SOCIAL CONSTRUCTIONS OF CREATIVITY
IN A MIDDLE-SCHOOL MATH CLASSROOM

Rick A. Berg

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Traditionally, creativity has been studied as a cognitive attribute of an individual. Theorists who acknowledge the importance of the “social world” in which the individual is a part examine how the social world affects the creative individual. They rarely reflect on how the individual became known as “creative” in the first place. In this paper I develop a new lens for looking at creativity. I start with the assumption that “creativity” is nothing more than a social judgment that functions in a variety of ways in different communities of practice. I build a new “lens” from this starting point, from which arises a new set of questions for study. Such questions include:

• When do patterns of interaction make judgments of creativity relevant?
• What language is available to the community for making judgments of creativity?
• What structures are available for maintaining and disseminating the judgment to others in the community?

I examine these questions in a community that has not received much attention in the creativity literature: a middle-school mathematics classroom. I have adopted a situative perspective (Greeno, 1992), using a variety of appropriate methodological tools from grounded theory, interaction analysis, discourse analysis, and the history and production of science. I gathered qualitative data from a variety of sources. The major source of data was video, but I also recorded field notes, gathered student work, and collected teacher stories from professional development settings.

The results of the study reveal a variety of practices that make up the process of something’s (or someone’s) becoming creative in the classroom. I have invented the term “creativization” to refer to this collection of practices. First of all, there is a language of evaluation in the classroom that varies among the teacher and students. Evaluation labels that are common in student discourse include “cool,” “radical,” and “fresh.” The
teacher uses the term “creative.” I contrast the function of these terms with terms like “good,” or “nice.”

One important class of interactions relevant for creativization has emerged from the data analysis. I refer to these interactions as “re-framing” episodes. Participants make things available to others (“presentations”), which may elicit a response of one sort or another (“acceptances”) (Clark & Shaefer, 1989). This interchange is guided by an interaction “frame.” The participants in an activity negotiate a “frame,” which constrains what will happen and structures expectation. In a “re-framing” episode, the frame is changed, and things that were previously inappropriate in the initial frame become appropriate in the new frame. Sometimes there is preparation that needs to take place in order for this to happen. Other times there is negotiation that needs to take place in order to achieve a common understanding of the new frame—an understanding which allows the participants to see the situation as something new and appropriate.

These “re-framing” events can be noticed by the participants and explicitly evaluated—the event becomes “creative,” or “cool,” or “radical.” These terms can become part of the community’s discourse around an individual, giving that individual a reputation as a “creative” person. In the classroom, “creative” moments are reified by inscriptions, models, stories, and formal events. These processes have one or more of the following features: permanence, mobility, accessibility, and accountability. Each of these features are important for maintaining and disseminating “creativity.”

Different classroom practices structure this process in different ways. From the analysis of “re-framing” episodes I have extracted nine dimensions that are important for creativization to occur. Two apply to the task: importance and negotiability. Four apply to the process: resources, reflexivity, re-representability, and convention. The final three apply to the presentation itself: ownership, potential for evaluation, and potential for dissemination.

I have looked at three typical environments in this math class. Design environments in the classroom feature positive aspects of most of the dimensions. Worksheet environments can be very conventionalized. “Re-framings” are less likely to occur, but when they do, they are more likely to be noticed and evaluated. Formal presentations provide a “window” through which the work can be evaluated. The
window may open to a large audience, but the window is often very narrow in terms of giving other participants a sense of the work that was done.

The analysis points towards three fundamental conceptual shifts in the way we understand creativity:

- A shift from focusing on originality to focusing on appropriateness.
- A shift from thinking about creativity as an ability to thinking about who is entitled to it.
- A shift from thinking about the creative personality to thinking about the social practices that structure a person’s becoming "creative."

The analysis points to two educational shifts:

- A shift from thinking about "creative" performances to paying attention to who has access to creativity in the classroom.
- A shift of thinking about ways for a teacher to "impose" creative assessments on students to ways that a teacher can uncover events which students themselves find to be "creative," or whatever semantically similar terms the students use for making creative assessments in the classroom.
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Creativity is nothing more than a social judgment. We cannot find or characterize creativity in someone’s head or in the things she does. Creativity is a social relationship. It is a judgment that emerges in activity and functions in various ways. The judgment can be fleeting or it can be maintained, packaged, and disseminated. Dimensions of these social practices can be characterized. In this paper “creativity” is uninteresting. The practices that elicit, maintain, and disseminate that label are not.

As a high school student, I perceived math, science, and most other areas of study as a set of things people needed to know to move on in education. Learning these things required sitting in rows, reading and memorizing the textbook, and checking answers (at least the odd ones) in the back of the book. The goal of the teacher was to make everyone know the same things. Sometimes they made the students figure those things out for themselves, as long as the students followed a prescribed recipe for success. School wasn’t this way, but it seemed like it to me, as a part of that system.

During my senior year I read Hermann Hesse’s *Beneath the Wheel*, which reinforced my view of schools (even though it was set in turn of the century schools in Germany). Hesse was even more critical than I ever thought to be, referring to schools as

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1 The term “creative” will function in several different ways in this paper, as it does in interaction. When I’m using the term I will be referring to “creative” as a social judgment, not as an inherent feature of a person, object, or event. Other researchers whom I cite in this paper have used the term in a variety of other ways.
places where the “struggle between rule and spirit” was constantly playing itself out. Schools valued ambition and intellect over the creativity of the soul.

Thus began my interest in creativity. I knew that schools could be different if only we understood and valued the creative process. Since high school my understanding of what creativity is has changed dramatically, to the extent that “what creativity is” may not even be an interesting question. Given my current understanding of creativity and of schools, however, several important questions can be asked. This paper is an attempt to ask those questions and find some answers to them in middle-school math classrooms.

The introduction of this paper is intended to set up the problem of creativity in schools, explore some of the traditional lenses through which it has been viewed, and develop a new lens which characterizes creativity not as an a priori attribute, but rather a social evaluation that is socially constructed, maintained, and disseminated. I will argue that creativity happens in classrooms, and it is structured such that it can be studied. Furthermore, it is a valued piece of our children’s education, and thus deserves to be examined more closely.

1.1 Does Creativity Happen in Classrooms?

Many theories of creativity provide little insight into how creativity becomes manifested in the classroom. Many theories attribute creativity only to a small subset of special people. Martindale clearly makes this point:

It takes no research to tell us that most people could not possibly be creative. No possible combination of the ideas with which the ordinary person concerns himself (e.g. what little Johnny learned in school today; where to plant the tulips this fall; the price trajectories of gasoline and lettuce; which team will win the Superbowl [sic]) could yield a creative insight. (Martindale, 1989)

In his theory, creativity requires “great” ideas, which he would consider rare within classrooms. The creative process in other traditional theories is divine, unconscious, or otherwise non-analyzable. Theories of this kind have been popular since Plato, who believed that creativity was the interpretation of the gods (Plato, 1961). Kant believed that the poet needed the faculty of genius to access the rules required to construct a creative product. Psychoanalytic theories (Freud, 1959; Kris, 1952; Jung, 1923) characterized creativity as being unconscious: the result of conflict between primordial
impulses and societal taboos. This presumption continues to be prevalent—I first began to explore creativity in a course that was in the department of “Gifted” Education.

The assumptions that frame the theories above have several characteristics: creativity is within the individual, these individuals are predisposed to possessing it, and environments (like classrooms) don’t necessarily affect the individual’s capacity for creative behavior. Given these assumptions, it might not be helpful to look at creativity inside of classrooms\(^2\). Such perspectives tell us little (if anything) about how classrooms could be structured to promote creative activity. The category “creative” belongs to a privileged few.

It is clear from listening to students and teachers, however, that the category “creativity” is both meaningful and consequential in the classroom. Most teachers and students regularly attribute creativity to a variety of people and objects in the classroom. I went into a classroom to work with some children, and the teacher, without my asking, told me who the creative students in her class were. In another case a student who was asked to evaluate a new, reform-oriented curriculum called it “more creative.” It is clear that “creativity” is a category that is available to, and valued by, many teachers and students in schools with which I have been associated.

Does creativity look have to look “great”? Let’s look at a moment out of a fifth grade classroom. A group of students is engaged in an activity in which it is necessary for them to visualize space and use area appropriately:

A group of four students are working on a floor plan of a cabin using software that allows them to drop segments of walls, windows, and doors onto a grid. They have a nearly completed external floor plan with many internal walls. They negotiate who gets to use the mouse when putting in the doors they want in their plan. Amanda notices the living room is only six square meters, and thinks that is too small to function as a living room. The group negotiates a series of proposals to eliminate walls and doors to create an area that better functions as a living room. The group for various reasons rejects the proposals. The teacher comes by, asking the group to make sure that everyone is participating. Manuel claims that he has an “awesome” idea. He proposes that they let the space that is too small be a bathroom and make one of the other, larger areas in the floor plan the living room. There is confusion about the proposal he is making, and Manuel works to get the other members of the group to see his plan as he sees it. Eventually the others see his proposal as coherent, and they agree to the plan. Manuel later confirms that the

\(^2\)Unless the researcher’s goal was to identify those few individuals who show this “genius” in the math classroom, as Stanley (1974) has done.
idea is a good one, as it makes the bathroom much more accessible from other areas of the cabin.\(^3\)

This vignette illustrates a piece of work that re-orient the group from resizing the rooms to renaming the rooms. According to one member of the group, the idea was “awesome.” This may be a fleeting moment, the only noticeable consequence of which is the relabeled rooms in the group’s final floor plan. On the other hand, the teacher was perhaps watching the event and had a similar reaction to the move. She may have judged Manuel to be the “creative” one in that group. She may even mark it in her grade book or journal, if assessments of creativity are important to her. Or Amanda might later have walked by another group struggling with the same problem, and suggested renaming the rooms, rather than resizing them. And Mike, who was ignored for the majority of the episode, may have thought the idea was ridiculous, and destroyed the floor plan after class (which he did, incidentally).

Many researchers (like Martindale, quoted above) would not call anything in that vignette “creative.” But the example does point out some of the complex activity, discourse, and value structures that mediate evaluations of creativity (or “awesome”-ness) in the classroom. Because assessments of this type do get made, an analysis of their structure is potentially important for two purposes:

- To tell a story about the patterns of interaction that “allow” judgements of creativity to happen, and
- to make recommendations for teachers and curriculum developers for supporting such interaction in classrooms where it is valued.

Becker (1982) makes the point that not all communities necessarily value individualism and creativity. Is it valued inside schools? It is. The rhetoric that reifies creative practice within the classroom also encompasses sources outside of the classroom. The view that curricula should support creative activity is reflected at the level of school reform. Recent changes in educational thinking have been characterized by an attempt to give students a different role in the construction of their own understanding. Groups of students collaboratively construct, discuss, evaluate, revise, and enact ideas within an investigative framework. The National Council of Teachers of Mathematics proposes assessment standards for these activities that include “flexibility

\(^3\) This vignette comes from classroom data collected by Jim Greeno, Rogers Hall, and Jennifer Knudsen.
in exploring mathematical ideas and trying alternative methods in solving problems” and “inventiveness in doing mathematics.” (NCTM, 1989). Such processes have historically been considered aspects of creativity (e.g. Guilford, 1967; Wallach & Kogan, 1965; Torrance, 1966).

One of the goals of schools is to provide the labor market with quality workers. The SCANS report for America 2000 (United States Department of Labor, 1991) advises schools to let students construct their own learning, through cooperative problem solving and working with real problems. The authors of the report desire students to enter the work force with the ability to solve problems and think creatively. Thus an official voice of the business community also conveys the importance of creativity.

“Creativity” is a part of the rhetoric inside and outside of schools, which includes teachers, students, policy makers, and business leaders. The framing assumptions of the “inspiration” theories characterized above are not adequate for seeing the kinds of creative practices in the school reform and business discourse. Business leaders, for example, are asking for a competent work force, rather than a single “inspired” creator. Reform education aims to have all students inventive, not just the “genius” in the class.

Back to the question of whether we, as researchers, should look at classrooms as places to explore the creative process. Because creativity is happening according to the people who have a stake in education and in standards of performance, I argue that classrooms are an interesting and potentially beneficial place to analyze the creative process.

### 1.2 The Focus of This Paper

In this study I intend to address three guiding questions that were chosen to reveal how creative moments are developed out of social interaction, evaluated according to social practice, and maintained through social representations:

- What interaction patterns structure events that participants find to be “creative”?
- How is the evaluation itself structured, both informally and formally (“for the record”)?
• How do these events play themselves out in common activities in a middle-school classroom?

The intent of the first two questions is to characterize the nature of the interactions that structure creative events in the classroom. The third question is intended to examine how curricula plays itself out in the classroom, specifically looking for relationships among dimensions that have consequences for presentation and evaluation structures.

The first question I will address is how practices get framed and re-framed in a middle school classroom. Within the classroom (or anywhere), change is always occurring. Every utterance or movement could be considered a “presentation” of some kind, made available to others, and having consequences for future actions (Clark & Shaefer, 1989). Most of this change is expected, and not noticed as something out of the ordinary. This expectation can be thought of as the result of a “frame,” an interaction structure that guides attention and action (Bateson, 1972; Goffman, 1974; Kendon, 1990; Tannen, 1993). When change occurs that is not readily interpretable within that frame, it may get noticed and acted upon.

When an event is re-framed, it may have a variety of consequences. The second question (How do evaluations of these events get structured?) explores that issue. Most of the time there is no reaction at all, and the interaction continues smoothly. In some cases, however, confusion can occur, and the participants need to negotiate a new frame, so that they are all seeing the event from the same perspective. A new frame may or may not get negotiated. Another possibility is a reaction of surprise and immediate acceptance of the new frame (“Oh, I get it!”). Judgments about the new frame are based on the values negotiated by the participants both in and beyond the classroom. For example, two students may do the same thing to re-frame a situation, and one gets judged as a troublemaker, and the other as creative. The judgment depends on many things, including how the teacher feels about the individuals, the context of the behavior, the teacher’s perceived evaluation of the students’ intent, etc. Additionally, the same event that the teacher evaluates as misbehavior may be judged favorably by other students. The nature of the presentation, to whom it gets presented, and the values by

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4 When I refer to a “presentation” throughout this paper, I will be referring to anything that the participants in the interaction make available to others to respond to. This can be as “small” as an off-hand comment, or as “large” as a finished multimedia production shown in an exhibition hall. The latter is an aggregation of many smaller presentations. Events that the participants in the classroom call “presentations” are usually special events that the students prepare for, such as oral presentations in front of the class, or exhibitions of work to people outside of the school. In this paper I will refer to these events as “formal presentations.”
which it is judged determine whether it becomes a creative event, both informally and “for the record,” into the teachers grade book or journal. Some of these new frames will become conventionalized as part of the classroom activity or discourse, and others will not.

The preceding paragraphs are meant to open up the discussion of the structure of creativization\(^5\) in middle school classrooms. In this study I will analyze what this process looks like in classrooms and how it happens. As an initial investigation into this question, I look at constellations of roles and practices across a variety of classroom activities, contrasting environments in which students are doing worksheets, working on design problems, listening to lectures, and giving presentations. If a problem is open-ended, it is obviously more likely to invite novel frames in the solution process. If a problem is not open-ended, new frames are more generally noticed, because the practices involved in the solution process are generally more conventionalized (at least in math classrooms). This assumes that windows onto the solution process exist, and there is someone paying attention on the other side of that window. I will show that the process of conventualization is an important part of the creative process, because conventualization creates expectation, and violation of expectation can invite judgements of creativity. Conventions carry with them socially shared attention (Kendon, 1990; Goffman, 1974), and conventions constrain the way things can happen given that the convention isn’t violated (Barwise & Perry, 1983). This paper pays particular attention to cases where the convention is violated.

The goal of the third question (How do environments in which students are asked to design something support these practices?) is to examine different activities as a way of contrasting structural dimensions. Some of these dimensions that have consequences for structuring creativization include the value of the problems to be solved, the negotiability of constraints, the authority for validating “right” answers, feedback provided within the activity, the history of the content matter within the group, and the information available to the participants for evaluating presentations. In some classroom activities, several constraints on the final artifact are generally negotiable. In others they are not. Another important question is who gets to be the authority for being “right.” In an environment in which the students have much of the

\(^5\)This is a term I will using to refer to the process by which something comes to be labeled as “creative.”
control over the content of their work, the groups generally construct a story in which
their design is a “right” answer. Students using a worksheet often consult the textbook,
the teacher, or a generally known “good student” in the class.

Information about how something came into being can also be important for
evaluating it. The resources for evaluation in some environments can be scarce compared
to environments in which students are actively engaged in creating the object of focus, as
in doing some kinds of design work (Bushéy, 1997). I will argue that pieces of
information can, in varying degrees, be “black boxed,” in that the students have no
information about where those facts came from (other than from the textbook or
teacher). At one end of the spectrum, information is packaged as a fact, closed tight
enough that students won’t (or can’t) make the effort to open it back up (Latour, 1987).
At the other end, the design group has negotiated much of the information; thus the
students know its history 6. This enables them to re-frame the information in ways not
always available in worksheet environments. Also, the nature of the problems that arise
and get worked on influence how the solutions will be evaluated. The emergent problems
which arise in design environments may be valued more and worked on longer than
those in worksheet environments (Bushéy, 1997).

In this paper I examine the practices which structure opportunities for an object’s
becoming “creative” in a middle school mathematics classroom. Chapter 2 provides a
theoretical basis for proposed study. Chapter 3 discusses the data that will be used for
the study and reviews the ethnographic methods used in my analysis. Chapter 4
discusses the nature of a creative event. Chapter 5 extends the analysis in Chapter 4,
examining more closely the activities in which middle-school students are engaged. I will
conclude with implications for creativity theory and education.

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6Israel and Perry (1991) refer to this as “incremental information,” which affects the way in which humans
make use of a piece of “pure” information. Part of my work here is to understand what incremental
information is available to the students and teacher and how they make use of that information. My claim is
that the incremental information is qualitatively different for the students in design environments because the
students themselves were involved in constructing it.
This chapter briefly examines traditional accounts of the creative process as it relates to schools. Such perspectives, I argue, fail to address important questions about creativity—leaving out any analysis of practices in the classroom that make it relevant for the participants to label something or someone as “creative.” In order to frame such questions, we need to develop a new perspective on the meaning of creativity. I will then develop a theoretical stance by examining assumptions underlying three key questions: how do we define creativity, what unit of analysis do we use to study it, and what methods are appropriate for that study.

2.1 Brief History of Creativity in the Classroom

Creativity has been conceptualized in a variety of ways that have provided perspectives on the nature of creativity in the classroom. I will briefly discuss three of those perspectives. In the 1960’s the prevalent theories conceptualized “creativity” as a part of one’s cognitive structure. In the mid 1960’s and early 1970’s many researchers (certainly not all) began to characterize the environments in which school children were placed (e.g. “formal” vs. “informal” environments). A move toward cognitive skills development (such as problem solving and analogical reasoning) has occurred more recently in the field of cognitive psychology. Researchers attempt to find computational rules and heuristics for solving problems creatively and teach them to students. Each of
these perspectives will be discussed, and then I will address the kinds of questions these theories illuminate and which kinds of questions they don’t make relevant inside the classroom. I claim that those questions which get filtered out of previous analyses (namely those examining the interactions among persons) are interesting and important questions to study. A more detailed look at traditional accounts of the creative process can be found in Appendix A (p. 150).

2.1.1 Creativity and cognitive structure

One perspective on the nature of creativity suggests that creativity happens in the mind. Researchers in this tradition theoretically determine the kinds of mental processes that are likely to underlie creative thought. They then construct tests that purport to test those processes and make claims about individuals based on test performance. Generally, they attempt to validate their measures by correlating test scores with scores of other creativity tests or with measures of creativity from “authentic” activity.

Such a perspective made a variety of questions relevant. Some researchers wanted to know what processes of the mind contributed to creative behavior. Guilford (1967), for example, parsed the mind into 120 distinct processes, which he called the “Structure of the Intellect.” One of the factors was “divergent production,” which included the 24 processes that underlie creativity. Another pursuit was whether creativity was part of, or distinct from, intelligence (e.g. Getzels & Jackson, 1962; Wallach & Kogan, 1965).

The educational environments that exemplified the theory were generally creativity training modules, aimed at enhancing specific behaviors associated with specific mental processes. Teachers trained students to be more fluent, flexible, and original on verbal tasks such as “how many things can you do with a brick?” and spatial tasks such as “how many different ways can you elaborate a circle into a picture?” (Myers & Torrance, 1964).

2.1.2 School environments and creative behavior

Another perspective for understanding creativity focused on the effects of various classroom structures on creative behavior. In the mid 1960’s Moustakas (1966) wrote “Intellectuality, convention, and the system is out of focus today; it is over
stressed and overused and in exaggerated forms stifles creativity and spontaneity.” This ideology was widespread among researchers taking this perspective. They characterized learning environments in a variety of ways, usually formal (traditional) vs. informal (open or discovery-based) environments. Formal environments were characterized as places where teachers were in control, structuring their classrooms so that they could maintain control and convey material to the students. Informal environments, on the other hand, allowed children much more freedom.

Such a perspective still focused on the individual. Many researchers asked whether environments had an effect on the creative behavior of children (e.g. Haddon & Lytton, 1968). Others focused on the interactions of age, sex, and intelligence with the structure of the environment (Ogilvie, 1974; Ramey & Piper, 1974; Johnson et. al., 1980). Again, the outcome measure was the creative behavior of the individual student.

Discovery-based environments exemplify the classroom structures that these researchers found to enhance the creative process. A child that has the opportunity to explore on his/her own will become more creative. Children are allowed to choose their own tasks and resources that they need to accomplish them.

2.1.3 Cognitive skills development

A third conceptualization of creativity comes from the field of cognitive science. These theories are characterized by finding problem solving strategies and heuristics for arriving at creative solutions. This work has been based on the metaphor of the mind as a computer.

One set of problems that became relevant from this perspective involves the modeling of human problem solving on computers. Some programs such as BACON.1 used heuristics for searching a data set to induce different scientific laws. The program gathers data, discovers regularities, and formulates scientific laws. The model successfully determined Ohm’s law, Boyle’s law, and Kepler’s law, among others (Langley et. al., 1987). AARON, a computer program developed by Harold Cohen, generates thematic drawings (including over 7,000 different ones during the World’s Fair) which do not violate “proper” pictorial form.

Another set of problems focuses on what cognitive processes are being used while engaged in a particular task. Subjects are given a problem to solve. The researcher
has operationally defined a solution process as being “creative”\(^7\) (e.g. Weisberg, 1986). Often the problem solver talks aloud as a way into the mind of the subject (Ericsson & Simon, 1984).

A teacher within a classroom environment that exemplifies this approach focuses on teaching the strategies and heuristics that creative problem solvers use. Potential strategies include ways of reducing or increasing the space of possibilities to search. Students must also learn to monitor his/her problem solving strategies, to know when to use one strategy or another (Carey & Flower, 1989). These are considered aspects of metacognition.

### 2.1.4 Where do we go from here?

The NCTM Standards suggest mathematics activity that goes beyond structured training. Classroom environments should not be completely unstructured, either. We want our middle school children to problem solve, explore, and reason, as the cognitive skills research suggests, but we expect them to do that in groups working on real-world, complex problems. What lens seems adequate? I intend to discuss a new version of creativity, one in which the focus is on the structures through which events come to be seen as creative in a math classroom.

New ideas about education and new social theories of learning and activity open the door to rethinking the problem of creativity. Creativity is couched in the social fabric of the community. New frames of reference are constructed, negotiated, labeled, and disseminated socially. Products and process can become evaluated as “creative” as part of the practices of the community, and as compared to those practices. I will refer to this process as “creativization,” simply because of the wordiness of the phrase “the process by which something comes to be called ‘creative’.” If it is within these practices that creativity lies, we must move the unit of analysis from the “creative” individual to an understanding of the evaluation practices within the community of interest. When one has made this shift, a series of new questions emerge about classroom activity that are

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\(^7\)In one of the tasks, which was created by Duncker (1945), subjects were given a box of tacks, a candle, and matches. The task was to support the candle on a wall one foot above the table. To solve the problem, the subject had to use the box as a support. Then she could tack the box to the wall, and set the candle into the box. Generally, subjects initially viewed the box as a container, rather than a support. This tendency was called “functional fixedness.” The breaking from this mindset appears phenomenologically as a flash of insight.
important for our understanding of learning, assessment, and curriculum. In the next section I will take a look at the assumptions of that perspective, and how my own understanding of the creative process has evolved.

2.2 Theoretical Framework

The intent of this section is to examine some traditional assumptions related to theory and methodology. I have purposely entwined theoretical critiques and personal narrative for two reasons: first, it provides an historical context for the study, and second, it provides insight into my personal perspective and biases. I will discuss my past research, the problems I found with the framework that I used, and the theoretical revisions that I was forced to make in light of those problems. This process has led to the perspective that I use to frame the analysis in this paper. Theories of creativity must deal with three issues: What creativity is, where it is, and how it is found.

2.2.1 What is creativity?

Many people believe that the creative process is mysterious, and unable to be analyzed. I believed, however, that creativity was not only analyzable, it was available to everyone.

Newell and Simon (1972) proposed a computational model that characterized problem solving as operations within a problem space. I felt, as they did, that creative thinking used the same processes as normal problem solving; the difference was just a matter of degree of novelty\(^8\) (Newell et. al., 1962). I used a methodology that they made popular, verbal protocol (see Ericsson & Simon, 1984), and tried to identify the strategies that creative children were using while drawing (Berg, 1990). I thought that the ability to access different “search spaces” efficiently led to creative behavior, and some children had strategies to do that on the task that I gave them\(^9\). I conceived of the search space as a semantic network, with various degrees of association strength between the nodes. Accessing and combining nodes that had little or no association was the basis of creative thinking, a belief shared by Mednick, author of the Remote Associates Test.

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\(^8\) Newell et. al. (1962) define creativity as the solving of ill-structured problems.

\(^9\) I tested one child at a time on two drawing tasks (2nd and 3rd graders). In the first task (which I considered to be “convergent”) I had a toy fish, and the subject had to copy the fish as best she could. In the second task, the child was supposed to be a zookeeper, and draw a fish that was “so amazing everyone in the world would want to come to your zoo to see it. A fish like no one has ever seen before...” After drawing this fish, they were given selected questions from the figural portion of the Wallach and Kogan Creativity Test for Children. Verbal protocol was taken throughout the tasks.
(Mednick & Mednick, 1967). In my study, a subject who would put sunglasses and
spikes on a fish would be assessed as being more creative than a person who drew a big
fin instead of a little one, because the conceptual nodes “spikes” and “sunglasses” are
likely to be more remote to the node “fish” than “large fin” is.

As I gathered more data, however, I found that it was very hard to justify this
conclusion. It was somewhat disturbing that the subject who scored the lowest on my
task, whom I chose for a training study, was the person that the teacher told me was the
most creative student in the class. What does this say for my definition and
methodology? At the time I had several thoughts about this, which may or may not have
been true. First, the teacher saw the student in a much wider array of activity than I did.
Also, the teacher probably had criteria for calling the child “creative” which changed
according to the nature of the activity in which the child was engaged. One would think
that many other factors were involved in the teachers judgment: perhaps how much she
liked the child, the kinds of activities in which the child participates, the activity of the
other children in her class, etc.. Even though my task was open-ended, it was only one
possible activity, and the criteria for scoring well was very narrow. Many researchers
who do laboratory or computational research operationally define “creativity,” in
essence pre-determining a creative end-state, finding subjects (or computer programs)
which achieve that state, and attributing creativity to them. In practice there is no clear
end-state, nor are there clear social rules for what gets to be called creative and what
does not.

There is little consensus within the research community about the definition of
creativity. Taylor (1988) writes that “[his] investigation reveals the existence of some 50
or 60 definitions and the list is expanding every day.” (p. 118) The concept “creativity”
is an open system; there are no necessary or sufficient conditions for identifying its
occurrence. Researchers, however, still focus on the definitional issue, i.e. what creativity
is and who possesses it (Gardner, 1993a).

In addition to researchers, there are communities such as artists, scientists, and
musicians; each has conceptions of what is creative in their fields. Across cultures there

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10As noted earlier in this paper, an example is the BACON series of computer programs developed by Langley
et al. (1987). BACON used production rules to induce regularities out of a set of data. The program was
successful, as it rediscovered Ohm’s Law, Kepler’s Law, and the Law of Uniform Acceleration. In these cases,
the end-state is known, and productions must be written which can achieve that end-state. These
methodologies illustrate that discoveries can be made by computation alone, but provide little evidence that
humans actually use such processes. See Boden (1991) for a discussion of computational attempts to model the
creative process.
are also differences. Asian art relies heavily on the replication of traditional masters; in Western art, originality is more highly valued (Winner, 1989). It is also clear that judgments of creativity made by different communities are not stable over time. Van Gogh, whose work sold for 84 million dollars in 1990, died a pauper. Given the variations and instability of the concept, can we objectively define creativity? Probably not. Cole (1985) argues that an objective intelligence test would entail finding experiences across cultures that were structurally similar and equally frequent, which is implausible. The same can be said for operationally defining creativity across cultures, across communities within those cultures, and across time within those communities.

Researchers, however, continue to pursue an operational definition of creativity. Gardner (1993b) believes that creativity is a social judgment, rather than an attribute of the individual. He writes, “But the crucial (if controversial) point here is that nothing is, or is not, creative in and of itself.” (p. 36, Gardner’s italics) Several pages later he writes “I am not claiming that there are necessarily different biological or psychological processes at work in the individual that is ultimately deemed creative as compared to the one who is not so judged.” (p. 40) In these statements he seems to be positioning himself for a social perspective on creativity; namely, how things become judged as creative. This is not the case, however. He writes

Like intelligence, the term creativity has been applied over the years as an honorific label to a wide range of individuals, situations, and products. Such lay use of the terms creative, creativity, or creating, may have sufficed on the streets; but as happened with the term intelligence, the variant forms of creativity have seemed in need of more precise formulation. (Gardner, 1993b, p. 19)

Gardner goes on to define the creative person as “[one] who regularly solves problems, fashions products, or defines new questions in a domain in a way that is initially considered novel but that ultimately becomes accepted in a particular cultural setting.” (p. 35)

A definition of creativity (even one with a decidedly social component), however, does not capture the wide range of instances to which “lay uses of the terms” (as Gardner puts it) refer. It is these “lay uses” that are ultimately responsible for an object, person, or event’s becoming creative in social activity. Communities of practice do not “scientifically” verify that something is creative before they judge it as creative. Psychologists usually try to impose a structure on the phenomenon of study, rather than
working to see how the evaluation practices within the community get socially organized. An alternative to formulating a definition of creativity and applying it “on the streets” is to analyze uses of the terms “on the streets” in an effort to examine their meanings and functions in social interaction. In this paper I intend to take a step in that direction.

2.2.2 Where is creativity?

Csikszentmihalyi’s (1988) theory of creative systems led Gardner (1993b) to pose the question “Where is creativity?” rather than what it is or who has it. My initial hypothesis was that creativity was located in the mind. Humans develop a database of concepts that exist in various locations and were arranged in various ways. Individuals had strategies for retrieving that information (Kolodner, 1984). Making connections between remote concepts required strategies that some children used, and others did not. Some subjects would construct narratives while drawing, in effect verbally reminding themselves of things that they could put into their pictures.

After I had done the “creative fish” study, however, I was convinced that the creativity of the pictures was at a schematic level, rather than at a conceptual level. The narratives that the “successful” children used were not a strategy for recalling concepts but an event schema that was being “tweaked” in interesting ways to fit the context of an unusual fish. This idea seemed to be supported by a rarely cited study by Maier in the late 1960’s in which he had subjects write stories using words that they had just learned in a paired-associates test. He believed that the more creative individuals would separate more of the associates in the story and combine new ones. When judges assessed the degree of creativity in the stories, there was no correlation with the number of paired associates that they broke apart or recombined. Maier took this as a failure to confirm his hypothesis, and the study fell by the wayside (Maier et. al., 1968). This study failed to support a remote-associates model. What made the stories creative to the judges was not at the level of individual concepts, but at the level of event composition. The knowledge structures in which I was interested were at the level of scripts, plans, and schemata.

By this I mean that the concepts were not being haphazardly accessed and then combined on paper. There was an overall effect to be achieved that was schema driven. The concepts were instantiations of the slots of the schema. Some subjects instantiated their schemata in ways I found more interesting; thus, I judged the drawings (via my “objective” scoring criteria) to be more creative, and attributed creativity to the subjects.

Bartlett (1932) introduced schema theory. He had subjects try to remember stories, and found that some details tended to become lost, other aspects of the story were exaggerated, and the stories conformed better to
Schank and Abelson (1977) developed a model of event knowledge. Recently, Schank (1986), Kass (1990), Kolodner and Penberthy (1990), and Turner (1991) have used this model to explain the creative process. The creative person takes a known schema for a state of affairs or an event and tweaks it in some manner to apply to a new problem. Schank and Kass have developed a computer program that has a database of cases, and heuristics for accessing and tweaking those cases to explain new events (Schank, 1986; Kass, 1990). The researchers claim that such processes underlie creative thought in humans.

Going back to my data, I found that I couldn't reasonably infer event knowledge or schemata from the flow of activity of the children. Suchman (1987) has found similar problems with the notion of “plans.” An actor within a situation is reflective, in that she performs an action, monitors the results, and acts accordingly. Much of the actor's behavior is emergent, based on a “dialogue” between herself and the environment. Plans, scripts, schemata, etc. become reconstituted in action; in and of themselves they are not analytically sufficient.

Not only are the activities of creation situated in activity, the activities of evaluation are as well. The metaphor of person/environment “dialogue” is useful. Clark and Shaefer (1989) describe a discourse model that provides a means for looking at the structure of conversation. It breaks the process down into presentations and acceptances, which combine to form a contribution. Through this process, the individuals in an interaction develop more common ground, until mutual understanding is reached.

The concept of a presentation and an acceptance is fruitful for thinking about how objects become creative in social interaction. Within a stream of activity, presentations of various kinds are occurring continuously. They are available for others in the activity to perceive and evaluate. These presentations can become “accepted” and evaluated as creative. The presentation, acceptance, and evaluation must occur for it to become a creative contribution. Although analytically this characterization is

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13 Schön (1983) provides evidence that professional designers (as well as children creating fish drawings I assume) are constantly interacting with their environment, and changes in the state of their design changes the mental resources that the designer will use to interact with it.

14 Also, one would have to find a way to describe “distributed schemata” analytically, as the organization of the product in my initial study was a mutual achievement among various participants in the activity.
insufficient, theoretically it invites us to examine a new unit of analysis: the structure of interaction.

In my initial study, I gave children the task of providing “verbal protocols” for me to analyze. Returning to the data it is clear that the subjects were talking to me, and I was interacting with them. Even though I wasn’t saying that much, I was acknowledging them, shaking my head, gesturing, responding. The stories that the children told were in no way “strategies” for accessing and relating remote information, they were social activities between the child and myself. The drawings that the children created were a social achievement. Judgments of creativity were getting constructed within the experience that in some cases were similar to the eventual “objective” judgments based on the criteria, but in other cases they were different.

Several researchers have acknowledged the influence of others on creative performances, yet they continue to use the individual as the unit of analysis. In 1988, Sternberg proposed a model of creativity that had three facets: intelligence, intellectual style, and personality characteristics (Sternberg, 1988). Two years later, Sternberg revised his theory to include “environmental resources.” (Sternberg & Lubart, 1990) These resources provide ideas, nourish or suppress endeavors, and determine how the product will be evaluated. It seems that these environmental factors, however, are only important in terms of their impact on the creative person; thus, the theory continues to focus on the individual.

Gruber (1989) also acknowledges that the social context is important. At one point he writes

The approach is interactive. The creative person works within some historical, societal, and institutional framework. The work is always conducted in relation to the work of others. At the same time, the creator works alone, even when intimately bound up with others. This interaction produces varying patterns of conflict, confluence, and collaboration. (p. 4)

In other passages, however, he implicitly dismisses the “interactive” nature of creativity. He writes, “we take for granted that some human acts and products are creative, and others are not; some people lead creative lives, others do not.” (p. 4) He later argues, “But we do insist that the serious study of creative work requires careful and prolonged attention to the individual and must pay special attention to the very great.” (p. 6) Gruber studies people who have come to be labeled as “great”; another fruitful endeavor
would be to study how those people become labeled as “great.” That move represents a shift from an individual account of creativity to a social one.

The development of Weisberg’s theory seems to parallel Sternberg’s. Weisberg tried to dispel the “myth of genius” by illustrating that subjects used the same cognitive strategies to solve insight problems (like the candle and box problem) and “normal” problems (Weisberg, 1986). More recently (Weisberg, 1993) he addresses a wider spectrum of issues in creativity. He augments his analysis with case studies of eminent figures and their social contexts. He poses a question of how things become important:

All creative products are not of the same degree of importance: Some scientific work is widely influential, and has an effect on every part of our lives, while other work, original though it may be, lies unnoticed for generations, and perhaps forever. It stimulates no research; its creator is not accorded a place of honor in the community of scientists. ... Then again, two painters may work in obscurity in adjoining studios, both producing unique works, but one painter’s work will become crucial to art, while the other’s will be ignored. Why are some products of profound importance while others are ignored? (p. 6-7) [my italics]

To answer this question would require social analysis. If one were to study why somebody is “ignored,” one would not only need to know about the ignored person, but also the ignoring people. The same is true for people that do or do not get “noticed” as creative. There is a complex and essential evaluation activity that is part of practice.

Weisberg, however, ultimately rejects social evaluation as a basis for studying creativity:

If Watt’s steam engine had been ignored by succeeding generations, say because a cheaper and more efficient source of power had been invented shortly thereafter, the invention would surely still qualify as creative, because of its relation to what was then in existence: Watt produced a new kind of engine. The fact that -in this hypothetical example-it was soon surpassed is not relevant to the judgment of its creativity, although under these altered circumstances there would be no encyclopedia entries about Watt and the steam engine. In the same way, if Impressionistic painting had been initially rejected by most critics (which it was) and if it had been ignored by succeeding generations of artists and critics (which is was not), the creativity of the style and its developers would in my opinion be intact, although their positive evaluation would not be. (p. 244)

In practice, it is precisely things like the encyclopedia entry and the communities of artists and critics that evoke, distribute, and maintain the category “creative” in relation to the work; therefore, the process of something’s becoming creative requires an analysis
of the evaluation and dissemination activities of the community. Becker (1982) asks the age-old question “If a tree falls in the forest and no one is there to hear it, does it make a sound?” In his analysis of art that is appreciated, the answer was clearly “no.” I have come to the same conclusion for an analysis of something’s becoming creative.

We can make an analogy that captures an important point about creativity if we compare the concept of creativity to the concept of gravity. Gravity is not an object in and of itself. It is a phenomenon that occurs when “real” things interact. It cannot be applied to any given object, but to a relationship between objects. A researcher can find the mass of an object and its position in space. This information becomes important when the researcher learns how those characteristics interact with characteristics of other objects.¹⁵ Mass and position alone does not tell us anything about gravity. Creativity may be similar. It exists only as a relationship within complex interactions of people, artifacts, social rules, etc. Even if researchers could validly pinpoint the affective and cognitive characteristics of a person, they could not make any claims about creativity.¹⁶ As such, problems exist for traditional approaches studying how people become creative.

2.2.3 How do we find creativity?

Because the unit of analysis has shifted, methodology for studying the creative process must shift as well.¹⁷ Early philosophical theorists (e.g. Plato, 1961; Kant, 1952) assumed they know who is creative, and try to characterize why they are creative. Psychological methodologies include developing tests to find out who is creative (Guilford, 1967; Mednick & Mednick, 1967; Torrance, 1966), giving personality inventories to people judged by peers to be creative (Barron, 1969; MacKinnon, 1965), having people (or computers) perform tasks that they believe require creativity (Langley et. al., 1987; Weisberg, 1986), and doing case histories of creative people (Gardner, Barker (1968) advances a theory of ecological psychology that also makes this point. He claims that “a person’s momentary behavior is completely determined by his life-space, but if we wish to understand more than the immediate cross section of the behavior stream, knowledge of the ecological environment is essential.” (p. 9) By “ecological environment” Barker means the relations of the individual to the behavior settings in which the individual participates.

¹⁵ The claim is not that the individual is completely unimportant. Rather, in the flow of activity, individuals are constantly interacting with people and objects. This interaction cannot be taken for granted. Different individuals bring different resources to a situation, but the situation makes available opportunities to use those resources, and structures the manner in which those resources are used. Blumer (1969) writes, “Human beings in interaction with one another have to take account of what each other is doing or is about to do; they are forced to direct their own conduct or handle their situations in terms of what they take into account. Thus, the activities of others enter as positive factors in the formation of their own conduct; in the face of the actions of others one may abandon an intention or purpose, revise it, check or suspend it, intensify it, or replace it ... One has to fit one’s own line of activity in some manner to the actions of others.” (p. 8) One can only understand an individual’s line of activity when the interactional context is taken into account.

¹⁷ Cole, Hood, and McDermott (1979) make a similar point, calling for a methodology that describes scenes that individuals encounter in everyday life.
Many of these methods take for granted what is creative. Others rely on other methods of finding out what is creative, like paper-and-pencil tests or panels of peer judges.

Traditional theorists have characterized creativity as being intrinsic to the individual. This kind of blanket attribution simplifies the problem and may be misguided. Goffman (1976) makes this claim about attributions of gender: “It is not so much the character or overall structure of an entity that gets expressed (if such there be), but rather particular, situation-bound features relevant to the viewer.” (p. 7) I will argue that judgments of creativity occur because they perform social functions in particular situations. Creativity only occurs when it is functional to view something or someone as being creative.

If we approach creativity as a social relationship that becomes relevant only at certain times, can we characterize it? Gravity is a relationship, and a mathematical law\(^\text{18}\) has been constructed to characterize it (of course, scientists consider gravity to be relevant all the time). Certainly, the consistency one finds in the natural sciences is not applicable to social domains. We will never find a “law of creativity.” Part of the work that had to occur to make gravity a “scientific” concept was to understand and formalize its tendencies. The same approach can be taken toward the study of creativity\(^\text{19}\). The relationships that are in need of characterization are embedded in activity. Analysis of recurrent sequences that arise in activity is one way to find tendencies in the creative process.

Methodological tools from ethnographic research provide an alternative to traditional psychological methodologies. Lavie et. al. (1993) recently published a book discussing anthropological perspectives on creativity. The authors of its introduction advocate a study of creativity that takes into account social interaction:

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\text{[Creativity is defined as] human activities that transform existing cultural practices in a manner that a community or certain of its members find of value. ...At once a property of individuals and of social situations, creativity (not unlike laughter) often erupts at unpredictable times and on unexpected occasions. (Rosaldo, 1993, p. 5)}
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\(^{18}\) Bloor (1976) notes that even the phenomena that seem most “law-like” are mere tendencies of nature. He argues that the laws that have been constructed to account for planetary motion assume that nothing will enter the solar system and disturb the planets, which has been true for millions of years, but hasn’t always been true. The same could be true for gravity.

\(^{19}\) Of course, we will never approach the degree of specificity that the characterization of gravity has achieved.
The data in the book, however, ends up looking like the case studies used in Wallace and Gruber’s (1989) and Gardner’s (1993b) studies. The anthropologists study the practices of “creative” individuals in various cultures, as opposed to reflecting on how these people came to be known as creative. The book does make a significant contribution to the field, however. The researchers used ethnographic methods to carefully document the practices in which the individuals were engaged. This shift in methodology gave the researchers tools to document creativity in the contexts in which it happens.

Psychology has used external forms of evaluation (tests) and internal forms of evaluation (peer assessments) to determine who is creative. My goal is to try to understand the internal evaluation structures themselves. The question is no longer “who is creative?” like MacKinnon (1965) asked his architects. The question becomes “What is the structure of the work practices of architects that some can become labeled “creative” while others do not? Who gets access to the architect’s work? Who has the authority to say whether the design is innovative or not?” My goal is to illustrate the structures through which these evaluations occur. In addition to examining the patterns of interaction for evaluation, I intend to illustrate cases where explicit evaluation does not happen, but could have. In this case, I essentially become the “judge,” based on the categories I derived from the data for a potentially “evaluative” moment. I acknowledge that this leaves me analytically on less firm footing, but it remains closer to actual practice than creativity tests, because it is grounded in the evaluation practices of the community I am examining.

To understand how people and things become labeled as creative, we must look at interactions among people and artifacts. I agree with Gardner’s statement that “Nothing is ... creative in and of itself.” We, as humans, develop, share, and modify meaning in the course of activity. The symbolic interactionism approach to behavior claims that people act toward objects according to the meanings that they have for them. These meanings arise from social interaction, and are used and modified through interaction processes (Blumer, 1969). The concept “creativity” is a social object that has its meaning negotiated. In addition, other objects have their meanings negotiated such that sometimes they get to be interpreted as “creative.”

20“Objects” are “anything that can be indicated or referred to” (Blumer, 1969,p. 11). Thus, people, events, things, ideas, social categories, attitudes, etc. are considered an object.
Blumer (1969) addresses methodological implications of this perspective. The researcher must see the objects as the participants see them. Careful study must be made of what the actors take into account, how objects are used in various situations, and how participants refer to objects in discourse. Interaction patterns must be grounded in the data, as there is no unique pattern that individuals are likely to exhibit within an activity. Also, the researcher must address how the meanings of categories are negotiated and used in social interaction.

Several methodological approaches pay close attention to how meaning is constructed in activities. Ethnomethodology (Garfinkel, 1967), conversation analysis (Sacks et. al, 1974), interaction analysis (Goffman, 1983; Kendon, 1990), and discourse analysis (Tannen, 1993) all are concerned with behavioral interaction that becomes patterned when participants share understanding of a situation. The methods I used in from these traditions will be documented in the next chapter.

2.3 Summary

The study of creativity requires a theoretical focus on three important issues—a definitional issue, a unit of analysis issue, and a methodology issue. I have documented the development of my thinking on each. In doing so I have discussed the assumptions that I hold, I have provided a framework through which I will analyze activity in a middle-school classroom, and I have hinted at the methods I used to do the analysis.

There are several versions of creativity that a researcher could hold. The version that I am advocating focuses on the process by which and the structures through which something gets recognized as creative in the classroom, and the consequences of those judgments. In practice ideas and artifacts are socially constructed, compared, evaluated, and labeled. Participants, language, gesture, social rules, and artifacts mediate these activities. All of these things are being interpreted and reinterpreted in activity. This is as much (if not more) of the “stuff” of creativity as cognitive processes, personality traits, or divine inspiration.
The study of creative events requires a careful analysis of how artifacts and activities get presented and evaluated, as well as how that gets negotiated, maintained, and disseminated. Data was gathered during several field tests of Middle-School Math Through Application Project curricula. Videotape provided the central data for analysis, but classroom artifacts, field notes, and teacher interviews were also examined.

There are several reasons why interrogating this data can lead to insights into the interaction structures that characterize evaluation practices in the classroom:

- the data preserves much of the discourse and activity of a design group’s interaction, and that group’s interactions with other design groups and the teacher;
- the data was collected over long periods of time;
- the data reflects a wide variety of practices in “reformed” middle school math classrooms; and
- the data is in a content area (math) that is not usually studied when looking for creative practices.

Much of this work relies on videotaped pieces of activity. There are several advantages to videotape as data: it captures many of the features of the activity that is occurring, it provides a relatively permanent record of the data, and it also allows multiple viewings of the event, which is essential given the complexity of human interaction (Jordan & Henderson, 1993). There are drawbacks to using video analysis as
the only form of data, however. The media is much better at capturing local interaction among a small number of people than large, class-wide event structures. Also, many plausible interpretations can be made from a videotape of an event (Goodwin & Goodwin, 1992). Ethnographic data from other sources are needed to provide convergent evidence for the claims that one makes using videotape. I will use data from field observations in addition to the videotapes as support for the analytical categories that I will examine.

This data was collected over long periods of time (up to 12 weeks). This allows me to document longer histories within the classroom. I can track the generation and maintenance of frames and re-framing over time, as well as potential “conventionalization” processes of practices that become part of “normal” classroom activity.

Throughout these field tests, a wide variety of activities were captured. These included students working alone, working in a group, sitting at a computer, presenting a design, doing a worksheet, taking a test, questioning the teacher, responding to a lecture, etc.. The wide variety of activities in the classroom provides a comparative landscape for analyzing the differences and similarities of practice with respect to the generation, reaction, and evaluation of new frames within the classroom. Different levels of problematic situations, different time frames, different materials and resources, and different roles among the students and teacher all potentially have implications for the life of a creative event in the classroom.

Finally, math classrooms present an opportunity to look at creativity in a community not generally examined. Previous research that has examined the question of creativity from an interaction perspective tends to focus on settings where creativity is generally expected in our culture. Sawyer (1995a, in press) has looked at improvisational jazz and preschool play. Becker (1982) didn’t look at creativity per se, but at art “appreciation.” There is a lack of research on math classroom settings, and there is an interest for it from both education and business. Thus this study potentially will address issues valuable to both the research and education communities.
3.1 Research Sites

I used data collected in Middle-School Math through Applications Project (MMAP) classroom in the Bay Area. I focused on one school, but looked to other data to support, augment, and generalize the research categories. The school is in a large urban center with a highly diverse population, and I will refer to it as Polk Middle School. Ms. Reese is the teacher. Field tests in this classroom ran from November to June, nearly the entire school year. Additional field tests in other classrooms ran from early 1993 through summer 1995. Although I focus on the Polk Middle School classroom in this paper, I used data from other schools to refine my analysis.

The classroom at Polk Middle school has student desks that are pushed together into eight groups of four, with two students facing the other two in the group. There are six computers in the room, located against two adjoining walls. The teacher generally works from the overhead when addressing the class. In the initial field test in this class there were 18 girls and 14 boys in the class, as well as one teacher aid. The class was labeled “Gifted and Talented.” The class was combined math and science, one hour and fifty minute periods. The focus was on activities comprising MMAP’s *The Antarctica Project*, but researchers also observed a design activity from The Educational Development Center’s (EDC’s) *Designing Spaces for People* during this field test. During the second field-test there were 15 girls and 15 boys. This group was not labeled specifically, as they weren’t “gifted and talented,” nor were they remedial. This class was observed during *The Antarctica Project* and *Design a Dream Home*. In the Hoover Middle classroom, desks are set up for pairs of students to sit together, both facing the same direction. Six computers line the walls in this classroom as well. This group was engaged in *The Antarctica Project*.

A third research site is the Institute for Research on Learning (IRL). Once a month and for several weeks in the summer, MMAP teachers come to IRL to discuss their experiences, create curriculum products, view classroom video tape, discuss teaching and assessment, and showcase student work. Here I have collected stories that teachers have told and discourse around student materials that will be valuable data for this study.

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21 All names that appear in this document are pseudonyms.
3.2 Sources of Data

Several forms of data are used. The most important is video data. Field notes are also used. Artifacts from the classroom such as handouts, student work, and other relevant resources are used as well. Finally, student and teacher interviews are examined.

3.2.1 Video

The MMAP team was in the first classroom for 12 weeks, videotaping on 20 of those days (51 tapes total). In the second field test, which occurred in the same classroom one year later, the MMAP team collected tape on 22 days over a 5 week span (80 tapes total). The final field test lasted 10 weeks, and researchers collected tape on 23 days (45 tapes total). The video was taken with video-8 or Hi-8 cameras.

Often two cameras were focused on a group, one framing the interaction within the group and the other on the materials the students were using. When the group was at a computer, the “materials” camera was focused on the screen. If a materials camera wasn’t needed, two groups were generally captured simultaneously. Occasionally another camera was focused on another group, or following the teacher. Cameras also occasionally captured student and teacher informal interviews.

3.2.2 Student work

When appropriate, student work was collected. Available student work includes printed and soft-copy ArchiTech\textsuperscript{22} floor plans, final ArchiTech values, teacher created handouts, MMAP and EDC curricula handouts, student journals, pre and post tests (from the second Polk Middle field test only), and student evaluations of the curriculum. Additionally, mathmaps\textsuperscript{23}, final projects, and student journals are available from other field tests and MMAP teacher workdays.

3.2.3 Field notes

Each day in the field, the researcher kept notes that he/she observed in the class. These notes were then often (but not always) transferred and expanded into an electronic text document that was available to the entire MMAP research team.

\textsuperscript{22} An IRL-designed computer tool for creating floor plans and generating data such as building and heating costs. Parameters include insulation and temperature ranges.

\textsuperscript{23} Assessment tool designed for student reflection on the math he/she is learning
notes were often divided into descriptive accounts and analytical memos that emerge from the descriptions.

3.2.4 Other sources of data

I have also collected useful artifacts and insights from other places. In my work with the Challenge 2000 Multimedia Project I was able to document a wide variety of classroom practices, including public exhibitions of student work. Also, I have collected newspaper articles and other forms of representation that disseminates stories of "creative" work in the classroom. This data is important for showing how student work can go beyond the walls of the classroom.

3.3 Analytical Methods

A methodology is needed which fits this research agenda. Recent theoretical steps have been taken towards a more ecologically valid study of human behavior that examines the interactions between people and artifacts in the course of activity. This perspective has appeared under a variety of names, including situativity theory (Greeno, 1992), situated learning (Lave & Wenger, 1991), and situated action (Suchman, 1987; Clancey, 1993). Such perspectives arise out of a wide variety of disciplines, such as anthropology, ecological psychology, and sociology. Methodologies used by this tradition preserve relationships among participants and the objects with which they are interacting, precisely the information that other psychological perspectives ignore. Preserving this information, naturally, allows the researcher to analyze the information. Situated perspectives borrow methodological tools from several disciplines that I outline in this section.

Blumer (1969) promoted a methodology that focused the researcher on how individuals act toward and refer to objects. From these interactions one can observe and derive social categories, as well as give conceptual order to those categories. According to Blumer, the category is meaningless unless it is cast in terms of social action. The methods I have chosen to use are to do just that. I intend to create meaning for what I’ve called creativization by casting the concept in terms of the streams of interaction which emerge during classroom activity.

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24“Recent” in the psychological study of cognition. Similar theoretical perspectives can be traced to Dewey (1949) in education and Garfinkel (1967) in anthropology.
I used guiding questions to select video episodes for further study. From the video, I created analytical notes, which are attempts to induce structure out of the stream of interaction. I used these notes to select other video clips to confirm, disconfirm, revise, or conditionalize the categorical structure. I also used the notes to talk to other researchers and to select research literature that seems relevant. This process generated a new, finer-grained set of questions on which to focus. I went back to video episodes I have already looked at with the new questions in mind. I transcribed pieces that are particularly useful, both as an analytic exercise and as data that may end up in the final paper. The cycle continued until I was confident I could make a particular claim about the structure of an event that is consistent with the data. I made use of student work and teacher discourse to further support the interaction category.

The videotapes and other artifacts were brought to a central location for analysis. This process included expanding the field notes and making them accessible electronically. Content logs were created for the tapes using C-Video. These documents were generally rough characterizations of the activities in which the participants on the tape engaged. Transcriptions were created for events that a researcher found interesting. Events that were “interesting” were usually cases of mathematical learning, mathematical discourse, models and representations, or teacher practices. Another important research activity was to watch videotapes as a group to construct hypotheses about the events that were taking place.

I used information from this pool of tape and documents. I’ve used content logs and field notes to pick out events that are likely to contained events labeled “creative” by the participants. This was accomplished in two ways. First, Microsoft Word 5.1 was used to search all documents for “creative” or “creativity.” I then analyzed the events that I found. Second, I used the documents to guide my choices of videotape to watch. There were hundreds of hours of classroom activity on tape. I used the field notes and content logs to choose tapes that were likely to be interesting for my purposes. Most of the tapes that I analyzed contained groups of students engaged in design tasks. At times I viewed tapes of the teacher when the student’s were engaged in design, groups in non-design activity, and groups giving presentations to the class. When the students were at

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25 Jeremy Roschelle developed C-Video. It integrates a text editor with tools for controlling the video device from the keyboard or the mouse.
26 In this study, I also look at terms that have a “family resemblance” to “creative,” but are more common in middle school student discourse. Such terms include “cool,” “fresh,” “radical,” and “awesome.”
the computer, the screen image was generally synchronized with the group image and put onto the same tape using the picture-in-picture feature of a video editor. Pieces of tape that were particularly relevant were transcribed. Transcriptions can be found in Appendix B.

The data was interrogated using methods borrowed from several fields. I will discuss methods that I have grouped into the following categories: grounded theory (Glaser & Strauss, 1967; Strauss & Corbin, 1990), interaction analysis (Goffman, 1983; Kendon, 1990), discourse analysis (Gumperz, 1982; Sacks et al., 1974; Tannen, 1993) and the history and production of science (Knorr-Cetina & Mulkay, 1983; Kuhn, 1962; Latour, 1987; Latour & Woolgar, 1986; Lynch & Woolgar, 1988).\footnote{The categories here are very general, but serve the purpose of this paper. The methods of Sacks, Schegloff, and Jefferson's conversation analysis are different than the methods of Tannen's discourse analysis, but each relies on the idea that talk is structured and analyzable. Also, each of these researchers, with the exception of Kuhn, would probably consider their methods as "grounded," even though they don't explicitly ascribe to "grounded theory" as a method.}

3.3.1 Grounded theory

From the videotape, fieldwork, interaction analysis, and research literature, I closed in on a supportable interpretation of the concepts in which I was interested. As discussed by proponents of grounded theory, concepts emerged from the data, which are categorized and dimensionalized. Concepts that emerged from my data are then worked out in the form of words and sketches in my notebooks. My analytical notes tended to be pieces of analysis that eventually fit together in a coherent manner or else the ideas got changed or tweaked given new data.

I alluded to the value of working with others to come to new understanding of activity on videotape. The IAL, or interaction analysis lab, was one structure for doing this social analysis of tapes. I’ve spent (and propose to spend) many hours engaged with others, discussing what is happening on videotape. This was done with other members of the MMAP research team.

In general, I made analytical notes to myself after I have viewed a tape. These notes served to question assumptions I have made, find patterns in interaction streams, or tie data to concepts in the existing literature. From these notes and sketches arose new questions on which I focused when going back to the tape. The goal of this dialectical process was to document patterns in interaction that have consequences for creativization.
Through this cyclic process I moved from data to the dimensions of practice that structure creativization. Once I found these dimensions (and how they relate to each other), I looked across activities to examine how practices that differ along a dimension affect the structure of creativization. This process cycled until I tightened up the analytical category.

When I settled on the dimensions that underlie creativization, and how changes along those dimensions structure the process differently, I attempted to put the model together. I used teacher interview data and evaluations of student materials to fill in the gaps. I also selectively chose and code video episodes that provided insight into aspects of the model that were weak analytically. The resulting model reflected the creativization process in a “reformed” middle-school mathematics classroom, and it will allow us to make reasonable curriculum recommendations for teachers that value and assess creativity in their classrooms.

### 3.3.2 Interaction analysis

Video data, as I have mentioned, preserves positioning, gesture, and discourse of the group, as well as interactions with artifacts. Researchers who have developed theories of interaction analysis provide methodological clues for interrogating such data successfully. The amount of raw information in the videos and student work is immense, but the task becomes more focused when we pay close attention to the patterns occurring in the data.

One of the methodological implications of such an approach is that attention is a social achievement. I used this finding to focus on what the participants are attending to, and how that attention was structured. What are the “transactional segments,” or “the space into which he looks and speaks, into which he reaches to handle objects.” (Kendon, 1990, p. 211). Creativization, it seems, has a lot to do with what people are attending to and why.

A second implication I took was that I should pay careful attention to how interaction was made coherent in the activity. Positioning, discourse, and attention all are important clues for understanding how the interaction is “framed,” or how participants come to know what to expect, and what to do next (Goffman, 1974;

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28. I am grouping proponents of context analysis (Kendon, 1990) and symbolic interaction (Blumer, 1969; Goffman, 1974).
Individuals become attuned to the frame, as well as negotiate the frame
in the interaction (Kendon, 1990).

A third implication of the approach is that there is a relation between the micro-
interactions within an activity and macro-level phenomena beyond the local context
(Gilmore, 1990). Students in the classroom become directly or indirectly part of larger
networks of activity. One important method for understanding the phenomenon, then,
is to track what networks are formed, in and out of the classroom, and to better
understand the relations among them. I didn’t follow the students outside of the
classroom in either school, but I have been able to study networks of activities that
students take part in that go beyond the walls of the classroom, like media fairs,
newspaper articles about “innovative” schools, and public open houses. I wanted to
track the ways in which micro-level activity relates to macro-level activity, and vise
versa.

### 3.3.3 Discourse analysis

Methods for interrogating written or spoken data have been developed in the
field of ethnomethodology (more specifically, conversation analysis) (Garfinkel, 1967;
Sacks et. al., 1974), as well as sociolinguistics (Gumperz, 1982; Tannen, 1993). Gumperz
(1982) points out that researchers doing discourse analysis do not have a standardized
methodological toolkit. Yet there are several methodologies I used in my analysis.

As Boden (1990) and Heritage (1984) note, conversation is not simply serial, but
consequential. While looking at the transcripts of interesting cases, I tried to make an
analytical case for how each “presentation” was consequential for future activity of the
group, particularly with respect to re-framing the interaction.

Conversation is contextualized (Heritage, discussing Garfinkel, 1984). The
implication is that I paid close attention to the “extra-linguistic” environment, which
included objects like the materials that the students were using or the floor plan on the
computer screen. I also found it useful to let the conversations and the contexts in the
data elaborate each other in the course of the activity.

Also, according to Heritage (1984), no detail of the conversation can be
dismissed *a priori* as irrelevant. I kept this in mind as much as possible as I analyzed the
transcripts. Clearly my transcripts do not have nearly the detail of conversation
analysts, however (e.g. Sacks et. al., 1974); thus, I have already lost detail—letting some
things implicitly go as “irrelevant.” I had the video data to go back to, and did add more detail if I found it to be important.

As I examined the data I began to understand creativity as a shift from one structure that makes interaction coherent to another. I paid close attention to indicators in the interaction that suggest participants are in the same frame, such as (Tannen, 1993)

- non-syntactic anaphoric references (use of terms like “this” in relation to the general situation);
- modals, such as “can,” “supposed to,” “should,” or “may”;
- positive evaluations that keep the interaction moving;
- shared use of new terms.

There are other features that may indicate that the frame for interpreting the interaction was changed, including

- negatives and phrases like “instead of”;
- false starts in a conversational turn;
- long pauses in interaction;
- increased pitch, or surprise;
- interaction turns beginning with words like “but” or “anyway.”

I used such indicators to further my investigation of the characteristics of creativization within micro-level interaction.

3.3.4 History & production of science

This section brings together two very different things: the historical analyses that researchers of the history of science do (Kuhn, 1962; Bijker, 1987) and the ethnographic analyses of researchers who examine the production of science (Knorr-Cetina & Mulkay, 1983; Latour, 1987; Latour & Woolgar, 1986; Lynch & Woolgar, 1988). Both have methodological implications for this study.

Historical analysis makes use of the ways in which history is preserved. In the classroom, history is usually days or weeks, rather than years or centuries. Yet there are still ways in which the participants keep track of history, from things that go up on
bulletin boards in the classroom to stories that become part of the classroom culture. I attempted to use relevant parts of the data to track the production of history\textsuperscript{29} in the classroom.

Researchers who examine the production of science often focus on the representations that scientists construct. I examined the representations that students were using and creating, thinking about what aspects of the work the representations preserved, and how the representations structure perception.

### 3.4 Summary

The data works for this analysis for several reasons. First, it captures a wide variety of practices, both design- and non-design oriented, having different levels of questions, different time frames, and different group configurations. Second, the video and the artifacts capture both the process of the work and the products. Journal entries give us reflections on the process of the work. Finally, the data is useful because it gives us a window onto the creative process outside of art, music, and science—domains that have traditionally been studied by social scientists.

I have created a methodological toolkit from a variety of relevant disciplines. Different aspects of my data were better handled by different tools, but each tool was consistent with a situated approach to the problems I was addressing. The forms of data and the analytical tools enabled me to examine the process of something’s becoming creative within the naturally occurring activities of a middle-school math classroom.

\textsuperscript{29} Boden (1990) offers the term “production of history.”
As Henry’s story, or his “creative writing,” as one student called it, was coming to a conclusion, it became relevant for the teacher Mrs. Reese to comment on his “creative side.” In this case Mrs. Reese was politely making it known to the class that the nature of Henry’s presentation was not appropriate in this context. Other uses of the evaluation function in different ways. Despite these differences, the interaction which
makes a judgment like “creative” relevant is structured. I intend to show that the interaction is not simply structured, but also patterned; there are underlying similarities to episodes like this one in the classroom. There are like many different patterns. I will focus on one that is common and that has educational relevance—the re-framing of interaction.30

In the next two chapters I will talk about the structures and interaction patterns that are relevant for creativization. In this chapter I focus on the structure of activity frames, the structure of re-framing, and evaluation sequences inside the math classroom. In chapter 5, I examine more closely the dimensions that underlie the process, as well as how those dimensions play out within common practices in the middle-school math classroom.

4.1 Framing and Re-framing in a Middle-School Classroom

I set out on the analytic task of examining the evaluation practices that occur often in the classroom as the students and teacher move through the class period. I found that students had a variety of evaluation labels they used; terms like “good,” “fresh,” “cool,” and “radical” were commonly used in this classroom. My goal was to find out how the interaction structured such evaluations, how the interaction makes them relevant, and what consequences they have on future activity.

I found that all these terms were the result of a shared understanding of the situation. The process by which that shared understanding was achieved, however, made relevant different evaluation labels. When proposals were being generated within an interaction frame, often a judgment like “that’s good” emerged. When proposals were generated in response to a shift in the interaction frame, terms like “fresh,” “cool,” or “radical” emerged. Both forms of evaluation tended to mark a moment-in-time of the trajectory of a group’s activity that set the frame for future action, as well as closed off other possibilities. I then looked more closely at the terms themselves and concluded that the latter labels—“cool,” “fresh,” and “radical”—were playing a similar role in interaction as the term “creative” was in the classroom. From this I concluded that

30 “Common” here is a relative term—I have found that most events in the classroom are not evaluated as “creative.” By educational relevance I mean that re-framing is by its nature a learning event given my definition of learning—that learning is the emergence of new opportunities to participate in an activity. I will discuss this later in the paper.
episodes that are evaluated in response to a shifted interaction frame were examples of one aspect of “creativization.”

In the next section I will illustrate activity within a frame. Following that I will examine another episode in which the situation is re-framed by the participants.

4.1.1 The coherence of activity: an interaction frame

This episode illustrates a “good” idea, which will inform the discussion of what I consider to be a “creative” idea in the following section of this paper. “Good” ideas are quite common in Mrs. Reese’s classroom. The students are designing a house with various geometric shapes made from construction paper. The constraints of the task are that the group can only use a certain number of pre-cut shapes, except for one extra shape they can cut out. The extra shape can be anything they want it to be, and they can make as many as they want of that shape. The house they are designing is for a climate that is very hot and rainy (see Appendix C, p.175). Larry proposes making a slanted roof from the “extra shape” they get to make, which was one of the design constraints. Kyle and Tessa are working in the group with him:

01 Larry: What are we gonna use for the roof that we plan to have slanted so ==the rain will run off? (circles pencil over sheet)
02 Tessa: ==This... oh, the triangles. (presents triangle)
03 Larry: Triangles?
04 Kyle: Well we only have a couple of them.
05 Larry: Ok, then we've gotta save up triangles. (points to desk)

Given the constraint that the house the group is modeling with exist in a rainy climate, Larry suggests making a roof that is slanted so that the rain will run off. Tessa presents the group with a possible solution path in turn 02. Kyle hints at a potential problem, not enough of the triangles left, and Barry adds that they should save up the triangles. The group members give Tessa no indication that they don’t understand what she is proposing.

Tessa continues, this time using the construction paper pieces in a configuration that represents the solution she has in mind:
06 Tessa: See like this. *(collects and holds triangles together over pentagon)*

07 Kyle: Yeah.

08 Larry: No WAIT! But see, if you...

09 Kyle: Shh shh shh... Let Larry talk.

The presentation of the paper model seems both consistent with a reasonable solution, and it is consistent with Kyle’s interpretation of Tessa’s earlier verbal indication to use triangles. Kyle’s “yeah” affirms that Tessa’s move was plausible given his understanding of the situation. Larry suddenly realizes something. His emphatic “No WAIT!” is a reaction to Tessa’s model. He realizes that the hexagon is the equivalent in size to the six triangles. The six triangles will lie flat tiled on the hexagon, rather than “slanted so the rain will run off”:

![Figure 4–1 Tiling Triangles](image)

10 Larry: See but if you do that... if it’s gonna be over THIS thing *(points at hexagon in front of Liza)*

11 Kyle: It wouldn't fit.

12 Larry: Yeh. It'll just be FLAT. *(hands sweep flat surface)*

13 Tessa: What if you go like ==this? *(re-assembles triangles over pentagon)*
Tessa understands Larry’s concern and amends the model of her solution, pointing out that the triangles could be over a pentagon instead. Kyle doesn’t feel the solution will work, but for a different reason than Larry gave before (in turn 12). Tessa’s presentation was interpreted by Kyle as leaving a hole in the middle of the roof. That interpretation makes sense given the difficulty of trying to hold five triangles over a pentagon, as Tessa was attempting to do. The physical model Tessa constructed was imperfect given this difficulty. She defends her plan:

14 Kyle: ==If you made a point you'd just, it'd o[ver], it'd... cave in. It'd cave in. (palms up, then collapse)

15 Tessa: That, no... The, water would fall off you know? ==Roll off. (R hand sweeps down and over)

16 Kyle: ==Then there'd be a big humongous hole in the middle. (R hand spirals down)

17 Larry: (arms drop, sighs) Then we'd have ==to use a hexagon. (retrieves pentagon) W::, what if we made the house this big, right?

18 Kyle: ==Right, ok? See, if you use this, THIS they wouldn’t be able to touch, right? (grabs triangle, joins to Tessa’s pentagon)

19 Jen: (To Kyle) Maybe ==we could do SQUAREs then.

20 Liza: (to Larry) ==It’s a pentagon.

21 Larry: Yeah, see, and then just do the same thing. (joins trapezoid to pentagon) Cause if, see if you had five triangles, then they'd be pointed up so that the water could run off (hands trace perimeter of pentagon, slant up, then sweep down)

22 Kyle: Yeah, it'd be better if you did that. (points at Larry's pentagon)

23 Larry: Cause a hexagon, if we put all the triangles to make the roof, it would just be FLAT. (repeats prior series, then both hands sweep flat)

The group continues to make proposals related to the “slanted roof.” Even though the proposals vary, they are all understood as reasonable given the group’s shared understanding of the task. Kyle begins “making little stick people” out of his
pencils and paper shapes. This diversion from the sanctioned task involves a shift of attention, an evaluation, and a request to “come on” back to the original task in turn 33:

24 Kyle: Cool, a person. (grabs and cradles trapezoid)
25 Liza: (joining two triangles to a hexagon) Kyle:::
26 Kyle: Here, take these tapes and cut the rest
27 Tessa: Well, we might not need them yet. So [I'll just] put them here.
28 Kyle: See? A person. (joins pentagon to trapezoid)
29 Larry: Unless we use like the trapezoid, to make, the roof, or something. (grabs trapezoid)
30 Tessa: A head:::, huh huh. We're making little stick people. (places pencils for legs)
31 Larry: Oh, ==unless we made another shape. (R point beats paper between himself and Liza on the table)
32 Tessa ==Legs
33 Liza: Come on you guys! (R hand reaches to Kyle and waves in)
34 Tessa: Okay

Kyle presents his “stick person” with the label “Cool.” I will argue later in the paper that the term, in this case, functions as a way to “prepare” others for a shift in what is appropriate and inappropriate. In this case the shift involves how the construction paper shapes and pencils are being used. The shift also entails making features of the materials visible that were latent previously—pencils are straight like legs, hexagons are somewhat round like heads, and trapezoids look abstractly like bodies. Like many shifts of this sort, the behavior is ultimately seen as “mis-behavior,” rather than “creative” behavior, by the group. The effect of the diversion may have been positive down the line, however, as the group added “legs” to their house which ultimately became stilts to keep the house elevated in the rainy climate. It is unclear whether Kyle and Tessa’s activity here planted a seed for that idea.

The group refocuses on the task at hand. Larry realizes that they could make another shape. This suggestion leads to a clarification of the task constraints by the group:
Larry: Unless we made another sh... *(R point beats center)*

Tessa: What?

Larry: Unless we made another shape... **==to make the roof.**

Liza: **==(gets both trapezoids and leans them together)**

Tessa: We could make, yeah. We could make another shape. But how would we get **==the**

Kyle: **==But then how, we would have to fold it. We ==can only make ONE shape. *(Kyle signs “1” and beats)*

Liza: **==We can make a house with THIS. *(gets a square and joins between slanted trapezoids)*

Larry: NO sss. We should make one KIND of extra shape. It doesn't matter how many you make. Look, read it. *(points to task sheet)* It says, **==that you can make one extra shape.**

Tessa: **==Yeh, I already read that.**

Larry: And you can make... **as many as you WANT TO of that shape. Ok?**

Liza: Can you?

Kyle: Oh, oh, yeh yeh, that's what it says. Says you can cut out as many **==as you, yeh.**

The group clarifies what is appropriate given the task at hand. In this case the group uses the worksheet, which is the “authorized” document that contains come of the constraints of the task. Clearly other constraints which aren’t authorized are also being constructed, such as the constraint that the roof should be slanted. It is within this shared space of constraints that new proposals are understood and evaluated. Larry proposes making a “longer” triangle that will slant when tiled over a hexagon. Kyle evaluates the proposal as “good,” and it marks a point of consensus for the group.
48 Kyle: That's true. ==Yeh, yeh. Ok, that's good.

49 Larry: ==And water will run off when it rains, right? (R hand sweeps down)

For the continuation of this transcript, see Appendix B (p.170).

The activity continues for the remainder of the class period. They model the proposal that Henry makes in turn 47. That proposal was co-constructed, particularly building on Tessa’s proposals in turns 06 and 13. The episode illustrates some not-so-revolutionary points about human interaction. The group has a mostly-shared sense of the activity that they are engaged in. Expectations emerge, and the group is doing what’s expected. Each new proposal to the group is judged in relation to those expectations, and may shift what those shared expectations are. On occasion, expectation is violated and repair is necessary; eventually the group achieves consensus and continues the work of the task.

What structures this interplay between presentations and responses within this kind of case? I claim that they occur in a social-interaction “space” of possibilities, structured by physical space, representational media, material resources, and the understanding of the conventions and socially constructed meanings for the activity. I will refer to such a structure as a “frame” (Bateson, 1972; Goffman, 1974; Kendon, 1990; Tannen, 1993).

The frame is maintained partially by the focusing of attention by the participants. Clear examples of this are embedded in the language the group is using. In turn 06 Tessa says, “See, like this...,” and Larry, in turn 10 says, “See, but if you do that...” “See” is used several more times during this short episode. The “see,” whether or not it’s an actual or metaphorical reference, implies that the rest of the group should focus on a particular aspect of the task situation. The group uses other interaction techniques in addition to language to focus attention, such as creation of models with available artifacts and gestures.

The frame carries with it what is appropriate and what is not. It also carries with it what aspects of the situation can be seen in the situation and what aspects of it remain latent. Within a given interpretation there are “reasonable” things to do next.
These reasonable next steps can be thought of as “convention.” As new presentations are made by the group, constraints are clarified and expectation shifts. New aspects of the situation may become relevant, and the interaction progresses.

In this case there were misunderstandings that required repair. The repair clarified the frame for the participants. Sometimes repair is not achieved, but it does not matter for the interaction to proceed. The group had a misunderstanding about whether a particular configuration of shapes would create a “humongous hole,” but Tessa deferred her plan to the “longer triangles” solution that Larry proposed.

4.1.2 Breaking interaction coherence: the re-frame

The previous episode was necessary to illustrate the importance and consequences of a frame in interaction. I pointed out that the frame carries with it shared meanings and appropriate actions. In this episode three students are working on a floor plan for a research station in Antarctica on the computer (see Appendix C, page 178). The group is working on the placement of a wall. When the wall eventually gets placed, the group reacts differently than in the episode of the “good” example above. The group reacts with a sudden change in posture accompanied by the labels “cool” and “radical.”

What work has to happen to make “radical” or “cool” a relevant evaluation for Dena, Henry, and Kyle’s design group? We can examine some of the work it takes for the “crooked” wall to get presented, noticed, and evaluated. Initially we can look at the idea’s presentation. The dotted line that represents wall A is the wall that Kyle “draws” on

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31 Of course, participants certainly don’t need to be “conventional.” That will be explored in the next section.
the screen. Henry’s proposed plan is wall B.

The floor plan of the house consisted of four rooms and a hallway. The group had some furniture. Henry bids to finish the right side of the design.

04 Henry: I want to do that side, okay? (pointing)
05 Kyle: I messed up. [ ? ]
06 Dena: Oh the wall is crooked.

Henry tries to negotiate a structure in which he has access to the computer mouse. Kyle and Dena are focused on Kyle’s mistake. The event has become a “mess up” given a shared interpretation of the representational system presented on the computer screen, as well as an understanding that, in the world which that floor plan models, walls are straight. Henry’s proposal doesn’t become part of the group’s shared activity, presumably because the request isn’t relevant, given the orientation of Dena and Kyle towards a particular problem.

10 Henry: Make it crooked, make it crooked. That would be a cool house.
11 Kyle: No, it has to be a nice and pwetty house.
12 Dena: Oh

Kyle has selected the “wall” tool on the design interface, and has started to draw wall “A” on the floor plan. Henry, not having been given the computer mouse on
his previous attempt, bids once again. This time his proposal is an imperative to Kyle, who is doing the wall layout, but is also made available for a response from Dena. On this turn the utterance becomes available and is part of Kyle and Dena’s current attention and activity. It gets a response, in this case, a negative one. Up until this point, “crooked” has been used by the group to refer to walls that aren’t exactly vertical or horizontal, and thus they “staircase” on the computer screen:

Kyle responds that the house needs to be “nice and pwetty.” He alters his tone, intonation, and pronunciation in this response, perhaps marking the fact that these aren’t his “rules,” but someone else’s.

13 Kyle: Let me make a door.
14 Dena: There's lots of open spaces in the living room.
15 Henry: (Pointing) NO, make the wall like this, up here, like this.
16 Kyle: ==That a good door?
17 Henry: ==That'd be better
18 Dena: Yeah, it's a little big though.
19 Henry: No, no, please, listen...
20 Dena: ==(laughs) Yeah, Yeah (referring to Kyle’s design move on the computer)
21 Kyle: This is it.
22 Dena: Yeah, yeah.
23 Kyle: Want it to face the inside like that or not?
24 Henry: No go like this==
25 Dena: ==outside
26 Kyle: ==outside, okay.

Kyle proposes to make a door along the wall (A) the group has just constructed. At this proposal, Henry reacts with an emphatic “NO” in turn 15. Adding the door to the wall marks added investment into the current state of that wall, and such investment may result in a more permanent state of the design. The design schedule in this case (as with most inside school settings) is very tight, with little time to “undo”
parts of the representation that become interdependent with other aspects of the floor plan. He then uses another imperative, as he did in turn 10. This time he issues more details. He refers to a location, “up here, like this.” He coordinates his verbal proposal with a deictic gesture in front of the screen, waving his finger back and forth between the endpoints of the proposed wall (wall B in the diagram). In this case he not only makes an utterance (which may or may not become relevant for the other participants in the group), his gesture “invades” the physical space in which the “story-line track” of the interaction is getting coordinated (Goffman, 1974; Kendon, 1990). Dena and Kyle continue to attend to the placement of the door which Kyle is creating on the computer screen.

27 Henry: Let me do one thing alright, if you don't like it you can bulldoze it. Okay? (reaches for the mouse)

28 Kyle: Rotate, thank you.

Henry once again asks for the mouse, as he did in turn 04. This segment is characterized by two events that have not previously occurred: Henry lets the group know that his suggestion doesn’t have to be permanent, and he moves his hand toward the mouse. Making it known that the move does not have to be permanent is an important step that occurs within the interaction because of what it makes available to the design group. In previous attempts, the mouse was asked for and proposals were made, but those events gave very little information to support that design move. This utterance is a piece of the work that occurs in the negotiation of a new interaction space in which the creation of wall B can get done. The disclaimer is important, because the proposal carries with it a change to the “product” which will eventually be presented to other audiences such as the teacher. Because of the way this artifact is situated inside the practices of the classroom community, the group doesn’t want it “messed up.” The “bulldozer” feature of the computer interface makes this possible.

Henry concurrently reaches for the mouse. This behavior, in effect, “pushes” Kyle’s hand off of the mouse without touching having touched it. Kyle choreographs his letting up of his hand with Henry’s movement. Kyle realizes that he needs to rotate the door. The imperative he utters in turn 28 addresses at the computer, but functions to suspend Henry’s movement toward the mouse, giving him time to complete the action
while letting Henry know that it will be short. Once Henry has the resources to represent the idea as an actual artifact available for viewing on the computer screen, the structure of the interaction clearly changes.\(^{32}\)

(Henry takes the mouse and begins to bulldoze a wall)

29 Dena: Your just bulldozing an entire wall. Oh he's gonna make it crooked.

30 Kyle: Oh

31 Dena: Oh Cool==

32 Kyle: ==oh cool. Radical. (spinning his head around)

(Henry sits back smiling)

33 Dena: Make the door right there.

34 Kyle: That's cool.

35 Dena: So you can go out of the living room and go straight in the bathroom.

The act of representing the wall on the floor plan clearly brought a reaction from all of the participants. When the wall is complete, all three bodies, which have been leaning in towards the computer screen, straighten up at once. Kyle and Dena label the event as “cool” and “radical”. Henry had used the term “cool” to describe the proposed wall in turn 10. The availability of the visual representation on the screen to the participants, the conventions and values through which they interpret the representation, and the evaluation labels that make sense in to the participants in relation to such an event all play a role in the process of the wall’s becoming “cool.”

This event captures a resolution of a complex interplay of discourse, body movement, and representational practice. It lasts only one minute and sixteen seconds, but it raises several important issues in the creativization process. The first issue I address is the nature of units I am interested in, given the complexity of the interaction. I will refer to the units as “presentations” and “acceptances.” The second issue is how these presentations and acceptances are structured such that a design team member can make five attempts to get a “cool” idea realized. The third issue addresses more global

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\(^{32}\)Changes in the handling of the computer input device do not necessarily imply a change in “control” of the design process. This has been documented within MMAP classrooms (Cole, 1995)
issues of evaluation practices in the classroom, and how these evaluations move within and across groups of people over time.

4.1.2.1 Presentations and acceptances

Previously in this paper I referred to Clark and Shaefer’s (1989) categories of discourse contribution: presentations and acceptances. The researchers use the terms to categorize utterances within a conversation, but I feel they can be used, at least heuristically, to think about the nature of the events I have chosen to study.

Presentations could be utterances in the current context of study, but they also could be design moves on a computer interface, sketches on paper, or projected overheads. All of these practices are complex, and are social achievements involving several forms of representation. Acceptances occur when a mutual understanding is achieved among participants. They require some shared assumptions and shared understanding of the activity in which the participants are engaged.

In its broadest sense, a presentation happens when something is made available that is consequential for the behavior of others. The key for this study is the nature of that “something.” By this definition all interaction is presentation, or at least made up of presentations. That “something” is not useful for my purposes if it includes every interaction cue to which one could respond. But if interaction is patterned (which it is), then we can take these bounded sequences as recognizable “interaction events.” (Kendon, 1990) Such events can include making a proposal, explaining a design, telling a story, or waving good-bye. Each of these events can be seen in light of the conventions surrounding them, the resources for making them relevant and maintaining them, and the wider contexts in which they are a part. The “somethings” in this section of the paper are these interaction events. Acceptances, then, can be thought of pieces of these events as well. Acceptances may have explicit evaluation components built into them, either as linguistic judgments (e.g. “radical” or “cool”) or gestural/postural shifts that have meaning to the participants in the activity. Most often presentations and acceptances are interwoven into the emergent structure of the interaction, with acceptances becoming presentations. More inclusive classroom structures like lectures, formal presentations, and design environments are made up of reasonably coherent assemblies of those interaction events. Chapter 5 focuses more closely on the nature of these assemblies.
In the case above, the presentation was clearly a complex one, involving several conversational turns and a variety of supporting activity. His first utterance, “I want to do that side, okay?” was ineffective, at least in terms of its elicitation of a response. His second attempt, “Make it crooked,... That would be a cool house,” was accepted, in that he was afforded a response that made sense given Kyle’s probable understanding of the term “crooked” in this situation. Later Henry created a “virtual” model of his idea, using his finger to transverse the proposed wall. On Henry’s fifth attempt, the interaction was structured so that the action not only got noticed, but also explicitly evaluated. The final acceptance of the idea also a complex activity. There are instances where the Kyle and Dena didn’t respond, another where Kyle explicitly dismissed it, saying they needed a “nice and pwetty” house (Dena’s silence plays a role in this dismissal), and finally, the explicit positive evaluation that ends the episode.

4.1.2.2 The sensibility of action

I will try to do two things as I make the case for interaction frames in the episode: explain how Henry’s behavior was sensible given the activity of the others, and how Kyle and Dena’s activity was sensible given Henry’s activity. I will claim that these explanations require understanding the frames that were guiding the activity of the group.

At the beginning of the episode, Dena is making a presentation of her own, and it has no noticeable effect on the activities of Kyle and Henry:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Dena: Look at this house, this is their house. (holding another group’s model)</td>
<td></td>
</tr>
<tr>
<td>02</td>
<td>Other: Give us our house back</td>
<td></td>
</tr>
<tr>
<td>03</td>
<td>Dena: Oh my God, there’s a [?] to it (referring to the model)</td>
<td></td>
</tr>
<tr>
<td>04</td>
<td>Henry: I want to do that side, okay? (pointing)</td>
<td></td>
</tr>
<tr>
<td>05</td>
<td>Kyle: I messed up. [ ? ]</td>
<td></td>
</tr>
<tr>
<td>06</td>
<td>Dena: Oh the wall is crooked.</td>
<td></td>
</tr>
<tr>
<td>07</td>
<td>Kyle: I know.</td>
<td></td>
</tr>
</tbody>
</table>

In order to make her presentation, Dena turns her back on the location in which Henry and Kyle are working, so that she can reach over to another group’s table to get their
model house. She slips out of the situation that her group is in, and into one involving the other group. When she gets back to her own group, Kyle is drawing a line representing a wall on the computer screen. Henry is also looking at the screen. Dena then makes the house available to the group by holding it up, but doesn’t impinge upon their workspace (Kendon (1990) refers to this as the “transactional segment”). The presentation was picked up by the two members of the other group, as one member closest Dena reaches for the model and asks for it back. The girl to the side of her coordinates her movement with the other’s in order to view Dena. The body positionings and activity in effect set up two frames of interaction, one involving Henry and Kyle with the computer, and one with Dena and the other group, even though Dena attempts to present the model to her group members. The diagram below illustrates this:

The dotted lines represent the visual attention that is maintained through turns 01-03 of the segment. Kyle and Henry do not noticeably respond to Dena, and she hands the model back to the other group. There is little we can conclude from this segment now, but body positioning and visual attention begin to give us clues about how the interaction is being framed by the participants.

Also within that segment (turn 04) Henry makes his first attempt to make it known that he would like to do a section of the design. By this point in the interaction, Dena is back to watching Kyle make a wall on the screen. Henry’s presentation has no clear acceptance by the group. Kyle and Dena exchange conversational turns about the “messed up” wall that Kyle has drawn on the screen. The state of the representation on the computer has generated a problematic situation that Dena and Kyle clearly recognize and structure their conversation around. This is accomplished via a shared assumptions
surrounding walls in the “real world,” the meaning of the lines on the screen (conventions embedded in materials), the quality that needs to go into something they as students are producing to give to a teacher in a middle school math classroom (roles), and how much work they want to put into it (values). These shared assumptions by the participants about the situation help to maintain an interaction frame in which conversation anchored to that situation can be understood and relevant. Kyle, whether he recognizes the “messed up” wall or not, frames his presentation by another set of assumptions, based on opportunities he sees for doing “that side” of the house. Presumably, many of the same assumptions are maintaining the interaction between all three participants. The differences that do exist, like the understanding of what needs to get done, results in Kyle and Dena ignoring Henry’s proposal.

Because Kyle and Dena have seen this situation an instance of a class of situations, they have a shared basis for continuing the conversation:

<table>
<thead>
<tr>
<th>Kyle:</th>
<th>I like cracking the windows with the bulldozer.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dena:</td>
<td>Oh my God. Don't crack my window.</td>
</tr>
<tr>
<td>Henry:</td>
<td>Make it crooked, make it crooked. That would be a cool house.</td>
</tr>
<tr>
<td>Kyle:</td>
<td>No, it has to be a nice and pwetty house.</td>
</tr>
<tr>
<td>Dena:</td>
<td>Oh</td>
</tr>
</tbody>
</table>

Henry, on his next presentation, tells Kyle (and presumably Dena, although she’s not holding the mouse) to make it “crooked.” That term makes sense in terms of the assumptions underlying the diagonal wall Henry is proposing. It also makes sense that Kyle would respond that the house needs to be “nice and pwetty” given the assumptions framing the interaction with Dena. Dena had used the word “crooked” to refer to a mistake. There is evidence from two weeks earlier of “crooked” being used and interpreted in relation to something that wasn’t “perfect,” (Kyle and two others are creating a paper model of a house):

<table>
<thead>
<tr>
<th>Larry:</th>
<th>You guy's it's <strong>crooked</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Kyle:</td>
<td>it doesn't matter if it is <strong>crooked</strong>, Larry</td>
</tr>
<tr>
<td>Tessa:</td>
<td>it's not perfect it's not gonna be perfect</td>
</tr>
</tbody>
</table>
Kyle: But if you if we really made this, it wouldn't be *crooked*, this is paper Larry, what do you expect?

Henry’s use of the term was unconventional within the group, and interpreted given a different set of assumptions. Frames, then, carry information about what is acceptable and what is not acceptable. From this segment, it seems reasonable to track how the interaction eventually gets to a place where “crooked” is reinterpreted, and potentially conventionalized as a term referring to diagonal, rather than messed-up walls.

After Kyle says that the house needs to be “pwetty,” Henry changes his body position, turning his shoulder into the interaction making himself potentially more able to enter the “transactional segment.”

13 Kyle: Let me make a door.
14 Dena: There's lots of open spaces in the living room.
15 Henry: (Pointing) NO, make the wall like this, up here, like this.
16 Kyle: ==That a good door?
17 Henry: ==That’d be better
18 Dena: Yeah, it's a little big though.
19 Henry: No, no, please, listen...
20 Dena: ==(laughs) Yeah, Yeah (referring to Kyle’s design move on the computer)
21 Kyle: This is it.

The wall that has just been represented encloses a room, with no exists from it. Dena and Kyle once again exchange conversational turns, this time in relation to the door-less room situation. The shoulder move allows Henry to illustrate his plan by waving his finger over the expanse of the proposed wall in the representation. Again Henry’s proposal, along with the deictic gesture, doesn’t become part of the activity of the others. The gesture indicates that more resources are being brought into the interaction, resources for coordinating the activity of the group (and the attention, assumptions, and expectations within it) in a different manner. As in Henry’s first attempt, the assumptions shared by the group about the current situation differ and frame the
participant’s activity differently. His proposal again is not relevant, given the framing assumptions of the other members of his group.

As I discussed previously, Henry’s emphatic “NO” in relation to the door’s placement potentially illustrates the interplay between investment in a design and interaction frames. The state of the representation plays an important role in structuring the frames that emerge in relation to it; as the design progresses, so do the opportunities for interaction. New frames that emerge will potentially make Henry’s proposal less relevant than it is currently. Additions to the wall that Henry proposes to eliminate marks added investment into a particular activity trajectory, which makes negotiating a new trajectory more difficult. Changes to exterior walls where many interior walls connect, rooms that have been furnished in detail, and redesign of the perimeter of the first floor when a second floor has already been constructed are made less likely because of the investment it would take to undo what has been done, and the amount of class time to do it. Some students choose to redesign by coming into the classroom or computer lab during lunch or after school, if it is available.

The permanence of an event on the structure of the interaction plays an important role for how the event will be responded to. Henry negotiates a chance to make his changes, using the disclaimer that the change doesn’t have to remain:

27 Henry: Let me do one thing alright, if you don't like it you can bulldoze it. Okay?

This piece of negotiation can function to prepare others for a change in frame. It marks a participant’s assumption that what he/she is going to do violates the current frame, otherwise there would be no need to use a disclaimer such as the one above. When another group was creating a paper model of a house, one student said, “I’m gonna try something, okay? The tape will come off. It did before.” This is another example of an attempt to prepare the other participants in the design group for changes that may not be expected. Negotiation is often a part of a re-framing episode.

In the final segment of the episode, the frame is reorganized in such a way that the group sees the wall as an improvement on the design, and evaluates it positively.

28 Kyle: Rotate, thank you.

(Henry takes the mouse and begins to bulldoze a wall)
29 Dena: Your just bulldozing an entire wall. Oh he's gonna make it crooked.

30 Kyle: Oh

31 Dena: Oh Cool==

32 Kyle: ==oh cool. Radical. (spinning his head around)

(Henry sits back smiling)

33 Dena: Make the door right there.

34 Kyle: That's cool.

35 Dena: So you can go out of the living room and go straight in the bathroom.

The disclaimer and mouse access enabled Henry’s idea to become concrete. The frame has been organized such that what was once inappropriate, a “crooked” wall, has become acceptable. The change in the physical representation precipitated the change in frame, but much interaction work had to happen for the group to reach that point. Once the wall was embedded in the representation (rather than in a verbal description or in a deictic gesture) the event was noticed and evaluated. Of course, for the event to be noticed and reacted to the participants had to be attending visually to the salient aspects of the design move. The move, in effect, illuminated affordances for the group (such as possible endpoints for a wall) that were “latent” in the previous frame.

Latour (1987) believes that the new “visual culture” (the wall on the representation) not only redefines what there is to see, but also what it is to see within that situation. This opens up new possibilities for action within the frame, like Kyle’s door, which goes out of the kitchen and “straight in the bathroom.”

The situation not only has to be seen as an instance of a more general class of situations, it also has to be valued by the participants, which is implied in the fact that the event was evaluated. In addition, there must be a way of talking about such events, which reify the positive evaluation within the interaction, in this case terms like “cool” and “radical.”

Clearly the event served the purposes of the group. It was immediately reacted to in both discourse and posturing, and the wall remained in the group’s final design. The

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33 Similar perspectives on this point include Duncker’s (1945) study of “functional fixedness” in Gestalt psychology, Barsalou’s (1982) study of context-dependent and context-independent features of concepts in cognitive science, and Schön’s (1983) study of designers.
fact that the wall remains illustrates another aspect of “re-framings”; they serve a purpose in the interaction. This purpose can determine what is done with the new frame, and how long it will persist. Less than a minute before this episode, Kyle draws a large toilet spanning the outside of the house. He refers to the bowl as a “swimming pool” and the tank as a “diving board.” This was a re-framing as well for the group, but the toilet was immediately “bulldozed,” indicating that the presentation was meant to be a joke, and was accepted as such— with laughter.

4.1.3 Refining “re-framing”

In the previous two episodes—a “good” idea and a “creative” idea were compared. I’ve illustrated that the difference between the two cases hinged on re-framing the activity. From these cases and other analyses, there are aspects of a re-framing that are important for this discussion of creativization. First is the importance of “preparing” a presentation. Second is the relation between what is appropriate and what is presented. Also, the connection between the re-frame and creativity is important in this discussion. I will briefly examine each of these issues.

4.1.3.1 Preparing to re-frame

The work that gets done in preparation for a presentation is an important aspect of a re-framing event. Henry’s statement “Let me do one thing, alright? If you don’t like it, you can bulldoze it” is an example. The preparation that goes into a re-framing event can serve several purposes. First, it can create an opening to get the resources to make the presentation. Second, it can provide a way out if participants don’t like the presentation. Third, it can contextualize the presentation in ways that make it more or less likely to be considered “creative.”

Henry needed to negotiate access to the computer mouse. He was able to get access to it through a series of preparatory statements. Constructing an idea is one thing, getting the resources to enact it is another. Access to resources is clearly an important part of creativization, as it is for most other issues of participation and learning. Differential access to resources leads to inequity. Preparatory statements are one way that some students negotiate access to the resources they need.

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34 Schegloff (1980) refers to the work of creating a context for a future conversational turn as “preliminaries.” Such preliminaries might be in the form of a story, a question, an offer, etc.
An interesting difference between the “slanted roof” example and the “radical” wall example involves access to resources. Henry was able to physically implement his idea on the computer. Larry’s implementation was verbal and gestural. He indicated the slant of the longer triangles with his hands. This presentation was similar to Henry’s gestural presentation that didn’t get accepted as “radical.”

Preparatory statements can also serve to provide a way out. Henry’s “you can bulldoze it,” or Tessa’s “Let me try something, okay? The tape will come off, it did before,” make it clear to the others that the suggestion doesn’t have to be permanent. This kind of disclaimer can create an opening for a presentation to be made, and it can also provide a graceful way out of an inadequate presentation.

Another important use of preparatory statements is that they contextualize the presentation in ways that make it more or less likely to be considered creative. The frame structures the way participants understand a presentation. It is possible to shift the frame in ways that will make a presentation potentially more creative by providing different connecting facts\(^\text{35}\) (Barwise & Perry, 1983). One student framed his presentation with “Wait, I’ve got an awesome idea.” Another student in a fifth-grade class was about to present a drawing of a floor plan, and prepared the audience with “Okay, here’s, here’s the tables. We’re looking down at them, right?” The statement served to contextualize his drawing as a “bird’s-eye” view, preparing the participants for how to “attend to” a drawing he was about to make. This can be contrasted with preparatory statements that make a creative evaluation less likely, like “Yes, but it also says that …” referring to a handout. Preparatory statements that reference an outside authority (like the teacher, or, in this case, a worksheet) are less likely to be evaluated as creative. In addition, preparatory statements that reference convention (“I know how it’s supposed to be done…” are also unlikely to be “creative.”

Contextualizing the presentation can make “creativity” more likely when it allows the participant(s) access to resources or it fends off incommensurable understandings of the situation. Contextualizing can make “creativity” more unlikely when it works to gradually shift the frame, so that each presentation looks more like “normal” activity. Structurally, jokes are very similar to “creative” presentations, although they function differently. In some contexts, it might be advantageous to prepare

\(^{35}\) Gumperz (1982) refers to connecting facts as “contextualization cues.”
the audience for the joke, “Can I tell you a joke?” In other contexts, the joke works better when the audience doesn’t expect it to be coming. The same is true for a “creative” presentation.

In any event, the work of contextualizing a presentation may be just as important as the presentation itself. Wenger (1998) writes

Production is not simply the production of output, as in a computer program, but includes both producing the forms of artifacts and producing their meanings in various circumstances. (p. ?) [my italics]

It is precisely these meanings that need to be conveyed through preparation and negotiation with other participants in the activity.

Negotiating a new frame that elicits positive evaluations is more complex than it might look at first glance. Negotiation is often required before (and after) the re-framed event. How the event is contextualized, as well as how it is negotiated afterwards, help the participants come to a shared understanding of the advantages of the new frame.

### 4.1.3.2 Shifting what is “appropriate”

What caused Kyle to react both posturally and verbally to Henry’s “radical” wall, but not to Larry’s presentation in the “slanted roof” episode? Kuhn (1962) distinguishes “revolutionary” science from “normal” science by a breaking from the established scientific paradigm (or frame). What makes the latter interaction, in Kuhn’s sense, “normal”?

I argue that the situation is never re-framed by the participants. The goal is to get triangles that will be the right size to fit over a pentagon or a hexagon. The ideas that Larry has are “good” ideas within the frame. The others in the group are attuned to the same frame and paying attention to the same things at relevant moments. The evidence for this is that the participants understand what the others are saying and doing, they aren’t violating expectations of the other group members, at least in reference to the task, and they are doing work to further clarify the task constraints, like figuring out what the rules are for making a new shape. Larry’s proposal builds on Tessa’s work within the activity frame.

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36 Clearly attentional structures change throughout the interaction—Kyle even starts to make stick-men with his pencils—but when it is relevant to get back to the sanctioned task at hand, all the participants are interacting in a coherent frame.
One of the indicators of a re-framing can be initial confusion from other participants in relation to a presentation within a new interaction frame. In the “radical” wall episode, “crooked” walls were not appropriate in the original frame. When the interaction was re-framed, “crooked” walls became appropriate things to do. The meaning of “crooked” shifted within the new frame. Subsequent references to “crooked” in the interaction were expected to be about diagonal walls. Such a shift is in contrast to confusion in the “slanted roof” episode. Kyle felt that a proposed configuration of shapes would leave a “humongous hole.” The participants were able to clarify the proposal, such that it was clear that there would not be a hole in the roof. This clarification, however, was part of the negotiation of the current frame, rather than a re-framing of the situation. The difference between the two cases is that “crooked” became appropriate given the new frame in the first episode, but a “humongous hole” remained inappropriate in the latter case.

In the example that opened this chapter, Henry presents a fantasy narrative about his group’s construction paper model home to the class. The teacher and other students see this as inappropriate. It is acknowledged as “creative” by the teacher, but she makes it clear that she doesn’t want that style of narrative to become conventional. Since the teacher in this case carries the authority to influence what will become convention and what will not, the subsequent groups do not make such a presentation.

Appropriateness is judged based on the connecting facts one has in relation to the presentation. The following inscription, in and of itself, is not “creative.”

![Figure 4–4 The Parachute](image)
Contextualizing the inscription in different ways plays a role in negotiating its appropriateness. You may have implicitly or explicitly evaluated the picture already. If you knew that my neighbor drew this picture in his attempt to popularize nude skydiving, you might evaluate the picture differently. Depending on your view of the appropriateness of nude skydiving, the presentation could be “creative,” or “interesting,” or “bizarre,” or “inappropriate.” The sketch, however, was not made by my neighbor, but by Leonardo daVinci in the late 16th century. This fact can re-contextualize the artifact based on a set of meanings available to you about DaVinci and about the 16th century. Some readers might conclude that the inscription, or its creator, is “creative,” not because of what they know now about parachutes, but because of what they assume people knew back then about them. They might feel that there probably weren’t parachutes back then, so a drawing of one certainly changed the landscape of what was appropriate to depict. In fact, this is the earliest known depiction of (what became known as) a parachute. They also might consider the inscription “creative” because DaVinci entitled to creativity. “Entitlement” is certainly the result of many social negotiations about what it means to be a work of DaVinci in the communities that value such work.

4.1.3.3 Is every re-frame creative?

No, and not every creative moment involves re-framing. A re-frame represents only one aspect of creativization. In some cases, it is functional to react to the re-frame with an evaluation like “creative” or “radical,” and in some cases it is not. I argue that a re-frame is neither a necessary or sufficient condition for a creative moment to occur, but that it is characteristic of many of these moments that do occur in the classroom.

Many examples of re-framing are simply jokes, and may elicit laughter, or silence, or groans. Since a frame carries with it appropriate and inappropriate behavior, re-framing the situation can often be considered mis-behavior. Similarly, since a frame guides socially acceptable attention, a re-framing of the situation can be interpreted as not paying attention. This was the case when Kyle presented his “stick person.” If an evaluation accompanies a re-framing, it usually depends on a variety of factors, including how the audience was prepared for the re-framing.
Just as it sometimes becomes relevant to judge a re-framed interaction as “creative,” it may also become relevant to use labels like “creative” for other purposes, as well. It may be useful to use the term “creative” to help sell an idea, or as a nice thing to say to a parent about her student at a teacher conference. In a later section of this paper I argue that the label gets attached to people and objects for different reasons.

4.1.4 The model so far

From the previous discussion and other episodes that I have examined I can present a tentative model of creativization in the classroom. The diagram represents the structuring of expectation among the participants.

Figure 4–5 Structuring Expectation

At one level there are the locations in which events happen. They are made up of the participants and artifacts existing at that location. In the classrooms that I have examined, this includes desks, computers, meter sticks, textbooks, and other things. I

37 Gray (???) examined the uses of the word “creative” and found hundreds of businesses in New York City that used that term in their names. Clearly the term has a perceived function in a capitalistic society.
have attempted to show how body positioning in relation to other participants and artifacts plays a role in the structuring of events as in the case above.

Generally students hold many shared assumptions about the nature of the situation. These shared assumptions about the interpretation of a situation maintain what I have called a frame. The frame that guides participation in the interaction also may alter an individual’s view of the situation, allowing him/her to see the situation as something different (Schön, 1983). As long as expectation is not violated, the frame allows a stream of discourse that is understandable when anchored to that situation type. This activity is maintained by, and maintains, the frame. Frames certainly do not determine expectation, but allow it to happen. From the case above it was clear that Henry’s expectation for what could happen was different from the other participants, even though they were able to function as a group. When the “crooked” wall was finally accepted, an assumption about the best wall for that location changed with it, potentially reorganizing the assumptions maintaining further construction of the floor plan.

Interaction frames structure the ways in which participants act in situations. This is accomplished via understanding the type of situation that they are in, namely the general class of situations that have meaning for the individuals (Barwise & Perry, 1983). A situation type carries with it information about conventions (using “crooked” to mean staircased lines), roles (teacher, students, etc.), and tasks (constructing “pwetty” walls in the house). Situation types may change when new information, artifacts, or people (like the teacher) are brought into the current interaction. Expectations arise from these situation types (“crooked” means staircased lines) and structure the way the individual sees the activity. They also structure what may happen next in the interaction.

Here is a “thought experiment” to consider. In physics scientists can create a vacuum which eliminates air pressure from the situation. If we could create a “social vacuum,” (which we cannot), would anything be “creative?” My answer is “no.” Expectations arise from social conventions, as described above. New presentations are implicitly compared to those expectations. Without conventions, nothing is perceived as

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38 Clancey (1997) makes a similar claim, focusing on the activities that occur within situations.
appropriate or inappropriate. It is fundamentally a shift of what is appropriate in a situation that underlies a “creative” event.

Creativization may happen when 1) an unexpected event alters the interpretation of the situation type in such a way that the assumptions and/or resources maintaining the frame are changed, added, or abandoned (This may reorganize, perhaps to the extent that it replaces, the current frame; 2) the new frame is of value to the participants; and 3) the event is recognized and evaluated as “creative,” or “cool,” etc.. The new situation type may become part of the structure of the classroom as a new artifact or conventional practice. In the following sections I will take a closer look at the practices of evaluation, dissemination, and maintenance of the type of events modeled in this model.

### 4.2 Evaluation Practices

We’ve looked at a detailed example of a frame that set the stage for a judgment of creativity. Had the judgment of “radical” and “cool” not been made by the participants, would the re-framing still have been “creative”? I argue that it wouldn’t. Change is occurring all the time as people participate in their everyday lives. Most of the time, the change seems “normal,” or expected. Once in a while, change will be noticed and evaluated. Sometimes, if the change is deemed important enough by the relevant people, the change can even get a label, like “The Industrial Revolution,” for instance. The label reifies the event and provides a way of talking about it, such that it can be maintained and disseminated. When does change get evaluated?

Evaluation is crucial to something’s becoming creative. The example of the “radical” wall illustrates a re-frame that makes relevant a judgment. The case illustrated an event that wasn’t necessarily groundbreaking in the grand scheme of things. It seems like something that happens all the time in classrooms. The fact is, however, that it does not. As I pointed out earlier, most of the events of the classroom are “normal,” using Kuhn’s terminology: a frame is negotiated from social and classroom conventions and the interaction proceeds within that frame. Most ideas in a classroom are “good,” not “radical.”

If it is crucial for creative judgments to be made in order for the event to be considered creative, what practices and conventions (including language) are available
to participants in the event? Different communities have different evaluation practices. Do evaluation practices in the classroom have anything to do with the people whom the culture deems “creative”?

On the one hand, we have “creative” people who have shaped how history is told—Einstein, Mozart, and Gandhi. On the other hand, we have Henry, a seventh-grade student finding a solution to a problem that his peers think is “cool” and “radical.” There is clearly a difference in scale between the events that made Einstein “creative” and the events that made Henry “cool.” Gardner (1993a) refers to the difference as “Big-C” versus “Little-C” creativity. Amabile and Tighe (1993) refer to the difference as “ground-breaking” versus “garden-variety” creativity.

The difference in scale, however, should not be confused with a difference in the fundamental processes of something’s (or someone’s) becoming creative. In this paper I am arguing that the social processes that are at work in the classroom—the way work is framed and presented, defended, judged, maintained or discarded, and conventionalized—are similar social processes to the work it took for Einstein to become “creative.” The judgment of something’s creativity is just that—a judgment. The process of something’s becoming creative is social, and requires a variety of assessment, maintenance, and dissemination practices.

It is worth discussing Weisberg’s (1993) quote again in the context of maintenance and dissemination practices. As you recall, he argued that

If Watt’s steam engine had been ignored by succeeding generations, say because a cheaper and more efficient source of power had been invented shortly thereafter, the invention would surely still qualify as creative, because of its relation to what was then in existence: Watt produced a new kind of engine. The fact that—in this hypothetical example—it was soon surpassed is not relevant to the judgment of its creativity, although under these altered circumstances there would be no encyclopedia entries about Watt and the steam engine. In the same way, if Impressionistic painting had been initially rejected by most critics (which it was) and if it had been ignored by succeeding generations of artists and critics (which is was not), the creativity of the style and its developers would in my opinion be intact, although their positive evaluation would not be. (p. 244)

My argument here is that it is precisely those things—the positive evaluation of critics and the encyclopedia articles, for example—that make Watt and his steam engine “creative.” Creativity that goes “ignored,” in Weisberg’s terms, is not creativity at all.
It is this social dimension of creativity that can lead to inequity, both in the classroom and in our culture. As an example, three psychological books that have case studies of creative people: Weisberg’s (1993) *Creativity: Beyond the myth of genius*, Gardner’s (1993) *Creating Minds*, and Wallace and Gruber’s (1991) *Creative People at Work*. In these books there are 26 men and 4 women studied. That’s 87% male. Also, 29 of the 30 individuals are of European descent (97%). Why? There are many reasons, but I will mention two. Women and minorities have historically been excluded from the kinds of occupations that have been considered important to be written about. A nineteenth century poet is more likely to be called “creative” than a nineteenth century cook. There is a much longer trail of paper about the poet as well by biographers and critics. Additionally, some poet’s works were cherished enough to be maintained and disseminated. The second point, which is related to the first, is that we have an incredibly skewed version of history based on the recorded information available. This has been made clear in recent critiques of the historical record (Battersby, 1989; DeNora & Mehan 1993).

The ideas brought out in the preceding paragraphs are important. The argument is a “strong” version of constructivism (DeNora & Mehan, 1993). An event that doesn’t get noticed as “creative” is not creative at all. A “weak” version of constructivism would suggest that creativity happens all the time, but social processes work to mask some of those moments (like “creative women” historically, for example) and illuminate others. If the evaluation is crucial to the argument, as suggested here, classroom evaluation practices, including language, are an important part of how creativization happens among teachers and students.

What are the assessment practices (like the critic’s evaluation in Weisberg’s example) as well as the maintenance and dissemination practices (like the encyclopedia articles and other artifacts that help a “creative moment” persist) that occur commonly in a middle-school classroom? What windows do teachers, students, and those outside the classroom have to assess something’s creativeness? One crucial piece is a language for talking about it.

4.2.1 **Indicators of creative events: labels and “family resemblance”**

I began the analysis by trying to find cases of creative moments. I watched hours of videotape and selected some candidate cases. I looked for moments where the label
“creative” is evoked in activity, because I wanted the “creative” events to those that the participants in the classroom found to be creative, rather than events that I found to be creative by my criteria. The data that was collected, however, had very few occasions of this. The students have other evaluative labels in their lexicon which are evoked much more frequently in their classroom discourse than those the teacher used. Such student labels included “cool,” “radical,” “awesome,” and “fresh.” There were examples of some of these earlier in the paper. I had several options for making a case that these terms mark “creative” events for the participants. Such options included:

- Showing that terms like “cool” and “radical” in an event serve similar functions as “creative” does in similar events for the participants. I’m not confident that I can make this claim, particularly given the sparse data I have on the students’ use of “creative.”

- Broadening my analysis from “how does an object become creative?” to “how does an object become creative, or cool, or radical, or fresh, etc.?” All these terms are social evaluations. I believe that they are probably different semantically for the participants, however.

- Assuming that there is enough “family resemblance” (Wittgenstein, 1958) among the terms that using them in an analysis would not detract from the claims that I intend to make about creativity. I am making claims about the structure of an objects’ becoming creative. Although an evaluation of “cool” may be semantically different from “creative” for the participants, the structure of an objects becoming cool or creative may be similar.

The third option will suffice if the research community finds the events that I have selected to be reasonable to use in a paper about creativity in the classroom. Researchers approach this paper with a different set of experiences, or connecting facts, with which they understand these terms than the students do. As a means of illustrating that “cool” events are reasonable things to study in a paper about creativity, I will compare their structure to events that elicit the label “creative,”

Like “creative,” labels such as “cool,” “fresh,” and “radical” are clearly polysemic. Additionally, the meanings participants have for them and the reasons for using them are always embedded in a situation, and can only be understood in relation to that situation (Barwise & Perry, 1983). For a term to be used as an indicator of a creative event, it must arise in situations that are structurally similar to those in which

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39 The language of evaluation is different depending on the communities the participants are part of. Becker (1982) found that folk artists and gallery owners each had a different way of talking about, and evaluating, art.
40 I thank Reed Stevens at UC-Berkeley for proposing this alternative.
“creative” arises. It is the relationship between the terms and the situations in which they are used that determines their “family resemblance.” There are clearly some uses of these terms that are not evaluations that I am interested in. I will discuss uses of the term “creative,” and then discuss the structural similarities with other situations in which other evaluative labels are used.

The following episode illustrates two uses of the term “creative.” In one usage, the teacher refers to a group’s presentation as the “creative side” taking over. In the second usage, a girl in the class refers to the performance as “creative writing.” The group has just completed the “design a house for a hot and rainy climate” activity. The groups have been asked by the teacher to present their design, specifically addressing how they met the constraints of the problem, where the house would be located in the world, and the shapes that they used (they are allowed to create one extra shape in addition to the prefabricated geometric shapes that they have been given):

(The group stands to do their presentation. Several groups have already presented. Henry begins.)

Ms. Reese: Nice and loud, so we can hear...

Henry: This is Jack-in-the-Box.

Audience: OKAY

Henry: One of those two managers that killed those kids so-

Audience: Huh?

Henry: You know the Jack-in-the-Box--

Audience: --the tainted meat.

Audience: Food poisoning.

Henry: Yeah. We put food poisoning in it and we decided to take over the world. So we became richer than Richie Rich, so we extended our house. Um, oh yeah, later we ruled the world. (pause) Uh, the only people who lived were our slaves and they got no pay and they bought their own food.

Audience: Let's talk about the house

Ms. Reese: Okay...

Audience: They can't pay for it because you don't give them any money.
Henry: They steal it.

Audience: From who?

Henry: From Jack-in-the-Box

Audience: But you killed everybody...

Ms. Reese: Okay I think, we got kinda--the creative side took over there.

... (End of the period, after the presentations are over. The houses are being collected to be put into a box. Henry’s group’s house becomes the object of discussion.)

Tessa: It looks like a snake

Ms. Reese: I know

Ms. Reese: (to Henry) Where's your instruction... the ah

Henry: Oh, I'll get that.

Kyle: It's [referring to Henry’s group’s design] kinda messed up.

Larry: Wow

Kyle: Is this the big gallery with all the paintings that they stole [referring to part of the model]

Liza: Paintings [ box?]

Ms. Reese: Yes, I think that they got their subjects mixed up I think they thought this was English class.

Tessa: Creative writing. [pause] And they control the weather.

Kyle: You guys control the weather?

Henry: Yup.

Liza: Good-bye...

In this example, the teacher is clearly using the term “creative” in response to the unexpected story that Henry’s group has constructed. Since the story doesn’t further the mathematical goals of the classroom, the teacher uses the term to illustrate that she noticed the difference between this presentation and previous ones, and that she doesn’t want that style to become the norm for presentation practice in the classroom. The evaluation functions as a message to other groups that they shouldn’t give the kind of presentation that Henry just gave. Clearly the students picked up on it also. Kyle, who
was in the audience during the presentation, repeatedly looks from the performer (Henry) to the teacher, apparently trying to gage her reaction. Tessa, in talking with the teacher, also uses the term, in this case “creative writing,” to illustrate that the presentation was noticed as being different from the established frame. She also notes (when addressing the teacher) that it was inappropriate, as this is a math class, and not a writing class. “Appropriateness” is the fit between the presentation and the structures through which the event is experienced.

In another case of the use of the term during an informal interview, a student refers to the design activity as being “more creative,” as opposed to the text book work done previously. The group of students being interviewed called the activities more “hands-on,” “funner,” rather than “boring.” In this case “creative” refers to a general class of events in a classroom, and not to a specific occurrence. Similarly, Ms. Reese introduced Design a Dream Home as a unit where the students would have to be creative. Another student is waiting with others for the printer to print something out. They debate whether the printer is working, and she says it is, it just takes longer because it’s printing in color. She says, “It’s that it’s being creative.” In this case, the fact that the printer is in color and it is taking a long time makes it relevant to the girl to use the term “creative.”

Can we find structurally similar evaluations that do not use the term “creative”? We’ve looked at the following example of the “crooked” wall. The episode ends with the following evaluation:

| 27 Henry: | Let me do one thing alright, if you don't like it you can bulldoze it. Okay? (reaches for the mouse) |
| 28 Kyle:  | Rotate, thank you. |
| (Henry takes the mouse and begins to bulldoze a wall) |
| 29 Dena:  | Your just bulldozing an entire wall. Oh he's gonna make it crooked. |
| 30 Kyle:  | Oh |
| 31 Dena:  | Oh Cool== |
| 32 Kyle:  | ==oh cool. Radical. (spinning his head around) |
In the above case, “radical” and “cool” co-occur and play structurally similar roles. They are both used in relation to the same event, and there is no overt disagreement among the participants, suggesting that “cool” and “radical” have similar meanings for the participants in relation to the event. I also have documented a case of “cool” and “fresh” co-occurring in a similar structure. Additionally, these terms arise in relation to a re-framing (from a design space of rectilinear wall possibilities to a space that includes “crooked” ones), just as “creative” did in the presentation episode above. Clearly crooked walls weren’t expected, and the design move was accepted with the evaluative terms as well as temporary gross postural changes of the participants in relation to the artifact.

On the other hand, there are cases were “cool” is doing other work in the interaction (For example, on some occasions “That’s cool” simply means “okay”). Episodes that have other uses for the terms were excluded from the analysis. Nonetheless, the example above provides evidence that on some occasions evaluative labels are similar in terms of the work they do within situations for middle-school students. It does not, however, provide evidence to suggest that these moments are noticed, appreciated, or documented by teachers interested in “formal” assessments of creativity in their classrooms.

The teacher, Mrs. Reese, in one case interprets the students use of “cool” as an “aesthetic” judgment. In the following interaction, Larry and Henry are designing a “Malcolm X” house; a bird’s-eye view of the house shows that the house was designed from a series of interlocking X’s. As the teacher “grazes” from computer to computer, she comments on the floor plan:

Mrs. Reese: What’s your reasoning? Why did you put the lines through the space like this, rather than just...
Larry: Hmm?
Henry: I don’t know why.

Larry: Why do I like those shapes? (trying to clarify Mrs. Reese’s question)

Mrs. Reese: Yeah, there, what was your reasoning; was there any reasoning or was

Larry: I just liked the shapes. Like one of those “new wave” houses.

Henry: They look cool, okay Mrs. [Reese]?

Mrs. Reese: So it was more aesthetics than any other reason. In this, what would you have, what might be your bedrooms and what might be your workroom. You should start thinking that way.

Henry: [Larry] has. I’m still busy on the toilet.

There is a language for talking about creativity in the classroom. A variety of terms were available to the participants at the time of data collection. Undoubtedly, the labels would have been different in other classrooms or in other school years. The labels reflect, and are integral parts of, the aspects of the community that the kids in the school identify with. The label “fresh,” for example, was an early part of hip-hop culture, common in an urban area such as San Francisco. “Fresh” is less prevalent in today’s hip-hop culture, but other terms, such as “phat,” have evolved to take its place.

4.2.2 The evaluation of creativity

In the design episode of the “radical” wall, the physical proximity of the group members to the wall that was drawn afforded evaluation of the wall. The wall remains in the floor plan, so it is still there to be seen. When this artifact gets used in other ways, however, the wall may no longer be “cool,” for various reasons. First, I have hypothesized that frames are the structures through which an audience sees a presentation. The floor plan, when it moves into the teacher’s hands, may not structure attention in the same way that the partial representation did for the group in the episode above. The teacher may be looking for interesting use of walls, but then again, she may be scanning the image for other features relevant within her frame of perception. The “cool” wall may remain quite latent given what the teacher values, the kind of activity she is accountable for documenting, and the language she has for documenting it.
Second, activity and language that has been conventionalized in the group activity may not be conventionalized for the teacher or other individuals in the classroom, or vice versa. This affects how the presentation will be evaluated. It is because there is conventionalized activity that unconventional re-framings can and do occur. A big toilet used as a swimming pool is only a joke when there are conventions surrounding the size and activity surrounding toilets. Alternatively, if there are no conventions to situate an artifact or activity, interpretation is haphazard and shared assumptions need to be negotiated. The “seeing-as” that potentially gets achieved may be novel and valued by the group, but it may be seen as “normal” activity for someone else. This idea is at the crux of a problem that divides the psychological literature: is something creative only if it has never been done before anywhere, or can it be creative if it is new to the individual? I claim that the fundamental process of evaluation is the same, so the issue isn’t important for the study of creativity in practice.

Third, orientations to a product may have different consequences for creativization than orientations toward the process out of which the artifact emerges (Sawyer, 1995a). Knowing the process can be important for judgments of creativity. As an historical example, Poincaré (in Hadamard, 1944) describes his discovery of a proof of Fuschian functions:

The incidents of the travel made me forget my mathematical work. Having reached Coutances, we entered an omnibus to go to some place or other. At the moment when I put my foot on the step, the idea came to me, without anything in my former thoughts seeming to have paved the way for it, that the transformations that I had used to define the Fuschian functions were identical to those of non-Euclidian geometry. (p. 13)

Such a presentation highlights the “inspirational” nature of the event, while making the work, potentially years before and after that point, less important. Because of what Poincaré has chosen to present about process, his discovery is more likely to be seen as creative. There are other historical examples, like Kelkülé’s seeing the structure of a benzene ring in the smoke of his fireplace, or Archimedes, while getting into a bathtub, discovering that one can measure the volume of an irregular solid by submerging it in water. Becker (1982) has found a similar trend in art: artists who are salaried employees are evaluated less favorably because of the “laborious” process of their work. These

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41 “Inspirational” refers to the term used to describe the creative process by philosophers and scientists such as Plato, Kant, and Freud. It characterizes creativity as intuition.
“inspiration” stories are told to highlight the “magic” of the creative event while downplaying other more important events and interactions. The window that we have on these events has been carefully framed so that we only have certain connecting facts with which to interpret the events. The connecting facts that we have about process helps frame the event as “creative.”

4.2.2.1 Windows for evaluation in the classroom

What windows and evaluation practices do others in the classroom, including the teacher, have into the process that went into the design of the artifact? During the episode above, the teacher was “grazing” through the classroom, and was not watching that group at the time. The group in this instance was not keeping a journal or a logbook of their activity. There was no final presentation in which process could be discussed. Students do walk around the room at times, interacting with other groups. This was clear from Dena’s presentation of the other group’s paper model to Henry and Kyle. The ways in which the process of interaction can be witnessed or documented plays an important role for structuring evaluations of creativity in the classroom.

Crucial to the notion of evaluation windows is the idea of linking artifacts. In the classroom there are typically different roles that have very different flows of activity. Linking artifacts are the physical “stuff” that each role’s activity stream has in common. In Mrs. Reese’s classroom, there was the teacher, a student teacher, and the students themselves. Each participated in the classroom structure in a different way, and their activity afforded different kinds of assessments. The students’ flows of activity varied as well. Some tended to work in their groups, like Larry in the above episode, and some tended to wander from group to group, providing themselves with many windows and opportunities to compare and evaluate other groups’ work.

Linking artifacts are important because they structure attention on particular aspects of the students’ work. Most of the process of Kyle, Dena, and Henry’s floor plan was invisible to the teacher, except for what was preserved through the various

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42 Ueno (???) introduced the concept of “linking documents” in a recent paper, and I am broadening the category to include other artifacts (physical models, for example). In his study of a factory in Japan, he found that activity flows within the factory were different depending on a person’s role. The flow of activity for a manager was typically very different from that of a line worker. Linking documents were the material artifacts that were common to two or more flows of activity. In the factory, a common linking document was a specifications page, called the standard plan, that the customer, the line workers, and the managers all had access to at one point in the process of creating a product. It was what assessments were based on, and it provided the connecting facts (Barwise & Perry, 1983) that each participant used to construct a history of the product that was being produced.
representations available to the students. For example, the students got to tell the story of the floor plan during an oral presentation. They also had to turn in a printout of the plan. The public “telling” of the event and the physical document acted as linking artifacts, in that they were common to both the experience of the group and of the teacher.

These artifacts, however, are representations, and, as such, only contain some information with which interpretations can be made, but they lose a lot of other information. What information does each artifact preserve and what does it lose? The public presentation the group made about the floor plan of their research station was (in my opinion, and based on the behavior of others in the class who listened to two periods of such talks) quite dry. There was no mention of the “crooked” wall; it wasn’t a relevant thing for the group to highlight given the conventions and requirements of the class. Yet, the group could have focused on events like that. They could have created a narrative more like the “inspiration” stories of Poincaré and Kelkulé. They did not. Such stories can occur in the classroom, as you may recall Henry’s elaborate “Jack-in-the-Box” story during another public presentation, which was received as “creative” by both the teacher, and later, another student.43

The floor plan of the research station became the focus of attention both during the presentation and as a piece of the final report handed in by the students. The representation itself contained the “crooked” wall. Henry’s wall, however, was not seen as “radical” or “cool” when it was brought to new audiences that had a different connection to the floor plan than the group creating it. Why? Perhaps for several reasons. First, the attention of the group was on that particular aspect of the design. When the floor plan was brought into other settings, the focus was probably on other aspects of the plan. Second, the group designing the plan judged the new wall in relation to a specific alternative, the straight wall that Kyle had suggested. New audiences interpreting the plan were understanding it in relation to other criteria, most likely their own floor plans, as well as the floor plans of other groups of students that presented before them. Third, an evaluation of the plan was useful socially within the group. It made the point that the suggestion was unique and productive, and that the move

43 The story that Henry told in that instance was not a story about process, like the historical examples, but served the same purpose. They both contextualized artifacts (a model house or a scientific theory) in such a way that interpretations of the artifacts were more likely to be judged as unique in relation to the current state of beliefs and practices.
should remain in their plan. They were then able to use the new configuration of the artifact to make new conjectures about what should happen next. It’s not clear that the audience of the presentation needed to make such a judgment. The teacher did need to make a judgment, and she was primarily focused on the mathematical constraints of the design, as this was a math classroom.

One valuable linking document for many teachers was the final report that was turned in by the students about their Antarctica research station. The document usually contained a narrative of the function of the station, various representations of the floor plan, and the mathematics used by the students. The documents represented a point where informal assessments of creativity could be made formal, or “for the record.” As a formal assessment event, it had a degree of permanence that other, more fleeting representations, did not have.

The way in which students framed their work played a role in how it was received by the teacher. I will compare two fantasy narratives about an Antarctica research station. Both were produced by students in Mrs. Jones classroom, and were made available to me at a teacher workday at the Institute for Research on Learning. The first group of students produced the following narrative44:

As we enter the Antarctic Coast, we approach a site in a small, flat of dry rock. The research station, Antarchitect, measuring 17 by 30 meters, in diameter. What a site to be seen. It will be open for twenty years, and four scientists will live there at a time.

As we enter from the garage, and into the house. Across from us is the laundry room, where we wash 'n dry clothes. 2nd from the laundry room is Osco’s room. And third from the laundry room is JoJo’s room. Our bathrooms’ built inside, into our rooms. Below from JoJo’s room is the Exercise Room, where we work out everyday. Right from the exercise room is the Living Room, where we dine, and eat. Like every normal American family. To the lower left of the living room, is the Kitchen. Where our chef Michaelangelo prepares meals for us every day. And next to the kitchen is the Storeage room, for heaven knows what we store in there. Right of the Kitchen 'n Storage room, and across from the living room, is the hallway leading to the Walk In Freezer. Yes a clever and brilliant design of Group 4. Mysterious, is it? A room purely made of freezer medal, and instalated not by electryc, but by Antarctica itself.

Yes, and now, as we walk up the steps, leaving floor 1, we enter floor 2. Our big Work Space to the upper left. Where we study, everyday, just like our teachers use to force us to, back in the old days of school. The dead 90’s. Right the Work Space is Tony’s Room. Not very important, indeed.

44 Spelling and grammar are as in the student work.
At first he didn’t mind sleeping on the couch. But there came a time in his life when Tony, wanted a room of his own. And right from Tony’s room is the Big Bathroom. Where you get to use the John, everyday. ‘Cause when you gotta go, you gotta go. You gotta do the dew. You know what I mean. And as we continue our tour, below from Little Tony’s room is the Electric Storage room. When we store our computers, and other electronic software.

Our tour continues, and just as we walk up the steps leaving floor 2, we approach floor 3, the Hobbie and Activity Center. Just like at Home sweet Home. All the lushest fun and games you could ever imagine, along with Mike uncleaned, and never before scrubbed toilet, in the bathroom. Just sort of Boys being Boys, kind of thing. You know what I mean. Now ain’t life grad. And now as we continue on our tour, to the lower middle is the Shop n’ Hair Cut Room. Where barber Antony, is always pleased to give us a shave, and haircut. And across from the Shop n’ Hair Cut Room, to left; Paint Ball Maze, to the right; Rifle Range. ‘Cause everyone’s gotta have a hobbie. We’re just boys being boys. And these are our toys. Big toys that do lots of cool stuff, and make really neat sounds. Hey, Mrs. [Jones], let it be, after all, Mike’s got a permit. Above the Paint Ball Maze, Mike’s dirty room. Right from Mike’s dirty room, Mike’s Dirty Bathroom, and his never before scrubbed sink. Right from the bathroom is the storage room. For storing Paint Ball and Rifle equipment, in cabinets. And as we end our tour, sad to say, there is no Exit door, on this floor. So we have no choice but to throw you out the window. Happy Trails, up above you from three stories high, we want you good bye. Man, this is our place, no one visits and comes back alive, from the Reasearch Station, Antararchitect. BEWARE!

The narrative, in and of itself, of course, is not creative. It clearly was stylistically different from most other final reports that the teacher evaluated. The teacher’s “for the record” evaluation of the presentation was the following:

Very entertaining—however—I did not get convinced that a rifle range, paint ball maze, barber shop, etc. are necessary to add to the high building cost. These could have been omitted.

The evaluation was “entertaining,” although aspects of it weren’t reasonable given the evaluation criteria that the teacher was using. The teacher “did not get convinced” that the luxury items in the narrative were necessary. The ability to “convince” an audience that something is creative is an important part of a creative moment. As an example, I will compare the narrative with a second one. In the second case, the teacher was “convinced.” She wrote “Very well done! A lawyer might not be a bad idea.” The group’s narrative is on the same subject as the previous one, and also included rooms beyond the “typical” ones mentioned by the reports:
When you walk in the front door, to your right is a small desk for 2 computers and a microscope set-up. Proceeding to your left and through a single door is the kitchen. By going straight ahead, are 2 bigger work stations for all members of the household. As you continue to walk through the house to your right, is bathroom #1. Against that far wall and a little to the left is a door leading you to the living room / dinning room. To the left of the dinning room is a dinning room table, 4 chairs and to the right is a couch and a television. Down the hall, to the right, is the bedroom #1 occupied by Joe and Tony. By proceeding back up the hallway on the left is our storage room with a walk-in freezer cabinet. By going back down the hallway pass the television through a door leading to bathroom #2 and up the hallway and around the corner is bedroom #2 occupied by Qiana and Philip. By going back down the hallway, through the door, pass the living and dinning room is a stair case leading to the 2\textsuperscript{nd} floor.

Up the stairs to the right and through a door, will be the pool room and on the other side of this room is a door leading to the basketball courts and at the end of the courts will be another door leading to another hallway. Across this hallway is a gym to workout and lift weights and there are showers on the side of the gym. On the right side of the gym is a door leading to the tanning room. As we proceed to the door of the tanning room you will be in the hallway beside the stairs. As we go up the stairs we will arrive at the 3\textsuperscript{rd} floor.

To the right and down the hall is the laundry room. Out of the laundry room and to the left is the arcade room. Proceeding back out the double doors and down the hallway, you will arrive at the indoor race track.

And that’s our home.

Unlike the previous group, this group didn’t stop here. They added a separate page to their report providing a justification for rooms that weren’t necessary.

The reason we built the pool room was for Qiana. She likes to swim every chance she gets even in the winter time. Qiana is on a swim team and that is her way of obtaining daily exercise. She will be in Antarctica for 2 years, and really won’t be able to exercise on the outside. This is Qiana’s way of keeping in shape.

The gym and basketball rooms were build for the guys to workout and play ball. These rooms will allow the guys to work out any frustration they have and keep their bodies in shape. The basketball room will help them from being homesick. 6 months of the year the weather is below 0, it will still allow them to continue their daily activities before and after.

The arcade is really not necessary for our stay but we see this as another way of passing some of our time since we will be there for two years doing research. The arcades is another form of relaxation and it helps us to ease the tension of a rough day. There are some games that will allow us to compete with one another. We feel this is good for the soul.
The tanning room is necessary because in the Antarctica there is only 6 months of daylight out of the year. The tanning room would be used by all of us only during the 6 months of darkness. This will allow us to keep our skin tones even due to the dry, cold weather. It would also allow us to continue to feel the California rays.

The race track is used for us animal lovers. We would be able to pet the horses and also ride them. This would allow us to keep in touch with the animal life and care for it. This is a form of excising our bodies and mind. It will give us a opportunity to bond together and the race track is something we all have in common.

I argue that such work provides contextualization for others to understand the narrative in the same way the group understood it as they were designing the house. The floor plan itself leaves out much of the process that went into creating it. The narrative captures different aspects of the process and provides more context for understanding the plan. This group went one more step, providing the teacher with information necessary for showing how the “unnecessary” aspects of the design, are, in fact, necessary. Or, to say that another way, what may be interpreted by the teacher as inappropriate, as she did in the first example, can be contextualized and made appropriate. This negotiation is a crucial piece of getting something noticed as creative rather than wrong. The information that the group in the first example used, “just boys being boys,” was not enough to convince the teacher that the rooms were appropriate.

### 4.2.2.2 Evaluation and Intention

Another important aspect of how a presentation gets evaluated is based on the perceived intentions of the participants doing the presenting. Harrison (1978) refers to the difference between making sandcastles and playing in the sand. He provides a potential counter-argument that he finds unsatisfactory:

> On the whole it does seem reasonably clear that simply to rearrange a heap of stones or bricks into a slightly differently ordered pile is merely to alter the configuration of the pile. This could conceivably prompt some intellectual puritan to maintain that the building walls or houses was then equally “merely” altering one heap or pile of material found in the builder’s yard into another of a different configuration on the building site. Hence, he might conclude, if one knocks over a wall so that the stones are once again a heap of rubble, one has “made” something, the heap, in just as full a sense as if one had “made” a wall out of a pile of stones. And that full sense is of course, a pretty empty one. (Harrison, 1978, p. 16) [Harrison’s italics]
The difference, I will claim, between the heap of bricks and the building wall is that socially, a building wall is usually seen as intended, the heap of bricks is usually not.

Perceived intention of the participants can be the difference between being “creative” and being a troublemaker. In a first grade class I watched a child with a paper plate he was using for an art project. He through it up in the air, exclaiming, “It’s a bird!” Then he pushed it along the floor and said, “It’s a turtle!” The teacher in the room asked him to settle down and temporarily took his project away from him. Similar behavior merits high marks for creativity on some assessments of creativity for children (e.g. Wallach & Kogan, 1965).

Perceived intention can also be the difference between being “creative” and being “lucky.” When a presentation is made and is clearly intended, it is more likely to be called “creative” than if it was perceived to be unintended (accidental). Historically, Alexander Fleming potentially lost some of his perceived “creativity” because the “origin myth” of his discovery of penicillin makes the occurrence seem quite accidental.

We have seen that teachers, as well as the NCTM standards and industry, value creativity. As teachers and curriculum developers we are working to find assessments that can capture the moments that often get missed by more traditional assessments. Direct observation of groups, journals, and design reviews are ways that we can create more windows for teachers and other students to attend to, and interpret, the activities of students in the class. Judgments of creativity rely on these windows, coupled with the language and practices of evaluation in the classroom, for creativization to occur in the classroom.

### 4.3 Maintenance and Dissemination Practices

How does the class organize to preserve some of the work done before? When something does get judged as creative, there are two major processes by which others can become attuned to that fact. One can be acquainted with the event, or one can have access to someone’s description of the event. To illustrate these, I will use the example of Einstein as a “creative” scientist. A theoretical physicist who reads Einstein’s theory for the first time may become attuned to information in such a way that she re-frames

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45 Following McDermott and Webber (1998).
46 Design reviews are often a part of adult design practice, such as architecture studios (Schön, 1983).
47 “Acquaintance” and “Description” are categories taken from the work of Bertrand Russell.
her notion of how the world works. In light of this, she might find the label “creative” relevant in relation to Einstein. She is acquainted with Einstein’s “creativity.” Another person, however, can come to know Einstein as “creative” not because he re-framed anything for that person, but because textbooks, encyclopedias, television, and other media in the culture have labeled him creative (or, because there is a large picture of him hanging on the wall of the classroom, as was the case in Mrs. Reese’s classroom\(^48\)).

![Figure 4–6 Mrs. Reese and Einstein](image)

Thus, that person became attuned to the understanding of Einstein as “creative” in a completely different way than the theoretical physicist did. The person is attuned to the fact that other people have described him as creative. Acquaintance is evaluation embedded within the re-framing episode; description relies on representational practices that maintain and disseminate that evaluation to different audiences.

Whether inside or outside the classroom, moments that become “creative” can be fleeting or can be maintained for centuries. What are the features of practices that make a difference in the classroom? I will suggest four possibilities:

- Inscription,

\(^{48}\) The poster, in and of itself, does not disseminate the label “creative” or “genius” in relation to Einstein, but it carries with it a language and cultural meanings that help maintain Einstein’s creativity.
• Modeling,
• Stories, and
• Events and exhibitions.

I will describe common practice in the classroom that involves each of vehicles of dissemination. At the conclusion of the discussion I will abstract the important features that help reify creativity in the classroom.

4.3.1 Inscription

Clearly practices in which people draw or write can help to reify a “creative” moment’s place in the history of a group. Practices that maintain and disseminate “macro-level” creativity include newspapers, magazines, books, and more recently the internet.

Inside the classroom students write in journals, do worksheets, create overheads for public presentations, write notes to each other and pass them under the table, create final reports, and create other inscriptions that can disseminate a “creative” judgment. Schools and classrooms are now using the World Wide Web more often. Many of the recordings are informal. Others, such as the teacher’s grade book, are not.

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49 “Group” here can mean something as small as Kyle, Dena, and Henry, or as large as the audience of people who have become attuned to “creative” in relation to Einstein and the work attributed to Einstein.
In the classroom inscriptions marked important points in the students’ flow of activity. Electronic inscriptions, such as the floor plans of the research station, became physical documents when the group was sufficiently satisfied. Printing the document often marked the point when the floor plan was no longer going to change. The printed document, then, afforded other representational activity. Many students marked up their printouts—labeling rooms and adding information that the computer could not do. These marked up printouts were then transferred to overheads, a form that could allow the entire class to view it.

Different types of inscriptions carry with them different information relevant to the evaluation of creativity. Consider this example, in which a group of students are working on re-designing their classroom. One of the problems that they have found access to overhead machine presentations—not everyone can always see. They propose designing an overhead that projects onto all four walls of the classroom:

Ralph: Like here, look, look. (leans in and begins to draw)

Melissa: That’d be neat if we had, OK. (to Mark) If we had like a tall thing in the middle of the room (hands make a column upwards)
Melissa makes a good point in her final turn in this episode: a drawing affords interpretations that may not be the same as a representation in “words.” How does the group get a “cool” idea in a form that others, such as the teacher, can experience as “cool”? Creativization involves finding the best representations to carry information about appropriateness to other audiences.

4.3.2 Modeling

Models were another way that creativity was maintained and disseminated in Mrs. Reese’s classroom. Outside of the classroom models are created for many reasons; for example, architects use 3-d models to sell their ideas to clients and scientists use models to make features of their theories relevant to the scientific community.

The models in Mrs. Reese’s classroom afforded the embedding of different kinds of information than inscriptions did. They were constructed, displayed, and passed around the room. The provided something for groups to tell stories about, describe, and assess. The models that I focused on were the construction paper homes for a hot and rainy climate that each group constructed (see Appendix C, p. 175).

The same group that was designing the “slanted” roof was now nearing completion of the task. The physical properties of the model afforded various ways of looking at it that a paper floor plan would not have. The paper floor plans afforded talk about the function of internal space—what rooms should go where and whether or not the rooms were big enough. The paper model, on the other hand, afforded talk about the
external structure of the building. Since it was three dimensional, the group could “run” various simulations on it:

Kyle: I know what we could do to test it...

Larry: You guy's it's crooked

Kyle: it doesn't matter if it is crooked, Larry

Tessa: it's not perfect it's not gonna be perfect

Kyle: But if you if we really made this, it wouldn't be crooked, this is paper Larry, what do you expect?

Larry: Okay, well, something's wrong with this design

Tessa: how are we supposed to hold the ceiling up with a bui building like that?

Kyle: You could==

Larry: ==you could add a you could add little things here (using a gesture to indicate something vertical)

Tessa: a big pole? ==what if somebody chopped thought it was a

Kyle: ==But you know how they make arch, you know how they make arches and there's a keystone right in the middle, right. It could be like that.

Tessa: there could be like a bar inside going like this holding this part up ==so it could support itself

Kyle: ==yeh. somehow it needs to be reinforced. There would be a big... The test to see if the rain'll ah if the rain'll come through when it drips through here, like that, it just sprinkle some water on it.

Tessa: Yeh but==

Larry: ==The rain's coming in this direction though (indicating a slant towards the gap in the structure) 'cause you know how rain comes at an angle, it'll go shhhhhhh ==right into the house

Kyle: ==yeh, oh yeh, unless we put a ==skylight there

Tessa: == a WINdow

Kyle: Be a window
Kyle suggests “sprinkling some water” on the model to see if the rain could get in. The group also was engaged in talk which linked the model more closely to the building it was modeling. They were exploring the structural implications of the design, using narrative to reinterpret features of the design; for example, the “gap” in the model is an arch or a curved window.

Models also afforded being viewed by multiple audiences. When groups were working alone or on worksheets, as we shall see in Chapter 5, there wasn’t much interaction across groups of students. The size and mobility of the models gave other groups windows for evaluating it. In this interaction, the group could see Laura’s model from across the room:

Tessa: Look at Laura's (pointing)
Kyle: Oooo, [?]
Larry: Oh, coolness.
Kyle: Ours sucks.
Larry: I know. Ours sucks.

Here is another instance:

Tessa: (looking over at the model that Melissa is adding to) Oh that looks so fresh.

The size of the model in relation to the size and layout of the room afforded windows of evaluation that would have been unavailable with different media. 50 This allowed a wider classroom audience the opportunity to make classroom events “cool” or “fresh.”

Models also provided a vehicle of dissemination beyond the walls of the classroom. Several teachers gave the 3-d models that their students had built to IRL,

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50 Becker (1982) found that there were size considerations for a piece of art to get recognized. It generally had to be big enough that a small group of people could stand around it in a gallery, but not so big that it didn’t fit in with the other works of art. If it didn’t meet these criteria, galleries often wouldn’t show the work.
where they were shown to audiences of teachers and curriculum developers. These individuals seemed to enjoy the detail that students put into them—like miniature book shelves filled with small books the students had created.

4.3.3 Stories

Stories are another way that creative evaluations can be disseminated. Teachers often tell stories about “creative” things students did in their class. During an event at IRL, one teacher told a story of a student who had invented math terms that made more sense than the conventional ones. Historically, stories also help maintain and disseminate creativity. Stories abound, such as the ones mentioned earlier. Archimedes discovered that one could figure out the mass of an irregular solid by measuring water displacement. One can imagine that this story was told before it was written down, and it still gets told today.

Stories are important in the classroom because, in practice, creative moments generally don’t last very long. They are often limited by the constraints of occurring in a school. Often in school work is forgotten about at the end of the school year in preparation for the next school year (if not sooner). Art on the walls is taken down, student work is thrown away, and students return to different classrooms with different teachers. Only the stories tend to remain.

Research on “teacher lounge” conversation suggests that stories are an important part of teacher interaction (references?). Students also tell stories. A story about Tessa’s cruise elicited the labels “cool” and “fresh” in relation to the Murphy beds on the cruise ship.

4.3.4 Formal events and exhibitions

Events and exhibitions bring student work to a wider audience. Students give a final, formal presentation. Teachers put student work on the walls to prepare for open house. Students put in last minute work to prepare for a multimedia exhibition of their floor plan. A high school in Los Angeles invites the public to see student work, just as an art gallery would.

Such events serve two important purposes for creativization. The obvious one is audience. They serve as ways of taking a local presentation and bringing it to successively wider audiences. The second purpose is as crucial—the students need to
move from “presentations” to “presentable forms” (Becker, 1982). Presentable forms in art “signal, in a conventional way, that you want your work taken seriously, counted up in the balance of your reputation…” (Becker, 1982, p. 237) Events and exhibitions signal a similar thing. Students often must find the best way to situate what they’ve done for new audiences. They work to find stories to tell and connecting facts to present, so that others see their work as worthy and appropriate.\textsuperscript{51} This is crucial for others to evaluate their work as “creative.”

Another aspect of such events is that they can draw the attention of others, furthering the dissemination avenues of the work. A local newspaper recently did a story on the “Whizzes of tomorrow,”\textsuperscript{52} documenting the best of a math and science fair. Another local paper disseminated an article about a school’s multimedia fair. This attention is not common, but is important for work to become “creative” for wider audiences.

4.3.5 The reification of creativity

Earlier in this paper I made an analogical comparison of creativity to gravity. The point was that creativity, like gravity, is essentially a relationship, and is vacuous in and of itself. Yet there are ways gravity is made to be real. Use of the word “gravity” itself is one way. Another might be a formula. A third might be a physical law. A physicist might draw a diagram with a line representing the force in between two objects. Each of these representations reify the concept of gravity. What are the features of inscriptions, models, stories, and exhibitions that can reify creativity in the classroom? I will argue that together these maintenance and dissemination practices have the features of permanence, mobility, accessibility, and accountability. I will briefly discuss each of these features.

\textsuperscript{51} The “inspiration” stories alluded to earlier can be thought of as “presentable forms.” They are packaged to elicit a certain kind of public evaluation.

\textsuperscript{52} San Jose Mercury News, April 1, 1999, p. 1B.
Table 4-1 Features of Dissemination Vehicles

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Most of the interaction that occurs in the classroom is fleeting. Aspects of it, however, can be maintained. It is this opportunity for permanence that is one feature of maintenance and dissemination mechanisms in the classroom. Inscriptions and models certainly have this feature. Stories can have this feature as well. Oral traditions depend on it.

Mobility refers to the ease in which the creative object, person, or evaluation label can be moved around into new contexts. The mobile nature of inscription, models, and stories enable them to be handed off and redisplayed in other contexts of activity. The mobility of the models also afforded viewing them from multiple vantage points; in effect, there was more to see.

Accessibility refers to the representation as a “linking document.” Given the flows of activities that individuals coordinate together in (and out of) the classroom, who gets access to what opportunities for a creative moment to occur? Traditional classroom work usually doesn’t leave the loop between the teacher and student. In some cases, other students may enter the loop as well. This may be informal, or structured as a peer review. Parents might be brought into the loop if the work goes home. In the case of an exhibition, many different people are brought into the loop. The student, the teacher, the school principle, as well as the maintenance person who arranges the gym so that the event can happen potentially have access to the work. Parents and business people from the community, who are generally the “target” audience, have access to the
work. If a newspaper covers the event it and shows a picture of a “creative” work, even more people are given access to the event.\(^3\)

Part of the culture of schools in this country is accountability. Because of the difficulties in capturing everything that goes on, assessments have been constructed which are easy to collect, compare, and grade. The fleeting nature of activity has always been a thorny problem for performance based assessments in the classroom. As is the case for classroom assessment, inscriptions and other physical representations provide a way that informal assessment of creativity can become “formal.” A teacher might jot a note in her grade book, or check off a particular math assessment standard related to creativity. These inscriptions provides a base of evidence, for better or for worse, that the teacher can use to make assessments of a student that may become part of the “permanent record” of the student.

### 4.4 Summary

I have shown examples of the kinds of events inside the classroom I consider to be “creative” events. I have illuminated the kinds of “creative” moments that I am focusing on, as well as the indicators that I use to determine these events. I have chosen “re-framing” episodes for three reasons. First, they seem to best exemplify the common sense view of what creativity is. Second, they are common in a math classroom, although explicit evaluation of them is less frequent. Finally, “successful” re-framings have relevant implications for the mathematics classroom. Any successful re-framing can be thought of as a learning event, in that the actors have seen the situation as something new, in effect opening up new opportunities for participation within that activity. This learning can become long term if the new practice is conventionalized into the regular practices of the classroom. In the discussion which follows I will provide more specific analysis on the dimensions that structure frames in the classroom, the process of re-framing, and the structure of evaluations within that event.

A re-framing can become evaluated as “creative.” I have illustrated that there are a variety of terms that are structurally similar to “creative” in interaction. These terms are specific to different communities and evolve over time.

\(^3\) Accessibility in creativization relies on the relationship between the creation and the community who’s accessing it. Most “works of art” don’t necessarily travel well outside of a very particular community of people.
Inscriptions, models, stories, and formal events all have features that help reify creativity—packaging it so that it can be moved into new contexts and new communities. The dissemination vehicles can be manipulated by clever kids and adults, because they never carry all of the information, only some aspects of it. Those aspects that are emphasized and those that are not can contextualize an event such that it is more or less likely to be creative. Those evaluations have the potential to move to wider audiences who will be viewing the event through a different lens. Often, in order for the event to remain “creative” in relation to this new audience, the ways of contextualizing the event change as well.
I have discussed how some common structures of creative moments emerge in the classroom, as well as the practices that maintain and disseminate the label in relation to the event. Several dimensions of creative events emerge from the previous discussion. In this chapter I will focus on how the dimensions that underlie creativization relate to three interaction structures that were common in Mrs. Reese’s classroom: design, worksheet, and formal presentation structures.

I will discuss the dimensions of classroom practice relevant for creativization based on the analysis in chapter 4. I will use these dimensions as a way to frame an investigation of the relationship between common classroom structures and creativity. I will examine two design environments, one from MMAP’s *The Antarctica Project* and one from EDC’s *Designing Spaces for People*. I also will examine an episode in which students are working together to answer a series of questions about Antarctica, some of which require mathematical solutions. Finally, I will analyze a presentation session from *The Antarctica Project*.

5.1 Dimensions of Classroom Practice Relevant to Creativity

From my data analysis inside and outside of Mrs. Reese’s classroom, I have found relevant dimensions of student work related to 1) the tasks that they are engaged in, 2) the process of constructing a presentation, and 3) the structure of the presentations
themselves. The table below summarizes the dimensions I will discuss. These dimensions are, for the most part, interdependent. I will talk about each out of context here. The data in the next section will illustrate some of the relationships among the dimensions.

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Table 5-1 Dimensions of Participation Structures

5.1.1 Features of the task

Obviously, the activity that the students are working on structure different kinds of work. The participants in the interaction work to negotiate goals, define and refine problems, and work toward solutions. These activities are situated among constraints that that group itself has generated, that the teacher asks of them, and that the physical environment places on them. Several properties of this task environment are important for creativization.

5.1.1.1 Importance

The importance of the task being worked on changes the way in which a presentation will be judged in the classroom. “Importance” of a task is socially constructed and varies across contexts and classrooms. Historically, poets, musicians,

54 Unlike traditional cognitive accounts of the task environment, end-states are not known in advance, operators are socially negotiated among the participants, and resources for doing the work may come and go. Cognitive theories focus on problems and solutions. My analysis has shown that presentations that are judged to be “creative” can sometimes be solutions to problems, but they are not always. “Solutions” are a special case of a wide range of “creative” presentations.
and artists have worked on more “important” tasks than cooks or street cleaners, at least in terms of what has been constructed to be “creative” work.

Presentations that are socially “important” are more likely to become reified, and therefore persist. Some important presentations may become convention in the classroom. This certainly is not very common in classrooms. We get a better understanding of why it does occur we must ask “important for what?” Many tasks in the classroom are important to get a good grade or to learn something that might be relevant in the future. Often such tasks are important in ways that are too remote, or even alienating, for students. Tasks that have importance for students are those that they can identify with; those that are perceived by the students as affording them the chance to align themselves with the communities that they wish to be a part (Wenger, 1998).

Another feature of “importance” is whether finding a resolution of the task is required to move on to another stage of the activity. Problems that arise out of embedded activity take on greater importance than those that are imposed on the students (Bushéy, 1997). Presenting solutions to such problems are more likely to get a noticed, evaluated, and perhaps disseminated to other groups working on the same task.

5.1.1.2 **Negotiability**

Another relevant feature of the task environment is the negotiability of the constraints. Participants often refer to constraints of the task when making judgments of appropriateness. Some of these constraints are imposed by the worksheet, the teacher, or by the resources available to the students. Other constraints, however, are evolve socially as the group engages in the task. Each decision that gets made can create a new set of constraints that the group must grapple with.

Negotiable constraints are important for creativization for two very different reasons. The first reason is that the more constrained or convention-driven (routine) the task, the more likely that presentations will be expected, or wrong. The more

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55 Newell and his colleagues (Newell et. al., 1962; Newell & Simon, 1972) refer to problems with negotiable constraints as “ill-defined,” and those that have a limited and pre-specified set of operators for engaging the task as “well-defined.” Very few problems that arise outside of the laboratory are “well-defined,” but the constraints on them can be more or less negotiable. Traditional tasks in schools have tended to have little room for negotiation, but more “reform-oriented” project-based tasks are often highly negotiated among the students and the teacher.
unconstrained, the more opportunities there are to negotiate different sets of constraints, which leads to a wider variety of “appropriate” presentations within and across groups in the classroom.

There is a second reason that negotiable constraints are important. “Mavericks,” in Becker’s (1984) terms, often play with constraints that were not previously thought to be negotiable. In the classroom, this sort of activity is likely to get students in trouble, but it can lead to “creative” assessments as well, particularly from other students.

5.1.2 Features of the process

The “task” referred to the space of appropriate actions available to be adopted or constructed by the participants. The “process” dimensions here refer to the ways that the tasks get accomplished. I’ve identified four dimensions of that characterize the activity process in the classroom, and that are related to the creativization. There are the three R’s—resources, reflexivity, and re-representability—as well as “convention,” the paradoxical dimension. Each of the three R’s are ways that make new interpretations of a situation possible. Convention is a necessary part of the process, because it is in relation to convention that new interpretations of situations are noticed and evaluated.

5.1.2.1 Resources

Resources, broadly speaking, are anything available to the participants for accomplishing a task. Resources can be tools, such as calculators and pencils, authorities, such as the teacher and the textbook, or even language. It’s important to note, however, that resources only become resources when the participants are attuned to the affordances it provides or furnishes (Gibson, 1986).

Access to a variety of different resources can make “creative” presentations more likely. Different resources afford different opportunities for participation in an activity. These resources can be used to make, justify, evaluate, or disseminate a presentation. All of these processes are important for making a trajectory of participation an appropriate direction for the interaction to go.
5.1.2.2 Reflexivity

When an activity is “reflexive,” any given state of the activity retains information about what came before it and provides information about what to do next. Reflexivity is the characteristic of the activity that gives the participants opportunities to be reflective (Schön, 1983; Bamberger & Schön, 1983).

Reflexivity is important in a conversation about creativization for a number of reasons. First of all, each change in the state of the activity changes the resources available for interpreting the situation. If the situation can be “seen-as” something else, a new set of appropriate inferences can be made and actions can be taken. Also, each change in the state of a reflexive activity potentially make new, relevant questions emerge. New questions which are authentically related to activity have more potential to be “picked up” and negotiated by the participants. There are ways to preserve different states in a reflexive environment, which affords comparison. When a group prints a floor plan and then makes changes to the electronic version on the computer, the current version can, and often does, get compared with the previous version. This comparison is another way of generating new inferences from the resources available in the situation.

5.1.2.3 Re-representability

Some of the work in the classroom was represented in a variety of different ways by the students. Floor plans were created on the computer, printed, and presented. The groups coordinated these artifacts with gestures, narratives, and inscriptions. Each of these were ways that the research station was being represented. Representations, by nature, highlight some aspects of the “represented” and downplay others. Thus having multiple representations of the same phenomenon affords a wide range of different opportunities for interpreting and expanding the presentations within the activity.

Traditionally, use of analogy or generative metaphor (Schön, 1990) has been thought of as being important aspects of creative thinking. I also have found it to be important, but for different, less cognitive, reasons. An analogy or a metaphor is a way

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56 As previously noted, Bushéy (1997) has found this to be true in design activities in the classroom. Kuhn (1962) also found this to be true in a discussion of the sociology of science.

57 “Authentic” is a term used in many different ways in relation to math teaching and assessment. What I mean by it is that the problems have not been imposed, by the teacher for instance, but come up in the course of activity.
that participants re-represent the situation and come to shared understandings of the situation. This idea can perhaps be best expressed with an example of the group working on the construction paper house:

<table>
<thead>
<tr>
<th>Turn</th>
<th>Participant</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Larry:</td>
</tr>
<tr>
<td>02</td>
<td>Tessa:</td>
</tr>
<tr>
<td>03</td>
<td>Larry:</td>
</tr>
<tr>
<td>04</td>
<td>Tessa:</td>
</tr>
<tr>
<td>05</td>
<td>Liza:</td>
</tr>
<tr>
<td>06</td>
<td>Kyle:</td>
</tr>
<tr>
<td>07</td>
<td>Tessa:</td>
</tr>
<tr>
<td>08</td>
<td>Larry:</td>
</tr>
<tr>
<td>09</td>
<td>Tessa:</td>
</tr>
<tr>
<td>10</td>
<td>Larry:</td>
</tr>
<tr>
<td>11</td>
<td>Tessa:</td>
</tr>
</tbody>
</table>

Tessa metaphorically relates the group’s model with a Neiman Marcus department store in turn 02. This representation affords Larry’s comment about escalators in turn 03. This exchange frames the interpretation of the model as having two stories, and Larry in turn 08 suggests a having a loft.

Metaphor and analogy, then, serve the social function of construction a shared vision of the activity. Since the members of the group have all had some sort of experience with the “big giant Christmas tree” at Neiman Marcus, Tessa uses the metaphor to make the way she is viewing the model available to everyone. This creates a coherent frame the group can work from, which makes new opportunities, such as the loft, possible.
5.1.2.4 Convention

Convention is another important part of the process. “Conventional” work is not usually labeled as “creative,” but “creative” work is judged in relation to convention. “Convention” consists of the constraints inherent in the task. These can be social constraints (routines) or physical constraints (we can’t actually build a house in the classroom, but we can build a model of one…). Convention is also built into the resources that the students use to make presentations. The more routine the activity, the more likely a presentation which changes the routine will be noticed. A shift from routine can create an anomaly with which the participants must deal.

Theories which claim that anomaly tends to get noticed can be found at both the cognitive and sociological levels of analysis. Schank’s (1982) theory of dynamic memory is built on the idea that humans remember stories because they are in some way anomalous with conventionalized routines of activity (scripts). Kuhn (1962) has found that science progresses in the face of anomalous data. Routines and paradigms in science, however, tend to make most data consistent with current ways of thinking, which drives “normal,” rather than “revolutionary,” science.

In my version of the story, anomaly isn’t necessarily part of the cognitive structures of the individuals, or part of the sociological structures of a field, but rather part of the process of coherent interaction among participants in an activity. Coherent action is guided by convention and routines, but participants are well equipped to socially negotiate new meanings in the face of apparent incoherence within an interaction. It is in these moments that “creativity” often happens.

5.1.3 Features of a presentation

In this section I will examine the final three dimensions relevant for creativization. Each of the dimensions I will discuss are features of the presentation, which may be a solution to a problem, a story, a “formal” presentation, or a drawing. “Presentation” refers to anything that is made available for others to respond to. As mentioned before, presentations occur all the time. Presentations, as defined here, are an inherent part of interaction. They can take on different characteristics, however. They can differ in the degree in which the participants identify with it, and the degree in which other
participants have access to it. I will discuss ownership, potential for evaluation, and potential for dissemination of the presentation.

5.1.3.1 Ownership

Ownership is defined by Wenger (1998) as having a role in the production of meaning of the artifact being created. It is about producing meanings rather than adopting them. Why is this important for creativization? There is the obvious reason that producing anything is more likely to be noticed as “creative” than adopting something. But there are more important issues surrounding ownership that structure interaction in ways that presentations are more or less likely to be considered “creative.”

The negotiation of “adopted” presentations looks different in interaction than those of “produced” presentations. The group that was grappling with the “slanted roof” worked to negotiate some of the constraints of the task:

| 42 Larry: | NO sss. We should make one KIND of extra shape. It doesn't matter how many you make. Look, read it. (points to task sheet) It says, ==that you can make one extra shape. |
| 43 Tessa: | ==Yeh, I already read that. |
| 44 Larry: | And you can make... as many as you WANT TO of that shape. Ok? |
| 45 Liza:  | Can you? |
| 46 Kyle:  | Oh, oh, yeh yeh, that's what it says. Says you can cut out as many ==as you, yeh. |

Henry’s idea adopted a solution which was sanctioned by the “rules” of the activity. The sanctioned authority in the classroom presumably is the teacher and the curriculum. In this case the curriculum laid down the rules. It is quite possible that “radical” moments happen in spite of authority, or perhaps even in opposition to it. Larry may not have had ownership of his longer triangles—the idea was part of the established, and in this case authorized, frame.

In the following example the same group co-constructs a new rule with the teacher’s approval. Up to this point, there has not been a rule, made either by the teacher or the curriculum, regarding the bending or folding of the pieces. The group has
negotiated a presentation which involves doing just that. They still check with the teacher, but the constraint was “produced” by them. It leads to an evaluation of “cool”:

(Larry catches Mrs. Reese as she is walking by their table)

Larry: Miss [Reese], can we make it round?
Mrs. Reese: You can bend 'em (cupping gesture with hands)
Larry: Cool. Oh cool. We could hold the house up with like these, like this. (proposing bending trapezoids to use to keep the house elevated)
Tessa: Okay, cool
Kyle: Ok, do that.
Larry: Okay.

Ownership of the meanings that are constructed among the participants in the activity is important for evaluations of creativity. If the participants have adopted the meanings, they will often negotiate a presentation’s appropriateness externally, by making reference to a classroom authority (“But Mrs. Reese said…”). Constructed meanings are negotiated internally by the participants. The latter is more likely to be labeled “creative.”

5.1.3.2 Potential for evaluation

I’ve discussed this dimension, as well as the next one, previously in this paper. I will go over it again briefly. Evaluation is crucial for something’s becoming “creative.” The dimension “potential for evaluation” refers to the windows that others have on the presentation, as well as the language available to others to make the evaluation.

An artifact that becomes a “linking document” has a greater potential for evaluation, because it becomes part of multiple flows of activity. The inscriptions that the teacher gets to see are not generally all the ones that the students produce. Those that the teacher does get to see are more likely to get “on the record” as being “creative.”

Also, the community must have a language available for reifying something as “creative.” I’ve found several overlapping terms that seem to do the trick in the classroom, although it’s not clear that the terms mean similar things to the students and the teacher. It is conceivable that there are communities that do not have a language for
talking about “creativity.” Other communities may have more refined ways to label it, with terms referring to different “shades” of creativity.

5.1.3.3 Potential for dissemination

As I’ve mentioned earlier, a “disseminable” presentation has one or more of the following characteristics: permanence, mobility, accessibility, and accountability. I will not discuss these characteristics here. Different practices in the classroom create opportunities for different kinds of presentations. These presentations vary along the dimension of potential for dissemination, and affect where a “creative” evaluation can go and how long it can persist.

5.2 A Closer Look at Classroom Practice

I’ve shown how one important class of “creative” events, which I’ve called “re-framings,” are structured. From that discussion, I discussed nine underlying dimensions that are relevant for moments like re-framings to occur. In this section I will look more specifically at three kinds of structures that were common in Mrs. Reese’s classroom:

- students working on a design,
- students doing a worksheet in groups, and
- students making a group presentation.

I will examine these environments with respect to the nine dimensions that are important for creativization discussed above.

5.2.1 Design environments

The Middle-School Math through Applications Project approached math through design activity. Having been part of MMAP, I will briefly discuss the curriculum model that was created. Participants in MMAP had a mission to create materials to support environments in which all middle school students could learn, particularly those students that had been traditionally under-served in school. One way to do that, we thought, was to create opportunities for students to collaborate on “real-life” scenarios, from which math would arise. The project had a hunch that design environments would be a structure in which this could be accomplished. Not only can math flourish in this
environment, creativity can as well. I will describe MMAP’s model in more detail, and provide a detailed analysis of one group of students’ design process.

5.2.1.1 **The design model**

Design, in its most inclusive sense, is the process of making things. Models of the design process have been developed in cognitive science (e.g. Chan, 1990), engineering (e.g. Ballay, 1987; Pugh, 1991), and other diverse fields. Schön (1987) illustrates the nature of design:

> In contrast to analysts or critics, designers put things together and bring new things into being, dealing in the process with many variables and constraints, some initially known and some discovered through designing. Almost always, designers’ moves have consequences other than those intended for them. Designers juggle variables, reconcile conflicting values, and maneuver around constraints—a process in which, although some design products may be superior than others, there are no unique right answers.” (p. 42)

This conceptualization captures the aspects of design that MMAP thought would engage students in mathematical activity. The activity is common among adult workers, the environments are engaging, and the problems are complex and open-ended.

MMAP developed a simple model of the design process, characterized by iterative cycles of research, design, and analysis, resting on a bed of mathematics (Figure 5–1). As students cycle through the design activities, they run into opportunities for learning math. The roles that the teacher takes on include coaching the students through the design process, and making the mathematics they are doing explicit.
Materials are constructed that support each of the processes in the above diagram. Research activities include going to the library, using relevant “casebooks” that MMAP has developed, reading fact sheets relevant to the problem, and sharing information. Design activities include creating floor plans, models of ecological systems, and cryptographic systems. Analysis activities invite students to use mathematics to evaluate their design decisions, and redesign based on what they learn. Assessment occurs throughout the projects. MMAP stresses giving students multiple opportunities to show what they are learning in a variety of different media, to a variety of different audiences. MMAP also creates technical support activities that help the students learn the basics of the tools to which they will have access.

5.2.1.2 Re-designing a dormitory

This case of design involves a group of three students (two boys, Nathan and Kevin, and one girl, Tessa) from Polk Middle School redesigning a structure for a colder climate (see Appendix C, page 176). The activity was a one day assessment at the end of The Antarctica Project. The purpose of this case is to illustrate the complex nature of design work inside an MMAP classroom. The case proceeds in four parts. In Part I, the
boys in the group initially work on structural changes to the building while Tessa finds an average temperature. In Part II, the group goes to the computer, and they work on refining the indoor and outdoor temperature for their redesigned structure. The group monitors costs as they continue the redesign, making structural changes as well as changes to the plan’s insulation in Part III. The group addresses scale, figuring out how big a table needs to be in order to fit into their floor plan in Part IV.

This group has been asked to redesign a dormitory that was built for Seattle so that it can be used by students in Duluth, Minnesota. The floor plan is for a building that will house eight students with separate bathroom facilities for men and women, and the redesign should not have less living space than the original. In a “Request for Proposal” (RFP) the fictitious client, The University of Minnesota-Duluth, asks that the building materials plus the heating cost for twenty-five years is less than $100,000. The group is given a series of temperatures for both Seattle and Duluth, a paper copy of the Seattle floor plan, and a computer model of the Seattle floor plan to be used with ArchiTech, a computer aided design tool for students. The group also has access to meter sticks, calculators, and their text book (which the teacher uses concurrently with the design curriculum). The group has about thirty minutes to complete the redesign.

Part I. The teacher, Ms. Reese, reads the RFP as the group members look through the artifacts in front of them. As she speaks, Nathan asks, “What’s the temperature?” Moments later Kevin asks, “What’s the scale?” while looking at the Seattle floor plan in front of him (Figure 2). Tessa has taken the table of temperatures for Seattle (Figure 3) and a calculator and starts to find the average.

The group proceeds to clarify the constraints and figure out the resources that are available to them. Kevin asks Ms. Reese about whether the changes that they can make are to variables such as the insulation values, or the actual architectural design of the structure.

Kevin: The insulation, but I’m talking about the architectural design.

Ms. Reese: You can change that too if you find that the costs make a difference.

Kevin: Like if... (points to RFP) if we took the wall out so that would be a bathtub and a...== [bathroom] right there.
Ms. Reese: ==Okay, you can, that's something you need to talk about right now in your group, what you think. So before you go on the computer== go through

Nathan: ==Is does this already saved on the computer?

Ms. Reese: *(nodding)* It's already ON the computer.

Nathan: On all of the computers?

Ms. Reese: That one over there. *(points)*

Nathan: What is it under?

Researcher: *(off camera)* It's up. It's on the screen.

Ms. Reese: It's on the screen. *[Whenever you're] ready.

Early in the design process the group is clarifying the constraints that they are under, which, in turn, clarifies the problem they have to solve. When Nathan asks about the tools available to them, he is also clarifying the situation. The tool is not simply a resource for solving a problem, it changes the way in which the group sees the situation and the problem itself. The fact that the Seattle design is available to the group on the computer means they have access to a different set of opportunities for engaging and understanding the problem.
Figure 5–2 Seattle Floor Plan

### Heating Costs in Seattle with Inside Temperature at 20 C (68 Degrees Fahrenheit)

<table>
<thead>
<tr>
<th>Month</th>
<th>Outside temperature (Fahrenheit)</th>
<th>Outside temperature (Celsius)</th>
<th>Monthly Heating Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>36</td>
<td>2</td>
<td>76.05</td>
</tr>
<tr>
<td>February</td>
<td>40</td>
<td>4</td>
<td>67.60</td>
</tr>
<tr>
<td>March</td>
<td>44</td>
<td>7</td>
<td>54.93</td>
</tr>
<tr>
<td>April</td>
<td>47</td>
<td>8</td>
<td>50.70</td>
</tr>
<tr>
<td>May</td>
<td>50</td>
<td>10</td>
<td>42.25</td>
</tr>
<tr>
<td>June</td>
<td>57</td>
<td>14</td>
<td>25.35</td>
</tr>
<tr>
<td>July</td>
<td>66</td>
<td>19</td>
<td>4.23</td>
</tr>
<tr>
<td>August</td>
<td>62</td>
<td>17</td>
<td>12.68</td>
</tr>
<tr>
<td>September</td>
<td>56</td>
<td>13</td>
<td>29.58</td>
</tr>
<tr>
<td>October</td>
<td>53</td>
<td>12</td>
<td>33.80</td>
</tr>
<tr>
<td>November</td>
<td>45</td>
<td>7</td>
<td>54.93</td>
</tr>
<tr>
<td>December</td>
<td>39</td>
<td>4</td>
<td>67.60</td>
</tr>
</tbody>
</table>

Note that $C = (F-32) \times 5/9$

| Total Cost to Heat in 1992 | 519.70 |

Figure 5–3 Temperature and Heating Costs
Design is open-ended, and many of the constraints have to be negotiated by the participants. There are many avenues for participating within design structures, and these avenues emerge based on the manner in which the constraints are negotiated. The group continues to clarify the solution, in effect continuing to clarify the problem:

Kevin: I don't really think we need a... there doesn't need to be a door right here, *(circling with pen)* in either of these areas. I mean, cause that's just a walk in area where you can wash your hands.

Tessa: *(singsong)* The average temperature is nine point seventy five degrees==- Celsius.

Nathan: ==That means there's not wall there. *(thumb down on floor plan)* That means we don't need a wall there.

Kevin: Well, no, I mean this is the entrance== to the whole thing.

Nathan: ==I mean, that's what I meant, *(thumb down)* right here.

Kevin: This is the entrance to the==

Nathan: ==Right HERE! *(thumb down)*

Kevin: What's... ==Ok, we need, no. Well I mea, you could still have a WALL... *(pen points to floor plan)*

Tessa: ==*(resumes calculation, head down)*

The group begins to brainstorm ways to decrease costs of the structure, presumably to make up for increased heating costs for Duluth. Kevin begins to propose changes to the Seattle design, and is using the artifact as a model for redesign. Nathan also is engaged in this activity. Simultaneously, Tessa has done some calculations. Tessa offers an average temperature to the group, but the others do not seem to pick it up at this point. Designing the simulation of a building in Duluth involves calculation of temperature; it seems that Tessa is still in a design space, but is working not on 'structural' design but rather on the design of parameters that will impact the structure in ways relevant to the given constraints of the modeling task.
The mathematical work being done is distributed among the participants, and is structured by the representations that each has in front of him or her. Tessa has a table of temperature values that affords a one important mathematical activity that the others do not immediately pick up, because it was not immediately relevant to the redesign work that was afforded by the paper floor plan they were looking at. Tessa also was interacting with a calculator, another resource for doing the kind of work she had decided to do. The data that the calculator was generating was unavailable to the others in the group. Later, when the group goes to the computer, Tessa’s temperature modeling activity is picked up. The computer invites changes in temperature parameters more than the paper Seattle floor plan did (at least for Kevin and Nathan).

Nathan: Yeah, but how do you walk in?
Kevin: Huh? You [still have a hall].
Nathan: How do you get from one side of the house to the other? *(R hand pats one side, then other)*
Kevin: Actually, she doesn't have... OH! You go in through there and go out, to there. *(traces route with pen)*
Nathan: But if there wasn't a DOOR.
Kevin: Yeah, NO DOOR! *(looks up at Nathan)*
Nathan: Oh, there's no door.
Kevin: I mean space there, *(hand waves back and forth)* just a big space, you know, so you walk in like this and walk out like that. *(pen traces exit route)* You understand?
Nathan: *(nods head)*
Kevin: Alright, *(taps Tessa's calculator)* are you listening? Alright... do you think, we don't really need doors right here. *(pen points at floor plan)* I, I don't== know if this [is gonna] save anything.
Tessa: *(points to floor plan)* What's this?
Kevin: This is the same as this, but this is the women's side. I imagine *(looks at Ms. Reese)*... right?
Nathan: Or the men's side, it doesn't matter.
Kevin: It doesn't matter.

Tessa: Doesn't matter, you could just... You can just let 'em have, cut this part off and make a bathtub or something. (points to floor plan) It doesn't matter.

Kevin: It's the exact same thing. See, this is there, and this is there.

Tessa: Move this over. Just move this part. Just move this part. (hands frame rooms to one side) Move the whole thing over... (pushes framed rooms over) there.

Nathan No. (shaking head)

Kevin: What do you mean?

Tessa: Put this thing... (hands frame rooms) You cut this part out (points) and scoot it up (frames and pushes parts over)... like that.

Kevin: Cut what part out?

Tessa: This part. (finger traces floor plan)

The paper floor plan is being used extensively to make proposals to change the model. Much of the speech and gesture requires the artifact for the actions to make sense. Tessa squeezes her fingers together over the artifact to make a proposal for a relatively large structural change to the floor plan. There is also pointing and indexical language that is organized and made coherent by the existing floor plan. The floor plan is physically altered by Tessa’s and later by Nathan using a pen. The Seattle artifact seems to be getting changed in two ways: Literally, by the use of pencils, and interpretationally, by the use of language and gesture to create a new way of seeing the artifact.

Representational activity in this segment of activity is occurring quickly in multiple forms. Verbal models of the functions of the rooms and gestural representations of the manipulation of space interact in a series of proposals, questions, and explanations. Every proposal allows the designers to see possibilities, both the intended consequences of the proposal and unintended ones (Schön, 1992). These consequences give rise to new ways of interpreting the representation, and new ways of interacting with it.
The group proceeds to refine their proposals for changing the structure of the Seattle floor plan for several more minutes. They get to the point where they realize it is more beneficial to be using the computer tool to continue the design activity:

Kevin: We can push this (the perimeter of the structure) out to here, right? Like a big box?

Nathan: Yeah. Mean this (floor plan) is just an example? It can be any thing like this?

Tessa: No, close to it sort of.

Ms. Reese: Close to it. You’re making some modifications.
Kevin: Do we have a certain amount of space that we can use?
Ms. Reese: It’s more like you would stay==
Nathan: ==Within this square (the external extent of the plan).
Ms. Reese: Yeah. Within that [...]...
Kevin: So, we should move to the computer now?
Tessa: We should do it as fast as we can

Part of a designer’s competence involves understanding a variety of tools, and knowing which tools to choose when. Quite often in math classrooms the tools are chosen for the students to help them with a very defined task. For example, textbooks traditionally have sections that are specifically for use with a calculator. In this case, the students are moving quite well between a variety of tools, using a paper representation, pencils and pens, calculators, and temperature tables. Tessa chooses the calculator to do her work, the boys use their understanding of spatial representations to do theirs. When they feel they need a different tool, they move to the computer.

In the beginning of Part I the students were engaged in simultaneous frames of activity. Kevin and Nathan, both in their discourse and their transactional segment (Kendon, 1989) indicate that they were negotiating a common frame. Tessa’s activity was different, yet valuable. Her attention was structured by the temperature tables and her calculator. Kevin physically invades Tessa’s transactional segment, tapping on her calculator and asking, “Are you listening?” Throughout the interaction new models are being negotiated over the floor plan with discourse and gesture (Berg et. al., 1994).
Part II. As they situate themselves in front of the computer, Tessa’s work with temperature becomes relevant, since it is a parameter that can be put into the computer model. Tessa asks the group if they should use an average temperature. The group works on finding an appropriate outside temperature for Duluth:

<table>
<thead>
<tr>
<th>Tessa:</th>
<th>Should we do average? That’s what we did last time. Change that (points to temperature on the computer screen)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kevin:</td>
<td>Have a seat.</td>
</tr>
<tr>
<td>Nathan:</td>
<td>What are we going to do now?</td>
</tr>
<tr>
<td>Tessa:</td>
<td>Outside temperature.</td>
</tr>
<tr>
<td>Nathan:</td>
<td>How much?</td>
</tr>
<tr>
<td>Tessa:</td>
<td>Nine point seven five. Use ten degrees.</td>
</tr>
<tr>
<td>Kevin:</td>
<td>Oh look here’s the temperature. (taking out temperature tables)</td>
</tr>
<tr>
<td>Nathan:</td>
<td>Ten Celsius?</td>
</tr>
<tr>
<td>Tessa:</td>
<td>(nods)</td>
</tr>
<tr>
<td>Nathan:</td>
<td>What’s the inside?</td>
</tr>
<tr>
<td>Kevin:</td>
<td>What’s the Fahrenheit?</td>
</tr>
<tr>
<td>Tessa:</td>
<td>(reaches for calculator)</td>
</tr>
<tr>
<td>Kevin:</td>
<td>Where’s the math book?</td>
</tr>
<tr>
<td>Tessa:</td>
<td>[ ]</td>
</tr>
<tr>
<td>Kevin:</td>
<td>Oh it already tells you what it is. Is this (looking at the table of values that Tessa is using to compute an average) Duluth? No see this is Seattle. So what’s Duluth?</td>
</tr>
<tr>
<td>Tessa:</td>
<td>Noo</td>
</tr>
<tr>
<td>Kevin:</td>
<td>Yes!</td>
</tr>
<tr>
<td>Nathan:</td>
<td>How much insulation should we use?</td>
</tr>
</tbody>
</table>

The computer interface asks for temperatures in Celsius, although much of the students’ experience is with Fahrenheit. Because only one outside temperature value can
be put into the computer model at one time, the group must figure out what that number should be. They used an average when they did their Antarctica research station, so they go with that again. Tessa once again offers the average temperature value that she calculated, rounding it off to ten. This information is made relevant by the computer model and made easier by the calculator. A consequence of it is a discussion about how average is calculated:

**Kevin:** Aren’t we moving to Duluth?

**Ms. Reese:** Yes, you’re moving to Duluth

**Kevin:** Well this is Seattle. So we have to figure out what it is for Duluth. Where does it say that?

**Ms. Reese:** You have that information on that sheet you’ve got here. And you’re just doing an average of the seasons... (Figure 4)

**Nathan:** Let me do it, let me do it.

**Kevin:** Okay look. Spring is in April right? April to

(begins to work silently)

**Nathan:** (inputting numbers into a calculator)

**Tessa:** March is Spring too.

**Nathan:** Okay what’s that divided by?

**Tessa:** Ah, one two... FOUR.

**Nathan:** Then we have one negative number. So it’s three point five Celsius. But we have the negative number too so it would be lower.

**Tessa:** No. [ ]. Three point five.

### Comparison of Average Seasonal Temperatures (1951 to 1980)

<table>
<thead>
<tr>
<th>City</th>
<th>Winter</th>
<th>Spring</th>
<th>Summer</th>
<th>Fall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seattle, WA</td>
<td>4 C (39 F)</td>
<td>9 C (49 F)</td>
<td>18 C (65 F)</td>
<td>11 C (52 F)</td>
</tr>
<tr>
<td>Duluth, MN</td>
<td>-14 C (6 F)</td>
<td>3 C (38 F)</td>
<td>18 C (65 F)</td>
<td>7 C (44 F)</td>
</tr>
</tbody>
</table>

*Figure 5–4 Temperature Comparison*
The group moves between several representations of temperature data. In the situation are values in tables, an algorithm for finding the average of those values, the average, a rounded average, and the understanding of temperature that the students take into the design activity. Mathematical discourse and negotiation becomes part of the activity as the students move from one representation to the other, in order to achieve a mutual understanding of the model and of each other. The group settles on an outside temperature. Tessa and Kevin later check Nathan’s work, explaining to each other how to find the average with a negative number.

The group then begins to decide what the inside temperature should be:

Nathan: How hot do you want it in here?
Tessa: In Celsius?
Nathan: So look at the math book so we can convert. I don’t my math book. Do you have any ideas? We gotta know how much we want it inside. Need somethin’ that’s not so hot and not so cold.
Kevin: (works on finding the average of the Duluth temperatures in Fahrenheit)

Once again the group shows that they can move between the various tools available to them. The text book that the students use has a conversion chart in the back of it, which Nathan feels will be helpful. Kevin gets the book, and the chart (another representation of temperature) becomes another important piece of the discourse surrounding the design of the structure.

In this case the text book is being used as a resource which connects concepts in the context of an open-ended problem in which the students are engaged. The information from the book helps the group come to a consensus about a solution within the constraints they are working under.

Tessa: We need it at least nineteen degrees inside.
Nathan: In Celsius?
Tessa: I’ll put it about seventeen.
Kevin: It (the conversion chart) says about forty-five. The average in San Francisco is about fifty. Fifty-five.
As the students negotiate an inside temperature, they clearly are using benchmarks that they know from past experience. They also are debating the utility of those benchmarks. Past experience is a valuable resource in design, and the problems are open-ended enough that students can participate on many levels. These experiences provide “precedents” which can be the springboard to new ideas. They can serve as explanations to achieve mutual consensus. They make abstract concepts in the design constraints concrete, so that the students can better construct and evaluate aspects of the solution on which they are working.

The group negotiates a shared understanding of “cold.” This negotiation is the kind of creation of meaning that characterizes “ownership.” This is in contrast to the information that the group is getting from the conversion chart. The temperature
conversion chart is a conventional representation in the classroom, and provides the group with a way to “adopt” information relevant to their work.

**Part III.** The group then begins to calculate the total cost of the building for materials and heat for twenty-five years. Nathan orients the group to this activity by alluding to the total cost constraint:

<table>
<thead>
<tr>
<th>Nathan:</th>
<th>What did it say it had to be, under a hundred thousand?</th>
</tr>
</thead>
</table>

The group finds a total cost, but Nathan realizes that the group still has to make the rest of the house. Kevin calculates the total cost by using the formula

$$(63 \$/\text{month} \times 12 \text{ months} \times 25 \text{ years}) + 78,900$$

$78,900$ is the cost of materials for the proposed design. Knowing that there is more redesign to be done to the structure, Kevin suggests writing these values down:

<table>
<thead>
<tr>
<th>Kevin:</th>
<th>Write that down! Write that cost down. What was the heating cost per month? Sixty-three dollars. Design cost was seventy eight thousand nine hundred. I just figured it out.</th>
</tr>
</thead>
</table>

In design environments, problems that emerge and the “answers” the students achieve are not independent of one another, as in many worksheet activities in the classroom. This group keeps a running list of values, so that they can evaluate future cost calculations against prior ones, keeping in mind the twenty-five year cost constraint. Another aspect of design is that each problem emerges in the context of work the group has done, so the group has resources for “unpacking” an answer— for figuring out what causes the changes in the values that they are getting from the computer model. Algorithms in other classroom environments can be fairly “black boxed” (Latour, 1987) for students, in that they have few resources or energy to try to understand the relationship between the numbers “going in” to them and the numbers “coming out.” As Nathan changes the structure, the others monitor and predict changes in cost. Adding
inside walls and doors increases building cost but not heating cost. Increasing insulation increases building cost but reduces heating cost. The group moves through a series of iterations within this activity space.

As the students implement their redesign on the computer, the activity looks similar to the activity in Part I of this case. One major difference is that proposals can be more explicit, because changes can be made directly to the floor plan. The group no longer has to rely on gesture and verbal models in relation to a paper artifact. Also, consequences in terms of cost data can be immediately generated. There is lot of talk about making structural changes while maintaining a functional building. For example, effort goes into making sure that everyone has reasonable access to the bathrooms. What is “reasonable” is negotiated by the group. Design proposals build on each other, as lines on the screen are seen, chunked, and labeled as rooms, halls, etc.

Even though the group is keeping track of costs, they are still surprised by the final data they get:

(The group updates the values)

Tessa:    OH, It’s less!
Kevin:    Yes it is.
Tessa:    Seventy nine. Oh it is less.
Kevin:    Plus, oh the heating cost is the same.
Nathan:   Because it has the same area.
Kevin:    (uses the calculator to find the total) Ninety eight thousand two hundred. Actually it’s more. (writes the total down on the paper he uses to keep track of the values)
Tessa:    How come?
Kevin:    I don’t know.
Tessa:    How’d it go up?
Kevin:    Maybe ’cause we added... Oh well it doesn’t matter because we’re still under. We’re still under.

The group, in-between the last time they requested new values and this time, had done a lot of structural redesign. Two new walls was the net result of adding and eliminating
interior walls to the floor plan, resulting in the same heating cost but a slightly higher building cost. The anomalous data opens up opportunities for explanation. Nathan points out that the heating cost may be the same because the area of the design didn’t change. Nathan later explains the qualitative relationship between insulation and cost: as insulation is raised, heating cost becomes less and building cost becomes more. Tessa adds that the heating cost doesn’t go up that much when roof insulation is made slightly lower. Nathan makes another change, and Kevin says “Don’t do anything, now update values,” illustrating a desire to systematically control the variables, changing one thing at a time to figure out what is happening to the costs. They write down the new design cost, and finish up the design (Figure 5) and finalize the costs.

![Figure 5–5 Re-Designed Floor Plan](image)

In Part III the group generates various inscriptions. These inscriptions are being used to track progress, and do not get evaluated as “creative.” The group is clearly using resources at their disposal—particularly the computer program—to generate
presentations that are judged in relation to a non-negotiable constraint. The structure must cost less than $100,000.

**Part IV.** After completing the floor plan and calculating the total costs for twenty-five years, the teacher asks the group to put a representation of the table in their classroom onto their floor plan. This generates an activity around the issue of scale:

<table>
<thead>
<tr>
<th>Tessa:</th>
<th>==How far is this? <em>(sweeps length of table)</em> One and a half meters or what?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ms. Reese:</td>
<td>What do you think it is?</td>
</tr>
<tr>
<td>Tessa:</td>
<td>It's about ==one and a half.</td>
</tr>
<tr>
<td>Nathan:</td>
<td>==What should we use it as? <em>(selects furniture palette)</em></td>
</tr>
<tr>
<td>Tessa:</td>
<td>Bench. Make it a bench. This table is== like, here...</td>
</tr>
<tr>
<td>Kevin:</td>
<td>==My foot's a meter! <em>(extends leg along length of table)</em></td>
</tr>
<tr>
<td>Tessa:</td>
<td>(laughs)</td>
</tr>
<tr>
<td>Kevin:</td>
<td>No I mean ==my leg</td>
</tr>
<tr>
<td>Tessa:</td>
<td>==Your leg. Kevin. It's about one ==... [equal]</td>
</tr>
<tr>
<td>Kevin:</td>
<td>==One and a quarter.</td>
</tr>
<tr>
<td>Tessa:</td>
<td>It's about one and a quarter.</td>
</tr>
<tr>
<td>Ms. Reese:</td>
<td>There, there are meter sticks== you can get one.</td>
</tr>
<tr>
<td>Tessa:</td>
<td>Oh okay, I'll be right back. <em>(gets up, leaves camera view)</em></td>
</tr>
<tr>
<td>Kevin:</td>
<td><em>(turning head toward Tessa)</em> It's one and a quarter. <em>(5 sec)</em> We have to make the scale, right?</td>
</tr>
<tr>
<td>Nathan:</td>
<td>I can't get the... <em>(mousing out bench for table)</em></td>
</tr>
<tr>
<td>Kevin:</td>
<td><em>(to Tessa off-camera)</em> It's one and a quarter.</td>
</tr>
<tr>
<td>Nathan:</td>
<td>Dang.</td>
</tr>
<tr>
<td>Tessa:</td>
<td><em>(arrives with meter stick)</em> [Move away Nathan...]<em>(laughs)</em> Your leg's a meter.</td>
</tr>
</tbody>
</table>
| Kevin: | *(places stick at his left, then extends right)* See:::? ==Look!
The group decides that the table needs to be measured, and Kevin responds by stretching his leg out and estimating that the table is a meter and a quarter, which is quite close to the 1.18 meters that they find when they use the meter stick. Again, the group is using a variety of tools. Kevin’s leg provides an estimate of the length of the table, but the group needs the meter stick for precision. The discussion brings up other issues of precision: Is one and one fifth meters close enough to one meter and eighteen centimeters? This structures a nice piece of discourse dealing with rational numbers, which is mostly Kevin clarifying the issue for himself, but doing it publicly for his group to hear.

Nathan and Tessa work together to draw the representation of the table onto the computer screen. Tessa wants to get a measurement of the icon on the screen. Nathan drags the “arm span” icon out into the design space. The group decides they must change the setting (in centimeters) of the arm span icon:

---

58Students can type in an arm span in centimeters. The arm span icon will adjust it’s size accordingly. It can then be dragged into the design space for measurement.
Tessa: OK, I want to see how... big it is.

Nathan: But you have to do it like this. *(pries mouse out of Tessa's hand)* That doesn't tell you, you have to take this... drag it. *(aligns 200 cm arm span over table)* No that's bigger than it... That's two meters.

Tessa: No it's not.

Nathan: Yes it, LOOK! *(moving arm span icon over along table)*

Kevin: Two hundred centimeters is two meters.

Nathan: So we gotta do... *(mouse to value field of arm span icon)* one hundred and eighteen centimeters.

Kevin: One hundred and twenty.

Nathan: ==Okay...

Tessa: ==But I thought you said two of 'em was two hundred?

Nathan: *(typing 118 into value field)*

Kevin: TWO::: That, that's one and one fifth of two meters. That's one and one... fifth meters. *(laughs)*

Nathan: *(drags smaller arm span icon over to table)*

Tessa: Okay now scoot it OVER.

Kevin: One meter and one fifth.

Tessa: You have to make that bench BIGGER.

The group’s estimation based on the grid marks in the design space was a little small, so Tessa exclaims that the bench needs to be bigger. The move from an estimated quantity to a precise quantity in the “real” world (Kevin’s leg to the meter stick) was recapitulated in the “representational” world (Grid marks to measurement icon).

Kevin explores some of the mathematical constraints implicit in the work. If the arm span icon was set to 200 cm, how many meters must that be? If the table was one and one fifth meters, what should the arm span icon be set to? This activity made explorations of the constraints built into quantities relevant for the group (particularly Kevin) to think about.
The scale in the design space was not negotiable (one grid mark equals one meter), nor was the size of the table. Negotiation in this activity centered around how to implement the size of the table on the computer screen and on what furniture icon to use, what to do with the scale icon, etc.

The group uses both conventional representations, such as the ruler, and unconventional representations, such as Kevin’s leg. Throughout this episode, the group was negotiating constraints, engaging in reflexive problem solving, using conventions and resources, and creating meanings for their work. This particular task, perhaps because it was an assessment, provided very few windows for evaluation. The task was constructed in order to create one important window—the teacher was able to watch the entire twenty minute episode. Other students, however, were explicitly excluded from experiencing this group’s work. Disseminable products, such as the floor plan and other inscriptions, were also limited due to the fact that this was an assessment. Potentially, dissemination work was done after class, as Tessa, Nathan, and Kevin told others the story of their experience. Certainly dissemination of these assessments were done by myself and the other researchers on our team—we collected the work, videotaped the assessments, transcribed them, showed episodes at conferences, created written products such as this paper, etc. None of this work, however, was evaluated as “creative” in the episode.

5.2.1.3 Design and creative moments

In many school mathematics units math content is taught to the students, and then an application problem is given, onto which that content must be mapped. The flow of activity is structured by the layout of the content. This provides teachers with a way of seeing the students’ activity; teachers know when students are doing math, whether they are doing it right, and what they should do next. It structures assessments and hierarchical learning of skills. Students also can see the math in which they are engaged. They have recognizable labels for what they are doing, usually at the beginning of every chapter of the textbook.

In the previous episode, design activity structures the math. Design is open-ended, cyclic activity. It is not clear that one set of mathematical skills is a prerequisite for another. The content of the math is emergent, rather than pre-specified. The “math
map” in these units is constantly being generated, rather than followed. There is more emphasis on the teacher to see different “versions” of math (Bushey, 1995), ones that are not lock-stepped or prescribed. These versions emerge out of design practice, and are not common within the math classroom. It is also difficult for the students to see that they are doing math. The teacher generally has to do a lot of work to explicitly label her students’ math practices, so that they realize they are doing math as well.

Within these units the math is different than in traditional classrooms. The mathematical practices that develop are structured by design activity, and are in service to that activity. Math practices result that are common in professional practice, but rare in middle school math classrooms (Hall & Stevens, 1996). This reform effort necessitates a change in how we (researchers, teachers, students, parents) see math in the classroom.

From the episode above and the dimensions of classroom practice relevant for creativization, four conclusions based on the dimensions emerge:

- Design is constraint satisfaction, and mathematical discourse occurs around the negotiation of these constraints.
- Design is reflexive, such that each change to the emerging design opens up new opportunities for the students to participate. Sometimes these new opportunities are mathematical.
- Design requires multiple representations, so that design teams frequently have to negotiate moving from one representation to another.
- Design requires resources, and design teams frequently seek out mathematical tools such as the computer, calculators, and rulers to help them with their designs.

These characteristics of design environments afford math learning opportunities in which the math is contextualized, functional, and meaningful for the students involved.

*Design and constraint negotiability.* Unlike a traditional worksheet, many constraints in MMAP design environments are negotiable. Many of the constraints are generated by the students, as opposed to a teacher or a textbook. This gives the teacher authority over the structure of the class, while the students have authority over much of the content of the class.

In this case, much of the discourse around constraint satisfaction centered on maintaining the function of the dormitory in light of proposed design changes. The group
was concerned with what constituted “living space;” for example, whether they needed a kitchen or dining room. The $100,000 over twenty five years constraint was firm:

| Nathan: | What did it say it had to be, under a hundred thousand? |

The manner in which this was achieved was negotiated by the group. This group chose to make structural changes and changes to insulation; other groups did one or the other on this project.

Sometimes these constraints are imposed, like the constraints of the construction paper house task as set out by EDC’s handout:

- The sides of shapes can touch but shapes cannot overlap.
- Use all of the shapes in your set.
- You can choose to add one more kind of shape to your set. You can cut out as many copies of your new shape as you can make from a 20 cm x 20 cm piece of cardboard. Your new shape must be different from the shapes you were given.

Other constraints, however, were negotiated by the students. In the EDC task, the group working on the “slanted roof” negotiated what it meant for a roof to be “slanted,” for example.

**Design and reflexivity.** Each move in the design space opens up the possibility that the situation will be seen as something new, which changes the manner in which the participants engage the activity (Schön, 1983; Bamberger & Schön, 1983). These situations emerge in the context of making a design, and some of these situations require mathematical analysis. Each problem builds on, and is related to, the previous problems. This gives the problem a history for the group; understanding that problem may simply require reconstructing that history. When the group was modifying it’s design on the computer, the members were surprised by a result that the computer generated. The group had some idea of what they had tried since the last time they updated the values. Worksheets often have problems that are independent of each other; within a design, activity decisions have an impact on future activity. Students must track their activity in new ways, like creating a table of values to find the optimal
cost of a structure as they cycle through different states of a floor plan. As the design progresses, the new states of the design open up new opportunities for learning.

There are a variety of different ways to address these problems, like the data anomaly. Kevin proposes controlling variables and systematically recording differences. Tessa relies on her understanding of what the group has done over the past few minutes to create the anomaly. Nathan invokes the concept of area, claiming that heating cost should be the same because the area is the same (and they hadn’t changed insulation values up to that point).

Design and multiple representations. The design environment requires the students to move back and forth among a variety of different representations. Temperatures, for example, are represented by tables, averages, variables, equations, and stories in the documented case. Scale is implicit in the computer environment, the paper floor plan, and can become explicit in the discourse that gets generated among the participants (e.g. conversations around things being “bigger” and “smaller,” discussions of the arm span icon).

Movement among these different representations can get confusing, so there is much mathematical discourse that results from trying to reach a group consensus. When a group member moves to a new representation of the information, like from a table of values to an average, that process sometimes gets explained to others in the group, and learning can occur within that discourse. Participants must also figure out for themselves the representational form that is most natural for the work they are trying to do. In many worksheet environments, the representational forms are pre-selected for the students.

Design and tools. Inside of the design environment, the students have a variety of tools to help them work. These range from explicitly mathematical tools like calculators, meter sticks, tables and equations, to computer environments, pencils, and paper, and finally to student-invented tools like Kevin’s leg. These tools are not prescribed to the students, but made available for when they feel they would be useful.

The computer gives students variables to manipulate and immediate feedback, which they would not have in a classroom without such technology. It also provides a way of structuring this data into a table, although in this case the students are doing this
structuring “off-line,” using other tools (paper and pencil) to record the data. Papert (1980) wrote

...Before we had computers there were very few good points of contact between what is most fundamental and engaging in mathematics and anything firmly planted in everyday life. But the computer—a mathematics-speaking being in the midst of the everyday life of the home, school, and workplace—is able to provide such links. The challenge of education is to find ways to exploit them.” (p. 47)

MMAP uses the computer as a tool to make these connections, helping the students capacity to “capture, store, manipulate, manage, and reflect” (Schön, 1992) on the mathematical data in front of them. The computer can do some of the tedious things for the students, so that they are free to make higher-order conceptual connections among the data and math concepts.

Students use tools to attain mathematical precision. Quantities that are needed are estimated until the group has a tool that affords more precision. Early in the activity, Tessa has such a tool (a sheet of temperatures). Nathan and Kevin, however, do not have any financial data with which to make judgments about their design proposals. They use a qualitative model of cost (less structure—>less cost) which is part of a larger issue— that they need to save money, because heating costs will be more. These judgments become quantitative when they go to the computer. Later in the design, when scale becomes an issue, they create quantities initially by estimating. Kevin’s leg serves as a physical model of quantity. Ms. Reese suggests a meter stick, and Tessa gets the tool. The estimated quantity now becomes a precise number. Kevin begins to talk more generally about how quantities are related. By the end of the activity, the group has used temperature charts, grid marks on the computer screen, on-screen data tables, the meter stick, and the scale icon as affordances for numerical quantification.

Other aspects of design. This episode failed to shed light on some of the other dimensions, but previous “design” examples documented in the paper do. In many ways, EDC’s construction paper house and MMAP’s design a research station tasks structured work differently. Many of the constraints that the student’s dealt with in the EDC task were embedded in the geometric shapes; MMAP constraints that were negotiated were often around costs of the building. Much of the work in the EDC task

59 These findings are from work done with Rogers Hall and Ming Chiu at UC-Berkeley.
was about designing exteriors; MMAP work was often designing interiors of the model. EDC models were three-dimensional; MMAP models were two-dimensional. Many of the design presentations of the EDC models were “unstable,” as students often used narrative to turn “bugs” of their design into features; MMAP models were often more stable, using inscriptions or furniture icons to fix features of their design (a room with toilets meant a “bathroom,” and those rooms usually didn’t change over the course of a design).

Although the design environments were different in many ways, they were very similar along the dimensions relevant for creativization. Both provided “important” problems, in that the students were engaged in working on them for long periods of time, from two days to four weeks. Both had negotiable and non-negotiable constraints that structured the work the students were doing. MMAP activities brought in a wider variety of resources, but EDC’s design task required some as well: geometric shapes, rulers, and scissors, for example.

Both were reflexive, by the nature of design, and provided opportunities to represent presentations in multiple ways. In EDC’s task, one group used a variety of terms to refer to their design throughout the course of the work. In addition to referring to it as a “house,” they also saw it as a “cat,” a “muppet,” and a “hat,” based on its shape. Each representation afforded opportunities to bring new information to light. Both design environments contained a wide variety of conventional representations and routines. In the EDC task Kyle said, “how are we supposed to hold the ceiling up with a building like that?” Kyle is comparing the model to conventions for building houses. Similarly, MMAP designers rely on the conventions for laying out a house—putting a bathroom next to a bedroom, for example. Such convention is necessary for unconventional work to be noticed.

I illustrated earlier that the EDC task had a variety of windows for evaluation and dissemination. The models themselves were big enough that other groups could see them and evaluate them. The nature of the models allowed them to be picked up, carried around, and passed from student to student. The MMAP task had a variety of states of the design—a computer version of a floor plan, printed versions of the plan, overheads
during the formal presentation, and narrative versions of the structure in their final reports.\footnote{The next year Mrs. Reese also had students make a floor plan on graph paper, before they went to the computer. This allowed the students more freedom than the constrained, computer version.}

### 5.2.2 Worksheet environments

Another common task structure in Mrs. Reese’s classroom was groups of students answering questions on a worksheet. This provides a contrast with design work. Without even looking at the data, most people would say that design work structures creativization better than a worksheet environment. Those people, for the most part, would be right. The comparison can, however, give us more insight into the set of questions I am addressing in this paper. How does a worksheet environment differ from design?

One way to interrogate the data would be from the standpoint of problem solving. Models of the problem solving process generally involve problem representation, strategies or operators for moving from one problem state to another inside of a problem space, a goal, and evaluation processes for knowing when the goal has been reached (Newell & Simon, 1972). These processes, in one form or another, are part of both environments.

From this point of view the worksheet questions would be thought of as well-defined, having a clear problem, conventionalized strategies for finding the solutions, and a clear “right” end-state or goal. Design is ill-defined, in that the end-state is not clearly defined, nor are the operators for moving towards that state.

In the course of activity these processes start to look quite similar from the perspective of an abstracted problem-solving model. Problems that seem to be well-defined can look ill-defined because of alternative solution methods than the conventionalized ones. Design problems are broken into smaller problems that may or may not have conventionalized means of solving them. Although I claim that both design and worksheet environments are ill-defined, as cognitive psychologists have defined the term, the practices of design appear to be much different than those of doing a worksheet. For one, design is part of many professions, doing worksheets is not. Doing a worksheet is unique to places like classrooms. What does the practice look like?
5.2.2.1 The answer to #13

In this episode, a group of students has been working on a worksheet that the teacher created to make sure that the students had an understanding of some relevant concepts about Antarctica. At this point, they were in the midst of designing their Antarctic research station. This is a piece of a longer transcript (see Appendix B, page 166). The group is now on question number 13 (see Appendix C, page 179):

Bonnie: (Reading next problem) Robert Falcon Scott's expedition died just () Died? just eighteen kilometers from the depott (mispronunciation) of ss supplies. How many miles away were (begins to mumble)... How many kilometers are there in a mile?

Tessa: One thousand seven hundred and sixty?

Bonnie: Really?

Henry: In A mile? Oh, kilometers. (continues, but can't be heard over Kyle)

Kyle: (walks up to Bonnie from another group) [?] know how many kilometers there are in a mile.

Bonnie: Oh THANKS [Kyle] (sarcastically)

Tessa: How many kilometers are there in a mile?

Barb: (walks up to Bonnie from another group) What's thirteen I don't get thirteen help me on thirteen.

Bonnie: I'm stuck there. How many kilometers are there in a mile?

Problem number 13 requires the students to convert kilometers to miles. The group works on finding out how many kilometers there are in a mile. As they are working on this, Kyle comes over from another group, asking the same question. Barb informs the group that she, also, needs to know what thirteen is. The activity thus far suggests that the group knows there is a right answer but it is not clear what the answer is. Other groups are having the same issue on this question.

Barb: I don't know.

Bonnie: MATH book (begins to search table)
Barb: (looking around to other tables) How many kilometers...

Tessa: (Reaching toward Bonnie) YOU took my math book.
Bonnie: Oh, hh hh.

Larry: (Leaning forward, toward Bonnie) It's under equivalencies. (Bonnie opens math textbook) No, not there. In the back.

Bonnie: In the back.

Larry: OH, in the front. In the math section. (Bonnie flipping pages) There, you passed it. Passed it.
Bonnie: I must have passed that...

Larry: No, it's in here. The pink one. I think that's it, right? The pink one.

Bonnie: Kilometers—

Larry: The pink one—

Bonnie: One mile—

Larry: The PINK one. The PINK one.

Bonnie: OH, ok Barry, I'm sorry. Larry I'm so sorry. One point six oh nine. One point six oh nine.

Larry: One point six oh nine.

The group successfully uses their math book as a resource, just as the group did in the design a dormitory task in the design episode. There is 1.609 kilometers per mile according to their book. There was some difficulty in finding this figure, but they finally found it on the “pink” page.

Bonnie: Kilometers in, which is more?

Larry: [?]

Bonnie: So there's one point six..

Barb: How do you know the supplies were in the storeroom? Huh huh huh huh do ya do ya do ya? (Tessa laughs) sorry.

Another question arises. Is there 1.609 kilometers in a mile, or 1.609 miles in a kilometer? While the group begins to figure out “which is more,” Barb makes an
observation, probably a joke, about the worksheet question itself. Just because Robert Falcon Scott died 18 kilometers from the depot doesn’t mean that there were supplies there that would have saved him and his crew. This was a “re-framing,” not within the activity of finding a solution, but about the task itself. Tessa, the only participant in the activity to hear Barb, laughs.

| Larry: | So there's one point six oh nine... |
| Bonnie: | So so we divi so we multiply one point six oh nine by eighteen, right? |
| Larry: | Ahh, I guess. |
| Bonnie: | (doing calculation with pencil on paper) |
| Barb: | How do ya.. (long pause) What is it then, huh? |
| Bonnie: | What? |
| Barb: | How do ya know the supplies are in the storeroom? |
| Bonnie: | What are you talking about? What supplies what number are you on? |

Barb tries to orient others in the activity to her joke about the question, but fails. Bonnie is confused by the presentation, as she is attending to the task of answering the question. Rather than trying to negotiate a new frame with Bonnie, Barb lets it drop. Bonnie tries to figure out whether to multiply 18 by the conversion factor, or to divide it by the conversion factor.

| Larry: | Just [?] miles. Write miles. Write it. |
| Bonnie: | You don't even care about this one... |

Larry’s “write it” indicates a push to move on. “Writing it” marks the end of each segment of activity while doing the worksheet. Unlike design, each segment of the activity doesn’t structure the next segment. Each question on the worksheet, in terms of the content, is independent from the previous work. Bonnie assumes Larry’s comment means he doesn’t care about the question.

Certainly there are social relationships that carry over from one question to the next. Content isn’t reflexive in this environment, but social relationships always are.
Larry: If it's miles then the answer's gonna come out less.

Barb: No THIRTEEN!

Tessa: (to Larry) ?

Larry: OH nine. OH nine.

Tessa: No it's six nine.

Larry: (to Polly) Is it one point six OH nine or one point six nine?

Bonnie: One point six oh nine.

Bonnie: I just multiplied it. It's twenty eight point nine six two.

Barb: (looking off of Bonnie’s paper) No it's kilometers, not miles!

Larry: (looking at Tessa’s calculator) Eleven point one...

Tessa: Let's just put eleven miles.

Bonnie: (surprised) Eleven?

After more clarification about the conversion factor, Tessa says, “Let's just put eleven miles.” This was based on work Larry had been doing with his calculator, another resource that the group brought in to complete the activity. This number, however, conflicts with Bonnie’s answer of 28.962.

Barb: It's kilometers, not miles it's kilometers to miles!

Larry: (overlapping talk with Barb) You divide it, not multiply it. If if...

Bonnie: (loudly, raising arms at the elbows) WAIT! Listen to Barry, wait.

Tessa: You multiply it. Because kilometers are more than miles.

Larry: No No. Are kilometers more or less than miles?

Tessa: More. See you do multiply it.
Bonnie: You STILL multiply it. Whichever way around you still multiply it!

Mrs. Reese: (teacher overhears raised voices) Okay, what's your problem?

The group debates whether kilometers are more than miles, or miles are more than kilometers. Eventually the teacher steps in to help. This episode provides a contrast with design work in several ways. Although the group is struggling with an important mathematical concept, the group doesn’t have the resources to evaluate the work they’ve done (Bushéy, 1997). The group looks to an “authority,” such as the textbook. In this case the textbook provided information that could be interpreted in two ways. The conversion factor was “black boxed” (Latour, 1987), such that the group didn’t have the resources to “open it up” and evaluate it in a useful way for solving the problem.

The questions on the worksheet also provided a structure in which answers to those questions were commodities. Some people or books in the classroom had the answers, others didn’t. Everyone wanted the answer. When they got an answer, they often checked other groups to see if it was the “right” answer. In design, answers were not talked about as if they were commodities, rather as presentations that could be negotiated, changed, and justified. The “authorities” were not the book or the teacher, but themselves. They knew more than the teacher did about the meanings they had constructed in relation to their designs.

Ownership of presentations is one of the keys to creativization. It requires an entitlement on the part of the participants to create and justify their own meanings. Another key is a reflexive environment; one which builds on the successes of the group. History is maintained in a reflexive environment, and that history is owned by the participants. They know why certain decisions were made, where various states of the design came from, and often what to do next. In a worksheet environment the group often has to construct a new history for every question on the worksheet.

5.2.2.2 Problems of importance?

I haven’t justified “importance” as a task dimension relevant for creativization up to this point. I will shed some light on it now. Part of the activity of the group is
structured by the questions that arise while doing the work. In the following table are two lists: on the left side are questions asked by participants during a segment of the worksheet task, and on the right side are questions asked by participants during a segment of the construction paper house task. The questions that arise while doing a worksheet are aimed at clarifying (non-negotiable) constraints of the task or finishing the task. The questions that arise during design, for the most part, focus the group on sustaining engagement in the design task.
<table>
<thead>
<tr>
<th>Questions generated by participants while doing a worksheet:</th>
<th>Questions generated by participants while doing EDC construction paper house problem:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glen: What's 12, what's number 12? 13, what's 13? What's an expedition? I got 12, what's number 13? What's number 13? What's number 14? What's number 14? what's number 14 and 10? It's what 1/3, 2/3, what was it again? Miss Muniz, does it have to be in complete sentences? Where's my pen, where's my pen? Three. What's number three?</td>
<td>Kyle: But if you if we really made this, it wouldn't be crooked, this is paper Larry, what do you expect? Tessa: how are we supposed to hold the cieling up with a bui building like that? Tessa: a big pole? ==what if somebody chopped thought it was a Liza: ==so, we're not making a window, right? Liza: fine. Do you want to put one in then? It can be one story, okay? Larry: the people are supposed to be like this tall, right? (about 2 inches) Larry: an inch tall::? that tall::? Larry: do you realize that this house is as high as the auditorium? Kyle: can't we just make the people that tall? (indicates about 3 inches) Tessa: How are they supposed to get their how can they fit they're head through there, and come out?</td>
</tr>
<tr>
<td>Dena: (Reading) “What percent of an iceberg is under the water line”, what does that MEAN?</td>
<td></td>
</tr>
<tr>
<td>Liza: What's number 13? How do you spell temperature?</td>
<td></td>
</tr>
<tr>
<td>Glen: What's number 10 we only need number 10 What's number 10? (Brook “not that thing”) What thing? How'd you get number 10?</td>
<td></td>
</tr>
<tr>
<td>Larry: Is this the time out test? So, what's left? [this, this, and this] If it's three miles thick then convert it into inches, right?</td>
<td></td>
</tr>
<tr>
<td>Liza: Are we still doing number one?</td>
<td></td>
</tr>
</tbody>
</table>

Table 5-2 Questions: Worksheet vs. Design
Questions during the worksheet task tend to be process questions. The group is focused on “Where are we now, what are we supposed to be doing, and do we have what we need to move on.” The design questions that emerge tend to push the group to construct new meanings in relation to their design.

Clearly this is only a surface level analysis, and I don’t intend to go any deeper here. I will suggest, however, that the questions provide some evidence that the participants have constructed the design task as being more “important” than the worksheet task. Future research can confirm or refute my hunch based on this data.

5.2.3 Formal Presentations

The final classroom structure I will examine is a formal presentation. The formal presentation was actually one of the practices of design in Mrs. Reese’s classroom, coming at the end of both the construction paper house activity and the Antarctica research station activity. The event was significantly different from the design work that preceded it in both cases—it was a special event that was an important “on the record” assessment. Groups prepared for the formal presentation in advance.

In Mrs. Reese’s classroom the final presentation provided access to a classroom-wide audience, but in the end provided a very narrow window on the actual design work. During the majority of the formal presentations on the Antarctic station, students identified rooms, one by one on their floor plans, read a list of numbers, which were the building and heating costs of their research station, and responded to audience questions.

Most of the creativization moments that had occurred during design work were lost in these events. In creating a “presentable form” (Becker, 1982), each group systematically put together a presentation which had the criteria by which their presentation was going to be evaluated. They were asked to talk about their station and relevant mathematical variables. All the groups followed the routine.
Henry’s final presentation of his group’s construction paper house came before the Antarctica final presentations. It clearly was not “routine.” His “Jack-in-the-Box” story was not routine, to the point that Mrs. Reese noted “The creative side took over there.” This classroom structure afforded the viewing of this presentation by all the students in class. At least the one’s who were “paying attention.” The model itself was permanent, unlike the narrative that Henry told about it. Tessa was able to dig the model out of a box and refer to it (along with Henry’s story) as “creative writing.”

There are opportunities to construct meanings during formal presentations, as Henry’s narrative illustrates. Although the groups may have had a sense of ownership over their designs, the formal presentation of those designs tended to follow the conventions of the classroom.

Formal presentations, then, provide opportunities for evaluation and dissemination, but in this classroom tended to be routine. I observed a middle school math class participating in a multimedia exhibition, and the event structured a different form of participation. The students’ presentations were far less conventionalized. Future research is required to better understand the “presentation” as a formal event in the classroom and how it gets arranged by the participants.
5.3 Summary

Nine dimensions emerged from my analysis of creative moments, and I used these dimensions as a lens to look at design, worksheet, and formal presentation activity in Mrs. Reese’s classroom. The following table provides a gloss-level look at how the dimensions relevant for creativization played out in these activities.

<table>
<thead>
<tr>
<th>Importance of activity</th>
<th>Design Activity</th>
<th>Worksheet Activity</th>
<th>Formal Presentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task generality</td>
<td>Task generates questions that sustain activity</td>
<td>Goal of task is to finish</td>
<td>Unclear results</td>
</tr>
<tr>
<td>negotiability</td>
<td>Very negotiable</td>
<td>Not very negotiable</td>
<td>Potentially negotiable, but groups tended towards the “routine”</td>
</tr>
<tr>
<td>resources</td>
<td>Many</td>
<td>Some</td>
<td>Some</td>
</tr>
<tr>
<td>reflexivity</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>re-representability</td>
<td>Many opportunities</td>
<td>Some opportunities</td>
<td>Some opportunities</td>
</tr>
<tr>
<td>convention</td>
<td>Some routines and conventions</td>
<td>Many routines and conventions</td>
<td>Very routine in most cases</td>
</tr>
<tr>
<td>ownership</td>
<td>Many opportunities for constructing meaning</td>
<td>Most meanings were adopted rather than produced</td>
<td>Constructed meanings, but presented them routinely</td>
</tr>
<tr>
<td>Potential for evaluation</td>
<td>Several windows for evaluation, including self-evaluation</td>
<td>Windows for group, teacher, and students from other groups who “didn’t get it”</td>
<td>Potential for the entire class to evaluate the presentation</td>
</tr>
<tr>
<td>Potential for dissemination</td>
<td>Artifacts were relatively mobile and permanent</td>
<td>Artifacts were relatively mobile and permanent</td>
<td>Yes, in that they gave a wider audience access to the work</td>
</tr>
</tbody>
</table>

Table 5-3 Summary of Chapter 5 Results

The table is not a substitute for the data, but shows the trends that emerged. From the results in this chapter, I will conjecture that design activity supports creativization differently than worksheet tasks or formal presentations.
Participants doing design structure work such that there are many opportunities for “re-framing” relevant moments. The reason is that design provided many affordances for seeing the situation in new ways, which can then be negotiated, evaluated, and perhaps conventionalized. This is intertwined with opportunities to construct meanings along with the work they are doing (Wenger, 1998). Worksheet environments, on the other hand, are much less likely to provide these affordances. One advantage that a worksheet does have is that it tends to be very conventionalized. When a “re-framing” does happen, it is potentially more likely to be noticed by the other participants. Once it is noticed, it can be evaluated in a number of ways, “creative” (or a similar label) is one possibility. Formal presentations have the feature of providing a structure that affords the entire class to focus attention on relevant aspects of the work. In this classroom, the “relevant” aspects of the work did not include the things that were “cool” about their artifacts while they were constructing them. This doesn’t always have to be the case, as Henry’s narrative illustrates.
At the beginning of this paper I asked the following questions about the process of creativity in a middle-school classroom:

- What interaction patterns structure events that participants find to be “creative”?
- How is the evaluation itself structured, both informally and formally (“for the record”)?
- How do these events play themselves out in common activities in a middle-school classroom?

In Chapters 4 and 5 I provided an analysis which gave us insights into these questions. In this chapter I will summarize my assumptions underlying this study and the model that emerged from my data analysis.

Several of the assumptions that underlie traditional approaches focus the research scientist on variables that, by themselves, do not provide sufficient insight into how things become creative. One drawback of previous studies is that the theorists have reified creativity as something that exists independent of social judgments. Creativity is reified within the practices of the community, and can be studied in those contexts. Many have tried to define creativity as a closed concept, when in practice it is dynamic, fluid, and unstable. A second problem is that they have located creativity in the individual. I have tried to argue that creativity exists as a social object, negotiated in
social interaction. Understanding the individual only becomes interesting when we examine how her line of activity is shaped, and shapes, the activity of others.

The following points are important given the theoretical framework that I used to frame this study:

- creativity is fundamentally social;
- creativity cannot be fully understood outside of the contexts in which “creative” evaluations are constructed, shared, and disseminated; and
- creativity can be better understood using methodologies that preserve the structures that emerge and frame interaction.

From these assumptions emerged a plan for studying the social construction of creativity in a middle-school classroom. I began finding similar labels to “creative” that were used in the middle school classroom that I was studying. I used these labels to mark “creative” events. As I analyzed these episodes, a model of creativization emerged (Figure 6–1 A Model of the Creative Process). The model underlies one particular kind of creative moment, which I refer to as a “re-framing.” These moments are important to study because they are relatively common, they fundamentally involve learning, and they are similar to most people’s common-sense version of what creativity is. The model has implications for other kinds of creative moments as well.
From preliminary analysis of classroom data I focused on “re-framings” as episodes to study more closely. The claim is that the “trajectory” of action develops a frame, or a structured, socially shared perspective on what is important, what to attend to, and what to expect. Sometimes that “frame” is re-negotiated, in effect changing the trajectory of the activity and making relevant information that was previously latent.

Presentation

- As an artifact (like a floor plan model) is being developed, it gets done socially, even if only one person seems to be working on it. The interaction is structured by the task environment, available resources, and the interaction up to a given point. I refer to this structure as a “frame,” and this frame makes the interaction coherent, carries information about what is appropriate and what is inappropriate, and provides the participants with clues for what to expect next.
• At any moment in the process the group is organized to make certain actions possible on the part of the participants. These roles are defined by social organization and practices. A participant, or multiple participants, may work to prepare others for a presentation they are about to make. They may do this so that their presentation seems more creative. They may also do this to gain access to resources they need for accomplishing the presentation. For a number of reasons, preparation is important for contextualizing expectations about what is to come.

Acceptance

• Something in the organization changes, which breaks the current “frame.” This attunes the others to different information in the environment that was previous not being attended to. I refer to this as a “re-frame.”

• If members of the group are immediately able to switch frame and see the new frame as coherent, there is often laughter, gross postural repositioning, and expressions of surprise. If the group is not able to immediately switch frame, then the move is confusing or gets ignored.

• If the group (or all “relevant” members of the group) are not immediately attuned to different information, there is usually some negotiation that must happen. The actor(s) will then reorganize the situation through various representational practices like discourse, sketches, gesture, mouse events, etc. in order to get the others to see the situation as he/she/they now see it. I refer to this as a “seeing-as,” following Schön (1983).

• When this work gets done successfully, it may become relevant for the participants to evaluate the event as creative (or “fresh”, or “radical”, or...) for various purposes. This label is evoked and can become associated to the actor, event, and/or artifact. Thus the re-framing may get labeled socially as something (like a “creative” act) and credit might be assigned (a “creative” person) given the relation of the re-framing to the current practices and values of the community and given the evaluation practices of the community.

• The group settles back into the new frame, and work goes on as before.

Maintenance and Dissemination

• The re-framing, as well as the labels, may be maintained and disseminated by the practices of a community. The event can become part of larger audiences through various means. There are (at least) two possible ways other people can come to know something as creative. The first is for the event to be “re-played” in an ecological unit (Barker, 1968) consisting of more people. In the classroom, this can happen in a presentation to the class. The same “re-framing” that happened in the group can happen to a wider audience during the presentation. This larger audience becomes attuned to new information in the environment, and

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62 This serves a similar function to the premise of a joke. A joke is not funny without the right set-up, just as a presentation may not be “creative” without the right contextualization.
they generate the object “creative” to apply to that re-framing (I refer to this as “acquaintance” with a creative event). The second way is for other audiences to become attuned to the object “creativity” itself as information that becomes relevant when discussing to a person, artifact, or situation (a “description” of a creative event).

- A community often has ways of preserving work that has come before. One way work gets preserved is through the process of *conventionalization*. “Creative” ideas can become routine ideas over time, as practices that were once novel become commonplace. There are other ways that groups *preserve and reconstruct history*. In a classroom this may involve the telling of stories, work hung up on the bulletin board, or formal inscriptions in a teacher’s grade book.

The data suggests that several dimensions underlie the process described above. Such dimensions are important for understanding how creativization happens. Designers of environments that are constructed to make opportunities for creativization more likely should pay particular attention to these dimensions. Some of the features that are important include

- degree of importance of the problem being worked on;
- degree of “ownership” of the idea;
- degree of negotiability of the problem constraints;
- variety of resources for changing the interactive space;
- degree of “mobility” of the artifact or evaluation;
- potential for “evaluation windows” onto the creative moment;
- degree that the problem can be re-represented;
- degree that current practices within the activity are conventionalized;
- and a language of evaluation.

In Mrs. Reese’s classroom, design environments seemed to best fit the dimensions above. Worksheet environments were particularly conventionalized, which made noticing and evaluating a novel behavior more likely. Design environments, however, provided tasks that were more important to the participants, had many resources for producing presentations, and had a variety of windows through which participants could experience and evaluate presentations. Formal presentations gave the students the
opportunity to create “presentable forms” (Becker, 1984), packaging and contextualizing their work for the class and the teacher.
This study has implications for both our conceptual understanding of creativity and for education. This paper has presented a version of creativity that requires a shift in how we understand the concept. As part of the educational implications I will develop a narrative speculating about what an “ideal” classroom might look like if the teacher or administration had a strong interest in trying to support the collection of practices that comprise creativization.

### 7.1 Conceptual Implications

What implications does this paper have for future work on the study of creativity? A new lens for understanding creativity has “re-framed” the way that the phenomenon is to be understood. I will argue that three important conceptions of creativity need to shift: from talking about “originality” to talking about “appropriateness,” from talking about “ability” to talking about “entitlement,” and from talking about “traits” to talking about “structures.”

#### 7.1.1 Shifting from “originality” to “appropriateness”

Many traditional theories base a creative act or person on “novelty” or “originality.” These things only take into account statistical frequencies and probabilistic
likelihood when assessing whether something is “creative.” This study suggests that, in practice, there is a normative component that goes beyond simply probability. A judgment of “appropriateness” is based on the fit between the presentation and a shared space of meanings and values. A variety of different value systems emerge in the school among different groups of students (Eckert, 1989), and each carries with it a normative system of what is appropriate and what is not. When we discuss creative acts outside of the context of communities, novelty can be a useful construct. Within communities, however, evaluations are constructed by participants based on the appropriateness between the presentation made and the expectations of the community. These expectations cannot be independent of the meanings that participants create in relation to the values the community holds.

7.1.2 Shifting from “ability” to “entitlement”

Creativity theory has focused on the abilities of the individual that enable them to do what they do. This study provides a different way to look at the problem. Participants in an interaction arrange for a person’s becoming creative. In that same moment, they’ve also arranged for a person’s becoming wrong, or a person’s becoming a troublemaker. What makes the difference in how the event unfolds? It depends on what the individual is entitled to do in that interaction space. A participant must earn the right to play with conventions in a community. In Mrs. Reese’s classroom, the participants may have been entitled to “creativity” in their groups, but not during the formal presentations, in the presence of a larger community—the entire class and the teacher.

Young children are often entitled to break convention. They may unknowingly play with convention, construct complex fantasy play, or draw a spooky monster. Within the space that has been arranged for them, they are being creative. They are entitled to it. Not in all cases. In the church I went to as a child, everyone sat in rows, were very quiet, and followed along with the pastor. The social structure of that service, presumably, arranges mis-behavior, not creative behavior. As children enter school, fewer interactions arrange for them to be creative. Entitlement no longer comes “simply” from being a child, but from finding a socially-negotiated niche in the classroom community. Non-entitlement, then, is akin to alienation.
7.1.3 Shifting from “traits” to “structures”

Another implication for theories of creativity is a shift from thinking about traits of creative individuals to thinking about interaction structures. The analysis here indicates that judgments of creativity serve a variety of functions and emerge from complex patterns of interactions.

From the data presented here, a reader might say, “That Henry, he was pretty creative.” We could try to open up Henry’s head and figure out how he thinks. Or we could analyze how that comment was made relevant. First of all, as the transcripts show, the participants in the classroom arranged for the “Jack-and-the-box” and the “crooked wall” episodes to happen. As part of a research project, the interaction was filmed. This gave mobility and permanence to a couple of fleeting events. I watched these events many times and wrote about them. This paper traveled to the reader. She read the episodes and my analysis of them, and declared, “That Henry, he was pretty creative.” The reader had both a language and a reason to make that statement. I argue that the representations and language embedded in a wide variety of social practices is much more important to understanding how creativity happens than anything we could possibly find in Henry’s head.

7.2 Educational Implications

I’ve repeatedly argued that creativity isn’t “real,” at least in terms of commonly held versions of what creativity is. Yet, creativity is an important thing for many people and many communities, including schools. If we want to promote the process of creativization, we should understand that it is social, and work to ensure access to it and equity within it.

If for one reason or another we would want the occurrence of creative events in schools to be more frequent, how would we do that? Psychologists have been developing programs for “productive thinking skills” for years to address this situation, with relatively little documented success. This study inform educational practice in a variety ways that goes beyond “Have the kids think of how many different things that they could do with a brick.” I will start with a list of thoughts based on my analysis of the data:

- Classroom practices that involve “displayable” representations are more likely to afford creative events. As the groups built models using
construction paper, there was much inter-group evaluation going on primarily because the media was large enough that the groups could monitor each other’s work. This would not be the case if each group was asked to create a sketch.

- Activity structures that involve design structure creativization differently than worksheets. The nature of design is reflective; thus, the environment is constantly changing in ways that are relevant for the kinds of reorganization that tend to become labeled as creative. These changes create a situation which is much more likely to lead to a new interpretation, which frames the situation differently.

- The length of time a creative event will persist in schools is short. Practices can be instituted which can make these events persist much longer. Teachers can display “creative” work on the walls of the classroom as a way to create a history of creative products in the classroom (analogous to an art or history museum). Students can keep portfolios that house their creative works. Also, students should be encouraged to try to use past “creative” solutions to solve new problems.

- Finally, there are issues related to assessment. Terms like “inventiveness” and “flexibility” are part of the national framework for math assessment, and to some, these terms mean creativity. My concern about assessing creativity formally (meaning it has consequences beyond the classroom for the child) is that no child is creative or uncreative. It is not an individual attribute, and it is probably more accessible to some people than it is to others. Thus, by reifying the concept, some kids can be hurt by such a category.

Taking these thoughts into account, there are several educational constructs that need to be re-examined: creative performance and assessment. I will discuss these two shifts in how we should think about creativity in classrooms.

### 7.2.1 Shifting from “performance” to “access”

Traditionally the question of finding creativity in the classroom asks, “what does creative behavior look like in the classroom?” The data in this paper suggests that more time should be taken considering the question, “who has access to creativity in the classroom?” In Chapter 5 I outlined a number of dimensions that structure access to creativity in the classroom. Environments that have a number of these dimensions provide the participants with more resources for arranging a creativity-relevant moment. These arrangements, however, don’t often apply to every participant equally. We need to work to find ways to ensure equal access to the opportunities for creativity in the classroom.
7.2.2 Shifting from “imposing” to “uncovering” assessment

A “creative” judgment is made relevant through the structures and the values of the community. A classroom teacher is certainly entitled to make such judgments. Another fruitful endeavor, however, might be to do what I have done in this study—try to find the terms that the students use to talk about creativity, and then look for occurrences of those terms. The value system may be different for various groups of students and the teacher. The teacher can get more information about “creative” students if, in addition to the students she finds relevant to label “creative,” she also uncovers moments were students were evaluated as “cool” by other students, or whatever the en vogue term happens to be.

A mathematical moment that was labeled as “cool” by the other students may be an important moment for the teacher to notice and assess. Most peer assessments that are informal, like “cool,” don’t make it into “for the record” inscriptions. I will argue that capturing these moments formally is an important step in the assessment of creativity in the classroom.

7.2.3 The “ideal” classroom

If someone was going to build a new school, and wanted it to “enhance the creativity of the students,” what would it look like? Of course, I would phrase it differently—they would want it to “structure opportunities for the students to become creative.” Either way, it might be something like this:

Some students have just come back from the elementary school next door where they showed a model they had constructed for the new community center. The younger children were excited. The students had planned a jumping room with a bouncy floor just for them. The best part was that the class was working with the school district and the local government. The structure they are designing might actually be built!

They got back and sat down in their work areas. Each student in the school has been given a permanent spot to put her things. Emily has decorated her spot with geometric patterns, printed floor plans, and other things that she had down earlier in the school year. All their subjects are taught in this room.

The students with the feedback from the younger kids scratch all their new ideas on post-it notes and stick them on the big bulletin board, which everyone in the class reads each morning. The elementary kids’ feedback prompted a lot of new responses the next morning. One group, who was focusing on a resource room, was ready for a design review. They presented their work to the rest of the students, creating a narrative
account of how the room might be used. On the first day they generated eight different possible designs! They compared them and used what they learned to construct the plan they just presented.

The class had developed a set of values around doing “cool” work. Students strove to make things “cool,” and things that did become “cool” were admired locally and displayed to the class.

Throughout the process, members of the local city council came into the classroom to take a look at the work. They were impressed!

The teacher was helping the students when mathematical dilemmas emerged from their work. As she walked around, she kept a log of times when students seemed to have “aha” moments; where they seemed to see the situation in a new light. She also paid attention to the labels that the students used to talk about these moments. Sometimes she would use them herself when talking with the students, “Why did you think that was cool?”

The students were engaged in many different tasks at any given time. They were constructing prototypes, sharing resources, building representations, and constructing new ways of talking about the community center they were designing. The teacher paid special attention to how the kids got to participate in the activity. If a student was not getting opportunities, she subtly gave him another important task to do.

The story could go on. This story may not be realistic given the constraints of most schools, but it would very likely structure “creative” events given the dimensions I have discussed. The structure of school is slow to change, but this is one possible ideal to head for.

### 7.3 Directions for future research

There are several avenues for future research. I have looked at one interaction pattern which often led to an assessment of creativity for participants in an interaction—the “re-frame.” There are potentially more of such structures. Using the methods from this paper, future researchers could potentially uncover other patterns of activity that are part of the creativization process.

Second, there are sociological issues that could be explored. I have argued here, following Boden (1990), that the micro-structure of interaction gives us insight into larger communities of interaction. A goal of future research should be to make the connections between the micro- and macro-structure more explicit. My claim is that “important” creativity, the kind that makes the encyclopedias, is structured in similar ways to the
events in Mrs. Reese’s classroom. Interaction is re-framed, evaluations are constructed, and those evaluations get documented and reified in various ways. The practices that arrange this to happen in different communities change depending on the community. The practices are different, but the creativization model is the same. That is my hypothesis. Future work can sort it out.

A third line of future research parallels cognitive research. As I mentioned earlier in this paper, the individual is not completely unimportant, but must be understood in relation to the situations which she is interacts. There are some cognitive activities, if examined from a situated perspective, could shed light on aspects of the creativization model. The first question is how interpretation happens. Clearly it is an interaction phenomenon, but participants bring different information to the table. How do connecting facts change the way a participant interprets an event? Does anomaly structure attention, as Neisser (1976) suggests? A second question is how metaphor and analogy play themselves out in a “creative” moment. These processes have been historically important in creativity research. I suggest that they are used not only to generate new frames for interaction, but to communicate a new frame to others.

### 7.4 A Final Note

It is the nature of “strong” constructivist work to have to reify the very concept the researcher is trying to deconstruct. Every time I claim that “creativity” is nothing more than a social construct, I make the construct more real. Every time I argue that Einstein wasn’t really creative outside of social judgment, I add to the mystique of Einstein’s creativity. I claim that other works tend to choose European white males as examples of creative individuals. I argue, following others, that this is due to the construction of a skewed version of history. At the same time, I use examples of Einstein and DaVinci. I use those examples because the meanings surrounding those individuals would be available to many of the people who would likely read this paper. We are all products of the social meanings that came before us and surround us. This document adds to the layers of meaning that reifies and disseminates creativity, while it tries to understand that architecture. This enigma is part of being social. We can’t get “above” the social. There is no “view from nowhere” (Nagel, 1986).
The theory of creativity that I am proposing abandons several of the assumptions that traditional creativity researchers have held. This section is a review of some of the approaches that have been taken to study creativity, and is intended for a reader that is not familiar with the literature. I have grouped the theories according to five metaphors: creativity as magic, as a number, as a predisposition, as computation, and as a life. These metaphors are not mutually exclusive, so I’ve placed theories under the metaphors which best characterize each theory. My critiques of the theories are elsewhere in this paper.
<table>
<thead>
<tr>
<th>Approach</th>
<th>Theorist</th>
<th>Definition</th>
<th>Location</th>
<th>Methodology</th>
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<td></td>
<td>Plato</td>
<td>Poetry that is “interpretation of the gods”</td>
<td>Divinely inspired individual</td>
<td>Philosophical inquiry; Creativity assumed</td>
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<td></td>
<td>Bacon</td>
<td>Poetry that “accommodates the images of things to our desires”</td>
<td>Divinely inspired individual</td>
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<tr>
<td></td>
<td>Kant</td>
<td>“Beautiful Art”</td>
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<td></td>
<td>Coleridge</td>
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<td>Freud</td>
<td>Production of “phantasy” that elicits emotion “we had not even thought ourselves capable”</td>
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<td></td>
<td>Jung</td>
<td>Production of art</td>
<td>Individual, but made possible by the collective unconscious</td>
<td>Inquiry on psychiatric patients; creativity assumed</td>
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<td></td>
<td>Wallace</td>
<td>“The making of a new generalization or invention, or the poetical expression of a new idea...”</td>
<td>Individual, requiring conscious and unconscious mental events</td>
<td>Used reports from people generally assumed to be creative</td>
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<td></td>
<td>Guilford</td>
<td>“Divergent production”</td>
<td>Individual’s mind</td>
<td>Battery of tests</td>
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<td></td>
<td>Torrance</td>
<td>Process of sensing difficulties, formulating hypotheses, evaluating, revising, and communicating results</td>
<td>Individual’s mind</td>
<td>Battery of tests</td>
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<td></td>
<td>Mednick</td>
<td>Associating remote ideas into new combinations which are useful or meet specific criteria</td>
<td>Individual’s mind</td>
<td>Test</td>
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<tr>
<td></td>
<td>MacKinnon</td>
<td></td>
<td>Individual</td>
<td>Personality profiles of architects judged to be creative by other architects</td>
</tr>
<tr>
<td></td>
<td>Barron</td>
<td>“The ability to bring something new into existence”</td>
<td>Individual</td>
<td>Profiles of professionals judged to be creative by peers</td>
</tr>
<tr>
<td></td>
<td>Roe</td>
<td>“Discovery or invention, and the verification, elaboration, and systematization of the new product”</td>
<td>Individual</td>
<td>Personality tests of people generally assumed to be creative</td>
</tr>
<tr>
<td>Approach</td>
<td>Theorist</td>
<td>Definition</td>
<td>Location</td>
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<tr>
<td>Creativity as computation</td>
<td>Newell &amp; Simon</td>
<td>The solving of ill-defined problems</td>
<td>Individual’s mind</td>
<td>Completion of an ill-defined task</td>
</tr>
<tr>
<td></td>
<td>Shank</td>
<td>A set of rules that govern the production of new things or ideas</td>
<td>Individual’s mind</td>
<td>Find a computer algorithm that creates novel responses, assume human minds are similar</td>
</tr>
<tr>
<td></td>
<td>Johnson-Laird</td>
<td>Production that is “unique and novel ...for the creator”</td>
<td>Individual’s mind</td>
<td>Completion of an ill-defined task</td>
</tr>
<tr>
<td></td>
<td>Sternberg</td>
<td>Originality and value of the product in relation to the rest of the field</td>
<td>Individual in environmental context</td>
<td>Determines components using data from various laboratory studies</td>
</tr>
<tr>
<td>Creativity as a life</td>
<td>Gruber</td>
<td>Work that is original, purposeful, and compatible with other human needs</td>
<td>Individual in environmental context</td>
<td>Historical analysis of people assumed to be creative</td>
</tr>
<tr>
<td></td>
<td>Gardner</td>
<td>A person who regularly solves problems, fashions products, and/or poses new questions initially considered novel and ultimately accepted in a cultural setting</td>
<td>Individual, interacting with the domain of the work and the field of practice</td>
<td>Historical analysis of people assumed to be creative and “historiometric” statistical data</td>
</tr>
<tr>
<td></td>
<td>Weisberg</td>
<td>Goal directed activity that leads to novel productions</td>
<td>Individual in environmental context</td>
<td>Historical analysis of people assumed to be creative, combined with completion of tasks assumed to require creativity</td>
</tr>
</tbody>
</table>

Table 7-1 Traditional Accounts of Creativity

A.1 Creativity as magic

“Creativity as magic” is a metaphor that characterizes theories that assume that creativity is mysterious and unable to be analyzed. Boden (1991) divides these perspectives into “inspirational” and “romantic” theories. In the former group of theories the underlying assumption is that individuals are inspired from some external, metaphysical source. Romantic theories are characterized by innate genius or unconscious activity. Wallace and Gruber (1989) believe that these theorists replace the “mystery” of creativity with something equally as mysterious.

Inspirational accounts of the creative process seem to have the longest recorded history. Plato, in his dialogue The Ion, addresses the question of poetic inspiration. Ion
asks Socrates why Homer affects him greatly, while other poets cannot grab his interest. In Socrates’ reply he says

Just so the Muse. She makes men inspired, and then through these inspired ones others share in the enthusiasm, and a chain is formed, for the epic poets, all the good ones, have their excellence, not from art, but are inspired, possessed, and thus they utter all these admirable poems. ... Therefore, since their making is not by art, when they utter many things and fine about the deeds of men, just as you do about Homer, but is by lot divine—therefore each is able to do well only that to which the Muse has impelled him—one to make dithyrambs, another panegyric odes, another choral songs, another epic poems, another iambics. (Plato, 1961)

Sir Francis Bacon, often thought of as the founder of empiricism, also believed the creative arts were different in nature. He believed poetry was “of a divine nature,” not subjecting the mind to the constraints of the natural world, as other disciplines are. This theme has been common in works of literary criticism into this century (Nahm, 1956).

Romantic views of the creative process can be divided into two perspectives: creativity as genius, and creativity as unconscious processing. The former perspective can be traced back to Kant’s treatise *Critique of Judgment*, originally published in 1790. He writes

*Genius* is the talent (or natural gift) which gives the rule to Art. Since talent, as the innate productive faculty of the artist, belongs itself to Nature, we may express the matter thus: *Genius* is the innate mental disposition (*ingenium*) through which Nature gives the rule to Art. (Kant, 1952)

In Kant’s view rules make possible the construction of a piece of Art, yet there are no *a priori* rules which exist to construct a creative work.\(^{63}\) Kant postulates that genius is the gate that allows the creative person access to the rules “according to which [Nature] can bring about its product” (i.e. creative art) (Kant, 1952). Creativity, as expressed by these theories, is a gift given to a small number of people. It is a mysterious gift, whether innate or divined. Such accounts have remained philosophical and have spawned little empirical research.\(^{64}\)

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\(^{63}\)“*Creative*” is my word. Kant consistently uses the word “*Beautiful*”. Beautiful, in Kant’s sense, seems to refer to a product that is original and meets aesthetic considerations. It seems that the term fits under many current definitions of “creativity.”

\(^{64}\)An exception to this is the scientific study of genius pioneered in the late nineteenth century by Francis Galton. He empirically studied eminent individuals of the time, and concluded that genius was inherited. (Galton, 1869)
The second kind of “romantic” theory assumes that the creative process is not available to our conscious thought. Samuel Taylor Coleridge distinguished between primary and secondary imagination of the artist. The primary imagination is consistent with Kant’s faculty of human reason, and it accounts for most “normal” activity. The secondary imagination “dissolves, diffuses, dissipates, in order to re-create” (Coleridge, 1907). It is this unconscious process which works in parallel with conscious thought to produce creative poetry.

The psychoanalytic tradition has contributed theories of the creative unconscious. In the late nineteenth century Freud was developing a theory of personality which rested on unconscious conflict. The unconscious harbors wishes and desires (“id” impulses), primarily driven by libidinal forces, which are in conflict with socialized rules of behavior (“super-ego”). In 1908 Freud wrote that creativity is the result of these impulses being “sublimated” into more socially acceptable products, like creative writing (Freud, 1959). Ernst Kris viewed creativity not as sublimation of id impulses, but the “primitivization” of the ego: namely, a regression towards a primordial state. Kris likens the creative process to dreams, intoxication, and psychoses, all of which are instances of a weakened ego that allows more primitive impulses to emerge (Kris, 1952). Jung, who historically preceded Kris by three decades, proposed a theory of the “collective unconscious.” An individual can be creative because of the access she has to the collective realm of human possibilities:

... It [the collective unconscious] is nothing but a possibility, that possibility, in fact, which from primordial time has found expression in the definite form of mnemic images or anatomical structure. It is inherited in the structure of the brain. It does not yield inborn ideas, but inborn possibilities of ideas, which also set definite bounds to the most daring phantasy. It provides categories of phantasy-activity, ideas a priori, as it were, the existence of which cannot be determined without experience. In finished or shaped material it appears only as its regulative principle of its shaping, i.e. only through the conclusion derived a posteriori from the perfected work of art are we able to reconstruct the primitive foundation of the primordial image. (Jung, 1923)

Jung’s belief is that certain archetypal forms exist in the collective unconscious which, through experience of the individual, reach a threshold and become manifested consciously. This theory attempts to explain recurrent themes in art and the universal appeal of art (both occur because each of us is connected to the collective unconscious).
Psychoanalytic theories view the creative process as unconscious impulses reaching a threshold and entering consciousness. The theorists differ on how this process occurs.

One of the earliest accounts that covers creativity in a general, domain independent manner is Wallace’s (1926) work on the stages of creative production. He used personal accounts of scientists such as Poincaré and Helmholtz to devise a four stage theory of the creative endeavor. He found that the categories preparation, incubation, illumination, and verification seemed to characterize the process.

Preparation involves the accumulation of knowledge and materials. Next, “a series of unconscious and involuntary (or foreconscious and forevoluntary) mental events may take place,” and Wallace called these events “incubation.” Incubation occurs while the individual is consciously engaged in other, generally more relaxing, activities. Illumination is the bringing to consciousness a solution to the problem, which experientially feels like a sudden insight, or “aha” experience. The individual then again consciously engages the problem, carefully evaluating the solution (verification).

This theory has maintained much of its original popularity, as many contemporary psychologists have elaborated on Wallace’s stage model (See Davis, 1986; Torrance, 1988). This theory parallels the psychoanalytic tradition in that unconscious events are necessary for creative behavior to emerge.

### A.2 Creativity as a number

Several theorists have identified creative and uncreative people based on the scores of paper and pencil tests. Researchers in this tradition theoretically determine the kinds of mental processes that are likely to underlie creative thought. They then construct tests which purport to test those processes and make claims about individuals based on test performance. Generally, they attempt to validate their measures by

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65 Recent work in the cognitive tradition has tried to empirically study a threshold theory. Bowers et. al. (1990) gave sets of three words to subjects, two of which were remotely related. The researchers found that subjects could identify the two words that went together, often without being able to say why the words went together. The authors conclude that cognitive processing can occur without becoming explicit at a conscious level. They believe that unconscious processing is the same as conscious processing, but it is occurring below a threshold level.

66 The idea of an “aha” experience is generally thought to be a product of the Gestalt tradition of psychology. I believe that their use of the term involves sudden perceptual coherence, rather than conceptual coherence. Wallace’s notion seems to be the latter.

67 Martindale (1989) adopts a cognitive view of the incubation process. He views the mind as a hierarchical semantic network. During preparation, the individual is too focused on a small set of relationships. These “nodes” remain partially active below conscious threshold. Different nodes are accessed during other activities that may be relevant for solving the problem. These new nodes may be linked to the original set of relationships at a level higher on the conceptual hierarchy. The higher level node serves as a bridge between the old problematic situation and the new analogical situation. The analogy is suddenly brought to consciousness, resulting in an “aha” experience. Langley and Jones (1988) propose a similar cognitive explanation of Wallace’s traditional stages.
correlating test scores with scores of other creativity tests or with measures of creativity from “authentic” activity.

Many of the theoretical foundations of this approach were developed by Guilford (1967). Guilford parsed the mind into 120 distinct processes, which he called the “Structure of the Intellect.” One of the factors was “divergent production,” which included the 24 processes that underlie creativity. He then created a battery of tests which assessed the 24 mental processes, each which is considered as a cell in a six by four matrix:

<table>
<thead>
<tr>
<th>Units</th>
<th>Figural</th>
<th>Symbolic</th>
<th>Semantic</th>
<th>Behavioral</th>
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<tr>
<td>Classes</td>
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<td>Relations</td>
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<td>Transformations</td>
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<tr>
<td>Implications</td>
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</tbody>
</table>

![Guilford's Divergent Thinking Model (1967)](image)

There are six types of products, which can contain four different types of content. An example test question for the “symbolic units” cell is “How many different sets of letters could you put into the blank to make R______M a word?” Letters are considered to be symbols, and words are considered to be units. A “figural units” question might ask the test-taker to create as many pictures as they can out of a series of small circles.

After taking the test, scores were based on four factors: fluency, flexibility, originality, and elaboration. Guilford described “fluency” and “flexibility” as “the ready flow of ideas and with readiness to change direction or to modify information.” (p. 138). Originality is statistical uniqueness (“cleverness”), and elaboration is the ability to fill out detail.

The Torrance Tests of Creative Thinking (Torrance, 1966) and the Wallach and Kogan Creativity Test for Children (Wallach & Kogan, 1965) both developed out of the “Structure of the Intellect” model. The Torrance Tests are scored in the same manner as Guilford’s battery: Scores are based on fluency (the amount of ideas produced), flexibility (the amount of different kinds of ideas), originality (the amount of non-typical responses), and elaboration (the amount of detail in the responses). In such tests, the
individuals are asked questions such as “How many things can you do with a brick?” or shown a picture and asked “what could possibly happen next?”. In order to score highly on such tests, the individual must be able to use a concept like “bricks” in a variety of contexts. The questions on the Wallach and Kogan Test are similar, but they are only scored on fluency and originality. The Wallach and Kogan test is untimed, and administered in a “game-like” atmosphere. The tests are statistically reliable. Individuals tend to have similar scores across different occasions taking the same test, and they tend to score at a similar percentile when taking different tests (Wallach, 1970; Gardner, 1993).

The validity of the tests has been questioned. Several researchers have attempted to discriminate “divergent production” (or creativity) from “convergent production” (or intelligence). Wallach (1970) addressed this problem in relation to the Torrance Tests. He claims that there is no evidence to show that the group of “divergent” processes cohere better as a set than they do when “convergent” processes are included, suggesting a lack of discriminant validity. Wallach and Kogan (1965) also made claims about the distinct nature of creativity and intelligence. Their conclusions were questioned by Cronbach (1968), who believed the terms “creativity” and “intelligence” may not be proper labels for the factors that the researchers statistically created. Torrance (1988) defends the validity of the tests, citing correlations of .38 to .58 between test scores and creative achievement assessed 22 years later.

In Guilford’s model, fluency, flexibility, originality, and elaboration are the bases of creativity. Problems exist with this conceptualization, however. First, as suggested by Hocevar (1979), fluency confounds the accurate measurement of the other factors. When he statistically partialled out fluency, the factor “originality” vanished. In addition, internal reliability dropped considerably when fluency was controlled.

The Remote Associates Test (RAT) is another test that has been developed to assess the creative individual (Mednick & Mednick, 1967). This measure tests the individual’s ability to combine “two or more ideas that have been freed from their normal correlates.” (Brown, 1989). It is based on the hypothesis that creative individuals are less tied to familiar contexts and have greater abilities to make unique

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68 Torrance (1988) assessed creative achievement in three ways: “Judged quality of the three most creative achievements, number of publicly acknowledged and recognized creative achievements, and judged quality of creative achievements projected for the future.”
associations. The test was created by taking a concept, such as “cheese,” and having a large group of subjects freely associate to it. Uncommon associations such as “rat,” “blue,” and “cottage,” were then used as the test questions. The individual taking the test is given “rat,” “blue,” and “cottage,” and is asked to answer with the mediating concept (i.e. “cheese”). Mednick and Mednick (1967) provide data that suggests scores on their test correlate with contracts won by research scientists, and they use this relationship to show that their measure is valid. Wallach (1970) suggests that the score reflects the underlying cognitive process of “attention deployment,” which he believes is important for creative behavior.

A.3 Creativity as a disposition

This approach examines the personality characteristics of the creative person. It is assumed that there is a variety of internal and stable characteristics of some people which predispose them to be more likely to act creatively. The dominant methodology that has been used is similar to that of the previous approach: paper and pencil tests. The difference is that the tests in the “creativity as a number” approach claim to assess cognitive characteristics, and the tests in this approach assess personality characteristics.

There are several tests that have been used to assess the creative personality. The Thematic Apperception Test (TAT) is a projective test that has been used to infer characteristics about the individual. The subject is given a series of ambiguous pictures and asked to tell a story about what might be happening. The Barron-Welsh Art Scale (Welsh & Barron, 1963) shows subjects a series of figures, some symmetric and simple and some asymmetric and complex. Those who favor the latter figures are thought to be more creative. Researchers have also used results of the Minnesota Multiphasic Personality Inventory (MMPI) as a basis for assessing creative disposition. This test was originally designed to assess psychopathology. The Adjective Check List (ACL) (Gough, 1952) is a list of 300 personality characteristics, and the subject checks those that she believes applies to her. These are common personality inventories for assessing the creative person, but other similar scales have also been used.

The first concerted effort to study the creative personality began at Berkeley in 1949, under project director Donald MacKinnon (Barron, 1988). He found a large sample of practicing architects and had professors of architecture from UC Berkeley
judge the creativeness of their work on a seven point scale (MacKinnon, 1965). He created three groups based on these judgments: Architects I (work judged most creative), Architects II (work judged as slightly creative) and Architects III (work judged as least creative). He used a variety of existing scales, such as the Barron-Welsh Art Scale, the MMPI, and the ACL, to assess the personalities of those in the sample. He found that many attributes (including aggression and autonomy) were characteristics of the individuals in Architects I, significantly more common than in the other groups. The least creative architects, however, scored higher on several attributes, including affiliation, nurturance, self-control, socialization, and responsibility. He used the data to construct a personality portrait of the groups:

...What is most impressive about Architects I is the degree to which they have actualized their creative potentialities. ...Since they are not preoccupied with the impression that they make on others or the demands that others make on them, they are freer than the other two groups to set their own standards and to achieve them in their own fashion. It is not that they are socially irresponsible, but that their behavior is guided by aesthetic values and ethical standards which they have set for themselves and which have been effectively integrated into their images of themselves and of their ideals. They are perhaps the prototype of the person of strong ego, the man of will and deed. Confident of themselves and basically self-accepting, they are to an unusual degree able to recognize and give expression to most aspects of inner experience and character and thus are able more fully to be themselves and to realize their own ideals.

Architects III, on the other hand, appear to have incorporated ...the more conventional standards of society and of their profession. More dependent on the good opinion of others for their own good opinion of themselves, their goals and ideals are to an important degree those of the group rather than uniquely their own. (MacKinnon, 1965)

The project at Berkeley also studied mathematicians and writers (Barron, 1969). The interesting finding to arise from this work that differed from the study of architects is an apparent relationship between creativity and psychopathology. Using the MMPI researchers found that the average creative writer scored in the upper 15 percent of the population in measures of psychopathology. Barron views this finding in a positive light:

But the “divine madness” that the Greeks considered a gift of the gods and an essential ingredient in the poet was not, like psychosis, something subtracted from normality; rather, it was something added. Genuine psychosis is stifling and imprisoning; the divine madness is a liberation from “the consensus.” (Barron, 1969)
Prentky (1989) argues that many eminently creative people suffered from psychopathology. He found many to be schizophrenic, including Kant, Pound, Swift, Da Vinci, El Greco, Rembrandt, Mendelssohn, Copernicus, Descartes, Faraday, Newton, and Pascal. Others appear to have suffered from affective disorders, including Coleridge, Goethe, Hemingway, Fitzgerald, Frost, Plath, Shelley, Woolf, Michelangelo, Raphael, Van Gogh, Handel, Tchaikovsky, and Darwin. According to Prentky, personality disorders were also found in many eminent people, including Robert Browning, Elizabeth Barrett Browning, Eliot, Proust, Tennyson, Beethoven, Wagner, Einstein, Freud, and Nightingale.

Eysenck (1994) has also found a link between creative cognition and psychopathology. He believes that there is a strong link between “psychoticism” and creativity. Psychotic, or schizophrenic, thinking can lead to a faster connections between a greater number of concepts.

Personality traits of the individual have been uncovered. Androgynous tendencies, openness to experience, and disinhibition are findings common to studies of the creative personality. The assumption is that “creativity,” in itself, is not a trait, but there are some other constructs, which are traits, that underlie an individual’s capacity to be creative.

### A.4 Creativity as computation

A variety of computer simulations have been developed to de-mystify the creative process. Early programs such as BACON.1 used heuristics for searching a data set to induce different scientific laws. The data was represented as data clusters consisting of dependent and independent variables. The computer used heuristics represented as production rules to systematically vary the independent variables and induce the relationship between that variable and the change in the dependent variable (as a scientist might do in an experimental lab). The program gathers data, discovers regularities, and formulates scientific laws. The model successfully determined Ohm’s law, Boyle’s law, and Kepler’s law, among others (Langley et. al., 1987).

Models have been developed which create artistic representations. AARON is a drawing program which creates thematic drawings such as acrobats (Cohen, 1984). Each drawing that the program generates is different (over 7,000 drawings were made by the program at the World’s Fair in Japan). The program has a conceptual space in which to
work, defined by given constraints. The program uses the constraints to move through a hierarchical search space, making appropriate decisions at each juncture of the search-tree. Such a procedure can produce thousands of unique drawings which do not violate “proper” pictorial representation.

Kass (1990) developed a computer simulation of creative thinking which was based on Schank’s (1986) theory of explanation patterns. This computer program was designed to answer a question creatively by retrieving a candidate case it had stored in memory (in this model, a “case” was an “explanation pattern”), apply it to a new situation, evaluate its effectiveness, and adapt the explanation as necessary. This model goes beyond “solving every problem from first principles,” the “elegant” solution that most scientists in artificial intelligence try to generate. This model, according to Kass, is based on the way that memory actually works. It goes beyond simple retrieval, but illustrates how memory retrieves information and tweaks it for use in the current situation.

Computational theories assume we can model the brain with a computer. They create problems which are defined to be creative based on their assumptions, and then they develop a computer model which can solve the problem. Neural network approaches (e.g. Rumelhart & McClelland, 1986) attempt to bridge such computational theories with data coming from work on the biology of the brain. Such approaches would characterize creativity as new patterns of activation among the neurons in the brain.

A.5 Creativity as a life

There are generally three approaches to creativity in this category of theories. Several researchers use a “case study” approach (Gardner, 1993; Gruber & Wallace, 1989; Weisberg, 1993). In addition to case studies of creative people, some researchers have used the “historiometric” approach, as extensively used by Simonton (1984). This approach uses quantitative, statistical techniques to aggregate useful data about creative people. One common finding from this type of analysis is the “ten year rule,” which has shown that an individual’s most important contribution to a field usually comes about ten years into his/her work in that field. The third technique is interviewing creative people about their lives (John-Steiner, 1985).
Gardner (1993) has studied someone who is “creative” in each of his seven domains of human intelligence (Freud, Einstein, Picasso, Stravinsky, Eliot, Graham, and Ghandi). He paid particular attention to aspects of the individual, such as cognition, personality, and life patterns. Secondly, he paid close attention to aspects of the domain in which the individual was working—examining symbol systems, activities, and paradigms. Finally, he examined the individual in relation to the field, including the creative person’s relation to mentors and students, the political climate, and the individual’s position in the hierarchy of the field. He found that creative personalities were strong in their “intellectual” domain of expertise, but often were weak in at least one of the other domains. He found differences in the way they regarded others, as well as the way they promoted themselves. Freud, for example, was very good at promoting himself; Einstein was very ordinary. Gardner found that support systems were common among the creative individuals at the time of their greatest achievements. He also found that creative individuals often had to engage in a “Faustian bargain”; that they had to pay a price for their creativity.

Wallace and Gruber (1989) assembled a series of case studies of creative individuals. Wallace (1989) uses a case study method to do the work of understanding the creative individual:

Even in the study of creative work, with its emphasis on the novel and the unique, there is room for nomothetic research. However, psychologists interested in creative work would be evading a major responsibility if they did not confront the issue of uniqueness. What attracts our attention to the creative individual is his or her unique achievement, and to explain it we are required to examine the extraordinary characteristics and circumstances that brought it about. (p. 27)

They study a creator’s work in relation to the field which he/she was in. The series of cases reveals a wide range of ways in which creative people relate to the world.

John-Steiner (1985) interviewed creative individuals. She seeks to understand the “language of thought,” or the inner symbol system (in the Vygotskian sense) that creative individuals use to create meanings. She emphasized several things: prolonged apprenticeships, membership in a community, collaborations, and friendships. The underlying ability of the creative individual is to apply productive ideas such that they can be joined with profound the tools and craft of the individual’s discipline. The creative individual also combines self-knowledge with life-long direction and purpose.
A.6 Summary

I have characterized creativity theories in five different categories: creativity as magic, a number, a disposition, computation, and a life. The theories here are representative of the kinds of theories traditionally constructed to explain creativity, but they certainly are only a few studies in the vast landscape of work done in this field. Although I did not critique the theories here, these theories take a different approach to creativity than I develop in Chapter 2 of this paper. I have made an explicit attempt to move away from trying to understand the creative individual to trying to understand the practices and structures that make it relevant for an individual to become “creative.”
B.1 An oral presentation to the class

(The group stands to do their presentation. Several groups have already presented. Henry begins.)

Ms. Reese: Nice and loud, so we can hear...
Henry: This is Jack-in-the-Box.
Audience member: OKAY
Henry: One of those two managers that killed those kids so--
Audience: Huh?
Henry: You know the Jack-in-the-Box--
Audience: --the tainted meat.
Audience: Food poisoning.
Henry: Yeh. We put food poisoning in it and we decided to take over the world. So we became richer than Richie Rich, so we extended our house. Um, oh yeh, later we ruled the world. (pause) Uh, the only people who lived were our slaves and they got no pay and they bought their own food.
Audience: Let's talk about the house
Ms. Reese: Okay...
Audience: They can't pay for it because you don't give them any money.
Henry: They steal it.
Audience: From who?
Henry: From Jack-in-the-Box
Audience: But you killed everybody...
Ms. Reese: Okay I think, we got kinda--the creative side took over there.
...
(End of the period, after the presentations are over. The houses are being collected to be put into a box. Henry’s group’s house becomes the object of discussion.)
Tessa: It looks like a snake
Ms. Reese: I know
Ms. Reese (to Henry) Where's your instruction... the ah
Henry: Oh, I'll get that.
Kyle: It's [referring to Henry’s group’s design] kinda messed up.
Larry: Wow
Kyle: Is this the big gallery with all the paintings that they stole [referring to part of the model]
Liza: Paintings [ box?]
Ms. Reese: Yes, I think that they got their subjects mixed up I think they thought this was English class.
Tessa: Creative writing. [pause] And they control the weather.
Kyle: You guys control the weather?
Henry: Yup.
Liza: Good-bye...

B.2  A “Radical” Wall

01 Dena: Look at this house, this is their house.
02 Other: Give us our house back
03 Dena: Oh my God, there’s a [?] to it (referring to the model)
04 Henry: I want to do that side, okay? (pointing)
05 Kyle: I messed up. [ ? ]
06 Dena: Oh the wall is crooked.
07 Kyle: I know.
08 Kyle: I like cracking the windows with the bulldozer.
09 Dena: Oh my God. Don't crack my window.
10 Henry: Make it crooked, make it crooked. That would be a cool house.
11 Kyle: No, it has to be a nice and pwetty house.
12 Dena: Oh
13 Kyle: Let me make a door.
14 Dena: There's lots of open spaces in the living room.
15 Henry: (Pointing) NO, make the wall like this, up here, like this.
16 Kyle: ==That a good door?
17 Henry: ==That’d be better
18 Dena: Yeah, it's a little big though.
19 Henry: No, no, please, listen...
20 Dena: ==(laughs) Yeah, Yeah (referring to Kyle’s design move on the computer)
21 Kyle: This is it.
22 Dena: Yeah, yeah.
23 Kyle: Want it to face the inside like that or not?
24 Henry: No go like this==
25 Dena: ==outside
26 Kyle: ==outside, okay.
27 Henry: Let me do one thing alright, if you don't like it you can bulldoze it. Okay? (reaches for the mouse)
28 Kyle: Rotate, thank you.
(Henry takes the mouse and begins to bulldoze a wall)
29 Dena: Your just bulldozing an entire wall. Oh he's gonna make it crooked.
30 Kyle: Oh
31 Dena: Oh Cool==
32 Kyle: ==oh cool. Radical. (spinning his head around)
(Henry sits back smiling)
33 Dena: Make the door right there.
34 Kyle: That's cool.
35 Dena: So you can go out of the living room and go straight in the bathroom.

B.3 A group working on a worksheet

ST is “Student Teacher”

Bonnie: huh? Wai wai wait (looks down at paper, reading)
What do you have in common with the US operations (reads silently)
Liza: Why? Because there’s
Bonnie: I don’t understand the question. (looking at student teacher)
Larry: If you
Liza: (towards student teacher) We build houses in a different,==
ST: (reading) what do we have in common
Bonnie: Who’s “we”?
ST: (points to himself)
Bonnie: Oh
Liza: ==in a different place. And temperature.
ST: To (gestures with hand to signal the students to finish the answer)
Bonnie: What’s the question?
Liza: I don’t know.
ST: What’s the whole point of the Antarctica Project?
Bonnie: To design a house suitable to stay there.
ST: for
Bonnie: For the ==
Larry: Scientists==
Bonnie: ==scientists who’s going to study
Larry: ==to research==
Bonnie: ==and research there.
Larry: ==the krill.
ST: Taking into account the environment
Bonnie: So what—how do we answer this question?
ST: You just answered it.
Bonnie: (laughing) Ohhh (slaps her hand down to the table) Okay okay okay. What did I say?
ST: [?]
Larry: We are designing a house, to be like, in a cold climate.
Bonnie: (writing) A house, in Antarctica.
Brian: It's a research station.
Bonnie: (getting up and walking away) We're not building condos in Antarctica.
Bonnie: (jokingly) We're not?
Liza: Let's go skiing! (building on the condos idea)
(group finishes writing the answer)
Bonnie: (reading next problem) Robert Falcon Scott's expedition died just () died? just eighteen kilometers from the depot of ss supplies. How many miles away were (begins to mumble)... How many kilometers are there in a mile?
Tessa: One thousand seven hundred and sixty?
Bonnie: Really?
Henry: In a mile? Oh, kilometers. (continues, but can't be heard over Kyle)
Kyle: (walks up to Bonnie from another group) [?] know how many kilometers there are in a mile.
Bonnie: Oh THANKS [Kyle] (sarcastically)
Tessa: How many kilometers are there in a mile?
Barb: (walks up to Bonnie from another group) What's thirteen I don't get thirteen help me on thirteen.
Bonnie: I'm stuck there. How many kilometers are there in a mile?
Barb: I don't know.
Bonnie: MATH book (begins to search table)
Barb: (looking around to other tables) How many kilometers...?
Tessa: (reaching toward Bonnie) YOU took my math book.
Bonnie: Oh, hh hh.
Larry: (leaning forward, toward Bonnie) It's under equivalencies. (Bonnie opens math textbook) No, not there. In the back.
Bonnie: In the back.
Larry: OH, in the front. In the math section. (Bonnie flipping pages) There, you passed it. Passed it.
Bonnie: I must have passed that...
Larry: No, it's in here. The pink one. I think that's it, right? The pink one.
Bonnie: Kilometers--
Larry: The pink one--
Bonnie: One mile--
Larry: The PINK one. The PINK one.
Bonnie: OH, ok Barry, I'm sorry. Larry I'm so sorry. One point six oh nine. One point six oh nine.
Larry: One point six oh nine.
Bonnie: Kilometers in, which is more?
Larry: [?
Bonnie: So there's one point six...
Barb: How do you know the supplies were in the storeroom? Huh huh huh huh do ya do ya do ya? (Tessa laughs) sorry.
Larry: So there's one point six oh nine...
Bonnie: So so we divi so we multiply one point six oh nine by eighteen, right?
Larry: Ahh, I guess.
Bonnie: (doing calculation with pencil on paper)
Barb: How do ya.. (long pause) What is it then, huh?
Bonnie: What?
Barb: How do ya know the supplies are in the storeroom?
Bonnie: What are you talking about? What supplies what number are you on?
Larry: Just [?] miles. Write miles. Write it.
Bonnie: You don't even care about this one...
Larry: If it's miles then the answer's gonna come out less.
Barb: No THIRTEEN!
Tessa: (to Larry) [?]
Larry: OH nine. OH nine.
Tessa: No it's six nine.
Larry: (to Polly) Is it one point six OH nine or one point six nine?
Bonnie: One point six oh nine.
Bonnie: I just multiplied it. It's twenty eight point nine six two.
Barb: (looking off of Bonnie’s paper) No it's kilometers, not miles!
Larry: (looking at Tessa’s calculator) Eleven point one...
Tessa: Let's just put eleven miles.
Bonnie: (surprised) Eleven?
Barb: It's kilometers, not miles it's kilometers to miles!
Larry: (overlapping talk with Barb) You divide it, not multiply it. If if if...
Bonnie: (loudly, raising arms at the elbows) WAIT!
Tessa: You multiply it. Because kilometers are more than miles.
Larry: No No. Are kilometers more or less than miles?
Tessa: More. See you do multiply it.
Bonnie: You STILL multiply it. Whichever way around you still multiply it!
Mona: (teacher overhears raised voices) Okay, what's your problem?
Bonnie: Number thirteen. (paraphrasing the question) How many miles away were they from the supplies that could have saved their lives? Eighteen kilometers away so you still multiply ( ) eighteen times how many miles there are.
Mona: In what, what are you
Larry: [?]
Bonnie: (to Larry) SEE?
Mona: How can you tell that you are doing it correctly, what could you do?
Bonnie: (confused look) OH boy.
Tessa: twenty nine miles.
Bonnie: Huh?
Tessa: twenty nine.
Bonnie: I got twenty eight point nine six two.
Tessa: I know but then you round it.
Bonnie: okay. twenty nine miles.
Bonnie: (moving on to the next question) (reading)
Fourteen. What are some things you still need to correct on your plan? We don’t need to correct anything! Do we? ...

**B.4 Testing a Model**

Kyle: I know what we could do to test it...
Larry: You guy's it's crooked
Kyle: it doesn't matter if it is crooked, Larry
Tessa: it's not perfect it's not gonna be perfect
Kyle: But if you if we really made this, it wouldn't be crooked, this is paper Larry, what do you expect?
Larry: Okay, well, something's wrong with this design
Tessa: how are we supposed to hold the ceiling up with a bui building like that?
Kyle: You could==
Larry: ==you could add a you could add little things here (using a gesture to indicate something vertical)
Tessa: a big pole? ==what if somebody chopped, thought it was a
Kyle: ==But you know how they make arch, you know how they make arches and there's a keystone right in the middle, right. It could be like that.
Tessa: there could be like a bar inside going like this holding this part up ==so it could support itself
Kyle: ==yeh. somehow it needs to be reinforced. There would be a big... The test to see if the rain'll ah if the rain'll come through when it drips through here, like that, it just sprinkle some water on it.
Tessa: Yeh but==
Larry: ==The rain's coming in this direction though (indicating a slant towards the gap in the structure) 'cause you know how rain comes at an angle, it'll go shhhhhhh ==right into the house
Kyle: ==yeh, oh yeh, unless we put a ==skylight there
Tessa: == a WIndow
Kyle: Be a window
Tessa: then it will be shaped like this (inverted V gesture) inside sort of.
Kyle: it would be a really hard to make window, it would be curved.
Larry: How how==
Liza: ==so, we're not making a window, right?
Tessa: [?] make one like this (slanting hand near model)
Larry: whatever happened to the second story of this house?
Tessa: its in there somewhere.
Larry: is no:::t.
Tessa: fine. Do you want to put one in then? It can be one story, okay?
Larry: the people are supposed to be like this tall, right? *(about 2 inches)*

Tessa: one inch. About an inch.

Larry: an inch tall::? that tall::?

Tessa: That tall.

Larry: That tall?

Tessa: Exactly.

*(Liza brings out a ruler, places it vertical on the desk)*

Larry: do you realize that this house is as high as the auditorium?

Tessa: yeh.

Kyle: if they're that tall *(indicates about 3 inches)*

it is not as high as the auditorium.

Tessa: No, inch tall. ==They're an inch tall

Larry: Inch tall.

*(again Liza uses a vertical ruler)*

Tessa: count on my thumb. count on my thumb. *(4 sec)*

They're this tall. *(gestures about 1.5 inches)* *(7 sec)*

Kyle: can't we just make the people that tall?

*(indicates about 3 inches)*

Tessa: NO::

Kyle: why not?

Tessa: How are they supposed to get their how can they fit they're head through there, and come out?

### B.5  Designing a Slanted Roof

Larry: What are we gonna use for the roof that we plan to have slanted so ==the rain will run off? *(circles pencil over sheet)*

Tessa: ==This... oh, the triangles. *(presents triangle)*

Larry: Triangles?

Kyle: Well we only have a couple of them.

Larry: Ok, then we've gotta save up triangles. *(points to desk)*

Tessa: See like this. *(collects and holds triangles together over pentagon)*

Kyle: Yeah.

Larry: No WAIT! But see, if you...

Kyle: Shh shh shh... Let Larry talk.

Larry: See but if you do tha::t... if it's gonna be over THIS thing *(points at hexagon in front of Liza)*

Kyle: It wouldn't fit.

Larry: Yeh. It'll just be FLAT. *(hands sweep flat surface)*

Tessa: What if you go like ==this? *(re-assembles triangles over pentagon)*

Kyle: ==If you made a point you'd just, it'd o[ver], it'd.... cave in. It'd cave in. *(palms up, then collapse)*

Tessa: That, no... The, water would fall off you know? ==Roll off. *(R hand sweeps down and over)*
Kyle: ==Then there'd be a big humongous hole in the middle. (R hand spirals down)

Larry: (arms drop, sighs) Then we'd have ==to use a hexagon. (retrieves pentagon) W::: what if we made the house this big, right?

Kyle: ==Right, ok? See, if you use this, THIS they wouldn't be able to touch, right? (grabs triangle, joins to Tessa's pentagon)

Jennifer: (To Kyle) Maybe ==we could do SQUAREs then.

Liza: (to Larry) ==It's a pentagon.

Larry: Yeah, see, and then just do the same thing. (joins trapezoid to pentagon) Cause if, see if you had five triangles, then they'd be pointed up so that the water could run off (hands trace perimeter of pentagon, slant up, then sweep down)

Kyle: Yeah, it'd be better if you did that. (points at Larry's pentagon)

Larry: Cause a hexagon, if we put all the triangles to make the roof, it would just be FLAT. (repeats prior series, then both hands sweep flat)

Kyle: Cool, a person. (grabs and cradles trapezoid)

Liza: (joining two triangles to a hexagon) Kyle:::

Kyle: Here, take these tapes and cut the rest.

Tessa: Well, we might not need them yet. So [I'll just] put them here.

Kyle: See? A person. (joins pentagon to trapezoid)

Larry: Unless we use like the trapezoid, to make, the roof, or something. (grabs trapezoid)

Tessa: A head:::, huh huh. We're making little stick people. (places pencils for legs)

Larry: Oh, ==unless we made another shape. (R point beats paper between himself and Liza on the table)

Tessa: ==Legs

Liza: Come on you guys! (R hand reaches to Kyle and waves in)

Tessa: Okay

Larry: Unless we made another sh... (R point beats center)

Tessa: What?

Larry: Unless we made another shape... ==to make the roof.

Liza: == (gets both trapezoids and leans them together)

Tessa: We could make, yeah. We could make another shape. But how would we get ==the

Kyle: ==But then how, we would have to fold it. We ==can only make ON:E shape. (Kyle signs "1" and beats)

Liza: ==We can make a house with THIS. (gets a square and joins between slanted trapezoids)

Larry: NO sss. We should make one KIND of extra shape. It doesn't matter how many you make. Look, read it. (points to task sheet) It says, ==that you can make one extra shape.

Tessa: ==Yeh, I already read that.

Larry: And you can make... as many as you WANT TO of that shape. Ok?

Liza: Can you?
Kyle: Oh, oh, yeh yeh, that's what it says. Says you can cut out as many ==as you, yeh.

Larry: ==See, so if we make a triangle, if we make a triangle that's lo::nger, then it'll stick up. (holds up triangle, traces equilateral extension of one vertex, then slants R hand and L triangle up)

Kyle: That's true. ==Yeh, yeh. Ok, that's good.

Larry: ==And water will run off when it rains, right? (R hand sweeps down)

Tessa: Yeh, but see the company... She said that the company could only cut it one size hhh. (hand over mouth, hands collect together, L point over shoulder to Ms. Reese)

Kyle: No::;, she said they could be different size, uh, you're extra shape could be, a longer ==or shorter triangle.

Tessa: ==Ok, but in order for the company, the company she bought the wood from, is like only cuts 'em in these kind of shapes.

Kyle: No, but it says you can make ONE extra sh::;, you can make o:::ne different, uh, one ==more pattern (or) shape.

Tessa: ==Well ==[who] is gonna make it?

Liza: == (leans trapezoids together in center of table)

Kyle: You could make it out of THIS. (lifts paper stock)

Larry: What's that?

Tessa: Who's, no! But when the company makes it, they're not gonna make it cause everybody else, maybe, might want a different shape.

Kyle: It doesn't ma::ter. This, they're allowing us to have one extra shape. The company's gonna do that for us. They're, ==its a nice company.

Liza: == (joins triangle to leaning trapezoids, all fall down)

Tessa: Yeh, ok.

Kyle: They're kind people.

Tessa: Ahh, you spit on me.

Larry: I think we should just make a longer triangle.

Ms. Reese: Does block R [have some earphones that he could use ... xxx]

Liza: We have to [xxx] but I don't know [xxx].

Ms. Reese: You might.

Tessa: I have earphones at home. Hm hh.

Kyle: On my walkman, I do.

Liza: (leaves table)

Larry: So if we make a triangle that's like... that has one side this long. And then make it longer... Then we could make the ==roof... slant. (traces side on table, then sweeps out adjacent sides)

Tessa: ==Then it would, it would join like this... and go... like THIS. (joins two triangles together, then sweeps both up to show slant)

Larry: Ye::h. And then it would slant up. (hands sweep up) And then fit onto this thing. (R hand down to table)

Tessa: Yeh, but if it was smaller, if the, if the thing was smaller... we could just go like this.
(joins two triangles to adjacent sides of pentagon)

Larry: Yeh, see... but then that's that's not a five sided thing.
Tessa: Yeh... that's how many sides are there. So we just go like this.
Kyle: It still... it'd make, it'd make more room if we did this and just cut out a longer triangle. (points at hexagon near base of Tessa’s assembly)
Larry: ==Yeh. Then [they make]
Kyle: It's called designing spaces. (points to worksheet) We're supposed to make as much space as possible for these people.
Tessa: Then why did we use that little thing?
Kyle: Well we cut out an extra shape, ok? ==So we can cut out...
Tessa: ==Well why are we using little things like this? (points at hexagon) If we have to make the scale bigger, so, it would be as big as we WANTED it. ==It would be the same shape, see? (hands spread open)
Kyle: ==That’s true, that’s true. But...
ARTIFACTS

CLASSROOM HANDOUTS IN THIS PAPER
2. **Build a house to protect people from rain and heat.**

   **Note:** For this challenge, your group will use the same shapes as in Lesson 2, except you will have 4 more squares (for a total of 10 squares).

   As in Lesson 2, each side of the shapes you will use is 5 centimeters long, except for the bottom of the trapezoid, which is 10 centimeters long.

   Use your shapes to build a three-dimensional model of a house. The house should be designed for people who live in a tropical climate in which it is very hot and rains a lot.

   There are three rules:
   - **The sides of shapes** can touch but shapes cannot overlap.
   - **Use all of the shapes in your set.**
   - **You can choose** to add one more kind of shape to your set. You can cut out as many copies of your new shape as you can make from a 20 cm x 20 cm piece of cardboard. Your new shape must be different from the shapes you were given.

   Figure 7–2 EDC Build Construction Paper House Task
Innovative Residential Living
2550 Hanover
Palo Alto, CA 94304
(415) 496 7900

To: Presidio Designs
c/o Ms. Mona Muniz
Roosevelt Jr. High School

Re: Request for Design Proposal
Student Housing Complex at the University of Minnesota in Duluth

Innovative Residential Living (IRL) wants your help in designing student housing at the University of Minnesota in Duluth. IRL has designed similar housing in Seattle, Washington.

We would like you to modify our Seattle design for Duluth's colder climate, but don't give students any less living space. Also, the University of Minnesota wants a design that costs less than $100,000 for building materials and heating over 25 years.

You have 30 minutes to modify the Seattle design and present your proposal to our representative. You may ask our representative any questions you like about the Seattle housing or the proposed site in Duluth, Minnesota.

We provide the following information about the Seattle design:

(a) ARCHITECT™ floorplan for a unit housing 8 students. The floorplan has separate bathrooms for men and women. We show sample furnishings for a 2-person room and bathroom, but you do not have to furnish your design.

(b) Excel™ chart comparing average seasonal temperatures in Seattle and Duluth. These may help you to estimate heating costs.

You have 20 minutes to modify the Seattle design and 10 minutes to present your proposal to our representative. We suggest you talk about the problem first, before using the computer to work on a modified design. In your presentation, show how you modified the Seattle design and argue why the University of Minnesota should accept your proposal.

Let's get started!
Figure 7–4 Design a Dorm Task, Page 2

Outside Walls = 60.00 m
Inside Walls = 28.00 m
Outside Doors = 4.00 m
Inside Doors = 12.00 m
Windows = 16.00 m
Foundation Area = 148.00 sq m
Floor Area = 148.00 sq m
Roof Area = 148.00 sq m
Ceiling Area = 148.00 sq m
Outside Wall cost = $540 per m
Inside Wall Cost = $104 per m
Outside Door Cost = $1040 per m
Inside Door Cost = $300 per m
Window Cost = $383 per m
Ceiling Cost = $20 per sq m
Roof Cost = $82 per sq m
Floor Cost = $36 per sq m
Foundation cost = $63 per sq m
Design Cost = $80108
Heating Cost = $13 per month
Outside Temp. = 17°C
Inside Temp. = 20°C
Outside Insul. = 20 R
Inside Insul. = 20 R
Window Insul. = 1 R
Roof Insul. = 20 R

Document Title = Seattle design

Comparison of Average Seasonal Temperatures
(1951 to 1980)

<table>
<thead>
<tr>
<th>City</th>
<th>Winter</th>
<th>Spring</th>
<th>Summer</th>
<th>Fall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seattle, WA</td>
<td>4°C (39 F)</td>
<td>9°C (49 F)</td>
<td>18°C (65 F)</td>
<td>11°C (52 F)</td>
</tr>
<tr>
<td>Duluth, MN</td>
<td>-14°C (6 F)</td>
<td>3°C (38 F)</td>
<td>18°C (65 F)</td>
<td>7°C (44 F)</td>
</tr>
</tbody>
</table>

Heating Costs in Seattle with Inside Temperature at 20°C
(68 Degrees Fahrenheit)

<table>
<thead>
<tr>
<th>Month</th>
<th>Outside temperature (Fahrenheit)</th>
<th>Outside temperature (Celsius)</th>
<th>Monthly Heating Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>36</td>
<td>2</td>
<td>76.05</td>
</tr>
<tr>
<td>February</td>
<td>40</td>
<td>4</td>
<td>67.60</td>
</tr>
<tr>
<td>March</td>
<td>44</td>
<td>7</td>
<td>54.93</td>
</tr>
<tr>
<td>April</td>
<td>47</td>
<td>8</td>
<td>50.70</td>
</tr>
<tr>
<td>May</td>
<td>50</td>
<td>10</td>
<td>42.25</td>
</tr>
<tr>
<td>June</td>
<td>57</td>
<td>14</td>
<td>25.35</td>
</tr>
<tr>
<td>July</td>
<td>66</td>
<td>19</td>
<td>4.23</td>
</tr>
<tr>
<td>August</td>
<td>62</td>
<td>17</td>
<td>12.68</td>
</tr>
<tr>
<td>September</td>
<td>56</td>
<td>13</td>
<td>29.58</td>
</tr>
<tr>
<td>October</td>
<td>53</td>
<td>12</td>
<td>33.80</td>
</tr>
<tr>
<td>November</td>
<td>45</td>
<td>7</td>
<td>54.93</td>
</tr>
<tr>
<td>December</td>
<td>39</td>
<td>4</td>
<td>67.60</td>
</tr>
</tbody>
</table>

Note that C = (F-32)*5/9

Total Cost to Heat in 1992 = $519.70
To: AntArchiTects

Re: Welcome new AntArchiTects

Greetings and welcome to AntArchiTects, an architecture firm specializing in designs for cold climates. We hope you’ll feel right “AAT” home in your new job.

We also hope you’re ready to get right to work because we’ve got a hot (or rather, cold) new client: The Frozen Scientific Group. They need us to design a scientific research station on a site in Antarctica. Here is what you need to know:

- The site is on the Antarctic coast
- The site is a small, flat field of dry rock measuring 17 m x 30 m
- The station will be open for at least 20 years
- Four scientists will live there for two years at a time

Those are the basics, but the more you know about your clients and Antarctica, the better your design will be. We recommend you do some research now, and any time you think you need more information.

Other AntArchiTects will design research stations, too, and we will give all of the designs to the Frozen Scientific Group for them to evaluate. Good luck!

Figure 7–5 Design an Antarctic Research Station Task
TIME OUT TEST ON UNDERSTANDING WHAT IS GOING ON OR HAVE YOU BEEN PAYING ATTENTION TO THE MATH AND SCIENCE INFORMATION OF THE ANTARCTICA UNIT. (What a long title for a test)
(You can use your notebooks or your group as a resource.

1. Compare Antarctica’s size to the United States.
2. If the ice sheet is about 3 miles thick at its source, how many inches would this be? (Think label factoring)
3. Sketch what is the percent of an iceberg below the water line.
4. If the summer temperature is about 32 °F, what is it in Celsius?
5. What is the range of temperatures between summer and winter?
6. What are the coldest months in Antarctica? Is the same as in the United States? Why or why not?
7. About how many people stay on during the coldest months?
8. Why must scientists bring even their fuel for cooking and heating?
9. Why can’t wastes be buried on Antarctica?
10. What is the difference between a contradictory statement and a redundant statement?
11. Why is Mc Murdo considered one of the world’s most polluted spots?
12. What do you have in common with the US operations in Antarctica and the National Science Foundation?
13. Robert Falcon Scott’s expedition died just 18 km. from a depot of supplies. How many miles away were they from the supplies that could have saved their lives?
14. What are some things you still need to correct on your plan?

Figure 7–6 Antarctica Worksheet Task
References


Gray, (19??) dissertation submitted to...


