to another program or game during the evaluation period.

**Written Responses to the Game**

The written evaluations reflected the students’ observed responses to various components of the software. In addition, students liked the colors, the scenery, and the characters (especially Tom the Tomato\(^{72}\)). As my observation notes indicated, the score feature was also highly favored among the students. Still, students expressed difficulty understanding what had to be done in order to complete the puzzles in the different rooms, highlighting the need for a guiding worksheet.

It seems as though students were not quite able to ascertain what classroom content/terminology was being covered in Pickle Rescue, even though I had introduced the software to them in terms of volume and tessellations at the beginning of the Summative Evaluation. In answer to the question, “Could you tell what shapes the lock levers used to move water?”, student responses came in the form of “a triangle and a rectangle”. In fact, all of the shapes were 3D, and were taken directly from class worksheets. Refer back to Figure 49 for an image of the shapes used in this puzzle. At the same time, the students exhibited some recognition of volume equation patterns during this same puzzle.

\(^{72}\) I attribute the success of Tom the Tomato entirely to Candy. When the idea of a hint avatar first arose during Formative Evaluation #1, I had suggested a fairy, wizard, or other such mythical/helpful creature. While the designers summarily voted these suggestions down, it was Candy who mandated that I continue with the vegetable theme set by the Pickles. She also set forth guidelines that the hint avatar not resemble characters from Veggie Tales, because they were “for kids.” On my own, it is very likely that I would have veered in this direction, as I took many of my cues for color selection, etc. from cartoons.
Dexter: I found that if you work with the circle spheres, certain things like the cone, sphere, and, sphere, and cylinder, like, it was easier to find the other two. [Exit Interview, 25 May 2005]

While this sentiment was expressed during the Exit Interview (i.e., after the Summative Evaluation), I had encountered multiple students applying this approach as they thought aloud during game play portion of the evaluation itself.

As was the case with Ele-Man, for each of the questions on the written evaluations, the responses of the student designers aligned rather closely with the responses of the student reviewers. I again take this as a sign that the random selection of such a small subset of students (e.g., four per class) is sufficient for embedding elements in the software that the classroom as a whole will find engaging. However, in the case of Pickle Rescue, I take these written responses with a grain of salt, as student designer responses during the exit interview contradicted their written responses on the evaluation forms. For example, all of the designers claimed to enjoy the game on the evaluation form, but they all agreed during the exit interview that the game was “boring” and “confusing” and needed an extensive list of changes. As Dexter put it,

Dexter: So, things that we need are, um, different levels like easy/medium/hard, um, an obstacle to get to the table, and something that would make Tom the Tomato more noticeable. [Exit Interview, 25 May 2005]

Further conversation also highlighted the need for difficulty levels and more obstacles.

Bailey: I think you should be able to choose in the beginning if you wanted to play advanced, easy, or like, medium.
Dexter: Yeah, that’s what we said before. And also there should be like, um, when you actually do get to Picnic? I think there should be, like, an obstacle to get to the little picnic table thingie.
Candy: Yeah!
[Exit Interview, 25 May 2005]
In addition to “play” factors, students also critiqued the educational viability of the program. The primary instance of this was during our discussion of the Lock Room.

Bailey: I think what you should do instead, is put the area in the squares outside, and put the formula underneath the shape, and then give the measurements
Dexter: yeah, so that
Bailey: and then so we’d have to solve the formula.
Barb: Now if you had a worksheet to go along with it, and all the equations were there, would that be sufficient?
Dexter: Yeah.
Barb: Or do they need to be on the screen.
Bailey: No, it’d be easy then.
Barb: Okay. So as long as you have them somewhere to look up.
Bailey/Dexter: Yeah.
Bailey: Like, get our math text books.
[Exit Interview, 25 May 2005]

Meeting the Initial Software Criteria

In this section, I discuss the first three criteria set forth for the software. I do not include the fourth criterion in this discussion, following the design decision discussed in Chapter 4 to discard it. Unlike Ele-Man, Pickle Rescue falls short of meeting all but one of the remaining criteria. I discuss the possible reasons for these results below.

Software Criterion #1: The software aids students in meeting state/district proficiency standards.

The software best addresses the Patterns, Functions and Algebra Standard. The benchmarks of this standard that I am primarily interested in address the use of patterns and pattern matching in problem solving applications. In particular,

Benchmark J. Use formulas in problem-solving situations.
Benchmark J 6. Evaluate simple expressions by replacing variables with given values, and use formulas in problem-solving situations.

These benchmarks are most closely addressed by the Gate Room, in which students are currently solving the puzzle by using the formula hints given by Tom the Tomato (see Appendix V) to match shapes to their equations. This is also addressed by the Lock Room, in that it is a problem-solving situation.

While Nancy did not provide feedback on the match between the standards and this software, the assistant principal stated that she “saw the alignment with the standards and the use of it within the classroom” [Exit Interview, 13 June 2005]. Together with my own analysis, I assert that criterion #1 has been satisfied.

Software Criterion #2: The software is compatible with the teaching and learning philosophies of classroom teachers. Such software should also be compatible with their philosophies of how technology should be integrated into the classroom, as well as school policies on technology integration.

As noted in Chapter 3, Nancy drills problems from her place at the podium, occasionally asking students to work on the board. This style is borne of the philosophy that everything should first be driven by the standards, with accommodation of the various student needs and learning styles taking a secondary role. While she once used computer technology in the classroom, Nancy no longer does so, and viewed this study only as a means of producing an enrichment activity for her classroom. The school does not require the use of computer technology in the classroom, so her technology philosophy is consistent with the school’s.
Pickle Rescue meets Nancy’s teaching and learning philosophy in that it aligns with the standards, has colors and characters that appeal to the students (in her words, “not too mature, not too baby”), and incorporated some of the elements that she requested (e.g., pattern matching, and 3D volume and tessellation concepts). As part of a standalone enrichment activity, Pickle Rescue would also fulfill both Nancy’s and the school’s philosophies of technology integration.

In spite of these factors, Nancy feels that the current math curriculum, Everyday Math, sufficiently covers the knowledge base needed by the students, and that its cycling nature does not allow for the inclusion of additional software. Given these points, I assert that Criterion #2 has not been satisfied.

Software Criterion #3: The software presents the content in such a way that aids students in the individual construction of knowledge, in keeping with the students’ cultural models.

As with the science program, I rely on the data from the Summative Evaluation to assess this criterion, and measure the degree to which the math program has potential as a software “space” according to the students’ levels of engagement with the program.

As already noted, approximately 10 minutes into the Summative Evaluation, Nancy noted to me, “This is the quietest they’ve ever been”. And, as the software evaluation sessions indicated, students were engaged both by competing for high scores in the game and by the “cute” factor of the game characters. They also expressed pride in the fact that they could solve the lock puzzle by trial and error.
In addition to broader signs of engagement, the software tied to the students’ cultural models in the form of character design and in the gender stereotypes embedded in the software. Admittedly, the character design was spearheaded by myself in the generation of the pickle characters. However, when designing the “hint” character, I had suggested a wizard or other mythical and wise creature to provide information, but the students steered me back towards other vegetables and fruits. At the same time, they warned me to avoid making this character look like a Veggie Tales character, providing insight into their sense of ageism. The students’ gender stereotypes were also very prevalent during design sessions. I had suggested reversing the stereotypical storyline to have Maisy rescue Ninnian Pickle, but the students had a strong negative reaction to this change. I thus worked within the gender expectations of the students’ cultural models.

These ties to cultural models and signs of engagement aside, it seemed as though this software provided yet another means to drill concepts already covered in class. Additionally, the tessellation component of the software was not wholly mathematically accurate. By definition, a tessellation is a surface covering generated by repeating a shape over the entire surface of a plane without any gaps or overlaps. Neither the 3D bridge activity nor the raft generation quite fit with this definition. More accurate tessellation applications might have provided students with a better understanding of the concepts learned in class, or at least in a recognition of the class concepts.

As it stands, many of the student reviewers did not recognize the tie between the program’s puzzles and volume/tessellations until a student designer, the game character Tom the Tomato, or I told them. Further, especially in light of the negative responses on
the written evaluations, as well as the verbal reflections of the designers during the exit interview, Pickle Rescue did not have sufficient elements in it to be engaging for the bulk of the students. That is not to say the student reviewers were not engaged, but rather that, given that Nancy’s plans for this software were for individual enrichment and that the students required extra instruction on what to do in each room, I believe that the software has more potential for frustration than enjoyment. This point, when combined with the students’ inability to recognize the 3D volume content in the game, leaves criterion #3 unsatisfied.

**TOWARDS UNDERSTANDING THE VARYING SOFTWARE RESULTS**

As shown above, this study resulted in the development of one successful software product, Ele-Man, and one failure, Pickle Rescue. Many factors during the software design and development process contributed to these results. Below I discuss those features that I feel directly correlated to these differences. These influencing factors are summarized in Table 6.1.

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<thead>
<tr>
<th>Researcher</th>
<th>Teachers</th>
<th>Students</th>
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<td>Content knowledge</td>
<td>Content knowledge</td>
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<td>Interest in technology</td>
<td>Interest in technology</td>
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<td>Commitment to technology and the project</td>
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<td>Mutual understanding of expectations</td>
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<td>Access to class materials</td>
<td>Access to class materials</td>
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<td>Student selection</td>
<td>Interest in software design</td>
<td>Leadership</td>
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<td>Gaming experience</td>
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Table 6.1: Factors key to the success of the Revised ID Model.
Content Knowledge

In both the math and science cases, there was need for a content expert. As noted in Chapter 2, even while acknowledging the individual construction of knowledge, the teacher’s responsibility is still to steer students towards specific required knowledge. It was the intention of the Revised ID Model (see Chapter 2) that this role of context expert be filled primarily by the educational technologist (me) and the teachers (a.k.a., the Subject Matter Experts). In practice, this role defaulted entirely to me.

On the side of the students, the brainstorming sessions were timed such that the students should already have covered the potential software academic topics in the classroom, and be reasonably proficient on what they were supposed to know on those topics. During these sessions, the students’ ability to recall classroom knowledge pertaining to the software topic greatly aided in idea generation during the science sessions. However, the tessellation content of the math program, Pickle Rescue, was inaccurate. My focus in the case of the math sessions was diverted by the desire to design according to student direction, and I relied instead on the teachers making any necessary subject matter content corrections as part of their own reviews of the prototypes; no such teacher redirection occurred. In the case of math, I also relied more heavily on student direction for content, as the topics under discussion had been covered directly in the classroom. In science, the software was addressing a gap in the current curriculum, and so I felt more freedom in molding the content myself.

Having an additional design team member that was able to assess the academic worth of the software content and redirect as necessary could have alleviated the
inaccuracies of the content. This person’s role should not overlap with other roles in the project (e.g., programmer or teacher), so as to ensure that focus is not diverted from content analysis. Thus, an additional member should be added to the design team: a disciplinary expert in the content area. If the software is addressing multiple content areas, then there should be a disciplinary expert for each content area.

**Interest in Technology**

The teachers’ histories of technology use also indicate their investments in the design process. As noted in Chapter 4, Ethel viewed computer technology as a student motivator in and of itself, and worked to include computer technology whenever possible (i.e., when it supplemented other lesson components and did not take time from the covering of other required topics). This attitude extended to active interest in developing future technologies for her classroom, and in inciting the interest of other science teachers in the building regarding the software’s development and usage. This attitude also resulted in Ethel’s commitment to the project, which I discuss below.

**Commitment to Technology and the Project**

In Chapter 5, I noted that Ethel’s participation was proactive, which manifested itself in her not only working to satisfy all the requirements of the study, but also in her taking extra measures to ensure the success of the process (e.g., student design selection). Drawing from the effects of Ethel’s proactive participation on the success of Ele-Man, I surmise that teachers with her proactive attitude and personal investment in the software
product are more likely to dedicate the time required for software development than those who are not. While software designers might believe that a more “hands off” attitude would be beneficial in terms of design and development, the opposite is actually required in the school and classroom setting.

**Mutual Understanding of Expectations**

As noted in previous chapters, Ethel had a pre-existing commitment to constructivist learning philosophies. She also had some understanding of the demands of software development, as she had taken classes that required her to develop a software program. Because of this background, and our prior discussions regarding constructivism and technology, Ethel and I shared an understanding of the expectations of this study and our respective roles in the software development process. This allowed her to better adjust her actions to fit the needs of the study (e.g., selecting students for brainstorming), and to accommodate my needs during the study (e.g., providing necessary classroom materials). This understanding also allowed me to defer to Ethel’s expertise (in terms of both teaching and working with students) and other roles within the school to meet the needs of the study.

**Access to Class Materials**

As per the observations in Chapter 4, the unexpected observation of Ethel’s computer lab time provided great insight into the type of software Ethel wished to include
in her lesson plans. Thus, ensuring that at least one classroom observation takes place in the computer lab is essential to the success of software development.

Additionally, the Revised ID Model called for collection of (spare) copies of workbooks, tests, worksheets, lesson plans, specific context standards for that school, and other software websites or programs available to the students through the school. This was to work towards establishing how students are currently exposed to the required subject content. Having access to these materials was key to targeting the software content to the level required by the students’ current knowledge base and intellectual processing abilities.

While it is reasonable to assume access to textbooks and workbooks, the individual worksheets or other activities associated with particular topics can be collected once the teachers have worked with the educational technologist to select potential software topics. These materials also could have been better contextualized and supplemented if the classroom observations had been specifically targeted to the days on which the topics selected for software development were being covered.

**Student Selection**

It had been my intention to randomly select student designs from the classroom in order to promote fairness and equitable representation in the design process. As noted in Chapters 4 and 5, Ethel chose instead to modify my student selection procedures in order to increase parental consent return rates and to bias the selection process towards students that she felt would be best suited for software design. Following student selection, Ethel
also continuously discussed the design process with her students, thereby fostering and maintaining their interest in software design, as well as increasing the likelihood that students would remember who I was and why I was there from visit to visit and promoting a positive student attitude towards these visits. From this, I suggest that asking teachers to select student designers, or at least determine how best to motivate students to participate, and to follow-up with on-going student designer support, promotes student interest in software design.

**Interest in Software Design**

Teacher interaction was not the sole factor in generating interest in software design. For instance, there seemed to be a common conception (vocalized by Bailey) that software design would be “fun.” This interest was manifested in comments during classroom observations (e.g., greeting me every visit by eagerly asking if we were starting software design that day) as well as the inherent interest generated by external factors (e.g., one boy’s older brother designs software as well).

Because of this interest in software design, students were eager to begin brainstorming, and already came to the sessions with software ideas generated outside of the sessions. This interest also resulted in the students with other external motivators to design to take on leadership roles on the design teams.
Leadership

In both brainstorming sessions, there was one student – Freddy in science and Bailey in math – who led the brainstorming sessions. The vocalizations of these student leaders, both in terms of idea generation and in critiquing ideas that I generated, opened the way for other students to also contribute their own ideas. Given the limited rapport established with the students before brainstorming began, this leadership was essential to maintaining open communication and free-flowing idea generation with the students during brainstorming sessions.

Gaming Experience

The science student designers had more gaming experience than those in the math section, and this experience manifested itself in their prototype ideas. The math students generated various activities during their brainstorming sessions, while the science students drew from their experiences with other games (both from a class-based camp experience and from computer games) to focus/shape their prototype ideas. This resulted in more coherent and thorough prototype ideas in the case of science.

RE-EXAMINING THE PROCESS THROUGH THE LENS OF THE SOFTWARE ANALYSIS

It is the case that some barriers and facilitators to the process can only be recognized once the final product of the process has been analyzed. In this section, I
highlight the barriers and facilitators that became apparent or more prevalent once this product analysis was complete.

**Facilitators:**

1. Teacher involvement aids alignment with the standards. Guided by student performance on proficiency areas, the teachers are likely to select software topics for the areas in which students need extra assistance.
2. Selecting a small subset of the classroom’s students as designers seemed to be sufficient for indicating overall success of the program. Employing students as designers also seemed to work towards the incorporation of features appealing to that student population.

**Barriers:**

1. Reliance on students as design experts lead to being tied to the topics they generated and to their design decisions, rather than “going over their heads” and creating prototypes of real-life contexts for content or “scrapping” poor ideas in favor of beginning again if they wanted to forge on with an unsuccessful prototype. While not a problem for science, this issue did arise quite prominently in math. As I noted in Chapter 4 during my discussion of the teacher selection of prototype ideas, this phenomenon is due to the development of a single “make it or break it” prototype rather than multiple prototypes for the topics under consideration. There should always be at least three prototypes from which the students and teachers can choose.
2. Lack of development of an accompanying lesson plan allowed for the program to “take on a life of its own” in terms of how it defines the nature of knowledge and learning. Without knowing how the teacher plans to tie the software to the lesson – even she may not know if she hasn’t thought about how to design the new version of the lesson – the software designers are free to define what counts as knowledge and learning for that topic however they see fit, or however is convenient for prototype development.
3. Lack of a more “hands-on” approach from teachers in terms of prototype activity design (sometimes) led to educationally dubious activities. Additionally, the program’s format of classroom content was not always recognizable. Teachers, who have a better grasp on how their students understand and construct knowledge, would be better able to critique (at the design stage) and redesign activities to better suit the gaps in the curriculum and to better cue students to related classroom knowledge/activities. Face-to-face review with the teachers is
necessary, and focus group review with the students and teacher together is preferable.

4. Reliance on the educational technologist as the content expert, or on the teachers for redirection of software content during development, is not sufficient to ensure the accuracy of the embedded software content. An additional design team member – a disciplinary content expert – is required for this role. As the Model stands, this role was missing from the design team.

CHAPTER SUMMARY

In this chapter, I discussed each software product created during this project. For each product, I first provided a basic description of how it is played. I followed this description by a critical analysis of the embedded ideology of the product, which uncovered themes such as competition and drill-and-practice learning in the software. I then reviewed student responses to the product, and analyzed the software in terms of my original criteria set forth for the software. I found that while the science software was a success in terms of student and teacher needs, the math software left a lot to be desired. In order to understand this difference, I provided a review of those process factors that led to the success of the science program. Finally, I used these findings as a lens through which I re-examined the design process and identified barriers and facilitators to the design process based on the findings of the product analysis. In Chapter 7, I review the difficulties of designing constructivist software and speculate on the viability of the Revised ID Model in future software development applications.
CHAPTER 7

FINAL THOUGHTS

INTRODUCTION

In Chapter 1, I stated that the traditional instructional design (ID) model could be modified in a way that would “provide an avenue to explore a new way of embedding authentic content, employ student input to explore relevant ways of presenting educational content, and design and develop educational technologies that lend themselves to constructivist applications and environments.” These objectives led to the formation of four specific Software Criteria (see Table 1.1) that were aimed at meeting these objectives. I employed the literature on constructivism, cultural models, and instructional design to develop an ID model (see Chapter 2) and timeline that would aid me in achieving these software goals. The five Phases of the ID model’s timeline were first introduced in Chapter 3 as the initial research plan. In Chapter 4, I discussed the ways in which this plan was modified in response to the realities of the field, detailing the actual timeline and the nuances of the modifications. I also began a preliminary analysis of ways in which that data could be used to modify the plan for future use. In Chapter 5, I continued this discussion with the findings from the analysis of participant responses.
Finally, in Chapter 6, I discussed the actual software developed to further reveal some of the complications inherent in trying to design learner-centered software within the boundaries of content standards, and put forth a list of factors that influenced the success of the Revised ID Model.

In this chapter, I complete these discussions and analyses with a final review of the difficulties inherent in designing constructivist software. These difficulties are a response not only to the particular context of this study, but also other overarching nuances of the school climate. Since the focus of this study was the process of instructional design and not on researching the process of instructional design, I do not include in this chapter a revised Phase-based application of the Revised ID Model. The prescriptive overtones of such a revised Phase plan are at odds with the idiosyncratic nature of each individual school, and so it is up to the educational technologist applying the Revised ID Model to determine how to apply the Model in each school. The findings of Chapter 4 and 5 are of particular note towards this end. Instead of such a Phase-based plan, I conclude this analysis with a discussion of the viability of the Revised ID Model in the context of the Educational Climate of Chapter 1. Finally, I propose areas for future work in the area of constructivism and instructional design.

THE DIFFICULTIES OF DESIGNING CONSTRUCTIVIST SOFTWARE

In Chapter 2, I detailed an interpretation of constructivist learning theory and guidelines for developing an environment that fosters learning according to that theory. A key component of this discussion was that new information is best understood when
presented in authentic and relevant ways, according to the students’ lived realities (i.e., cultural models). Additionally, in constructivist classrooms, technology can be used in one of three ways: (1) to probe and organize student knowledge, (2) to explore concepts in simulated environments, and (3) to prompt reflection. The Software Criteria developed were designed to comply with this understanding of constructivism and aid in the development of software that could be used in these ways.

Even though the Revised ID Model was successful in producing a viable science program that can be used in constructivist ways, the Chapter 6 analysis of the software showed that the nature of knowledge and learning as embedded in the software was not necessarily constructivist. Throughout the study, I encountered many barriers and facilitators to the design of constructivist software, which were highlighted in Chapters 4 through 6. Based on these findings, I now outline four issues of primary importance when designing constructivist software: integrating curriculum, becoming familiar with and working within cultural models, the ease of designing drill and practice software, and the problem of authentic (and accurate) content. In those instances where barriers were encountered, I also suggest revisions to the Revised ID Model where possible.

**Integrating Curriculum**

I start with notes on an integrated curriculum, as the Software Criteria dealing with this point was the first to be sacrificed during this study. In Chapter 4, I noted my reasons for forgoing the fourth Software Criteria in favor of other demands of the Revised ID Model, namely
1. the conflicting curricular needs of the participant teachers,
2. my understanding of the necessity (or lack thereof) for a constructivist approach to persist throughout the entire school (see Chapter 2), and
3. the priority given to Software Criteria #2 over Software Criteria #4.

The existing departmentalization of the curriculum made these impossible barriers to overcome. Once the barrier was encountered, my other option would have been to conduct this study in another school, but by the time this decision was reached I already felt obligated to complete the study at Lochley Intermediate.

When screening for schools in which to apply the Revised ID Model and Software Criteria in the future, it is important to note that school factors (e.g., a departmentalized school or lack of teacher collaboration) might make it difficult to create software for an integrated lesson, or to design an integrated lesson at all. To this end, the degree of departmentalization or integration of the curriculum must be assessed. Given Software Criteria #4, a curriculum that is already integrated to some extent, or at least not departmentalized in any way (i.e., separated into strict groupings of subjects and teacher teams), is preferable. As such, the educational technologist needs to be familiar with the school context as early as possible so that s/he can change to a school that better fits the agenda of the technologist.

If the technologist is already committed to a particular school, I allege that for schools that do not already have an integrated curriculum or are not already working towards integration, it is better to focus on one subject only rather than trying to force integration. Creating multiple programs for multiple subjects, as happened during this study, is too much to simultaneously organize and manage; only one software product can be created at a time by a single design team. The problems of organization and
design team management are compounded as more design team members are added, and so I suggest only a single software product be developed even if a larger design team is working on it.

Becoming Familiar With and Working Within Cultural Models

During this study, I employed a student questionnaire to provide insight into the students’ cultural models. The open-endedness and low-tech nature of the brainstorming sessions were intended to provide further avenues for students to express themselves and their understandings of the content based on their cultural models.

While the student questionnaires provided me with an awareness of a specific set of software and attitudes towards that software, the brainstorming and software evaluation sessions were more useful in providing information about the students’ cultural models. As noted in Chapter 6, these forums allowed the math students to express their senses of ageism – in the warning to avoid characters that resemble those on Veggie Tales – their understanding of gender markers – in the repeated requests to have Maisy Pickle wear a pearl necklace (in spite of the fact that she had no neck), and in the requirement that the boy rescue the girl (all of the students rejected my suggestion that Maisy rescue Ninnian) – and their sense of coolness and extracurricular activities – in the suggestion that Ninnian use a skateboard as his mode of transportation and wear a backwards cap (this suggestion was not implemented because of wavering dedication to it). In both cases, math and science, the students also seemed to see a relationship between certain color palettes or environments and fun. For instance, I encountered
many instances during software evaluations in which students noted that the software looked “boring” and perhaps color changes or layout changes were needed to make it more “fun.” Specifically, colors needed to be bright (i.e., not pastel and not brown or black hues) and all outdoor scenes should be green and growing. These trends are seen repeatedly in children’s entertainment products. Further, particularly in the science group, there was a sense that better graphics meant a better software program, which was expressed both in the student questionnaires – “I don’t like software that looks like the makers didn’t try very hard.” – and in the software evaluation sessions themselves – in Snoopy’s response of “You made it better!” to shading effects added to Ele-Man. The focus on graphical elements could be a reflection of the students’ gaming backgrounds, of which constantly evolving graphical treatments are a focus.

Based on the usefulness of this information in understanding the students’ cultural models, I conclude that methods such as the questionnaire can provide only limited insight into the cultural markers of students’ cultural models, and that face-to-face interactions, particularly when focused on tangibles such as screenshot critiques or designs, are essential in understanding how the cultural markers inform the cultural models of students. While not directly gleaned from interaction with the students, the classroom observations and cultural markers relied on by teachers can provide insight as well. For instance, Ethel referred to Jimmy Neutron during her class lectures, which incited a conversation with the students regarding the current activities of that TV character. This conversation revealed not only extracurricular activities of the students,
but also how they can be tied to classroom teaching and learning according the teacher’s understanding of constructivism in the classroom.

So, in future applications, when uncovering cultural markers (e.g., avoidance of Veggie Tales or the desire for girls to wear pearls or the use of Jimmy Neutron to discuss a classroom topic), the educational technologist must ask,

1. What is it about the students’ cultural models that make them so invested in these markers?
2. What can be done to better understand what role these markers have in the cultural models?
3. How can the software be designed to work within these models? This is important particularly when the group of students is more diverse that that of Lochley Intermediate.
4. What further insight can teachers (consciously and as evidenced through their practices) give regarding their understanding of the students’ cultural models and how that knowledge is applied in the classroom?
5. What are other ways of exploring these students’ identities and cultural models? Must other interactions with the students be included in the ID Model in order to become familiar with the students’ cultural models?

In the case of this study, there also existed a tension between the students’ cultural models and the cultural model of the educational technologist (me) in terms of the use of gender stereotypes in Pickle Rescue. In instances such as these, the educational technologist must also ask,

6. How do I address this tension? Whose cultural models take precedence? What guidelines do I follow to determine when I prioritize my own cultural model over theirs?

I chose to prioritize the guidance of the students, but the relationship one establishes with the students (and other design participants) will determine how one answers these questions.
The Ease of Designing Drill and Practice Software

As noted in Chapter 6, the nature of knowledge and learning as embedded in both Ele-Man and Pickle Rescue aligned more closely with drill and practice styles of learning than constructivist philosophies. For instance, Ele-Man stressed recall and mastery of Periodic Table knowledge while Pickle Rescue emphasized the drilling of concepts through matching puzzles such as the Gate Room.

As I noted in Chapter 1, many software developers have recognized that drill and practice software is the easiest to design and develop. When an environment is self-contained, provides only one correct path through the environment, and allows for quantifiable measures for progress, it is much easier to anticipate and deal with user contingencies. It is also human nature to follow the path of least resistance, and quantifiable measures offer that path when programming. By melding my role as the educational technologist and programmer, it became easy to reign in or sacrifice the vision for the software in favor of the more practical constraints of the path of least resistance while programming.

In future applications of the Revised ID Model, I suggest that the role of designer (educational technologist) be separated from that of programmer. In the case of animated feature films such as Ice Age, it is the case that artists interpret a story, designing a look and feel for various scenes (i.e., a vision of the story), and programmers are then solicited to implement these visions. During implementation, it is common practice for the artist to continue to work with the programmers to ensure that the vision is maintained. Similarly, the educational technologist should fulfill the role of the artist, working with
the students and teachers to design a vision for the software, which the programmer then implements. Of course, adding an additional programmer can come with its own issues (e.g., the programmer’s vision), but this separation of roles allows for the educational technologist to focus on the vision rather than the practical ramifications and roadblocks in implementing that vision. By preserving the vision for the technology, I allege that there is a better chance for preserving the constructivist philosophy behind and vision for the software.

As a secondary point, even teachers who are “proactive” might not have the time to help shape the software as part of a lesson while the software design process is still ongoing. For those teachers who only develop the final lesson as needed, it is important that they be involved during software evaluations to focus student attention on those software features that should be noticed for the future lesson. Unfortunately, as noted in Chapter 6, not knowing what the future lesson is or how it is being formed allows for the design of software that posits knowledge, learning, and learning objectives in a way that might not be (wholly) compatible with that future lesson and its ideal use of technology. To this end, I suggest again\footnote{Recall the discussion on Access to Class Materials in Chapter 6.} that classroom observations be targeted specifically to include the lessons pertaining to the software topics, as these aid in shaping the vision for supplementary technologies and/or the reworking of the classroom lesson once a supplementary technology is available.
The Problem of Authentic (and Accurate) Content

In Chapter 2, I discussed the problem of preauthenticating software content, namely that it presumes a separation of cultural models (and the experiences that shape them) from the set of tasks and experiences necessary for the learning of new information to occur. I proposed that students be allowed to determine what makes an educational activity authentic, and that researching the students’ cultural models aids in creating this sense of authenticity, or space within the software. In Chapter 6, however, I noted that defaulting entirely to student conceptions of content led to inaccurate tessellation activities in Pickle Rescue, and suggested the addition of a content expert to the design team to aid in alleviating such issues of content inaccuracy.

In addition to the inclusion of a content expert, there were also other issues pertaining to authenticity that arose during analysis of the facilitators and barriers to the process. These issues related to (1) the educational background/knowledge of the educational technologist and (2) the ability of the students to relate school knowledge to real-life situations. To address the first point, the educational technologist must be able to “come to the table” with authentic ideas as a starting point. This first works towards preventing “designer’s block” by giving students an idea to critique and work from rather than relying on them to come with ideas. This was essential in both the math and science sections of the brainstorming sessions (refer to the Brainstorming notes on “Lacking Continuity: Requiring Prompts” in Chapter 5). Second, students will follow in the direction that they are pointed, but might need continual guidance to stay on track in
terms of both designing software that fits the curricular needs of the teacher and maintaining the balance between authentic/relevant content and “fun” software features. Students have a hard time relating school knowledge to real-life situations. Thus, even though students might be able to design in ways that are engaging on a “fun” level, it might be very difficult to steer students towards “authentic” (i.e., real life) ways of presenting the knowledge. In addition to clues from the students’ cultural models, the disciplinary knowledge of the content expert might provide the basis for these ties to real-life, and aid in the generation of ideas for the educational technologist to come with to the table.

CONCLUSIONS

Having established a general understanding of the barriers and facilitators of the Phase-based application of the Revised ID Model (see Chapters 4-6) and the overarching difficulties of designing constructivist software (see above), I now turn my attention to a final discussion on the viability of the Revised ID Model as a means of designing future constructivist applications. I claim that while some revisions are necessary, the Revised Revised ID Model still has potential to aid in the shaping of learner-centered environments in spite of the Educational Climate detailed in Chapter 1. Towards this end, I first make explicit the revisions needed to the Revised ID Model of Chapter 2. I then review the problems of the current Educational Climate as stated in Chapter 1, and note the potential of the Revised Revised ID Model to address these problems.
Revising the Revised ID Model

As I noted above, every school situation will be different, and so I cannot propose an alternate, “fixed” application/Phase timeline of the Revised ID Model. Rather, I ask the reader to recall those factors highlighted in Chapter 6 that directly correlated to the success of the Revised ID Model in the case of the science program, Ele-Man. Primarily, these included teacher/technologist

- interest in technology,
- commitment to technology and the project, and
- mutual understanding of expectations

and student

- interest in software design, and
- gaming experience.

Refer to Table 6.1 for a full listing of these factors. These factors can act as a guide when assessing the applicability of the Revised ID Model to a school context.

However, even with these factors in place, the Revised ID Model of Chapter 2 is not without fault. As noted previously, there is a need for revision to the design team members using the Revised ID Model. These revisions include:

1. The addition of a content expert to the design team. The addition of this role works towards the generation of initial “authentic”/real-life applications of content knowledge (for brainstorming), and towards ensuring the accuracy of the embedded content once software development begins.
2. The addition of a programmer to the design team – one who is distinct from the educational technologist. This addition aids in preserving the vision for the technology in the classroom, by freeing the educational technologist from the practical boundaries of programming concerns.

These two points are external to the specific school context, and directly relate to the inherent viability of the Revised ID Model itself. Without these revisions, based on the
results of this study, the Revised ID Model is not a viable approach for the design of educational software; a model that cannot ensure the accuracy of embedded content is not a model to employ, nor is one that sacrifices the vision of the software in favor of programming difficulties.

In addition to the inclusion of a content expert and programmer on the design team, there were also two other potential revisions suggested by the discussion on the difficulties of designing constructivist software. These are:

3. The elimination of Software Criteria #4 (i.e., the integration of lessons), provided that integration is not already a component of the existing curriculum or that the school is not working towards integration.
4. The potential need for other face-to-face interactions with the students towards the understanding of their cultural models.

These latter two points are school-specific, and must be addressed on a site-by-site basis. The fourth point, in particular, depends upon access to the students and the relationship established between the educational technologist and the students. These supplementary face-to-face interactions could take the form of additional brainstorming sessions or additional software evaluation sessions. Depending on the level of rapport established with the students, these additional interactions could also take the form of volunteer work in the classroom during non-software related activities.

The steps of the revised Revised ID Model are listed below. Note that the educational technologist now functions as a project manager (in terms of the programmer) as well as a co-designer. When not explicitly changed, it can be assumed that the design team members involved in a specific step are the same as in the original Revised ID Model of Chapter 2. While these steps might seem prescriptive in nature,
they are merely an outline of the stages of development I see as necessary to the design of constructivist applications, in keeping with the understanding of constructivism that I put forth in Chapter 2.

1. Identify the places in the current curriculum in which a computer-based tool could aid in the individual construction of knowledge.

   This decision is directed primarily by the teachers, who are most familiar with the curriculum and the points in the curriculum with which the students are having difficulty. The educational technologist might also be called upon to work with teachers towards assessing which topics can best be aided by computer-based tools. If software already exists in these areas, the educational technologist and teachers should also review these as alternatives to the design of new technologies.

2. Identify the relevant subject content and current delivery methods for the information. Also identify the relevant proficiency standards the current unit or future unit is meant to address.

   This can be accomplished by not only collecting the relevant classroom materials, but also targeting classroom observations to the days on which the potential software topics are being covered. Due to the fact that proficiency standards are interpreted by individual states and then districts, it is possible that school administrators should be involved in the discussion of the relevant standards. The technologist cannot assume that s/he can interpret the standards alone.

   Once content knowledge and standards have been identified, these should be reviewed by the educational technologist and the content expert in order to ensure that the educational technologist is informed enough on the subject matter to properly guide the brainstorming sessions. If possible, the technologist and content expert should also work towards identifying real-life applications of the subject matter. This, too, works towards guiding the brainstorming sessions.

3. Conceptualize a new lesson (or modify an existing one), supplemented by the computer technology.
   a. Brainstorm with students to design and develop approaches to this lesson, in keeping with the cultural models of the students.
   b. Work with teachers and the content expert to structure/sequence the students’ ideas or the student-generated software elements to fit the teachers’ needs for the lesson.
   c. Work with teachers to develop any additional materials needed by the lesson.
   d. Create or revise the prototype(s).

   While Step #3d initially involved the educational technologist programming the prototype(s), the task of implementation should now be given to a programmer whose sole task is implementation. Prototype ideas should have been discussed
sufficiently with the teachers, students, and content expert that the programmer can be given screenshot drawings and usability notes from which to work. These drawings and notes should be generated by the educational technologist, whose expertise should include usability and effectiveness of technological components, and revised by the other design team members.

If possible/necessary, additional programmers can be recruited for implementation, particularly in the initial stages of design/evaluation during which at least three prototypes should be generated (see Chapter 4 for more on this decision).

4. Conduct formative evaluations with teachers to evaluate the fit of the software to the teacher’s needs and with students to evaluate the delivery/environment/space of the software. This feedback can result in the return to #3 of this model, provided revision is required/requested by any of the co-designers (i.e., teachers or students).

Any changes made should also be verified by the content expert in order to ensure that accuracy of the embedded content is not being sacrificed in favor of other requests.

As per the findings of Chapter 4, it might be useful to conduct a formative evaluation with users other than the design team members before moving on to Step #5 of the Revised Revised ID Model. Also, the sooner the implementation can be tested the better, as the long gaps between brainstorming and evaluation sessions resulted in students requiring prompts and refreshers to refocus them on software design and the steps they had already taken to arrive at the prototypes before them (see Chapter 5).

5. Perform a summative evaluation of the final software product and the lesson components pertaining to the software.

These revisions recognize the school-based demands already placed on teachers and students outside of participation in software design, and work to place any additional responsibility on the educational technologist, content expert, and programmer. Given the nature of the school day, and the fact that teachers might only be able to meet for software design sessions during lunch or between other demands, the educational technologist should be as prepared as possible to discuss content, the students, or the software before each meeting. Where possible, visual aids should be used, as per the findings in Chapter 5 regarding the effect of tangibles on participation.
With these Model revisions in place, and with the four points on the design of constructivist software in mind, I believe that the Revised Revised ID Model is a viable option for designing learner-centered technologies and facilitating the creation of constructivist learning environments. It is also imperative that all design team members be aware of the Software Criteria towards which the educational technologist is working, and that the design team members agree with the intent behind them (as per the discussion on Mutual Understanding of Expectations in Chapter 6).

**The Viability of the Revised Revised ID Model in the Context of NCLB**

Recall from Chapter 1 that the primary issues I associated with the current educational climate were (1) disassociated knowledge, and (2) the favoring of tried-and-true behaviorist/transmission models of education over learner-centered environments. These issues were a result of the demands on students to meet proficiency standards and the political pressure placed on teachers and administrators for their students to excel.

**Meeting the Standards in a Learner-Centered Environment**

As noted in Chapter 6, both software programs were already successful in aiding students in meeting the state proficiency standards. Key to this success were the pre-established standards-based curriculum in the school and the teachers’ focus on areas that students still needed more help in in order to meet these standards. I conjecture that the learner-centered nature of the Revised ID Model, even before revision, aids in the construction of learner-centered environments. The revisions should merely further
support learner-centeredness by foregrounding student cultural models (and the resulting vision of the software) and ensuring that the content covered is accurate and beneficial in preparing students for the future.

I posit that for those teachers who employ a constructivist approach, the Revised ID Model’s implementation should be specifically geared towards also meeting the Software Criteria of Table 1.1 (with the qualification regarding Software Criteria #4 from above). For those teachers who do not subscribe to a constructivist philosophy, this Model should still suffice for the creation of software that is compatible with the philosophies of those teachers. In this latter case, the software design process will remain student-centered, but the final product might not, depending on the final product’s usage.

Disassociated Knowledge

As for the problem of disassociated knowledge, I conjecture that the addition of the content expert, with the responsibilities touched on above (i.e., aiding in the generation of real-life brainstorming ties to school knowledge and ensuring the accuracy of software content as that content is developed), will aid in alleviating this issue as well. The association of knowledge must be supported, however, by other classroom activities in order to be most effective. This association is most likely when the technology is employed according to constructivist principles of technology (see Chapter 2).
FUTURE WORK

There are three avenues for future work that flow naturally from the conclusions of this study. The first avenue for future work is in the testing of the Revised Revised ID Model, as discussed in this chapter. Namely, are these revisions sufficient for ensuring accurate content and in better preserving a constructivist vision for the software? Are other strengths or deficiencies of the Revised Revised ID Model highlighted by these revisions? Based on the findings of this study, it is my intuition that further barriers encountered will not be with the Model itself, but rather with the application of the Model.

Second, the Revised ID Model was applied at a very local level. What is the potential for the Revised Revised ID Model to be applied on a district level? Access to students and cooperation between teachers is an obvious barrier to expanding the project to a broader level. I suggest first that a single topic (e.g., science) be chosen based on the needs of the participating teachers from that district. Although ideal, it should not be a requirement that all teachers from the district participate, as they should be screened according to their pre-existing interest in technology, as stated above. To address issues of student access, it might be possible to work with that district’s students with Individual Education Programs (IEPs)\(^\text{74}\) as designers and testers, and work within that program to aid students in knowledge construction during software design as well as in designing software that will aid future students in knowledge construction. This avenue for research is a combination of the Revised Revised ID Model and Kafai’s (1995) and others’ models of promoting learning of specific content by requiring that student

\(^{74}\) For more on IEPs, refer to http://www.ed.gov/parents/needs/speced/iepguide/index.html.
designers work towards teaching other students. Of particular interest in this area is understanding what measures for scaffolding and customization can be built into the software to meet the needs of individual classrooms when the Model is applied to an entire district. This ties back to the assumption that the dynamics of every individual classroom must be accommodated by the software in order for the software to function as an extension of a constructivist environment and as a space for the students. While student designers’ cultural models will still be referenced towards the creation of the software space, the needs of the classroom teachers will take more concrete forms. For instance, customization could take the form of a front-end (i.e., an introductory setup/customization interface) to the software in which teachers select the type of scaffolding they want (e.g., hints), or whether they want scoring (an important feature to the math students in this study) on or off.

Third, one focus of the Revised ID Model of Chapter 2 was allowing for a software design “space” and software product “space” for the students’ cultural models. At the same time, I also noted that designers tend to design for others like themselves. Given the limited participation of teachers and students in the actual design process (see Chapter 4), and thus the prevalence of the educational technologist’s views and design decisions, to what extent would the inclusion of other programmers and content experts on the design team affect the ability to allow for these “spaces”? I posit that the ability of the educational technologist, teachers, and (primarily) students to clearly define an implementation plan for the programmer is key to the potential for this space. Related to this space is the preservation of constructivist principles during the design and
implementation of the software vision. Kapor (1996) argued for the potential of training of educational technologists and instructional designers towards more inclusive designs as a means of designing for inclusivity. Following this line of thought, is it possible to conduct training sessions for students and teachers on constructivist design? What would these sessions look like and how could they influence the process? I would argue that such training of students and teachers would confine the visions of participants for the technology to what they have seen in the training sessions, as people also tend to design according to what they have already seen\textsuperscript{75}. Rather, I put forth that group conservations with the teachers and other adults on the design team regarding the expectations everyone brings to the design process, as well as negotiating and establishing a shared expectation for the study, would be more beneficial in maintaining a constructivist vision. The question then becomes, What does this negotiation look like and how frequently during design does it need to be maintained? I do not include the student designers in these negotiations, as I do not feel it necessary to disclose this much theory to them in order to work within and be informed by their cultural models.

\textbf{WRAP-UP}

In Chapter 1, I discussed how the philosophies behind instructional design shape the educational technologies designed. Through the process of this study, I designed and tested an instructional design model that I felt would address some of the problems resulting from the political constraints of NCLB, namely disassociated knowledge and

\textsuperscript{75} I draw not only on the literature to support this (e.g., Kafai (1995)), but also on the effect that previous game experience had on the science prototypes versus the math prototypes.
the rejection of learner-centered environments in favor of tried-and-true methods. Addressing these issues was meant to foreground a constructivist philosophy and constructivist designs by foregrounding learner-centeredness at the heart of the design process.

I found that the model I designed required some key revisions, primarily the addition of a content expert to the design team to ensure accuracy of content and the addition of a programmer to free the educational technologist to focus on the vision for the software, but that it was already a viable option for creating software that leant itself to constructivist applications and accommodated students’ cultural models. Given this viability, I suggested that the model be applied at a district level to test its viability on a larger scale. I also wondered as to the possibility of training or other informal sessions to preserve the constructivist vision for the software and allow for the software to function as a space for student users.


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APPENDIX A

FORMAL LETTER OF INQUIRY TO THE SCHOOL
While this letter was originally addressed to the principal in business letter format, I have removed the address portion of the letter and de-identified the letter text in order to protect the identities of my participants.

I am writing you to request your permission to conduct a study at Lochley Intermediate School that examines the process of developing teacher and student centered educational software with two of your teachers during the 2004-2005 academic year. I am a Ph.D. candidate in educational technology at The Ohio State University. A B.A. and M.S. in computer science have provided me with the technical skills necessary for software development. I am now interested in developing an understanding of how educational software can be developed to support the particular needs of classroom teachers as well as help students meet state/district content and performance standards.

Prior conversations with Ethel, as well as a visit to your school last year, lead me to believe that your school would be an ideal setting in which to conduct my research. Both the computer facilities and the curriculum that Ethel discussed, Chicago Math, impressed me. This research would last approximately 7 months, during which time I would be working with Ethel and another teacher and their students to develop cross-curricular software around a single unit. At the end of the study, your school would receive software that is tailor-made for the participating classrooms. I would also supply you with a final report of my findings. A more detailed accounting of my research plan can be found in the included Research Proposal. I am sensitive to the requirements of a full curriculum and the demands of standardized tests and have therefore designed the study to minimize the time taken from regular classroom instruction.

Thank you for your consideration. I look forward to speaking with you and addressing any questions or concerns that you may have. I will call you to follow up on this proposal on June 17, 2004. If you wish to contact me before this date, I can be reached via email at olsafsky.1@osu.edu or by phone at 614-####-#####.

Sincerely,

Barbara L. Olsafsky
Ph.D. Candidate, Educational Technology
APPENDIX B

RESEARCH PROPOSAL (TEMPLATE)
Research Proposal

As part of my dissertation in the field of educational technology, I have constructed, and would like to assess, a new approach to the design and development of computer software for the classroom. I am primarily interested in designing software that meets the following criteria:

1) The software aids students in meeting state/district proficiency standards.

2) The software meets the needs of classroom teachers in that it is compatible with their philosophies of teaching and learning. Such software should also be compatible with their philosophies of how technology should be integrated into the classroom, as well as school policies on technology integration.

3) The software presents the content in such a way that aids students in the individual construction of knowledge, within the student’s cultural contexts. This criteria works towards student engagement with the material, which is one factor in fostering learning in the classroom. The software should also integrate curriculum from at least two subject areas so as to enable a deeper understanding of the context and applications of the learning content.

To this end, I see the design and development of educational technologies as not only the design and development of a technology, but also the design and development of the accompanying curriculum for that technology. To meet the individual needs of students and teachers within a school, it is imperative that they be involved in the design process.

It is my goal that at the end of this design process the participant teachers are left with a technology module as well as the accompanying curriculum for use in their own
classrooms. In essence, a lesson will be constructed that meets the needs set forth by the teachers’ teaching philosophies, those set forth by state/district standards, and the needs of the students in terms of relevance and engagement. This technology and curriculum will have been tailor-made for teacher use.

**Outline of Design Process**

The design process that I propose should take approximately 7 months in the school. The process is broken into 5 phases. A summary of this timeline in terms of participants and time requested is attached at the end of this document.

**Phase 1: Establishing School Context**

Duration: 2 weeks

Participants: Principal and Assistant Principal

Location Desired: Principal’s and Assistant Principal's offices

Description: An interview will be conducted to establish a school context for technology integration, state/district proficiency standards, and the possibilities and limitations of collaboration between teachers towards an integrated curriculum.

**Phase 2: Establishing Teacher Context, Pinpointing Content for Software**

Duration: 2 months

Participants: 2 teachers from different subject areas

Location: Classrooms
Description: Interviews will be conducted to establish 1) how teachers view technology requirements, how they currently use technology in the classroom, and their ideal views of technology in the classroom, 2) how standards are currently accommodated in the curriculum, and 3) philosophies of teaching and learning. Classroom observations will also be conducted at this time, preferably 1 per week, and informal interviews will be employed to explore questions that arose from these observations.

Phase 3: Establishing Student Context, Exploring Methods of Presentation and Learning of Content

Duration: 3.5 months

Participants: Students and teachers

Location: Classroom, computer lab

Description:

[Brainstorming in the Classroom]

In this phase I hope to explore how students have experienced the lesson as it is currently taught (most likely without technology). I would then like to explore with them how they feel the lesson could be altered if they were to teach that content to next year’s students. Using low-tech methods of paper and pencil, glue, etc., students can express how they feel the material should be covered through technology. This low-tech method enables us to explore interface design outside the bounds of existing technologies and without worry over varying levels of technological expertise. We will discuss their
designs one at a time before we end this session to make sure I understand the messages behind their visuals.

[Testing in the Computer Lab]

Student input will be used to design 3 software prototypes. These prototypes will be tested in the computer lab, and student/teacher feedback will be used to select a single prototype as well as guide revisions of the software. The first computer lab meeting will test the 3 software prototypes I create, with the subsequent 2 computer lab meetings used to evaluate revisions made to the prototype selected for development and to make suggestions for future development.

To allow for time to develop these prototypes, I propose that the first low-tech meeting be held at the beginning of the 3 month period. The initial 3 prototypes will be presented at the end of this month. The subsequent prototype tests will be 3-4 weeks apart, dependent upon the scheduling needs of the teachers and students.

As the technology evolves, so too should the accompanying lesson into which the technology is to be integrated. Short focus groups after the prototype meetings can be used to explore this evolution.

Phase 4: Final Evaluation

Duration: 1 visit, approximately 2-3 weeks after Phase 3

Participants: Students and teachers

Location: Computer lab
**Description:** In this phase I will conduct the final evaluation of the software. Changes will not be made after this point, but data on suggestions for change will still be collected in order to help inform future designs of this nature.

**Phase 5: Exit Interviews**

*Duration:* 1 week, 2 weeks after Phase IV to allow time for data review before interview

*Participants:* Principal and Assistant Principal; teachers; students

*Location:* Classroom

*Description:* As my research goal is an evaluation of the process employed here, I am interested in analyzing this process not only from my perspective, but also from the perspectives of my research participants. A focus group with the principal and assistant principal, a focus group with the teachers, and a focus group with the students will be conducted to discuss this design process. At this point I will also review with the participants my own analysis of the process in order to collect feedback and prompt further reflection on my part.

**Benefits of Participation**

As I stated before, this process should leave the participant teachers with a new technology and integrated curriculum plan for a single lesson. This study should also inform the approaches of other educational technology designers interested in working in the schools to design and develop technologies for the classroom. As such, this is a
chance for the principal, assistant principal, and teachers to voice the extent to which they would like to participate in technology design and development for their school.

**Participation and Confidentiality**

Prior to the study I will submit my research proposal to The Ohio State University's Human Subject Review Committee to ensure that my design will have no overt ill effects on the participants. In addition, participation in this study is wholly voluntary. If at any time a participant becomes frustrated, stressed, or uncomfortably for any reason, that participant can be excused from the study without penalty.

Confidentiality of the participants will be ensured first by the use of pseudonyms in my data write-ups. Additionally, any audiotape recordings will be used for my own research purposes only, listened to and transcribed by me alone, and will be destroyed one year after the study has been completed. Any documents collected during the course of the study, such as the low-tech brainstorming materials, will also be destroyed one year after the study has been completed.

All participants will be asked to sign a consent form detailing the terms of participation as detailed above. In the case of the students, the consent of a parent or legal guardian will be required. All participants, as well as the parents and legal guardians, will be provided with a copy of this consent form, which will contain my contact information.
Findings

A copy of the findings and my analytic write-up will be provided to the principal, assistant principal, and each participant teacher.

Summary of Project Timeline

<table>
<thead>
<tr>
<th>Phase</th>
<th>Participants</th>
<th>Time Required</th>
</tr>
</thead>
</table>
| Phase I     | Principal and Assistant Principal  | *Approximately 1 hour each for interview during the first month of this study *
| (2 weeks)   |                                    | *If necessary, no more than 1 additional hour to review relevant documents    |
| Phase II    | Teachers                           | *Approximately 1 hour each for initial interview                              |
| (2 months)  |                                    | *Classroom observations will be conducted every week for each class           |
|             |                                    | *Follow-up informal interview time should be no more than 2 hours during this 2 month period and can be conducted during the regular school day |
| Phase III   | Students and Teachers              | *Approximately 1 hour for design overview and initial brainstorming session    |
| (3.5 months)|                                    | *Approximately 1 hour for each prototype evaluation (3 total)                |
| Phase IV    | Students and Teachers              | *Approximately 1 hour for final (summative) evaluation of software product    |
| (1 week)    |                                    |                                                                                |
| Phase V     | [Students], [Teachers], [Principal & Assistant Principal] | *Approximately 30-60 minutes per group for exit interview over process        |
| (1 week)    | (two weeks after Phase IV to allow time for data review before interview)      |                                                                                |
APPENDIX C

SAMPLE “ACTION PLAN” FORMS FOR SETTING AND TRACKING GOALS
The first form listed here is the daily report of student achievement/practice and parental monitoring of progress, while the second form is the overarching “Action Plan” for success.

<table>
<thead>
<tr>
<th>Math Record</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name</strong>__________________</td>
</tr>
<tr>
<td><strong>Homeroom</strong>___________</td>
</tr>
<tr>
<td>I must practice _______________ facts this week.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facts practiced</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parent initials</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Math Record</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Name</strong>__________________</td>
</tr>
<tr>
<td><strong>Homeroom</strong>___________</td>
</tr>
<tr>
<td>I must practice _______________ facts this week.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facts practiced</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parent initials</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
ACTION PLAN

Goal:

Strategy:

Indicators of Success:
(How will you know if this strategy is successful?)

<table>
<thead>
<tr>
<th>Action Steps</th>
<th>Responsibilities</th>
<th>Resources</th>
<th>Timeline</th>
<th>Impacts (Intermediate set of accomplishments)</th>
<th>Success Indicator (How will you know if this activity is successful?)</th>
</tr>
</thead>
</table>
APPENDIX D

SAMPLE LESSON PLAN LAYOUT FROM THE TEACHER’S HANDBOOK.
The Teacher’s Handbook is supplied to each teacher each school year. Below is the sample lesson plan provided in the 2004-2005 handbook, pp.23-24.

Here’s a sample lesson plan:

**STANDARD:** Students will compare at least two characters in a reading selection.

**ACTIVITIES:**
1. Students met in four student-selected reading groups (Groups posed on bulletin board).
2. Discussion of Overview of Day (Underlined portion on board).
   - **Overview of Story** (2 very different people try to solve a mystery titled “___” by ___).
   - **Purpose for Reading** (to notice similarities and differences in 2 characters’ personalities-appearances).
   - **Read Story “___”** (Students will read in manner identified during goal-setting conferences – original version, original w/ audio, abridged, abridged w/ audio).
   - **Venn Diagram**
     1. Each group will discuss comparisons.
     2. Each student will complete a Venn diagram comparing appearances and personalities.
     3. Expectations – (see below for detail).
3. Students complete activities as teacher monitors and intervenes as needed.

**ASSESSMENT/EVALUATION:**
(recorded as +, √, -, 0 on daily log sheet – used to inform future planning)
~Accurate, thorough (minimum 3/category), supported identification of comparisons
~Legible, clearly labeled diagram
~Active participation in reading and discussion

**CIP GOALS:**
(Please refer to these goals).
APPENDIX E

SAMPLE “SHORT CYCLE” TEST
Number, Number Sense and Operations Standard

1. Use prime factorization to find the least common multiple of 35, 10, and 15. [4-2b]
   A. 5
   B. 35
   C. 210
   D. 135

Measurement Standard

2. Using the circles find: [4-2]
   A. the radius
   B. the square of each radius
   C. the total number of squares in each circle, count partial squares as 1/2, 1/3, etc.
   D. Find the ratio of C to B for each circle.
   E. Use this information to derive the formula for the area of any circle in terms of the radius and the ratios.

Geometry and Spatial Sense Standard

3. How many faces, edges, and vertices does the following geometric solid have? [4-2]

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A. 5</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>B. 6</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>C. 9</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>D. 5</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

Patterns, Functions and Algebra Standard

4. Represent the following function on the grid. [5-1]

<table>
<thead>
<tr>
<th>X</th>
<th>Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
</tr>
</tbody>
</table>

1 Square Unit
Data Analysis and Probability Standard
5. Select the mode, median, mean and range of the following data. [15-4]
   25, 36, 45, 33, 45, 60, 45
   
   A. 45, 45, 41.3, 35
   B. 45, 45, 46, 35
   C. 41.3, 45, 45, 35
   D. 45, 41.3 45, 35

These tests measure student progress towards being able to answer questions like the
ones they will be asked on the proficiency exams. Questions are grouped by the standard
they address.
APPENDIX F

LOCHLEY INTERMEDIATE SCHOOL VIDEO POLICY.
I have taken the liberty to emphasize (with boldface) those parts of this policy that reflect on the school’s teaching with technology philosophy, expectations for the teacher’s role in the classroom, and understanding of student learning.

Source: Teacher Handbook, p.26

LIS
VIDEO POLICY

Please consider the following when making instructional decisions involving videos:

A team should not schedule videos for a full day of viewing by students.

1. PG, PG-13 & R movies are forbidden.

2. Every video activity should have a lesson objective, as well as a pre and post activity.

3. Entertainment type videos, often viewed by younger students, should not be shown, unless you are showing a specific segment to support curriculum or to stress an instructional objective.

4. If additional videos are needed to enhance instruction for specific content, please request approved instructional videos. High interest instructional resources are available now from the History and Discovery Channels, as well as catalogs that arrive at our school in abundance.

5. When showing a video for instructional purposes, you should start & stop throughout to ask questions and assess student engagement, understanding and learning.

   All of our students need a quality education. They watch videos at home for entertainment. On days when attendance is not expected to be good and when schedules are irregular, there is a tendency to show videos. These days are good for Proficiency practice activities, or for reviewing or re-teaching concepts that some students may not have learned when they were introduced. You are accountable for the education of students in your classes. Question yourself: Is this video to introduce a topic or enhance understanding in an effective manner? Is this video evidence of a quality education?
APPENDIX G

PHASE 1 INTERVIEW QUESTIONS FOR THE PRINCIPAL AND ASSISTANT PRINCIPAL
**Is it okay with you that I tape record this interview?**

**Introduction**
I am interviewing you today in order to be able to describe the school context and structure in which this software design endeavor is taking place. My questions today cover the topics of teaching, learning, and technology. Do you have any questions for me before we begin?

**Teaching**
0. Before we turn to discussing this school and your perspective as principal of this school, I would like to learn a bit about your background as an educator. Did you teach in the classroom? How did you come to hold this position?
1. How would you describe the teaching philosophy of the school?
2. Is there a particular teaching methodology that you subscribe to? (particularly wrt math and science?)
3. What is your role in setting the classroom curriculum?
4. How do you understand the role of proficiency standards in the curriculum?
5. How do you understand the role of proficiency standards in teaching?
6. Could you describe to me the process of developing, communicating, and implementing policies?
7. How do you work to ensure that these policies are being implemented in every classroom?
8. What do you think the teacher's role is in the classroom?
9. How do you see this teacher team structure as functioning?
10. How do you see teachers working together?

**Learning**
1. How do you think students learn? Construct knowledge?
2. Do you have a particular learning theory that you subscribe to?
3. What do you think the student's role is in the classroom? What are their responsibilities? How much initiative do you expect students to show regarding assignments, etc.?

**Technology**
1. How would you describe the technology philosophy of the school?
2. What is your role in technology selection and integration in the classroom?
3. Do you believe that technology is an essential component of the curriculum? Teaching? Learning?

**This Study**
1. Can you tell me how it is that Mrs. Rausch and Mrs. Dearwester came to be the two teachers I will be working with for this study?
Thank you.
---

If I do not already have them, I will attempt to collect the following documents at this time:
1. Relevant proficiency standards
2. School technology policies
3. Documentation on the teacher team structures and guidelines for interaction
4. Documentation on the school’s teaching philosophy or mission
This script was used as a guide. It was not read verbatim to the participating classes. It has also been de-identified for inclusion in this dissertation.

Script:
Hi! My name is Barb and I am a Ph.D. student at The Ohio State University working with Dr. Richard Voithofer. I’m here at Lochley to do a research project about software design for the classroom. I’m going to be here for the next two months observing your classroom and how computers are used here. Once I have a feel for that, I would like to work with you to design a software program that can be used in this classroom by next year’s students.

We would be working to develop educational software, so its purpose would be to reinforce things that you’ve learned in class. We’d begin by first selecting content for the software, the information we want the software to be covering. Then we’ll try to figure out how our target audience, in this case next year’s students, needs to have this information organized and what activities they should be doing in order to learn something from using the software.

I think your involvement in this project is very important. While your teachers are experts on teaching and what you need to know, only you can be experts on you and how we can make this educational software fun and interesting to you and other students.

We would meet 4 times to discuss how to design the software and to play with small versions of the software so we can check how we’re doing. We’d be meeting during your study hall time, so you wouldn’t be missing any other class time. I need to record these meetings and observations to audiotape, but I’ll be the only one that listens to them.

I would like to have 4 volunteers from this class for the software design part of this study. There are no consequences if you do not volunteer, and even if you volunteer you can choose to stop participating at any time. In order to participate in the creation of the software I need your parents to sign and return these consent forms. If more than 4 people volunteer, I’ll choose 4 people at random. Everyone can get to participate in the end by trying out our software program and telling us what you think, but again there are no consequences if you do not want to participate. So I can observe your everyday classroom activities and so that you can try out and review the software at the end of the study, I also need your parents to sign a consent form.

In order to participate, I will also need verbal assent stating that you understand your role in this study and that you know that you can drop out of the study at any time without any consequences. We’ll do this after your parents have signed and returned their consent forms.

Do you have any questions for me?
APPENDIX I

PHASE 2 STUDENT QUESTIONNAIRE
Questionnaire for Students

As I told you, I am here to work with students and teachers to design computer software. By answering these 12 questions honestly, you will help me in understanding how you might like new software to be designed for you. Let me know if you have any questions about the questions.

Name (first and last)::

________________________________________________________________________

1. What is your favorite color?

________________________________________________________________________

2. What do you look for when you are choosing a software program to use? Certain characters? Certain types of activities? Something else?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

3. Are there things you avoid when you are choosing a software program to use? Certain characters? Certain types of activities? Something else?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

4. What is your favorite software program that you use at home? Why?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

5. What is your favorite software program that you use at school? Why?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
6. Do you believe you can learn things from using a software program?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

7. If you said “yes” to number 5, what software programs have you learned the most from? What helped to make it educational?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

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________________________________________________________________________

________________________________________________________________________

8. Is educational software boring? If so, what makes it boring?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

9. Can educational software be fun? If so, what are some of the things that make it fun?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

10. How much time do you spend on the computer?

Every day?

Every week?
11. What is your favorite thing to do when you're not on the computer? Please give an example. For example, if your favorite thing to do is read, please list your favorite book. Or if your favorite thing to do is play sports, please list your favorite sport. Why is this thing your favorite?
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

12. Is there anything else you want to tell me about?
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Thank you for answering these questions.
APPENDIX J

PHASE 2 INTERVIEW QUESTIONS FOR THE TEACHERS
**Is it okay with you that I tape record this interview?**

**Introduction**
I am interviewing you today in order to be able to describe the teacher context in which this software design endeavor is taking place. My questions today cover the topics of teaching, learning, and technology. Do you have any questions for me before we begin?

**Teaching**
0. I would like to begin with a little demographic information regarding your teaching experience. Can you tell me how long you’ve been teaching? And how long have you been teaching here at Creekview?
1. How would you describe your teaching philosophy?
2. Is there a particular teaching methodology that you subscribe to?
3. Is your teaching philosophy ever at odds with the teaching philosophy of the school or school administrators?
4. What do you think the teacher's role is in the classroom?
5. How do you go about constructing lesson plans for your classroom?
6. How do proficiency standards influence your lesson plans?
7. How do these teacher teams function?
8. Do you ever collaborate with other teachers towards integrated lessons?

**Learning**
1. How do you think students learn? construct knowledge?
2. Do you have a particular learning theory that you subscribe to?
3. What do you think the student's role is in the classroom? What are their responsibilities?

**Technology**
0. I was wondering if you would share with me what your comfort level or proficiency level with computers is. For instance, do you have any type of technology certification? How did you come to achieve your current levels of proficiency and comfort?
1. How do you understand the technology policies of this school?
2. How do you select technology for the classroom?
3. What characteristics do you want software to have? What do you look for?
4. Are there any characteristics you try to avoid?
5. Ideally, how should technology function in the classroom?
6. How does your classroom match this ideal?
7. What are the barriers to this ideal?
8. How do you integrate technology into your classroom?
9. What role do you see administrators having in deciding how you select and integrate technology in your classroom?
10. Do you believe that technology is an essential component of the curriculum?
11. How could technology be used to best fit your teaching needs?
12. How could technology be used to best fit student needs?
This Study

1. Are there any particular ways that you suggest I work with the students for this study? (Describe what I was thinking of and seek feedback here.)

Thank you.

---

If I do not already have them, I will attempt to collect the following documents at this time:
1. The list of classroom topics from each teacher that are potential lesson topics for the software.
APPENDIX K

PRE-SOFTWARE EVALUATION FORM
These questions were developed as a precursor to the actual formative and summative software evaluation forms used by the participants. They served as a guideline for the types of questions that I wanted to ask of the actual software created.

NOTE: An evaluation will be given for each prototype being evaluated. At the end of the first evaluation session, students will be asked to choose their favorite prototype (or prototype components) so that we can move forward developing a single software program.

**Introduction**

Please use the following pages to evaluate the software. Be as honest as possible. If at any time you want to tell me about something that is not covered by the questions, please write it on the back of the evaluation pages. Also, feel free to ask me questions at any time during this evaluation if there is something you do not understand.

**Exploration Tasks**

Complete 2 or 3 tasks aimed at exploring the software developed so far. These will be tailored to the actual activities developed.

**Interface**

1. Do you like the colors being used?
2. If you could change any of the colors anywhere in the software, which colors would you change and what would you change them to?
3. Were the different activities easy to find? [Will be explored by asking students to find and complete an activity and report on where they found it]

**Interactivity**

1. Do you find the feedback helpful?
2. If you could write your own feedback for right answers, what would it be?
3. If you could write your own feedback for wrong answers, what would it be?
4. Do you like the activities?
5. If you could change the activities, would you? If so, how?
6. If you could add in a new activity, what would it be?
7. Did you understand what you were supposed to do for each activity?
8. What do you think you are supposed to be learning from each activity?
APPENDIX L

PHASE 5 EXIT INTERVIEW QUESTIONS FOR THE PRINCIPAL AND ASSISTANT PRINCIPAL
**Is it okay with you that I tape record this interview?**

**Introduction**
As I noted in my research proposal, the focus of this study was to assess the effectiveness of this software design approach. In order to do this, I want to take into account as many perspectives as possible. I realize that you participated only on the fringes of the actual software design process, but would like to hear your reflections on this process taking place in your school.

1. Did you feel that this study was conducted in accordance with the research plan I provided to you?

2. Do you feel that design endeavors such as this one can enhance the level of educational resources available to schools?

2a. What did you think of the software samples I provided you with?

3. Would you have wanted to be more involved in the design process?

4. Did you at any time observe or hear of any practices associated with this study that you found troublesome?

5. Were there any times that you felt uncomfortable with my presence in this school?

6. Are there any things you want to tell other educational technology designers interested in this type of design process?

7. Would you be willing to participate in a design project such as this one again?

8. Are there any other things you want to tell me?

Thank you.
APPENDIX M

PHASE 5 EXIT INTERVIEW QUESTIONS FOR THE TEACHERS
**Is it okay with you that I tape record this interview?**

**Introduction**

As I noted in my research proposal, the focus of this study was to assess the effectiveness of this software design approach. In order to do this, I want to take into account as many perspectives as possible.

1. Did you feel that this study was conducted in accordance with the research plan I provided to you?

2. Do you feel that design endeavors such as this one can enhance the level of educational resources available to schools?

3. Would you have wanted to be more involved in the design process?

4. Do you feel like sufficient steps were taken to develop software that was tailored to your needs as a teacher?

4a. Do you feel like sufficient steps were taken to develop software that was tailored to the needs of the students?

5. Do you feel like sufficient steps were taken to develop software that met the needs of your class in terms of lesson plan development?

6. Do you believe that both your needs and the students' needs were respected and accommodated by this process?

7. Do you believe that the end product of this design endeavor will be useful for you in terms of teaching future classes?

8. How did you feel the design sessions with the students went? Do you believe there are better ways to conduct these types of brainstorming and design sessions? Do you believe they enjoyed (were actively engaged in) the sessions? If so, why?

9. Did you at any time observe or hear of any practices associated with this study that you found troublesome?

10. Were there any times that you felt uncomfortable with my presence in your classroom or the activities associated with this study? Offended with the methods I used to collect data?

11. Are there any things you want to tell other educational technology designers interested in this type of design process?
12. Would you be willing to participate in a design project such as this one again?

13. Is there anything else you want to tell me?

Thank you.

** must also ask about student engagement
APPENDIX N

PHASE 5 EXIT INTERVIEW QUESTIONS FOR THE STUDENT DESIGNERS
**Is it okay with you that I tape record this interview?**

**Introduction**
In addition to designing software, I was also interested in studying how to design software. I think it's important that I get your feedback as well. I'm going to ask you a few questions about your participation on this design team.

1. Did you enjoy working on this project?
2. Were there things you did not enjoy?
3. Were there any times that you felt uncomfortable working with me?
4. What did you think of those first brainstorming session we had with the construction paper and the gel pens and crayons and stuff? Do you think they were useful? Did you enjoy them?
5. Did you feel like I listened to your suggestions?
6. Were you happy with the final product?
7. Do you think other students will be able to learn things from using our software?
8. What could we have done better?
9. If you had the chance, would you work on a project like this again?
10. Is there anything else you want to tell me?

Thank you. And to thank you for helping me with my project, I have a CD with a copy of our software on it for each of you.

Research names?
Secret of the Bones

As a paleontologist on a dig in the Southwest, you have just unearthed and reconstructed the skeletal remains of a mystery beast. Can you use the clues to identify it?

Follow the directions carefully to get to the virtual lab on the Internet.

a. Type www.school.discovery.com in the address box and click “Go.”
b. Look at the left hand side and find “Science Fair Central.” Click on it.
c. Scroll down to “Science in Action” and click on it.
d. Find “Secret of the Bones” and click on this section to begin.

Answer the following questions as you work through this lab.

1. Name the seven major groups that scientists use to classify all living things.
   a. 
   b. 
   c. 
   d. 
   e. 
   f. 
   g. 

2. The largest group is ____________________________.

3. The smallest group is ____________________________.

4. In the virtual lab you can click on a ______________ to see examples.

5. We know our skeleton does not fit into the moneran or protist kingdom because ____________________________________.

6. An animal with no backbone is called ____________________.

7. Give three examples of vertables.
   a. 
   b. 
   c. 

8. Mammals are organized into 3 subclasses. List them.
   a. 
   b. 
   c. 

9. Identify the mystery skeleton
   Kingdom ______________________
   Phylum ______________________
   Class ______________________
   Order ______________________
   Family ______________________
10. This animal is more commonly called a __________________________.

11. Why do scientists classify living things? (extended response)
_______________________________________________________________________.
_______________________________________________________________________.
_______________________________________________________________________.
_______________________________________________________________________.
_______________________________________________________________________.
_______________________________________________________________________.
_______________________________________________________________________.
_______________________________________________________________________.
_______________________________________________________________________.
APPENDIX P

SAMPLE LESSON PLAN COLLECTED
Lesson Plan for Friday, October 29

Ethel

Science

2nd period, 3rd period, 7th period, 8th period

Standard: PO 8

Objective:

- Define molecule
- Identify/compare states of matter.
- Explain how matter changes states.

Activities:

1. Review previous day’s lab.
3. Use “A Matter of Matter” to define 3 states.

Evaluation:

A-mazing Matter
APPENDIX Q

TOPICS UNDER CONSIDERATION FOR SOFTWARE PROTOTYPES
Note that the lists contained in the table below do not contain unique entries. Rather, this is the sequence of topics listed on the lesson plans as they appear. Some topics are cycled back through based on the philosophy that students will learn better if the curriculum is spiraled through units multiple times rather than blocked into units that are covered in a cumulative fashion. This blocking of units is the more common method of teaching information, with each block building on the knowledge of the last block, but not requiring actually revisiting of previous blocks.

### Content Analysis for Math & Science Lesson Plans
#### August through December

<table>
<thead>
<tr>
<th>Science</th>
<th>Math (Everyday Math)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Use relevant safety procedures to complete scientific investigations</td>
<td>- Review topics from the 5th grade Everyday Math series</td>
</tr>
<tr>
<td>- Use a dichotomous key to identify and classify objects (x2)</td>
<td>- Draw and describe line plots. Use landmarks of data</td>
</tr>
<tr>
<td>- Use characteristics of a substance to develop an appropriate investigation (x2)</td>
<td>- Calculate and compare the median and the mean. Review naming numbers in different ways</td>
</tr>
<tr>
<td>- Review and use the scientific method to make observations and inferences</td>
<td>- Find the range, median, mode, and mean of a set of numbers</td>
</tr>
<tr>
<td>- Describe why it is important to keep clear, thorough, and accurate records</td>
<td>- Create line plots. Use landmarks of data</td>
</tr>
<tr>
<td>- Design an investigation to test evaporation time of 3 liquids (x2)</td>
<td>- Draw, read, and interpret broken-line graphs</td>
</tr>
<tr>
<td>- Demonstrate an understanding of the metric system</td>
<td>- Draw, read, and interpret bar graphs</td>
</tr>
<tr>
<td>- Explain the uses for quantitative and qualitative observations</td>
<td>- Draw, read, and interpret step graphs</td>
</tr>
<tr>
<td>- <strong>[Quality Tools; Proficiency Practice]</strong></td>
<td>- Review the Percent Circle, interpret circle graphs, and estimate percents on circle graphs (x2)</td>
</tr>
<tr>
<td>- Describe why it is important to keep clear, thorough, and accurate records</td>
<td>- Find the perimeter and area of a rectangle and use a graph to investigate the relationship between perimeter and area</td>
</tr>
<tr>
<td>- Observe and classify a bag of beans according to self-determined characteristics</td>
<td>- <strong>[Quality Tools; Proficiency Practice]</strong></td>
</tr>
<tr>
<td>- Demonstrate how to use a dichotomous key to identify objects</td>
<td>- Find the perimeter and area of a</td>
</tr>
<tr>
<td>- Recognize that kingdoms are divided</td>
<td></td>
</tr>
<tr>
<td>into smaller groups. Distinguish between fact and opinion.</td>
<td>rectangle. Use a graph to investigate the relationship between perimeter and area</td>
</tr>
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<td>---</td>
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</tr>
<tr>
<td>- [SEP 19] Evaluate the impact of research and technology on scientific thought, society, and the environment</td>
<td></td>
</tr>
<tr>
<td>- Apply knowledge of rock cycle to <strong>ext.</strong></td>
<td></td>
</tr>
<tr>
<td>- Use a dichotomous key to identify and classify various objects (x3)</td>
<td></td>
</tr>
<tr>
<td>- Use a simple key to classify objects, organisms, and/or phenomena</td>
<td></td>
</tr>
<tr>
<td>- Use a dichotomous key to identify and classify various objects</td>
<td></td>
</tr>
<tr>
<td>- Identify characteristics scientists use to classify organisms. Conclude that all living things belong to one of five kingdoms</td>
<td></td>
</tr>
<tr>
<td>- Recognize that kingdoms are divided into smaller groups. Describe the two-part scientific name of an organism. Identify vertebrates (x2)</td>
<td></td>
</tr>
<tr>
<td>- Recognize the kingdoms are divided into smaller groups. Identify vascular/nonvascular plants</td>
<td></td>
</tr>
<tr>
<td>- Examine the different ways plants support themselves. Describe how the plantae kingdom is separated</td>
<td></td>
</tr>
<tr>
<td>- <strong>Review classification information</strong></td>
<td></td>
</tr>
<tr>
<td>- Use a simple key to classify objects, organisms, and /or phenomena</td>
<td></td>
</tr>
<tr>
<td>- <strong>[REWARD MOVIE]</strong></td>
<td></td>
</tr>
<tr>
<td>- Define matter, molecules, properties of matter. Use properties of matter</td>
<td>- [SEP 19] Review material covered in Unit 1 (x2)</td>
</tr>
<tr>
<td></td>
<td>- Assess learning of 2.1 through 2.7</td>
</tr>
<tr>
<td></td>
<td>- Use scientific notation. Convert between scientific notation and standard notation</td>
</tr>
<tr>
<td></td>
<td>- Add, subtract, multiply with decimals</td>
</tr>
<tr>
<td></td>
<td>- Use and interpret scientific notation on a calculator (x2)</td>
</tr>
<tr>
<td></td>
<td>- Complete and graph 1 short cycle assessment</td>
</tr>
<tr>
<td></td>
<td>- Use and interpret scientific notation on a calculator</td>
</tr>
<tr>
<td></td>
<td>- Estimate quotients. Review and practice division</td>
</tr>
<tr>
<td></td>
<td>- Estimate and calculate quotients for division of decimals by whole numbers</td>
</tr>
<tr>
<td></td>
<td>- Practice and review material covered in previous 2 weeks.</td>
</tr>
<tr>
<td></td>
<td>- Division</td>
</tr>
<tr>
<td></td>
<td>- Estimate and calculate quotients for division of decimals by whole numbers. Obtain quotients to a specified number of decimal places</td>
</tr>
<tr>
<td></td>
<td>- Review students’ progress on material covered in Unit 2 (x2)</td>
</tr>
<tr>
<td></td>
<td>- Assess students’ progress on material covered in Unit 2</td>
</tr>
<tr>
<td></td>
<td>- Describe general number patterns in words and with number</td>
</tr>
</tbody>
</table>
to describe an unknown item
- Observe and describe some of the characteristics that can be used to classify substances
- Explain what an element is. Recognize that elements in same family have similar properties
- Measure temp of water as it changes states. Display temp data on a graph
- Define molecule. Identify/compare states of matter. Explain how matter changes states

| [NOV 17] | Compare objects by observing and measuring their characteristics |
| Recognize and describe physical changes matter undergoes |
| Observe and compare different types of changes (e.g., chemical reactions) |
| Experiment to find physical processes that reverse some physical changes |
| Describe how mixtures are made, how to separate mixtures. Identify different kinds of mixtures & solutions. |
| [Proficiency Practice] (Bill Nye video on chemical change) |
| Distinguish between suspensions, [mystery], solutions |
| Describe that in chemical change new substances are formed. In physical change the chemical properties remain unchanged |
| Prepare/evaluate an investigation of simple physical or chemical changes. |
| Explore the relationship between stored energy and energy of movement. |

| sentences having 1 variable. Write special cases for general patterns |
| Write special cases for general patterns having 2 variables. Describe such patterns, use 2 variables |
| Write and evaluate algebraic expressions |
| Study how formulas are constructed. Practice evaluating formulas by substitution |
| Complete and graph 1 short cycle assessment |

| [NOV 17] | Write and evaluate algebraic expressions |
| Name & use distributive property of multiplication |
| Name & use the properties of multiplication (distributive). Spreadsheet Scrabble |
| Review previously taught materials (x2) |
| Assess learning from Unit 3 |
| Use expressions involving integers to represent and solve problems |
| Review renaming fractions as equivalent fractions an in simplest form |
| Compare fractions with unlike denominators |
| Review adding and subtracting fractions with like and unlike denominators |
| Add and subtract mixed numbers with like denominators |
| Review concepts taught throughout the week |
| Add and subtract mixed numbers with like denominators |
| [Quality Tools] |
| Extend addition and subtraction to... |
| Explain how potential energy and kinetic energy are related. Describe how thermal energy moves between substances. | Represent the faction multiplication **algorithm** as a general pattern; and to use the algorithm to solve problems |
| Describe how electric energy can be produced from a variety of sources | Multiply mixed numbers by renaming mixed numbers as fractions |
| Describe how thermal energy moves between substances | Add, subtract, multiply fractions and mixed numbers |
| [Quality Tools] | Add, subtract, multiply fractions and mixed numbers |
| Describe how thermal energy moves between substances | Multiply mixed numbers by renaming mixed numbers as fractions |
| Describe what electricity is. Explain how electricity & magnetism are related. | Review renaming between fractions, decimals, and percents |
| Produce electricity from chemical energy (x2) | Review fraction concepts |
| Review energy concepts | **Lab safety. Scientific inquiry. (Play [Hazard/Precaution]) (x2)** |
APPENDIX R

SUMMARY/ANALYSIS OF STUDENT QUESTIONNAIRES
Questionnaire responses were not analyzed separately (i.e., once for math and once for science), because I was hoping to gather as much data as possible into these responses. The only area in which I separated out the information was for Question #1.

**Question #1: What is your favorite color?**

Math: Purple: 2; **Blue:** 7; Black: 3; Red: 2; Orange: 3; Gold: 1; Green: 2  
Science: **Green:** 4; **Blue:** 5; **Pink:** 4; Black: 2; Gold: 1; Red: 2; Purple: 1  
Total: Purple: 3; **Blue:** 12; Black: 5; Red: 4; Orange: 3; Gold: 2; Green: 6; Pink: 4

Note that even if the answer was “baby blue” or “neon green”, I simply condensed such answers to “blue” or “green”.

**Question #2: What do you look for when you are choosing a software program to use? Certain characters? Certain types of activities? Something else?**

After “FUN,” which was too nondescript for me to focus on, “GAMES” was the most prevalent theme in the students’ responses. Within this genre, students are looking for strategy (3), action (4) – either by name or via requirements of fighting/violence and reflexes/agility, adventure (2), and puzzles (1). Students also look for “funny” and brand name (e.g., Disney and Nickelodeon) characters. The desire for a 3D environment or 3D characters also came up (2), tempered by one student’s remark that “I don’t like software that looks like the makers didn’t try very hard.” I consider myself warned.

Although I am still not pleased with the task analysis portion of my data collection thus far, I am beginning to think about the format in which to put the software. These themes are leading me in the direction of the PBS TV show CyberChase. In this show, a group of children must solve various math-based problems in CyberSpace in order to defeat the show villain, Hacker. For example, in one episode the children are required to build a bridge using shapes that are all the same (a tessellation). For more information, visit [http://pbskids.org/cyberchase/](http://pbskids.org/cyberchase/).

**Question #3: Are there things you avoid when you are choosing a software program to use? Certain characters? Certain types of activities? Something else?**

These students seemed most concerned about avoiding “baby” games, which I guess is understandable given this age group. Outside of “boring” games, students also wished to not have to sit still a lot, merely typing as a form of interaction, characters that are bad at the game (should not be a problem for us in this instance), downloads, and games with no or “weird” graphics.
Question #4: What is your favorite software program that you use at home? Why?

I asked this question, because I felt this is where students would best be able to express their likes and dislikes about software. In being able to choose their own games, they should have a lot more to tell me about their likes and dislikes.

I was not that interested in the title of their favorite games as I was in the characteristics that the students chose to highlight. “GAMES” was again a theme here, especially those in which they can make/build things and try them out, “add on, have choices,” strategize and explore, and links to sports that they enjoy in their real lives (and “requires good timing”).

Question #5: What is your favorite software program that you use at school? Why?

Students highlighted “Type to Learn” as their favorite program at school, namely because they can see the return for using it (from #7). After this, various websites were highlighted as having a selection of fun games.

Question #6: Do you believe you can learn things from using a software program?

Nearly every students answered “yes” to this question. I wonder if this is because they all knew why I’m at the school.

Question #7: If you said “yes” to number 5, what software programs have you learned the most from? What helped to make it educational?

This is the question I screwed up. I meant to refer to #6. I renumbered the questions last minute and didn’t catch this until reading through an answer in which the students pointed out my mistake.

As with #5, the typing program was the most popular game for the reason I listed there. Also mentioned were a crossword puzzle on the topic of magnets and electricity, and being forced to complete math problems in order to move on to the next level.

Question #8: Is educational software boring? If so, what makes it boring?

Students answered primarily with a conditional “yes.” The answers suggest that we can avoid designing boring software if the software has games that are not boring, does not just relay information, challenges the student, and doesn’t require a test/quiz. “Type to
“Learn” was mentioned yet again as an educational program that is fun, as was the Zoombinies adventure game.

**Question #9: Can educational software be fun? If so, what are some of the things that make it fun?**

Students almost overwhelmingly answered that “GAMES” would make the software fun. Specifically, they wanted them to be “hands on,” “challenging,” “interesting,” wanted to be able to “solve problems and riddles to progress through the story,” include “cool information,” have an “ADVENTURE” theme, puzzles, and (“talking”) “cartoon characters.”

**Question #11: What is your favorite thing to do when you’re not on the computer? Please give an example.**

For the most part, these students are very active in sports. Students also enjoy playing with their friends, playing with their dogs/goats, watching TV, reading (Lizzie McGuire, HP, LOTR), and dancing. Paintball and crossword puzzles and word searches were also mentioned.

**Question #12: Is there anything else you want to tell me about?**

While most students answered “no,” there were a handful of other miscellaneous answers:

“Yes I am sorry for all of my lying that I have did to all of you teachers. I hope I start out with a fresh start.”

“Not really. I’ve always liked doing computer animation and I love art.”

“Maybe you can make an adventure game with levels and get your guy strong on the way.”

“I play on a hockey team in Dublin. My league is Pee-Wee. My team is the Penguins.”

“I am very excited about doing this.”

“Nope! Wait yeah one thing (skips a space) thank you 4 doing this with us!!”

“Yes um…well yeah I want you to know that I am always surrounded by computer and know a lot about computers, because my stepdad builds computers, fixes them and
everything so we have three computers at home not to mention the five in his office. that's it!”
APPENDIX S

EVALUATION FORM FOR FORMATIVE EVALUATION #1: SCIENCE
This form was modified to include only Ele-Man during subsequent evaluations, but the set of questions remained similar. Ethel’s evaluation form included some questions pertaining to the strengths and weaknesses of the prototypes, both educational and recreational, as well as lesson development.

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**Introduction**

Please use the following pages to evaluate the software. Be as honest as possible. If at any time you want to tell me about something that is not covered by the questions, or if you wish to elaborate on your answer, please use the back of the evaluation form and label your responses accordingly. Also, feel free to ask me questions if there is something you do not understand.

This evaluation is broken into 3 sections: “Simon Says: The Science Edition”, “Test Yourself! Physical and Chemical Changes”, and “EleMan.”

Also included are screenshots of the game screens. Use these, if you wish, to indicate places for change or items that you particularly like.

**Discussion**

1. What do you think you were supposed to learn from the activity?
2. Do you think that this software achieves this goal?
3. If you could change the activity, would you? If so, how?
4. If you could add a new activity, what would it be? If this software has triggered other ideas for software that you would like to develop for your classroom, please also include these here.

For Simon Says:
1. What should we call this? For copyright reasons, it cannot be Simon Says.

For Ele-Man:
1. Should we change the ghosties in Level 1 to amoebas?
2. What if the element you collect in previous levels helps you in the next? Such as collecting the water needed to kill the fire ghosties in Level 2? Or collecting salt in Level 2 to kill the slugs in Level 3?
Formative Evaluation #1a: Simon Says

Exploration of Tasks
Please begin this evaluation by completing at least one round of Simon Says. Sufficient directions should be included within the game pages.

Aesthetics & Mechanics
1. Do you like the colors being used?
   ___ I love the colors!
   ___ I liked all the colors
   ___ They were okay, but I don’t care much either way
   ___ Not really
   ___ Not at all

2. If you could change any of the colors anywhere in the software, which colors would you change and what would you change them to?

3. Did you like the feedback animations?
   ___ I loved the feedback animations!
   ___ I liked them
   ___ They were okay, but I don’t care much either way
   ___ Not really
   ___ Not at all

4. Did you like the graphics in the feedback animations?
   ___ I loved the way the feedback animations looked!
   ___ I liked the way they looked
   ___ They were okay, but I don’t care much either way
   ___ Not really
   ___ Not at all

5. Could you tell what was going on in all of the animations?
   ___ Yes
   ___ No
   If you answered ‘No,’ please list the animations that were unclear.
Usability
1. Did you understand what you had to do in order to play?
   ___ Yes
   ___ No

2. Did you understand how to move the hand around and how to get to the next problem?
   ___ Yes
   ___ No

3. Did you have problems getting the feedback animations to play when you dragged the hand around?
   ___ Yes
   ___ No

4. Did the feedback animations help you see what was going on when you combined stuff?
   ___ Yes
   ___ No

5. Was it clear from the feedback animation whether you had answered correctly?
   ___ Yes
   ___ No

6. Did the feedback animations help you to distinguish the features that categorize physical and chemical changes?
   ___ Yes
   ___ No

   Based on your experience with Simon Says, what do you think these features are?

7. Did you like the feedback text? Keep in mind both the animation text and the score feedback as you answer this question.
   ___ Yes
   ___ No

8. Were there any feedback phrases you would like to change? If so, to what?
9. If you could write your own feedback for right answers, what would it be?

10. If you could write your own feedback for wrong answers, what would it be?

11. Was it clear how and when you should navigate to the next problem?
   ___ Yes
   ___ No

12. Overall, did you understand what you were supposed to be doing? If not, tell me when you were confused and what you found so confusing. Also, what helped you figure it out?

12. Did you like the fact that the game kept track of your score?
   ___ Yes
   ___ No

13. Do you think the feedback on the final score page will help you do better next time you play?
   ___ Yes
   ___ No

**Fun Factor**

1. Do you like the activity?
   ___ Yes
   ___ No

2. Did you wish that more of the program had been developed so you could continue playing?
   ___ Yes
   ___ No

3. Did you feel like your ideas from the brainstorming sessions (the stuff we did on construction paper) were represented by this game?
   ___ Yes
   ___ No
Formative Evaluation #1b: Test Yourself!

Exploration of Tasks
Please begin this evaluation by completing at least one round of Test Yourself!. Sufficient directions should be included within the game pages.

Aesthetics & Mechanics
1. Do you like the colors being used?
   ___ I love the colors!
   ___ I liked all the colors
   ___ They were okay, but I don’t care much either way
   ___ Not really
   ___ Not at all

2. If you could change any of the colors anywhere in the software, which colors would you change and what would you change them to?

3. Did you like the quiz animations?
   ___ I loved the quiz animations!
   ___ I liked them
   ___ They were okay, but I don’t care much either way
   ___ Not really
   ___ Not at all

4. Did you like the graphics in the quiz animations?
   ___ I loved the way the quiz animations looked!
   ___ I liked the way they looked
   ___ They were okay, but I don’t care much either way
   ___ Not really
   ___ Not at all

5. Could you tell what was going on in all of the animations?
   ___ Yes
   ___ No
   If you answered ‘No,’ please list the animations that were unclear.
Usability
1. Did you understand what you had to do in order to play?
   ___ Yes
   ___ No

2. Did you understand how to answer the questions and how to get to the next question?
   ___ Yes
   ___ No

3. Did you have problems getting the quiz animations to play?
   ___ Yes
   ___ No

4. Did you find the feedback text informative? Did it help you understand why your answer was wrong or right?
   ___ Yes
   ___ No

5. Was it clear whether you had answered correctly?
   ___ Yes
   ___ No

6. Did the feedback text help you to understand WHY the animation was showing a physical or chemical change?
   ___ Yes
   ___ No
   If you answered ‘No,’ please elaborate.

7. Did you like the feedback text? Keep in mind both the animation text and the score feedback as you answer this question.
   ___ Yes
   ___ No

8. Were there any feedback phrases you would like to change? If so, to what?
9. The same feedback is used for right and wrong answers. Should there be different feedback text for right and wrong answers?
   ___ Yes
   ___ No

Answer Questions #10 & #11 only if you answered ‘Yes’ to #9.
10. If you could write your own feedback for right answers, what would it be?

11. If you could write your own feedback for wrong answers, what would it be?

12. Was it clear how and when you should navigate to the next problem?
   ___ Yes
   ___ No

13. Overall, did you understand what you were supposed to be doing? If not, tell me when you were confused and what you found so confusing. Also, what helped you figure it out?

14. Did you like the fact that the game keeps track of your score?
   ___ Yes
   ___ No

15. Do you think the feedback on the final score page will help you do better next time you play?
   ___ Yes
   ___ No
**Fun Factor**

1. Do you like the activity?
   ___ Yes
   ___ No

2. Did you wish that more of the program had been developed so you could continue playing?
   ___ Yes
   ___ No

3. Did you feel like your ideas from the brainstorming sessions (the stuff we did on construction paper) were represented by this game?
   ___ Yes
   ___ No
Formative Evaluation #1c: EleMan

Exploration of Tasks
Please begin this evaluation by completing EleMan up through the intro screen to Level 2. Sufficient directions should be included within the game pages.

Aesthetics & Mechanics
1. Do you like the colors being used?
   ___ I love the colors!
   ___ I liked all the colors
   ___ They were okay, but I don’t care much either way
   ___ Not really
   ___ Not at all

2. If you could change any of the colors anywhere in the software, which colors would you change and what would you change them to?

3. Did you like the ghosts?
   ___ Yes
   ___ No
   If you answered ‘No,’ please elaborate below. Try to include suggestions for replacement.

4. Did you like your avatar—the guy with glasses and a goatie?
   ___ Yes
   ___ No
   If you answered ‘No,’ please elaborate below. Try to include suggestions for replacement.

5. Did you like the animation showing the formation of H2O?
   ___ I loved the animation!
   ___ I liked it
   ___ It was okay, but I don’t care much either way
   ___ Not really
   ___ Not at all

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6. Could you tell what was going on in the animation showing the formation of H2O?
___ Yes
___ No
If you answered ‘No,’ please tell me what was unclear.

**Usability**

1. Did you understand what you had to do in order to play?
   ___ Yes
   ___ No

2. Did you understand how to move your avatar—the guy with the glasses and the goatie?
   ___ Yes
   ___ No

3. Did you understand that you had to collect the elements?
   ___ Yes
   ___ No

4. Did you understand how to pick up the elements?
   ___ Yes
   ___ No

5. Was it clear when it was time to move on to the next level?
   ___ Yes
   ___ No

6. Did the animation showing the formation of H2O help you understand how and why elements combine to form compounds?
   ___ Yes
   ___ No
If you answered ‘No,’ please elaborate below.

7. Should there have been a narrator explaining the H2O animation?
   ___ Yes
   ___ No
If you answered ‘Yes,’ what do you think should be said?
8. What do you think should happen when you run out of lives?

9. Should there be other elements that you are NOT supposed to pick up?
   ___ Yes
   ___ No

10. If you answered ‘Yes’ to #9, what happens when you pick up the wrong elements? Can you still pick up the ones you need?

12. Overall, did you understand what you were supposed to be doing? If not, tell me when you were confused and what you found so confusing. Also, what helped you figure it out?

12. Did you like it that the game was timed?
   ___ Yes
   ___ No

Fun Factor
1. Do you like the activity?
   ___ Yes
   ___ No

2. Did you wish that more of the program had been developed so you could continue playing?
   ___ Yes
   ___ No

3. Did you feel like your ideas from the brainstorming sessions (the stuff we did on construction paper) were represented by this game?
   ___ Yes
   ___ No
APPENDIX T

EVALUATION FORM FOR FORMATIVE EVALUATION #1: MATH
This form was modified to reflect the evolution of puzzles, both in terms of rooms and features, throughout the design process, but this format remained the same. Nancy’s evaluation form included some questions pertaining to the strengths and weaknesses of the prototype, both educational and recreational, as well as lesson development.

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**Introduction**

Please use the following pages to evaluate the software, ‘Pickle Rescue.’ Be as honest as possible. If at any time you want to tell me about something that is not covered by the questions, or if you wish to elaborate on your answer, please use the back of the evaluation form and label your responses accordingly. Also, feel free to ask me questions if there is something you do not understand.

The software takes place in the following context: Ninnian Pickle and Maisy Pickle were walking through the forest one day. Suddenly, a large human hand appeared from the sky and kidnapped Maisy! Ninnian must now quest to the Land of Picnic to save her.

Also included are screenshots of the game screens. Use these, if you wish, to indicate places for change or items that you particularly like.
**Formative Evaluation #1: Pickle Rescue**

*Exploration of Tasks*
Please begin this evaluation by completing Pickle Rescue. Sufficient directions should be included within the game pages.

*Aesthetics & Mechanics*
1. Do you like the colors being used?
   ___ I love the colors!
   ___ I liked all the colors
   ___ They were okay, but I don’t care much either way
   ___ Not really
   ___ Not at all

2. If you could change any of the colors anywhere in the software, which colors would you change and what would you change them to?

3. Did you like your avatar—the little green guy?
   ___ Yes
   ___ No
   If you answered ‘No,’ please elaborate below. Try to include suggestions for replacement.

4. Did you like the female avatar—the little green girl with the bow?
   ___ Yes
   ___ No
   If you answered ‘No,’ please elaborate below. Try to include suggestions for replacement.
5. Did you like the scenery?
   ___ Yes
   ___ No
   If you answered ‘No,’ please elaborate below. Try to include suggestions for replacement.

6. Did you like the hint bubbles?
   ___ Yes
   ___ No (please elaborate below)

Usability
1. Did you understand what you had to do in order to play?
   ___ Yes
   ___ No

2. Did you understand how to move between rooms?
   ___ Yes
   ___ No

3. Did you understand that you had to complete the bridge to move on?
   ___ Yes
   ___ No

4. Was it clear how to complete the bridge?
   ___ Yes
   ___ No

5. Would it have been preferable to select from 3+ piles of different shapes of bricks, with a true tessellation being the only one that would let you cross?
   ___ Yes
   ___ No

6. Was it clear how to collect the hint from the island?
   ___ Yes
   ___ No
7. Was it clear why two of the rafts did not work but the other did?
   ___ Yes
   ___ No
   What do you think the reason was?

8. Was the purpose of the volume levers clear?
   ___ Yes
   ___ No (please elaborate)

9. Was it clear how to free the ladder from the boxes?
   ___ Yes
   ___ No (please elaborate below)

10. Was it clear how to rescue the princess from the burger?
    ___ Yes
    ___ No

11. Was it clear how and when you should navigate to the next problem (room)?
    ___ Yes
    ___ No

12. Could you tell what the hint bubbles were trying to tell you?
    ___ Yes
    ___ No (please elaborate below)
13. Should the hint bubbles provide text instructions rather than images?
   ___ Yes
   ___ No
   If you answered ‘Yes,’ please provide some suggestions for hint text.

14. Overall, did you understand what you were supposed to be doing? If not, tell me when you were confused and what you found so confusing. Also, what helped you figure it out?

**Fun Factor**
1. Do you like the activity?
   ___ Yes
   ___ No

2. Did you wish that more of the program had been developed so you could continue playing?
   ___ Yes
   ___ No

3. Did you feel like your ideas from the brainstorming sessions (the stuff we did on construction paper) were represented by this game?
   ___ Yes
   ___ No
APPENDIX U

ROTHE’S GUIDELINES FOR APPLYING THE CRITICAL FRAMEWORK

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The following questions are provided by Rothe (1991, pp.379-380) as an example of the way in which his framework can be applied. I used these questions as a guide for my own analysis.

1. Language Usage  
   (a) What common-sense metaphors are found in the software to describe a technical process?  
   (b) Why are these metaphors used?  
2. Knowledge  
   (a) What knowledge is selected and neglected?  
   (b) How is the selected knowledge intended to be used by students?  
3. Ideology  
   (a) What basic perspective on the knowledge underlies the software’s knowledge content and student activities?  
   (b) What alternative perspectives can be considered?  
4. Profit  
   (a) To what extent is a software package marketed according to ideas of efficiency, cost-effectiveness, etc.?  
   (b) Is the software linked to the purchase of more software for the accomplishment of objectives?  
5. Culture  
   (a) What cultural tastes or attitudes are reflected in the software?  
   (b) How does these tastes and/or attitudes relate to the program user?  
6. Ethics  
   (a) What teaching structures are found in the software that are based on a basic value stance?  
   (b) What are the basic values underlying activities and content?  
   (c) How do these values interface with the values held by a community of users?
APPENDIX V

LIST OF “HINT” TEXT PROVIDED BY TOM THE TOMATO
Room #0

Maisy Pickle has been KIDNAPPED!!!
Journey with Ninnian…
…and his friend Tom…
…to rescue Maisy…
Begin

Room #1

Entry Text:
Click on me, Tom the Tomato, whenever you need help.

Loop of Hints:
Looks like we need to build a bridge!
Move the bricks to build a tessellation across the river.
The bricks need to be rotated perfectly before they’re added to the bridge.
The right mouse button will let you rotate, while the left button lets you drag.

Upon Picking a Brick:
REMEMBER: The right mouse button lets you rotate the brick until it’s right for the bridge.

Upon Having Perfectly Rotated a Brick:
That looks good!  (put the brick in place)

Upon Placing the Brick Into the Bridge:
Perfect fit!  Let’s get another brick.

End Text:
We’ve built the bridge.  Let’s cross it and rescue Maisy!

Room #2

Loops of Hints:
Looks like this has turned into a journey by sea!
We can use one of the raft kits to make a raft and sail away.
We should pick a shape that will create a tessellation.

Upon Opening a Kit:
Is that a tessellation?  A tessellation is our ticket out of here!

Upon Taking the Wrong Raft:
This raft seems to have some holes…Not a tessellation…
Exit Text – Upon Taking the Correct Raft:
Great job!

Room #3

List of Hints:
We’ll have to make our way down the lock.
Locks work by transferring water from the sides into and out of the middle.
Those levers and pipes at the bottom look like they transfer the water across.
Match the volume of the shapes at the bottom with the volume of water that needs to be moved.
The grid around the locks and the grid on the doors will tell us how much water we need.
Click on the red knobs to activate the levers.

Lever Feedback:
Good start, but we’ll need to move more water to open the lock.

Lever Feedback – Upon Trying to Add/Remove Too Much Water:
Ooops! That would put more water in the lock than the lock can hold. Try another lever.
Ooops! There’s not that much water left in the lock. Try another lever.

Lever Feedback – Upon Adding/Removing Enough Water to Move Across (either way):
Super! We can now move in to the next section of the lock!!!

Exit Text – Upon Passing Out Of the Second Lock:
We made it across! Yippee!! Next stop: the gates of Picnic.

Room #4

List of Hints:
Look over there! I think I can see Maisy’s pink bow behind that wall!
Looks like we need to match the shapes to their volume equations.
Click on a shape, then click on its volume equation.

Shape Feedback (one for each shape):
This equation takes the form: B * h
This equation takes the form: 1/3 * (B * h)
This equation takes the form: B * h
This equation takes the form: 1/3 * (B * h)
This equation takes the form 4/3 * pi * r^3
Room #4a

Pre-Rescue:
Excellent Job!!! Now you just need to escort Maisy off that table!

Post-Rescue:
Ninnian has rescued Maisy, and they can now return to Pickle and live Happily Ever After!
CONGRATULATIONS! <<accompanied by fireworks and twinkling flowers
APPENDIX W

FIGURES
Figure 1. Diagram of the ID process

Source: Morisson et al., 2001, p.6
Figure 2. Revised ID Process.
Figure 3. Screenshot of Ele-Man Level 1, first prototype

Caveat: The “oxygen” below is actually carbon. This was one of many bugs in the initial prototype, and was corrected in later prototypes.
Figure 4. Screenshot of Ele-Man compound formation movie (H₂O), first prototype

Caveat: The “oxygen” below is actually carbon. This was one of many bugs in the initial prototype, and was corrected in later prototypes.
Figure 5. Screenshot of Simon Says, question 1
Figure 6. Screenshot of Simon Says, question 1, wrong answer
Figure 7. Screenshot of Simon Says, question 1, right answer
Figure 8. Screenshot of Test Yourself!, sample quiz question
Figure 9. Screenshot of Test Yourself!, sample quiz question, playing movie
Fire & Logs: Chemical Change

After the logs are introduced to the fire, we can see that the logs catch fire, producing a lot of smoke. Once the fire dies down, we are left with a pile of ash. The smoke and the ash let us know that a chemical change has occurred. No more logs.
Figure 11. Ninnian Pickle

Figure 12. Splash Screen of Pickle Rescue, first prototype
Figure 13. Bridge Room of Pickle Rescue, first prototype
Figure 14. Bridge Room of Pickle Rescue, first prototype, bridge complete
Figure 15. Path Room of Pickle Rescue, first prototype
Figure 16. Raft Room of Pickle Rescue, first prototype
Figure 17. Raft Room of Pickle Rescue, first prototype, puzzle completed
Figure 18. Gate Room of Pickle Rescue, first prototype
Figure 19. Gate Room of Pickle Rescue, first prototype, gates opening
Figure 20. Gate Room of Pickle Rescue, first prototype, gate open
Figure 21. Fountain Room of Pickle Rescue, first prototype
Figure 22. Fountain Room of Pickle Rescue, first prototype, puzzle complete
Figure 23. Land of Picnic in Pickle Rescue, first prototype
Figure 24. Land of Picnic in Pickle Rescue, first prototype, rescuing Maisy
Figure 25. Land of Picnic in Pickle Rescue, first prototype, game completed
Figures 26. Hint for hint bubble in Pickle Rescue, first prototype, the completed bridge.

Figures 27. Hint for hint bubble in Pickle Rescue, first prototype, location of the clue in the second room.
Figures 28. Hint for hint bubble in Pickle Rescue, first prototype, standing on the island with the second clue.

Figures 29. Hint for hint bubble in Pickle Rescue, first prototype, matching equations and shapes.
Figures 30. Hint for hint bubble in Pickle Rescue, first prototype, freeing the ladder.

Figures 31. Hint for hint bubble in Pickle Rescue, first prototype, placing the ladder in the last room.
Figure 32. Splash Screen of Pickle Rescue, second prototype
Figure 33. Screenshot of Ele-Man compound formation movie (H₂O), final product, opening screen.
Figure 34. Screenshot of Ele-Man compound formation movie (H₂O), final product, compound forming.
Figure 35. Screenshot of Ele-Man compound formation movie (H₂O), final product, compound formed.
Choose your level of difficulty:

- Beginner
- Intermediate
- Expert

Figure 36. Splash Screen of Ele-Man, final product
Figure 37. Game Over (Death) screen of Ele-Man, final product
Figure 38. Ele-Man Level 1 (H₂O), beginner difficulty, final product
Figure 39. Ele-Man Level 1 (H₂O), intermediate difficulty, final product
Figure 40. Ele-Man Level 1 (H$_2$O), expert level, final product
Figure 42. Splash Screen of The Clickable Periodic Table
All elements like to have "full" electron rings. By studying the rings, we can understand why the elements are attracted to each other and why they form certain compounds.

The first (innermost) electron ring likes to have 2 electrons. Both the second and third electron rings like to have 8 electrons, so Chlorine is still looking for 1.

In the interest of more understandable visualizations, this periodic Table uses the deprecated theory of electron rings instead of clouds.

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Figure 43. Screenshot of Element Selection in The Clickable Periodic Table
Figure 44. Splash Screen of Pickle Rescue, final product
Figure 45. Bridge Room of Pickle Rescue, final product
Figure 46. Bridge Room of Pickle Rescue, final product
Figure 47. Raft Room of Pickle Rescue, raft kits, final product
Figure 48. Raft Room of Pickle Rescue, incorrect rafts have been sunk, final product
Figure 49. Lock Room of Pickle Rescue, final product
Figure 50. Lock Room of Pickle Rescue, moving from left lock to middle, final product
Figure 51. Lock Room of Pickle Rescue, moving from middle lock to right, final product
Figure 52. Gate Room of Pickle Rescue, final product
Figure 53. Gate Room of Pickle Rescue, final product
Figure 54. Gate Room of Pickle Rescue, gates opening upon puzzle completion, final product
Figure 55. Land of Picnic in Pickle Rescue, final product
Figure 56. Land of Picnic in Pickle Rescue, Maisy is rescued, final product